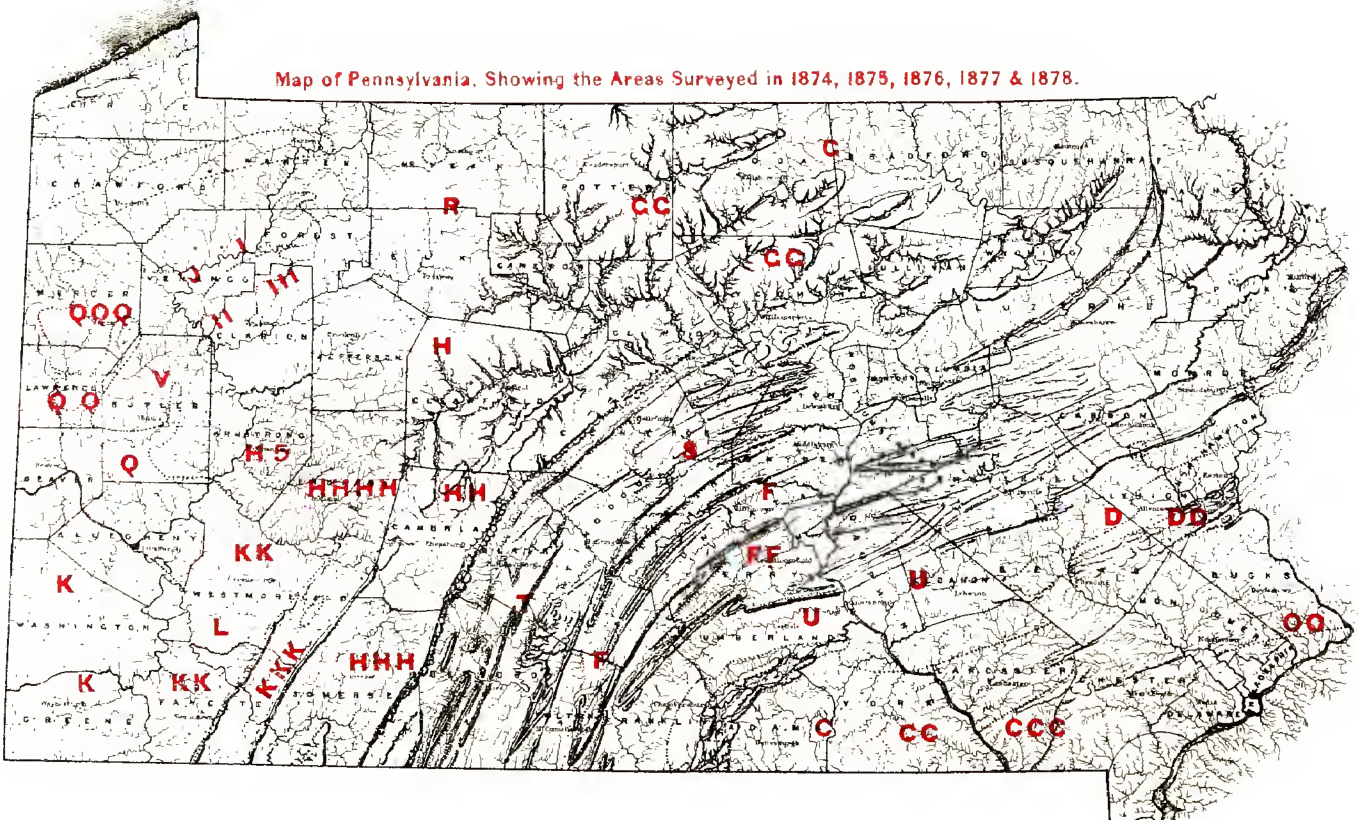
Map of Pennsylvania. Showing the Areas Surveyed in 1874, 1875, 1876, 1877 & 1878.



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA:
1876-8.
MM.

SECOND REPORT OF PROGRESS IN THE LABORATORY OF THE SURVEY AT HARRISBURG,

BY

ANDREW S. McCREATH.

INCLUDING

1. Classification of Coals, by Persifor Frazer, Jr.
2. Firebrick tests, by Franklin Platt.
3. Notes on Dolomitic limestones, by J. P. Lesley.
4. Utilization of Anthracite Slack, by Franklin Platt.
5. Determination of Carbon in Iron or Steel, by A. S. McCreath.

WITH 3 INDEXES, PLATE, AND 4 PAGE PLATES

HARRISBURG:
PUBLISHED BY THE BOARD OF COMMISSIONERS
FOR THE SECOND GEOLOGICAL SURVEY.
1879.

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LABORATORY OF THE GEOLOGICAL SURVEY,
223 MARKET STREET,
HARRISBURG, *March 8, 1879.*

Prof. J. P. LESLEY,
State Geologist:

DEAR SIR: I have the honor herewith to submit my second report of progress in the Laboratory of the Survey.

It contains all such analyses as are fit for tabulation or which might be of general interest; but a large amount of analytical work—qualitative and quantitative—has been done the results of which are not here recorded.

Wherever it has been possible the analyses have been classified geologically as well as geographically; and it is believed that this method will prove a valuable aid in determining the character of the different rock strata throughout the State.

The various reports of progress of the Survey have generally been made the basis from which I have obtained the data for describing the different coal, iron ore, clay, and limestone beds; and these reports are in most cases the authority for the classification adopted.

The work of the survey is necessarily one of progress; and as the connection between the different rock strata throughout the State has not yet in every case been clearly established it may be found necessary as the work advances to modify some portion of the classification given, so that for the present such classification should be considered merely provisional.

It seems very desirable that mere local synonyms of coal beds, &c. should give place to well known geological names applicable to the beds throughout the whole State; and in this report an attempt has been made in that direction, retaining however many of the local names where the identification of the bed has not been clearly established.

It has been thought desirable to postpone a discussion of the coals and ores until our data for so doing shall be more complete.

In presenting this large body of analytical work I have to acknowledge the able assistance and kind coöperation which I have received from the different Assistants in the Laboratory ;—of Dr. David McCreath, from February, 1876, to July, 1877 ; Mr. Joseph Hartshorne, from December, 1876, to June, 1878 ; and Mr. S. S. Hartranft, from March, 1878, to January, 1879. All their analyses have been duly credited to them in the body of the report ; those not otherwise designated have been made by myself.

I desire also to avail myself of this opportunity to place on record the services of Mr. John M. Stinson, which have been truly valuable. Since his connection with the Laboratory in 1875 he has manifested much interest in the work, has been thoroughly conscientious in everything, and has performed the various duties assigned him with rare fidelity.

I may not close this letter without expressing to you my sincere thanks for your valuable counsel and assistance at every stage in the preparation of this report, as well as for the indexes which accompany it.

Yours, very respectfully,

ANDREW S. McCREATH.

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REPORT OF PROGRESS

IN THE

CHEMICAL LABORATORY AT HARRISBURG,

1876, 1877, 1878.

By ANDREW S. McCREATH.

CHAPTER I.

Analyses of Coals, Cokes, &c.

§ 1. *Washington Main Coal Bed.*

This is the highest workable bed of importance in the Coal Measures of Pennsylvania; lying about seventy feet above the great Waynesburg Sandstone, which has been empirically adopted as the base of the Upper Barren Measures of South Western Pennsylvania;—five hundred and thirty feet above the Pittsburgh coal bed, which has been adopted as the base of the Upper Productive Coal Measures;—eleven hundred feet above the Mahoning Sandstone, which has been adopted as the base of the Lower (or properly Middle) Barren Measures (or Barren Measures of the First Geological Survey;)—and fourteen hundred feet above the Pottsville Conglomerate, or Millstone Grit, popularly considered the base of the Carboniferous System, but now known to be divisible, containing its own coal beds, and having coal beds underneath it; so that the Washington Main coal may be said to lie sixteen hundred feet, more or less, above the Sharon Block coal of Mercer county, Pennsylvania, and of the counties of Eastern Ohio, which is the lowest known large workable coal bed in any part of the State.

The Upper Barren Measures* exist only in Washington and Greene counties, and in Westmoreland and Fayette counties in Pennsylvania; but they spread westward and southward into West Virginia and Ohio. They are divided into an upper and a lower group, called the Greene County group, and the Washington County group.

The Greene County group, as preserved in the highest lands along the State Line, measures about seven hundred feet, and contains ten limestone beds, No. XIV, down to No. VI,—(see plate facing page 48, Report of Progress K,) the Upper Washington limestone, thirty feet thick, being adopted as the basal stratum of the group;—and four thin coal beds, or layers of carbonaceous shale.

The Washington County group (under the last mentioned measures,) in Greene county three hundred and sixty-seven feet, and in Washington county two hundred and ninety-five feet, from the bottom of the Washington Limestone down to the top of the Waynesburg Sandstone (see plate in K, and pages 44 and 45 K,) contains five limestone beds and five coal beds, viz: the Jollytown bed near the top, and the Washington Main, and Washington Little, the Waynesburg *b*, and Waynesburg *a*, near the bottom.

In Greene county the Little Washington is in one place seven feet thick and the Washington Main is never seen more than two and one half; but in Washington county, the Little Washington is but one foot and the Washington Main ten feet thick.

The Washington Main lies (as was said) seventy feet above the Waynesburg Sandstone (seventy feet thick) and twelve feet under the Sandstone lies the Waynesburg Main coal from seven to ten feet thick. Consequently there is a vertical interval of about one hundred and fifty feet between

*A report of Progress on the Coal Plants of Greene county and the neighboring counties of West Virginia, by Professors Fontaine and White, of the University at Morgantown, to be published in 1879, will present facts in evidence of the *Permian* age of a portion of the Upper Barren Coal Measures.

the Washington Main coal and the Waynesburg Main coal. But as the former is insignificant in Greene county, and the latter insignificant in Washington county,—and as no instrumental differentiation of the Barren or Productive Coal Measures was made by the First Geological Survey, nor by any surveys up to 1875, it was supposed that the great bed mined around Waynesburg must be the great bed mined around Washington.

They are now known to be separate beds one hundred to one hundred and fifty feet apart, with the massive Waynesburg Sandstone formation intervening; and as this has been adopted as a well marked and easily recognized division plane between two systems—the Upper Barren Coal Measures and the Upper Productive Coal Measures—it follows that the Washington Main Coal falls into the Barren and the Waynesburg Main coal into the Productive series.

The Washington Main coal bed is the same as the "Brownsville coal" of Prof. White's papers in the Annals of the New York Lyceum of Natural History, and of Prof. Stevenson's "Notes on the Geology of West Virginia." The name was changed in Prof. Stevenson's first Report of Progress K (see page 51) "because in a large portion of Washington county it becomes of much economical importance, which it rarely does elsewhere. Though quite variable in thickness it never disappears, and is persistent equally with either the *Waynesburg* or *Pittsburgh*. In the Ohio Report I have identified with this the Coal XII of that State; but in so doing I was in error, as its equivalent there is the one which I have numbered XIII."

The geographical area occupied by the Washington Main coal bed is nearly the same, but a little less than that of the Upper Barren Measures *colored deep grey* on the county maps of Greene, Washington, Westmoreland and Fayette published with Report of Progress KKK, 1878, inasmuch as the outcrop of the bed is always less than one hundred feet (vertical) from the outcrop of the Waynesburg Sandstone, which marks the limit of the Upper Barren Measures. But as the bed is not of workable thickness except in Washington county, only one specimen of its coal has been selected for analysis.

Washington County.	(147.) *A. Henderson.*
Water @ 225°,	1.695
Volatile matter,	39.150
Fixed carbon,	46.658
Sulphur,	1.972
Ash,	10.525
	100.000
Coke, per cent.,	59.155
Color of ash,	Grey.
Fuel ratio,	1 : 1.19

(*147*) *A. Henderson's Coal bank*, near Taylorstown, ten miles from Washington, Buffalo township, Washington county. See Report K, page 256.

The coal is hard and compact, with resinous luster; it carries numerous thin seams of pyrites and considerable slate.

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§ 2. *Waynesburg Main Coal Bed.*

This bed is the highest workable bed of the Upper Productive Coal Measures, and lies about three hundred and ninety feet above the Pittsburgh bed. Its thickness varies from six inches to seven feet. In Ohio it is known as the "Jumping Six Foot," Coal XI. It is the chief source of supply in Greene county, Pa., and it is mined also in eastern Washington county, but grows poor and thin towards the west. It is commonly a triple bed, but sometimes has but two benches, and occasionally is much split up.

Its area in the four counties bordering the Monongahela river is practically marked on the colored geological maps (in KKK) by the deep grey color assigned to the Upper Barren Measures.

Specimens of the coal from this bed have been analyzed from Greene and Washington counties.

Upper Bench of Waynesburg Bed.

Greene County.

	(164) *L. L. Minor.*	(8) *J. Stevenson.*
Water @ 225°,	1.230	1.036
Volatile matter,	33.135	38.304
Fixed carbon,	49.115	48.966
Sulphur,	1.705	2.726
Ash,	14.815	8.968
	100.000	100.000
Coke, per cent.,	65.635	60.660
Color of ash,	Grey.	Grey.
Fuel ratio,	1:1.48	1:1.27

(*164*) *L. L. Minor's bank*, near Jefferson, Jefferson township, Greene county. See Report K, pp. 139, 377.

The coal has a dull, dirty appearance, generally, being coated with iron oxide. It contains a good deal of mineral charcoal, and numerous thin partings of pyrites.

(*8*) *J. Stevenson's bank*, two miles from Carmichaels, in Cumberland township, Greene county.

The coal is hard, with a somewhat columnar structure and resinous luster. It carries some partings of mineral charcoal and iron pyrites. (S. A. Ford.)

Washington County.

	(151) *James.*	(152) *J. J. Hill.*	(150) *S. W. Rogers.*
Water @ 225°,	1.385	.770	.740
Volatile matter,	37.210	36.115	36.010
Fixed carbon,	42.335	48.554	46.890
Sulphur,	3.710	2.146	2.375
Ash,	15.360	12.415	13.955
	100.000	100.000	100.000
Coke, per cent.,	61.405	63.115	63.220
Color of ash,	Red.	Grey, red tinge.	Grey.
Fuel ratio,	1:1.13	1:1.34	1:1.30

(*151*) *James' bank*, two and a half miles south from West Middletown, Hopewell township, Washington county.

Coal compact, with bright shining luster. Contains numerous thin partings of slate and pyrites.

(*152*) *J. J. Hill's bank*, two miles northeast from Hillsboro', Somerset township, Washington county.

Coal exceedingly tender; generally coated with an efflorescence of sulphate of iron; seamed with charcoal and pyrites. (D. McCreath.)

(*150*) *S. W. Rogers' bank*, half a mile north of Beallsville, in West Pike Run township, Washington county.

Coal hard and compact, seamed with mineral charcoal and pyrites; laminæ very distinct in some pieces. (D. McC.)

Lower Bench of Waynesburg Bed.
Greene County.

	(*155*) *G. C. Sayers.*	(*156*) *U. Lippincott.*	(*153*) *S. C. Orr.*
Water @ 225°,	1.265	1.235	.920
Volatile matter,	34.685	36.185	33.710
Fixed carbon,	49.590	46.723	52.064
Sulphur,	1.270	2.972	1.121
Ash,	13.190	12.885	12.185
	100.000	100.000	100.000
Coke, per cent.,	64.050	62.580	65.370
Color of ash,	Grey.	Reddish grey.	Grey.
Fuel ratio,	1:1.42	1:1.29	1:1.54

(*155*) *G. C. Sayers' bank*, one and a half miles from Waynesburg, Franklin township, Greene county. See K, pp. 147, 377.

Coal very hard and compact; resinous luster; somewhat slaty. (D. McC.)

(*156*) *U. Lippincott's bank*, on Ruff's creek, Morgan township, half a mile from Martinsville, Greene county.

Coal has a dirty appearance, being coated with a yellowish white efflorescence of sulphate of iron. It carries considerable pyrites in thin partings.

(*153*) *S. C. Orr's bank*, near Centre School House, Morgan township, four miles from Jefferson, Greene county.

Coal hard and brittle; seamed with mineral charcoal and pyrites. Shows a slight efflorescence of sulphate of iron. (D. McC.)

	(*154.*) *L. L Minor.*	(*157.*) *Shape.*	(*158.*) *Jer. Price.*	(*7.*) *A. Groom.*
Water @ 225°,	1.175	1.200	1.000	1.180
Volatile matter,	35.615	38.860	35.675	32.344
Fixed carbon,	49.725	49.402	50.846	51.582
Sulphur,	2.280	2.345	1.694	1.306
Ash,	11.205	8.190	10.785	13.588
	100.000	100.000	100.000	100.000

Coke, per cent.,	63.210	59.940	63.325	66.476
Color of ash,	Pink.	Pink.	Cream.	Cream.
Fuel ratio,	1:1.39	1:1.27	1:1.42	1:1.59

(154.) L. L. Minor's bank, near Jefferson, Jefferson township, Greene county.

Coal shining, iridescent; brittle, with numerous partings of pyrites.

(157.) Mr. Shape's bank, three miles from Jefferson, Greene county.

Coal very brittle; of dull, dirty aspect; mostly coated with iron oxide; fresh fracture of pitchy luster. Contains a good deal of pyrites.

(158.) Jer. Price's bank, Rice's Landing, Greene county. Coal of dull, dirty aspect; much coated with iron rust and a yellowish efflorescence of sulphate of iron. Contains considerable slate partings and iron pyrites.

(7.) A. Groom's bank, one mile from Carmichaels, Cumberland township, Greene county.

Coal hard, with resinous luster; carries a good deal of pyrites in thin partings; also some mineral charcoal and slate. (S. A. Ford.)

Washington County.

	(148.) *C. Denning.*	*(149.)* *Jas. Moninger.*
Water @ 225°,	1.810	1.190
Volatile matter,	38.520	36.585
Fixed carbon,	51.181	43.489
Sulphur,	1.179	2.806
Ash,	7.310	15.930
	100.000	100.000
Coke, per cent.,	59.670	62.225
Color of ash,	Cream.	Grey.
Fuel ratio,	1:1.32	1:1.18

(148.) C. Denning's bank, on Brush Run, near Atchison P. O., Buffalo township, two miles west by north from Washington, Washington county.

Coal compact; bright shining luster; numerous thin partings of charcoal, slate and pyrites.

(149.) Jas. Moninger's bank, at Pleasant Valley village, eight miles south-east of Washington.

Coal hard, compact; seamed with charcoal, slate and pyrites; much coated with a yellowish white efflorescence of sulphate of iron. (D. McC.)

Specimen not marked from any special bench in the bed.

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§ 3. *Sewickley Coal Bed.*

This bed is the next but one* above the Pittsburgh bed, and overlies it by an interval of one hundred and fifteen feet on the Monongahela river.

Its geographical area in the four south-western counties is nearly the same as that of the Pittsburgh bed; but the isolated hills which take in the latter in Allegheny, Beaver and Indiana counties are seldom high enough to reach the Sewickley bed.

It occupies, however, the long narrow strip of the Salisbury basin in Somerset county, where it overlies the Pittsburgh bed at only ninety feet, but is very thin. (HHH, p. 91.)

West of the Monongahela river it is of importance only in the south-eastern portion of Greene county (K, page 65). On Dunkard creek it is five and a half feet thick, in two benches; but becomes only three inches thick on the Parkersburg branch of the B. and O. R. R. in W. Virginia. It represents the Ohio coal bed No. VIII *b*, and No. VIII *c*.

In the Blairsville-Connellsville basin it is usually every-

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* The next bed in order downwards is the *Uniontown coal bed*, which underlies the Waynesburg about ninety feet and overlies the Pittsburgh about two hundred and ninety feet. But we have no analyses from this bed ready to report. Mined on a very small scale in Greene and Washington, occasionally three feet thick, in two benches, it degenerates to a cannel shale full of fish scales and teeth, and lies directly upon the upper member of the Great Limestone. (K, page 62.)

In Fayette county, about Uniontown, it is three feet thick, but not mined. (KK, p. 36.) It is not easily traceable towards Blairsville beyond Connellsville; not at all in the Greensburg basin; and not north of the Pennsylvania railroad in the Lisbon basin in Westmoreland county.

In Somerset county it seems to be represented by a worthless bed lying on the Great Limestone, one hundred and sixty or one hundred and seventy feet above the Pittsburgh bed, in the hill tops opposite Salisbury.

where workable, and becomes five feet thick south of the Youghiogheny, but thins down northward almost to nothing on crossing the Loyalhanna. It is thin and poor in the Greensburg basin; and in the Lisbon basin loses its size and value north of Sewickley creek.

Greene County.

	(5) *Lucas.*	(9) *Whitely Creek.*	(10) *Gray.*
Water @ 225,	1.790	1.500	1.083
Volatile matter,	35.400	30.428	34.012
Fixed carbon,	56.818	55.638	51.783
Sulphur,	1.152	1.406	2.261
Ash,	4.840	11.628	10.856
	100.000	100.000	100.000
Coke, per cent.,	62.810	68.072	64.900
Color of ash,	grey.	grey, red tinge.	grey, red tinge.
Fuel ratio,	1:1.60	1:1.80	1:1.52

(5) *Mr. Lucas' bank*, two miles from Taylorstown, Dunkard township, Greene county. *Upper bench.* See Report K, p. 92.

Coal compact; comparatively dull luster; much mineral charcoal; little pyrites; tendency to break in cubes.

(9) *An opening near the level of Whitely Creek*, one mile from Mapleton, Monongahela township, Greene county.

Coal compact; generally dull luster; much coated with efflorescence of sulphate of iron; has thin slate partings; tendency to break in cubes. (S. A. Ford).

(10) *Mr. Gray's bank*, one mile from Mapleton, Monongahela township. *Lower bench.*

Coal of dull resinous luster generally; rather friable; with tendency to break in cubes; has seams of mineral charcoal and pyrites. (S. A. Ford)

Fayette County

	(500) *Woolsey.*
Water @ 225,	1.060
Volatile matter,	34.805
Fixed carbon,	53.538
Sulphur,	2.432
Ash,	8.165
	100.000

Coke, per cent.,	64.135
Color of ash,	grey, pink tinge.
Fuel ratio,	1 : 1.54

(500) C. Woolsey's bank, two miles south of Masontown, Nicholson township, Fayette county.

Coal compact, bright; carries considerable mineral charcoal and pyrites. (D. McC.)

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§ *4. Redstone Coal Bed.*

This is the next above the Pittsburgh bed, and co-extensive with it, except in isolated hill tops in the country north and east of Pittsburgh too low to contain it.

On the Monongahela it overlies the Pittsburgh bed about sixty feet, and varies from one to four feet in thickness. In Ohio it is represented by a variable, worthless bed No. *VIII a*, (K, p. 68.)

In Westmoreland and Fayette it varies from two to four feet in thickness, and is a good workable bed along the Sewickley and Youghiogheny. Along the Pennsylvania railroad, where it is known as the "Eighty Foot Coal," it is from one to three feet thick.

In the Greenburg basin it seems to be represented by a small bed only ten to twenty feet above the Pittsburgh.

In the Connellsville basin it is four feet thick on the State Line; only six to eighteen inches thick on Redstone, Georges, and Dunbar creeks and the Youghiogheny river; three feet on Jacob's creek; six to ten inches on the Loyalhanna.

In Ligonier valley it is two to three feet thick and only seventeen to thirty-two feet above the Pittsburgh bed. (KK, p. 46.)

In the Salisbury basin of Somerset it is probably the four to five foot bed, lying forty-four feet above the Pittsburgh bed, and much sub-divided. (HHH, pp 86, 87.)

	Washington County. (146) I. Teeple's.	Somerset County. (350) Keystone.
Water @ 225°,	1.060	1.290
Volatile matter,	33.590	20.865
Fixed carbon,	48.688	67.201
Sulphur,	2.367	1.839
Ash,	14.295	8.805
	100.000	100.000
Coke, per cent.,	65.350	77.845
Color of ash,	Grey.	Reddish grey.
Fuel ratio,	1:1.44	1:3.22

(*146*) *Isaac Teeple's bank*, near Pigeon Creek, in Scott's Hollow, two miles west of Monongahela City, Carroll township, Washington county. See K, p. 211.

Coal hard, compact; resinous luster; carries a good deal of slate and pyrites.

(*350*) *Keystone Coal and Manufacturing Company's coal bank*, about three miles south of Meyersdale, on the Cassellman river, Somerset county. See HHH, p. 87.

The coal, which had been exposed to the weather for a year, has a dull, dead luster; on fresh fracture it is bright and shining; generally compact, with numerous thin partings of pyrites.

§ 5. *Pittsburgh Coal Bed.*

The Pittsburgh bed is the principal coal bed of South-Western Pennsylvania; and most of the mineral fuel which is mined along the Youghiogheny and Monongahela rivers, to be used in the coke ovens of the Connellsville region, and in the blast furnaces and mills and factories of Pittsburgh and its vicinity, and to be shipped to western and southern markets, comes from this bed.

The Pittsburgh bed underlies all Greene county, and nearly all of Washington county,* and long synclinal areas in

* The approximate depth in feet beneath the surface at which it lies at many places is marked on the maps of these two counties published with Vol. K.

Westmoreland and Fayette counties, west of Chestnut Ridge. Outlying patches of it occupy the hill tops in Allegheny and Indiana counties. Several such outliers exist near Ligonier in eastern Westmoreland county; and an important oblong patch of it, about ten miles long, occupies a ridge opposite Salisbury, in Somerset county. It is the great bed of the Cumberland Coal Basin in Maryland; and a small fragment of the bed remains in the highest summit of Broad Top in Blair county.

From all the rest of the State the bed has been removed by erosion; but there is good reason for believing that it formerly extended beyond the Susquehanna river, and that it has been preserved as one of the beds of the anthracite basins of Eastern Pennsylvania.

There is a natural prejudice against the assertion that the superior eleven to twelve foot bed at Connellsville is the same with the inferior six or seven foot bed in the hills around Pittsburgh. But the fact is indubitable; and any one may trace the connection by riding along the outcrop of the bed from Connellsville, or East Liberty, southward to Uniontown, McClellandtown and New Salem (Fayette county,) and then northward to Perryopolis, and so down the river to Pittsburgh. By the sections published in Reports of Progress KK and L the connection is shown in the plainest manner.

The Pittsburgh bed has its best development in the Connellsville trough, between the Conemaugh river at Blairsville and the mouth of the Cheat river at the Maryland State Line. It becomes thinner westward; and after passing Pittsburgh and descending the Ohio river towards the Ohio State Line it loses almost all its value as a source of fuel.

At Pittsburgh it is mined in the hillsides at an elevation of more than three hundred feet; but its outcrop slowly descends to the Monongahela river water level near Bridgeport, and to the Youghiogheny river water level near West Newton.

The Pittsburgh bed lies sometimes six hundred, sometimes seven hundred, feet above the Freeport Upper coal bed, and about nine hundred feet above the Conglomerate base of the Productive Coal Measures of south-western Pennsylvania. The six hundred feet above mentioned represent the Barren Measures.

The Pittsburgh bed is usually divided into a roof division, varying from two inches to eight feet, (in extreme cases,) sometimes solid, sometimes in two benches, always poor, and a main body of coal, varying from three and a half to nine feet (extremes) and always sub-divided into four benches, known as the Upper bench, the Bearing-in bench, the Brick bench, and the Lower Bottom bench.

Roof Coal; Pittsburgh Bed.

	Greene County. (*160*) *L. Vernon.*	*Washington County.* (*145*) *Patterson.*
Water @ 225°,	1.020	.775
Volatile matter,	38.490	36.770
Fixed carbon,	45.895	51.467
Sulphur,	2.905	2.098
Ash,	11.690	8.890
	100.000	100.000
Coke, per cent.,	60.490	62.455
Color of ash,	grey.	grey.
Fuel ratio,	1:1.19	1.1.39

(*160*) *L. Vernon's bank*, near Millsboro', three miles from Rice's Landing, Jefferson township, Greene county. See K, p. 136.

Coal very compact; of resinous luster generally; with numerous thin partings of pyrites.

(*145*) *Mr. Patterson's bank*, near Patterson's Mills, one and a half miles north-east of Centreville, West Pike Run township, Washington county. See K, p. 287.

Coal hard and compact; luster resinous; seams of mineral charcoal and pyrites; considerable efflorescence of sulphate of iron.

Upper bench of Pittsburgh Bed.

Washington County.

	(139) Magee.	(177) Bushfield.	(165) Thomas	(166) New Eagle Works.
Water @ 225°, . .	1.510	1.730	1.080	1.180
Volatile matter, .	40.510	37.735	40.350	35.830
Fixed carbon, . . .	41.324	54.561	50.311	58.154
Sulphur, . .	7.566	1.499	2.594	.761
Ash, ...	9.090	4.475	5.665	4.075
	100.000	100.000	100.000	100.000
Coke, per cent., . .	57.980	60.535	58.570	62.990
Color of ash, . .	deep pink.	grey.	red.	grey.
Fuel ratio, ...	1:1.02	1:1.47	1:1.24	1:1.62

(*139*) *James Magee's bank*, one mile north of Independence, Independence township, Washington county.

Coal compact, with resinous luster; contains numerous partings of charcoal and pyrites. [Specimens marked "upper bench: roof."]

(*177*) *Mrs. Bushfield's bank*, near north and south forking of Cross Creek, one and a quarter miles from Patterson's Mills, Cross Creek township.

Coal compact, bright; many partings of charcoal. (D. McCreath.)

(*165*) *Mr. Thomas' bank*, two miles west of Finlaysville, Peters township.

Coal of dull aspect; coated with efflorescence of sulphate of iron; numerous partings of pyrites in minute crystals.

(*166*) *New Eagle Works bank*, one mile below Monongahela City, Carroll township, Washington county. See Report K, p. 212.

Coal bright and clean looking; contains much mineral charcoal and a few scales of *calcite*.

	(181) Liddell.	(185) Reed.	(186) Neil.	(187) West.	(188) White.
Water @ 225°, . .	.650	1.110	1.090	1.220	.890
Volatile matter, .	35.075	35.315	35.350	35.420	36.810
Fixed carbon, . .	55.030	57.332	55.010	60.537	55.312
Sulphur, ...	1.910	.648	.895	.658	.643
Ash, ...	7.335	5.595	7.745	2.165	6.345
	100.000	100.000	100.000	100.000	100.000

Coke, per cent.,	64.275	63.575	63.650	63.360	62.300
Color of ash,	cream.	cream.	grey, red tinge.	red.	cream.
Fuel ratio,	1:1.56	1:1.62	1:1.55	1:1.70	1:1.50

(*181*) *Mr. Liddell's bank*, near Taylor's Mills, 1¼ miles north-east from Centreville, West Pike Run township, Washington county.

Coal hard and compact; seamed with charcoal and pyrites. (D. McC.)

(*135*) *Mr. Reed's bank*, one half mile below Greenfield, East Pike Run township, Washington county. See Report K, pp. 202, 203.

Coal bright and very compact; shows small scales of *calcite.*

(*136*) *Mr. Neil's bank*, one half mile below Greenfield, East Pike Run township.

Coal bright and shining; with thin partings of slate and only a small amount of pyrites.

(*137*) *Mr. West's bank*, two and one half miles north-west of Greenfield, East Pike Run township.

Coal bright and shining; numerous partings of charcoal; some scales of pyrites.

(*138*) *Mr. White's bank*, three miles north-west of Greenfield, East Pike Run township, Washington county.

Coal of bright resinous luster; slightly iridescent; a good deal of pyrites in scales.

Westmoreland County.	(*638a*) *McFarland.*
Water @ 225°,	1.275
Volatile matter,	25.195
Fixed carbon,	65.517
Sulphur,	2.248
Ash,	5.765
	100.000
Coke, per cent.,	73.530
Color of ash,	grey.
Fuel ratio,	1:2.60

(*638a*) *Col. John McFarland's bank*, two and one half miles north from Ligonier, Ligonier township, Westmoreland county.

Luster generally bright, resinous; somewhat coated with iron oxide; numerous thin partings of pyrites and a yellowish white efflorescence of sulphate of iron.

Indiana County.

	(680) *Evans.*	(677) *Ashbaugh.*	(685a) *Doty.*	(685b) *Smith.*
Water @ 225°,	1.040	1.110	1.370	1.130
Volatile matter,	36.940	37.555	29.130	28.895
Fixed carbon,	50.850	53.639	58.461	56.409
Sulphur,	1.465	1.436	.849	2.571
Ash,	9.705	6.260	10.190	10.995
	100.000	100.000	100.000	100.000
Coke, per cent.,	62.020	61.335	69.500	69.975
Color of ash,	grey.	grey, red tinge.	grey, red tinge.	grey, red tinge.
Fuel ratio,	1:1.37	1:1.42	1:2.00	1:1.95

(*680*) *J. Evans' bank*, at West Lebanon, Indiana county. See HHHH, p. 276.

Coal compact and brittle; luster generally greyish black, with thin bands of bright crystalline coal running through it; considerable pyrites in minute crystals.

(*677*) *J. L. Ashbaugh's bank*, one mile north north-east from Clarksburg. See HHHH, p. 274.

Coal compact and brittle; iridescent; with numerous bands of bright pitchy coal.

(*685a*) *G. M. Doty's bank*, five miles north-east of Blairsville, Indiana county.

Coal compact, with deep black luster; carries numerous bands of bright crystalline coal; also some slaty coal; a small amount of pyrites in minute crystals throughout the mass.

(*685b*) *R. Smith's bank*, two miles north-east of Blairsville.

Coal generally compact, with deep black luster; numerous thin bands of bright crystalline coal run through it; also some slaty bands.

Main Bench of Pittsburgh Bed.

Greene County.

	(6) *Maple Farm.*	(159) *L. Vernon.*	(161) *L. Vernon.*
Water @ 225°,	1.030	1.040	.850
Volatile matter,	36.490	37.225	38.580
Fixed carbon,	59.051	56.608	54.185
Sulphur,	.819	.982	1.290
Ash,	2.610	4.145	5.095
	100.000	100.000	100.000

Coke per cent.,	62.480	61.735	60.570
Color of ash,	Cream.	Cream.	Grey, red tinge.
Fuel ratio,	1:1.61	1:1.52	1:1.40

(*6*) *Maple Farm bank*, three miles from Greensboro', Dunkard township.

Coal compact, with a tendency to break in blocks; luster bright; shows a yellowish white efflorescence of sulphate of iron.

(*159*) *L. Vernon's bank*, near Millsboro', three miles from Rice's Landing, Jefferson township. *Middle of main bench.* See K, p. 136.

Coal generally bright and shining; somewhat coated with a yellowish white efflorescence of sulphate of iron; carries much charcoal.

(*161*) *L. Vernon's bank*, near Millsboro'. *Upper part of main bench.*

Coal of bright resinous luster; exceedingly hard and compact; shows some slate and a few thin partings of pyrites.

	[*Washington County.*] (*180*) *Ashurst.*	[*Westmoreland County.*] (*638 b*) *McFarland.*	[*Indiana County.*] (*683*) *George.*
Water @ 225°,	1.010	1.190	1.680
Volatile matter,	40.995	26.080	34.975
Fixed carbon,	48.769	59.789	57.000
Sulphur,	2.206	3.116	.665
Ash,	7.020	9.825	5.680
	100.000	100.000	100.000
Coke, per cent.,	57.995	72.730	63.345
Color of ash,	Red.	Grey, red tinge.	Reddish grey.
Fuel ratio,	1:1.18	1:2.29	1:1.62.

(*180*) *P. Ashurst's bank*, about three miles from Washington, near Chartiers creek, Chartiers township, Washington county. See K, p. 232. ["Sample probably a little better than the average."]

Luster bright, shining; seamed with charcoal, slate and pyrites. (D. McCreath.)

(*638 b*) *Col. John McFarland's bank*, two and one half miles north from Ligonier, Ligonier township, Westmoreland county.

Coal bright and tender; shows a large amount of iron pyrites in thin partings.

(683) *R. R. George's bank*, one mile north-east of West Lebanon, Indiana county. See report HHHH, p. 276.

Luster deep black; compact; seamed with mineral charcoal.

Lower Bench of Pittsburgh Bed.

Washington County.

	(179) *Magee.*	(142) *Eagle Works.*	(143) *Liddell.*	(140) *Neil.*	(141) *White.*
Water @ 225°,	1.130	1.140	1.425	1.120	1.290
Volatile matter,	38.720	35.275	36.880	34.655	34.125
Fixed carbon, .	40.253	58.167	56.829	60.414	57.979
Sulphur, . .	3.722	.758	.796	.766	.586
Ash,	16.175	4.660	4.070	3.045	6.020
	100.000	100.000	100.000	100.000	100.000
Coke, per cent.,	60.15	63.585	61.695	64.225	64.585
Color of ash,	pink.	grey, red tinge.	cream.	cream.	cream.
Fuel ratio, .	1:1.03	1:1.64	1:1.54	1:1.74	1:1.69

(179) *James Magee's bank*, one mile north of Independence, Independence township, Washington county.

Coal exceedingly hard and compact; seamed with charcoal, slate and pyrites. (D. McC.)

(142) *New Eagle Works bank*, one mile below Monongahela City, Carroll township, Washington county.

Luster generally resinous, with seams of bright crystalline coal through the mass; considerable mineral charcoal, and a small amount of *calcite.*

(143) *Mr. Liddell's bank*, near Taylor's Mills, one and one quarter miles north-east from Centreville, West Pike Run township.

Coal hard, compact, clean looking; little slate; much charcoal; a small amount of pyrites.

(140) *Mr. Niel's bank*, one half mile below Greenfield, East Pike Run township, Washington county. See K, p. 202.

Slightly iridescent; luster generally resinous; numerous partings of charcoal.

(*141*) *J. White's bank*, three miles north-west of Greenfield, East Pike Run township, Washington county.

Luster shining; much charcoal, and a yellowish efflorescence of sulphate of iron.

Indiana County.

	(679) Evans.
Water @ 225°,	1.460
Volatile matter,	31.995
Fixed carbon,	53.788
Sulphur,	.997
Ash,	11.760
	100.000
Coke, per cent.,	66.545
Color of ash,	reddish grey.
Fuel ratio,	1:1.68

(*679*) *J. Evans' bank*, at West Lebanon, Indiana county. See Report HHHH, p. 276.

Coal compact, greyish black, cannel like; fracture conchoidal.

Pittsburgh Coal—Bench not stated.

Greene County.

	(162) Miller.
Water @ 225°,	.900
Volatile matter,	38.390
Fixed carbon,	52.649
Sulphur,	1.941
Ash,	6.120
	100.000
Coke, per cent.,	60.710
Color of ash,	reddish grey.
Fuel ratio,	1:1.37

(*162*) *D. Miller's bank*, near Miller's Steam Mills, one and a half miles below the mouth of Cheat river, in Dunkard township, Greene county. See K, pp. 92, 380.

Coal, dull, dirty aspect; mostly coated with iron oxide; contains a good deal of sulphate of iron and pyrites.

Washington County.

	(134) Harding.	(144) Thomson.	(178) Redd.
Water @ 225°,	1.540	1.095	.680
Volatile matter,	37.825	39.790	38.525
Fixed carbon,	57.063	55.033	55.920
Sulphur,	.762	1.172	.855
Ash,	2.810	2.910	4.020
	100.000	100.000	100 000
Coke, per cent.,	60.635	59.115	60.795
Color of ash,	cream.	grey.	red.
Fuel ratio,	1:1.50	1:1.38	1:1.45

(*134*) *Mr. Harding's bank*, one and a half miles north of Washington, Washington county. See K, p. 240.

Coal, bright, clean looking; contains an unusually large amount of mineral charcoal; seems generally free from slate and pyrites.

(*144*) *J. Thomson's bank*, near the Pittsburgh pike, near Cannonsburg, on Plum Run, eight miles north north-west of Washington, in Chartiers township, Washington county.

Coal, hard, compact; luster pitchy; many seams of charcoal, but little pyrites.

(*178*) *Mr. Redd's bank*, Fallowfield township, Washington county.

Coal, generally compact; with seams of charcoal and pyrites, and much efflorescence of sulphate of iron. (D. McCreath.)

	(690a) Slocum.	(690b) Slocum.	(690c) Slocum.	(690d) Slocum.
Water at @ 225°,	1.130	1.150	1.320	1.410
Volatile matter,	38.040	36.920	35.410	35.835
Fixed carbon,	52.670	52.067	59.545	58.058
Sulphur,	1.450	.748	.640	.677
Ash,	6.710	9.115	3.085	4.020
	100.000	100.000	100.000	100.000
Coke, per cent.,	60.830	61.930	63.270	62.755
Color of ash,	grey, yellow tinge.	grey.	reddish grey.	cream.
Fuel ratio,	1:1.38	1:1.41	1:1.68	1:1.62

(*690a*) *James Slocum's pit*, above Brownsville, on the Washington county side of the Monongahela river, on

Krepp Knob farm, Washington county. "*Specimen from top, under the horseback.*"

Coal bright, brittle, pitchy; with thin partings of pyrites.

(*690b*) *James Slocum's pit.* "*Specimen from midway down.*"

Coal bright, brittle, pitchy; with little pyrites.

(*690c*) *James Slocum's pit. Specimen from bearing-in bench.*

Coal bright, brittle, pitchy; with little pyrites.

(*690d*) *James Slocum's pit. Specimen from below bearing-in bench.*

Coal has the general appearance of specimen 690c.

Fayette County.

	(*498*) *Beal.*	(*501*) *McCormack Heirs.*	(*496*) *Townsend.*
Water @ 225°, .	1.020	.960	.890
Volatile matter, .	31.840	33.635	34.545
Fixed carbon, . .	61.844	60.200	59.450
Sulphur, . .	.736	.905	.895
Ash, . . .	4.560	4.300	4.220
	100.000	100.000	100.000
Coke, per cent., . .	67.140	65.405	64.365
Color of ash, . . .	grey.	cream.	reddish grey.
Fuel ratio, ...	1:1.94	1:1.79	1:1.72

(*498*) *L. Beal's mine*, three miles west of Uniontown, on Uniontown and Masontown road, Manellen township, Fayette county.

Coal compact and brittle; seamed with charcoal and pyrites. (D. McC.)

(*501*) *McCormack Heirs' mine*, one mile south of Cook's Mills, on Redstone creek, Franklin township, Fayette county.

Coal bright, shining; somewhat iridescent; carries considerable mineral charcoal, and a few thin partings of pyrites. (D. McCreath.)

(*496*) *Aaron Townsend's mine*, two and a half miles south from Perryopolis; head of Crab Apple run, Perry township, Fayette county.

Coal compact, bright; seamed with mineral charcoal; shows a few scales of pyrites. (D. McC.)

	(30) Frick & Co. [Lump coal.]	(440) Frick & Co. [Slack coal.]	(499) Kendall.	(497) Swan Heirs.
Water @ 225°,	1.260	.950	1.040	.930
Volatile matter,	30.107	29.662	32.815	33.710
Fixed carbon, . .	59.616	55.901	60.241	59.391
Sulphur, .	.784	1.931	1.249	.909
Ash,	8.233	11.556	4.655	5.060
	100.000	100.000	100.000	100.000
Coke, per cent., .	68.633	69.388	66.145	65.360
Color of ash, . .	Reddish grey.	Reddish grey.	Grey.	Grey, red tinge.
Fuel ratio, ...	1:1.98	1:1.88	1:1.83	1:1.76

(30) *Frick & Co.'s mines*, at Broad Ford, near Connellsville, Fayette county. *Lump coal.* See report L, p. 62.

Luster generally dull resinous, with some seams of bright crystalline coal; somewhat coated with a yellowish white silt. Coal generally firm and compact; with numerous bands of slaty coal and mineral charcoal.

(440) *Frick & Co.'s mines.* Connellsville *slack coal.*

(499) *J. P. Kendall's mine*, one and a half miles south from McClellandstown, on Brown's run, German township, Fayette county.

Coal compact; luster bright, shining; seamed with mineral charcoal and pyrites.

(497) *Swan Heirs' mine*, two miles west of Uniontown, North Union township, Fayette county.

Coal bright and compact; seamed with mineral charcoal; shows a few scales of pyrites. (D. McCreath.)

Westmoreland County.

	(473a) Westmoreland Coal Company. Southside mine.	(473b) Westmoreland Coal Company. Foster Mine.	(473c) Westmoreland Coal Company. Larimer Mine, No. 2
Water @ 225°, . . .	1.410	1.310	1.560
Volatile matter, .	37.655	37.100	39.185
Fixed carbon, .	54.439	55.004	54.352
Sulphur, . . .	.636	.636	.643
Ash, . .	5.860	5.950	4.260
	100.000	100.000	100.000
Coke, per cent., .	60.935	61.590	59.255
Color of ash, . . .	cream.	reddish grey.	reddish grey.
Fuel ratio, . .	1:1.47	1:1.48	1:1.38

(*473a*) *Westmoreland Coal Co.'s mines*, North Huntingdon township, Westmoreland county. *Southside mine.* See KK, p. 338.

Coal bright, resinous, with seams of bright crystalline coal running through it; generally free from slate, and shows but little pyrites.

(*473b*) *Westmoreland Coal Co.'s mines*, North Huntingdon township, Westmoreland county. *Foster mine.* See KK, p. 333.

Coal compact, bright; shows but little pyrites.

(*473c*) *Westmoreland Coal Co.'s mines*, North Huntingdon township, Westmoreland county. *Larimer mine, No. 2.* KK, p. 339.

Coal bright, clean looking; with little pyrites.

	(*505a*)	(*505b*)	(*505c*)
	Penn Gas Coal Company.		
	Irwin, No. 1.	*Irwin, No. 2.*	*Sewickley.*
Water @ 225°,	1.780	1.280	1.490
Volatile matter,	35.360	38.105	37.153
Fixed carbon,	59.290	54.383	58.193
Sulphur,	.680	.792	.658
Ash,	2.890	5.440	2.506
	100.000	100.000	100.000
Coke, per cent.,	62.860	60.615	61.357
Color of ash,	cream.	cream.	red.
Fuel ratio,	1:1.67	1:1.42	1:1.56

(*505a*) *Penn Gas Coal Co.'s mines*, one half mile east of Irwin's Station, P. R. R., Penn township, Westmoreland county. *Shaft No. 1.* See KK, p. 333.

Coal firm, bright, clean looking, with little pyrites.

(*505b*) *Penn Gas Coal Co.'s mines*, one half mile east of Irwin's Station, P. R. R., Penn township, Westmoreland county. *Shaft No.* 2.

Coal bright, firm, with thin seams of slate.

(*505c*) *Penn Gas Coal Co.'s mines*, near Sewickley Station, on the P. & C. R. R., Sewickley township, Westmoreland county. See KK, p. 353.

Coal has a bright, shining luster; is firm and compact, and seems in the main free from slate and pyrites.

	(489) *Fulton & Pinkerton.*	(480) *Greensburg Coal Co.*	(482) *Horner.*
Water @ 225°,	1.200	1.020	1.200
Volatile matter,	32.955	33.495	33.600
Fixed carbon,	54.830	61.344	58.491
Sulphur,	.635	.861	.794
Ash,	10.380	3.280	5.915
	100.000	100.000	100.000
Coke, per cent.,	65.845	65.485	65.200
Color of ash,	reddish grey.	reddish grey.	cream.
Fuel ratio,	1:1.66	1:1.83	1:1.74

(*489*) *Fulton & Pinkerton's mine*, on Sewickley creek, five miles from West Newton, Sewickley township, Westmoreland county.

Coal generally of a resinous luster, with seams of bright crystalline coal running through it; iridescent; somewhat slaty.

(*480*) *Greensburg Coal Co.'s mine*, one and a half miles south from Greensburg, Hempfield township, Westmoreland county.

Coal generally of a dull luster; coated with a yellowish white silt; compact. Seams of bright crystalline coal run through it.

(*482*) *Mr. Horner's bank*, three miles south from Harvey's Five Points, Salem township, Westmoreland county.

Coal bright, iridescent; carries considerable mineral charcoal.

	(474) *Hunter.*	(476) *Kunkle.*	(495) *Saltzburg.*
Water @ 225°,	1.250	.970	1.070
Volatile matter,	42.110	37.845	35.515
Fixed carbon,	48.820	53.234	56.458
Sulphur,	2.075	1.541	2.257
Ash,	5.745	6.410	4.700
	100.000	100.000	100.000
Coke, per cent.,	57.640	61.185	63.415
Color of ash,	grey.	reddish grey.	reddish grey.
Fuel ratio,	1:1.15	1:1.40	1:1.58

(*474*) *J. Hunter's bank*, one mile south-west of McLaughlinstown, Burrell township, Westmoreland county. See KK, p. 367.

Coal, luster generally resinous; seams of bright crystalline coal run through it; compact; shows considerable pyrites in thin partings.

(476) *Mr. Kunkle's bank*, two miles north-west from Saltzburg, Bell township, Westmoreland county.

Coal exceedingly compact; somewhat coated with silt; luster resinous; considerable pyrites in scales.

(495) *Saltzburg Coal Co.'s mines*, Loyalhanna township, Westmoreland county. See KK, p. 322.

Coal compact, bright, with partings of mineral charcoal and pyrites. Shows considerable efflorescence of sulphate of iron.

	(506) *Saxman.* [*Lump Coal.*]	(423a) *Saxman.* [*Slack Coal.*]	(423b) *Saxman.* [*Slack Coal.*]	(436) *Saxman.* [*Slack Coal.*]
Water @ 225°, .	1.590	.810	1.210	2.020
Volatile matter,	30.945	29.330	28.145	29.555
Fixed carbon, .	63.489	57.399	58.511	57.163
Sulphur, .	.796	1.308	1.019	1.622
Ash, ...	3.180	11.063	11.115	9.640
	100.000	100.000	100.000	100.000
Coke, per cent.,	67.465	69.860	70.645	68.425
Color of ash, . . .	reddish grey.	reddish grey.	reddish grey.	reddish grey.
Fuel ratio, . .	1:2.05	1:1.95	1:2.07	1:1.93

(506) *M. Saxman Jr., & Co.'s* mines, Latrobe; at the mouth of Saxman's run, Derry township, Westmoreland county. *Lump coal.* See KK. p. 286.

Coal, deep black, bright, very tender; shows but little pyrites.

(423a) *M. Saxman Jr., & Co.'s* mines, Latrobe. *Slack coal.*

(423b) *M. Saxman Jr., & Co.'s* mines, Latrobe. *Slack coal.*

(436) *M. Saxman Jr., & Co.'s* mines, Latrobe. *Slack coal.*

These three samples of slack coal were selected from car loads used in the experiments of making coke from anthracite dust and different proportions of bituminous coals.

	(475) *Seanor.*	(503) *Lomison.*	(471) *Millwood.*	(483) *Seaton.*	(484) *Cauffield.*
Water @ 225°,	1.010	.830	1.240	.580	1.050
Volatile matter, .	32.980	31.030	30.715	24.850	25.170
Fixed carbon,	62.962	62.819	63.799	64.779	69.602
Sulphur,	.788	.746	.621	3.496	.668
Ash, .	2.260	4.575	3.625	6.295	3.510
	100.000	100.000	100.000	100.000	100.000
Coke, per cent., .	66.010	68.140	68.045	74.570	73.780
Color of ash, . .	cream.	cream.	reddish grey.	red.	red.
Fuel ratio, . .	1:1.90	1:2.02	1:2.07	1:2.60	1:2.76

(*475*) *W. Seanor's bank*, near New Alexandria, Derry township, Westmoreland county.

Coal, compact, shining; somewhat coated with silt; free from slate partings and shows but little pyrites.

(*503*) *Dr. H. G. Lomison's bank*, one and a quarter miles west from New Derry, Derry township, Westmoreland county.

Coal compact; somewhat coated with infiltrated silt; shows but little slate and seems in the main free from pyrites. (D. McCreath.)

(*471*) *Millwood Coal and Coke Co's. mine* at Millwood, Derry township, Westmoreland county.

Coal generally bright; somewhat coated with silt; rather firm and compact; shows but little pyrites.

(*483*) *T. S. Seaton's bank*, one and a half miles north from Ligonier, Ligonier township, Westmoreland county.

Coal bright and very tender; shows a large amount of pyrites and considerable efflorescence of sulphate of iron.

(*484*) *R. Cauffield's bank*, one mile west from West Fairfield P. O., Fairfield township, Westmoreland county.

Coal generally bright; somewhat coated with silt; shows but little pyrites.

	(479) *Kehoe.*	(481) *Chambers.*	(477) *Anderson.*
Water @ 225°,	.930	1.140	.880
Volatile matter, . . .	27.365	29.880	31.720
Fixed carbon, . . .	49.651	62.227	61.072
Sulphur, ...	.859	.668	1.143
Ash, ...	21.195	6.085	5.185
	100.000	100.000	100.000

Coke, per cent.,	71.705	68.980	67.400
Color of ash,	grey.	grey, red tinge.	reddish grey.
Fuel ratio,	1:1.81	1:2.08	1:1.92

(*479*) *Mr. Kehoe's bank*, one and a half miles south-west from Beaty's Station, on the P. R. R., Unity township, Westmoreland county.

Coal dull; coated with iron oxide; carries numerous thin partings of slate, and shows but little pyrites.

(*481*) *J. Chamber's bank*, one and a half miles north-west from Pleasant Unity, Unity township, Westmoreland county.

Coal compact, dull, iridescent; with little pyrites.

(*477*) *J. Anderson's bank*, half a mile west from Youngstown, on the Greensburg pike, Unity township, Westmoreland county.

Coal bright, tender; somewhat coated with silt; carries considerable pyrites in thin partings.

Indiana County.

	(*684*) *T. Sloan.*
Water @ 225°,	.850
Volatile matter,	27.385
Fixed carbon,	49.748
Sulphur,	3.017
Ash,	19.000
	100.000
Coke, per cent.,	71.765
Color of ash,	grey.
Fuel ratio,	1:1.81

(*684*) *T. Sloan's bank*, near Blairsville, Indiana county. See HHHH, pp. 160, 162.

Coal of deep black luster; rather compact; carries numerous thin bands of slaty coal and a large amount of iron pyrites in thin knife edges.

Somerset County.

	(*458*) *Beachy.*	(*443a*) *Wilhelm.* [*Lower bench.*]	(*443b*) *Wilhelm.* [*The rider.*]	(*459*) *Yoder.*
Water @ 225°,	1.680	1.190	1.570	1.465
Volatile matter,	21.010	21.000	21.450	21.285
Fixed carbon,	69.016	66.907	69.986	69.677
Sulphur,	.764	.713	.679	.693
Ash,	7.530	10.190	6.315	6.880
	100.000	100.000	100.000	100.000

Coke, per cent.,	. 77.310	77.810	76.980	77.250
Color of ash, . .	. grey, red tinge.	reddish grey.	reddish grey.	reddish grey.
Fuel ratio, ...	1:3.28	1:3.18	1:3.26	1:3.27

(*458*) *M. J. Beachy's mine*, two and a half miles southwest of Salisbury, Somerset county. See HHH, p. 83.

Coal very tender; luster generally resinous, but with seams of bright crystalline coal; fracture shows oblique faces.

(*443a*) *Wilhelm mine*, one and a half miles west of Salisbury. *Lower bench.*

Coal very tender; luster generally resinous, with seams of bright crystalline coal; carries a good deal of mineral charcoal.

(*443b*) *Wilhelm mine*, one and a half miles west of Salisbury, Somerset county. *Specimen from the rider coal of the bed.* See HHH, pp. 84, 85.

[It is possible that this represents the Redstone bed; but the similarity of the analysis with that of (459) Yoder's coal is to be noticed.]

The coal is very tender, with bright, resinous luster; it carries considerable mineral charcoal. Its fracture is uneven, as if from oblique strains.

(*459*) *E. Yoder's mine*, three quarters of a mile south of Mechanicsburg, (West Salisbury,) Somerset county.

Coal bright, shining, tender; seamed with mineral charcoal and iron pyrites.

	(*456*) *Livengood & Keim.*	(*349*) *Keystone.*	(*457*) *Cumberland and Elk Lick.*	(*460*) *Saylor Hill.*
Water @ 225°,	. 1.665	1.050	1.385	1.630
Volatile matter, . .	. 22.350	19.610	21.470	19.965
Fixed carbon, . .	68.774	70.239	69.352	66.510
Sulphur, .	. 1.246	.761	.763	.775
Ash, . . .	5.965	8.340	7.030	11.120
	100.000	100.000	100.000	100.000
Coke, per cent.,	75.985	79.340	77.145	78.405
Color of ash, .	. grey, pink tinge.	grey.	reddish grey.	grey, red tinge.
Fuel ratio, ...	. 1:3.07	1:3.58	1:3.23	1:3.35

(*456*) *Livengood & Keim's mine*, one mile north of Salisbury, Somerset county.

Coal bright, compact; laminæ very distinct.

(*349*) *Keystone Coal and Manufacturing Co.'s mine*, three miles south of Meyersdale, on the Castleman river. See HHH, p. 78.

Coal very compact; luster bright, resinous; carries a large amount of mineral charcoal.

(*457*) *Cumberland and Elk Lick Coal Co.'s mine*, two miles south of Meyersdale, Somerset county. See HHH, p. 77.

Coal bright, shining, tender, with a large amount of charcoal.

(*460*) *Saylor Hill mine*, three quarters of a mile west of Meyersdale, Somerset county. See HHH, pp. 76, 77.

Coal exceedingly tender, and somewhat slaty; luster generally dull; seams of bright crystalline coal run through it.

Cumberland Coal, (*probably Pittsburgh Bed.*)

	(*1001a*)	(*1001b*)	(*100 c*)
Water @ 225°,	1.230	1.110	.710
Volatile matter,	15.470	15.300	15.260
Fixed carbon,	73.510	73.280	68.250
Sulphur,	.700	1.230	2.540
Ash,	9.090	9.080	13.240
	100.000	100.000	100.000
Coke, per cent.,	83.30	83.59	84.03
Color of ash,	grey.	grey, red tinge.	reddish brown.
Fuel ratio,	1:4.75	1:4.78	1:4.47

(*1001a*) (*1001b*) (*1001c*) *Coals from the Cumberland Basin*, Maryland, analysed by myself in 1872.

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§ 6. *Elk Lick Coal Bed.*

The Elk Lick coal bed is a thin but persistent horizon of carbonaceous matter underlaid by limestone recognizable on a little search wherever the Pittsburgh coal bed exists. It lies about one third of the way down in the Barren

Measures; about two hundred* feet beneath the Pittsburgh coal; and about four hundred feet above the Freeport Upper coal, (as at Forwardstown, in Somerset county, HHH, p. 219.) It was named in 1840 from an opening on Elk Lick creek, in Somerset county, where the measurement of the depth beneath the Pittsburgh bed is easily made, and amounts to something over two hundred and five feet. The interval between it and the top of the Mahooning Sandstone is here three hundred and thirty feet. (See HHH, pp. 60, 61, 73.)

The massive sandstone, fifty to sixty feet thick, over it, represents the Morgantown Sandstone of the Monongahela River valley.

The bed is nowhere larger than four feet, and is nowhere much mined except in Somerset county. It has been wrongly identified with the Barton bed of the Cumberland basin, in Maryland; and it has been used as a name for many different beds in the lower part of the Barren Measures in the reports of the First Geological Survey, and in private reports and text books.

It is opened in Indiana county (HHHH, pp. 101, 103) by Mr. Stevens, near Dilltown, on Black Lick, in the Armagh valley, and is reported three feet thick, but may not yield more than one foot of coal.

In southern Butler county, it has been opened by Mr. Hayes on Glade creek, two feet thick (Q, p. 79), and by Mr. Flemming on Little Bull creek, two and a half feet thick (Q, p.91).

In northern Allegheny county, it is seen (three hundred and sixty feet above the Freeport Upper coal and two hundred and fifty feet beneath the Pittsburgh coal) at several places (Q, pp. 149, 154, 164, 171, 172, 174) on Hite's, Wood's and Duff's run, and Pine creek, yielding at one place three and a half feet of good coal, but being usually a thin bed of bony coal, slate or impure cannel.

In northern Beaver county, it was once opened at the

* Three hundred and forty is a misprint for two hundred and forty, R. of P., HHH. Preface, xxxiii.

top of Gross' knob, on McPherson's branch, and although not under good cover, seemed to hold three feet of coal. (Q, p. 180.)

There is no reason for doubting its former extension over large areas further north, and its presence in Ohio.

Its place is clearly marked by the well known Green Crinoidal Limestone lying at a depth of thirty feet, more or less, beneath it; this Green Crinoidal Limestone being one of the most plainly marked and widely spread of the Barren Measure strata.

Somerset County.

	(399) *Berkey.*
Water @ 225°,	.890
Volatile matter,	20.525
Fixed carbon,	65.903
Sulphur,	1.142
Ash,	11.540
	100.000
Coke, per cent.,	78.585
Color of ash,	reddish grey.
Fuel ratio,	1:3.21

(*399*) *Mr. Berkey's bank*, at Jenner Cross-Roads, Jenner township, Somerset county. [This bed is supposed to be the Elk Lick bed.] See HHH, pp. 219, 220.

Coal (from the drift) generally compact and somewhat slaty; luster resinous; carries a few thin partings of pyrites.

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§ 7. *Berlin Coal Bed.*

The Berlin coal bed is only mined in Somerset county, along the Blue Lick valley, where it is about four feet thick.

It underlies the Pittsburgh bed about three hundred feet, and the Elk Lick bed about ninety feet.

Ten feet under it lies a limestone eight feet thick. (See R. of P. HHH, Plate 3, pp. 22 and 39.)

In other parts of south-western Pennsylvania it and its limestone are scarcely recognizable.

Somerset County.

	(461) W. G. Walker. [Upper Berlin.]	(428) H. N. Coleman. [Upper Berlin.]	(442) S. P. Fritz.	(410) Berkey.
Water @ 225°, . .	1.945	2.010	1.625	1.110
Volatile matter,	21.935	20.535	22.760	20.505
Fixed carbon, . .	68.554	68.321	67.467	63.470
Sulphur, . .	1.161	.744	.803	3.785
Ash, ...	6.405	8.390	7.345	11.130
	100.000	100.000	100.000	100.000
Coke, per cent.,	76.120	77.455	75.615	78.385
Color of ash, .	grey, red tinge.	grey, red tinge.	reddish grey.	red.
Fuel ratio, ...	1:3.12	1:3.32	1:2.96	1:3.09

(*461*) *W. G. Walker's bank*, near Pine Hill church, south of Berlin, Brother's Valley township, Somerset county. See HHH, pp. 39, 40. [This is the *upper* of the two Berlin coal beds.]

Coal bright, tender, seamed with mineral charcoal and iron pyrites.

(*428*) *H. N. Coleman's bank*, one and a half miles south of Berlin, Brother's Valley township, Somerset county. [This is the *upper* of the two Berlin coal beds.]

Coal bright, shining, tender; seamed with slate and pyrites.

(*442*) *S. P. Fritz's bank*, near Berlin, Brother's Valley township, Somerset county.

Coal bright, iridescent, rather compact; with thin seams of mineral charcoal and slate.

(*410*) *Mr. Berkey's bank*, at Jenner Cross Roads, Jenner township, Somerset county.

Coal dull looking, tender; coated with iron oxide and seamed with pyrites. (D. McCreath.)

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§ 8. *Platt Coal Bed.*

The Platt bed, (called also the Weighley bed, and the Berlin lower bed, R. of P. HHH, pp. 29, 30, 41, 43, 44, and Plate 3, p. 22,) worked formerly near Berlin, in Somerset county, consists there of alternate layers of sulphurous coal and slate, with a total thickness of seven feet. 'It was so unusual an exhibition in the Barren Measures, that it was popularly identified with the Pittsburgh coal of the Salisbury basin, three hundred and twenty-five feet above it.

The Platt bed underlies the Berlin bed at a very regular distance of twenty-five feet, the limestone coming in between them. (See the detailed section of both beds, and the limestone in Fig. 23, p. 41, HHH.)

This bed has been detected with more or less probability in other counties.

Somerset County.

	(396) *Weighley.*
Water @ 225°,	1.000
Volatile matter,	18.175
Fixed carbon,	53.521
Sulphur,	5.384
Ash,	21.920
	100.000
Coke, per cent.,	80.825
Color of ash,	pink.
Fuel ratio,	1:2.94

(*396*) *Mr Weighley's bank*, one mile south-west of Berlin, Brother's Valley township, Somerset county. See HHH, pp. 29, 30, 31.

Coal generally compact; of resinous luster; inclined to break up into blocks; carries some slate and an unusually large amount of iron pyrites.

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§ 9. *Price Coal Bed.*

The Price bed, which has also received its name in Somerset county, lies sixty feet beneath the Platt bed, and three hundred and eighty-five feet beneath the Pittsburgh bed. See section Plate 3, HHH, pp. 22, 23, 42, 44, 72, 290.

It is from three to four feet thick in the Berlin district, and two feet thick in the Salisbury district.

In Cambria county it was once worked by Mr. Brown at Summerhill, (HH, pp. 38, 39, 40,) in the hill tops, sometimes five feet thick, but very irregular and unreliable.

In Indiana county it is probably Marlin's bed at Five Points, and on Plum creek and Pine run, sometimes three feet thick. See HHHH, pp. 257, 281, 282.

It seems to be wanting west of the Allegheny river.

In Westmoreland and Fayette, it seems to be represented by an insignificant coal bed a few feet underneath the Black Fossiliferous Limestone horizon, (KKK, p. 24.)

	Somerset County.	*Cambria County.*	
	(372)	*(378)*	*(379)*
	T. Price.	*Brown.*	*Brown.*
		[Upper bench.]	*[Lower bench.*
Water @ 225°,	.870	.820	.550
Volatile matter,	20.330	19.155	17.325
Fixed carbon,	68.944	70.175	61.632
Sulphur,	1.176	.445	1.033
Ash,	8.680	9.405	19.460
	100.000	100.000	100.000
Coke, per cent.,	78.800	80.025	82.125
Color of ash,	grey.	grey.	grey.
Fuel ratio,	1:3.39	1:3.66	1:3.55

(*372*) *T. Price's bank*, at the terminus of the Buffalo Valley R. R., Berlin, Brother's Valley township, Somerset county. See HHH, pp. 27, 28.

Coal bright and tender, with a few thin partings of slate; shows only a small amount of pyrites in the form of scales. (D. McC.)

(*378*) *Brown's mine*, three fourths of a mile north northwest of Summerhill, Cambria county. *Upper bench.* See HH, pp. 38, 39; also HHH, p. 290.

Coal bright and tender; seamed with mineral charcoal and pyrites. (D. McC.)

(*379*) *Brown's mine*, three quarters of a mile north north west of Summerhill. *Lower bench.*

Coal exceedingly compact, with dull resinous luster generally; has seams of bright crystalline coal running through the mass. (D. McC.)

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§ *10. Philson (Rose) Coal Bed.*

The Philson* (or Rose) bed of Somerset county lies one hundred feet below the Price bed (HHH, section Plate 3, Fig. 10, p. 22,) and four hundred and eighty-five feet beneath the Pittsburgh bed.

It is but one foot thick at Berlin (HHH, pp. 24, 37;) but at Ursina (as the Rose bed, HHH, pp. 250, 293, 312) where it lies one hundred feet above the Freeport Upper coal, it averages five feet in thickness, and at the Krieger mine reaches six feet.

It has three feet of limestone under it.

In the Ligonier valley in Westmoreland and Fayette this bed has been recognized in nine townships (KKK, p. 25, etc.) always as the first bed above the Mahoning Sandstone from forty to ninety feet above the Freeport Upper coal. But it is possible that in some instances it has been confounded with the Gallitzin bed. It is one, two, and sometimes even three feet thick. The limestone underlies it along the Laurel Hill side but not along the Chestnut Ridge side of the valley.

In Indiana county it has been recognized around Armagh (HHHH, pp. 24, 75, 244,) and on Round Top (p. 129,) with its underlying limestone; on the Conemaugh, Black Lick, Yellow Creek, in Deep Hollow, and near Marion, (p. 257,) sometimes three and even four feet thick. But there is not always a certainty that it has not been confounded with the Gallitzin bed.

If the Brush Creek coal of the country west of the Allegheny river be rightly identified with the Gallitzin, then the Philson bed has not been recognized in that region.

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* The next bed to the Price coal in order downwards, before coming to the Philson, is the Coleman, sixty feet beneath the Price. But we have no analyses of the Coleman coal yet to report.

Somerset County.

	(351) P. & B. C. Co.	(46) P. & B. C. Co.
Water @ 225°,	.920	1.555
Volatile matter,	22.950	23.480
Fixed carbon,	66.999	63.483
Sulphur,	3.096	4.037
Ash,	6.035	7.445
	100.000	100.000
Coke, per cent.,	76.130	74.965
Color of ash,	grey, red specks.	pink.
Fuel ratio,	1:2.91	1:2.70

(*351*) *Pittsburgh and Baltimore Coal, Coke and Iron Co.'s bank*, near Ursina, Upper Turkey Foot township, Somerset county. *Lump Coal.* See HHH, pp. 249, 250, 251.

Coal bright, shining, very tender, with numerous thin partings of pyrites, and considerable sulphate of iron.

(*46*) *Pittsburgh and Baltimore Coal, Coke and Iron Co.'s bank*, near Ursina, Upper Turkey Foot township, Somerset county. Rose opening. *Slack Coal.*

Coal bright, very tender, with a very large amount of iron pyrites.

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§ *11. Gallitzin* (*Brush Creek?*) *Coal Bed.*

The Gallitzin bed (Brady's Bend bed, Brush Creek bed) is the lowest in the Barren Measures, and was so named in Cambria county. (HHH, p. 293.)

In the general section along the Pennsylvania railroad, &c., it comes sixty feet above the Freeport Upper coal, and between the upper and lower members of the Mahoning sandstone, as it does on Broad Top also, in Blair county.

It is less than two feet thick, and of no importance whatever east of the Allegheny river, although it is recognized in Indiana county, in the Ligonier valley, (HHHH, pp. 24, 27,) at Nineveh, (p. 83,) at the mouth of Brush creek, one foot thick, (p. 111,) on Yellow creek, three feet thick, (p. 128,) and near Marion, (p. 257.) It has not been noticed in the Blairsville basin.

South of the Conemaugh, it may have been confounded with the Philson.

On the Allegheny river, at Brady's Bend, it is four feet thick; and all through Allegheny, Butler, and Beaver counties, it plays a considerable rôle under the local name of Brush Creek bed, (Q,) varying from six inches upwards, but never over three feet thick; and therefore generally called "the three foot seam" in Beaver county, at Darlington and elsewhere. (Q, p. 235, &c.,)

Lawrence County.

	(626) *Miller.* [*Upper bench.*]	(635) *Miller.* [*Lower bench.*]
Water at 225°,	1.940	1.930
Volatile matter,	39.265	40.125
Fixed carbon,	55.828	55.606
Sulphur,	.727	.849
Ash,	2.240	1.490
	100.000	100.000
Coke, per cent.,	58.794	57.945
Color of ash,	reddish grey.	reddish brown.
Fuel ratio,	1:1.42	1:1.38

(*626*) *Mr. Miller's bank*, five miles north from Wurtemburg, Perry township, Lawrence county. *Upper bench.*

The coal is compact and brittle, with bright, pitchy luster; it carries numerous thin partings of mineral charcoal, and shows small, delicate fossil impressions.

(*635*) *Mr. Miller's bank*, five miles north from Wurtemburg, Perry township, Lawrence county. *Lower bench.*

The coal is compact and brittle, with resinous luster; it carries numerous partings of mineral charcoal.

Butler County.

	(*488*) *Cable.*	(*472*) *Wilson.*
Water @ 225°,	1.740	1.500
Volatile matter,	42.450	43.860
Fixed carbon,	45.551	47.415
Sulphur,	4.104	2.700
Ash,	6.155	4.525
	100.000	100.000
Coke, per cent.	55.810	54.64
Color of ash,	deep pink.	grey, pink tinge.
Fuel ratio,	1:1.07	1:1.08

(*488*) *Mr. Cable's bank*, five miles north-east of Harmony, on the Little Connoquenessing creek, Connoquenessing township, Butler county. See p. 123, Q.

Luster generally resinous; strongly iridescent; partings of pyrites unusually numerous in specimens received.

(*472*) *Mr. Wilson's mine*, at mouth of Semiconon creek, two miles east of Whitestown, Connoquenessing township, Butler county. See p. 125, Q.

Luster bright, resinous, generally; somewhat iridescent; conchoidal fracture; considerable mineral charcoal and pyrites.

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§ *12. Freeport Upper Coal Bed.* (*E.*)

This is the highest and principal bed of the Lower Productive or Allegheny River Coal Series; as the Pittsburgh is the lowest and principal bed of the Upper Productive or Monongahela River Coal Series.

At Pittsburgh the Pittsburgh bed lies in the hills three hundred feet or more above the river level; and the Freeport bed about three hundred feet below the river level.

This bed, therefore, underlies the whole country south of the Ohio and west of the Monongahela rivers solid, as well as that half of Westmoreland and Fayette counties lying between the Monongahela river and Chestnut Ridge, along the west flank of which it outcrops in a continuous line extending from the West Virginia State Line northwards through Indiana county into Clarion.

West of this outcrop (of Chestnut Ridge) the bed underlies all Indiana, southern Armstrong, Allegheny, and southern Beaver, except where it is cut through by the main rivers; and all the highlands of northern Armstrong, middle Butler and northern Beaver; and the hill tops of southern Lawrence and south-western Clarion.

This extremely irregular and broken area is shown in detail by a *medium tint of grey* on the geological colored maps of the above mentioned counties published with Reports of Progress KKK, HHHH, and Q.

The bed occupies also a strip five miles wide along the entire length of the Ligonier-Armagh Valley, between Chestnut Ridge and Laurel Hill, from the West Virginia State Line northward, through eastern Fayette, eastern Westmoreland, eastern Indiana, and north-western Cambria, into Clearfield and Jefferson counties; in one place in Greene township, Indiana county, lapping over the summit of the Chestnut Ridge.

In the same manner it occupies the wide double trough between Laurel Hill and the Allegheny Mountain (except where eroded from the back of the Negro Mountain in Somerset, and the back of the viaduct axis in Cambria county) from the Maryland and West Virginia State Line northward far in Clearfield county. Isolated patches of it occur in Centre county, and possibly in McKean and Lycoming; certainly in Tioga and Bradford counties; and it is undoubtedly represented in the anthracite coal basins.

It is the best known bed also in the Broad Top Coal Field in Blair county; and is plainly recognized in the Cumberland Coal Field of Maryland.

The wide preservation of this remarkable coal bed is plainly due to the protection afforded to it by the massive Mahoning Sandstone which overlies it and supports the Barren Measures,—a sand and gravel deposit co-extensive with the coal fields of Pennsylvania, and rivaling and often exceeding in thickness and solidity the Pottsville Conglomerate No. XII, which lies two or three hundred feet lower down in the measures.

The Freeport Upper Coal bed was so named by the First Geological Survey in 1837, from the village in Armstrong county near which it rises (northwards,) above the surface of the Allegheny river as a tolerably large and very pure mineral stratum. From this onwards (up stream) its double outcrop slowly ascends the opposite walls of the valley and finally gets to the hill tops and passes off across the country in broken patches, westward into Lawrence county, and eastward towards Clearfield and Centre.

The reader must consult Reports of Progress H, HH, HHH, HHHH, KK, KKK, Q, and QQ, for the character of this perhaps most widely useful of our coal beds. It sometimes, of course, appears in a worthless condition, but is a good five or six foot bed over extensive districts. The analyses given below will secure its reputation for purity; but wherever it comes directly into competition with the Pittsburgh coal bed, as in the south-west, it yields the floor.

Beaver County.

	(173) Todd. [Bottom.]	(182) Todd. [Upper.]	(172) Swearingen.	(174) Wilson.	(171) Cotter.
Water @ 225°,	1.500	1.370	2.080	1.530	1.660
Volatile matter,	39.870	37.800	39.520	41.380	37.065
Fixed carbon,	46.960	54.463	54.691	49.798	51.351
Sulphur,	4.595	1.587	1.249	2.467	2.709
Ash,	7.075	4 780	2.460	4.825	7.215
	100.000	100.000	100.000	100.000	100.000
Coke, per cent.,	58.630	60.830	58.400	57.098	61.275
Color of ash,	red.	grey.	yellow.	yellow.	grey.
Fuel ratio,	1:1.17	1:1.44	1:1.38	1:1.20	1:1.38

(*173*) *Mr. Todd's bank*, three quarters of a mile north of Hookstown, Greene township, Beaver county. *Specimens from bottom or "bearing-in" coal.* See K, p. 347.

Coal hard, brittle; luster dull; carries a large amount of pyrites in minute crystals.

(*182*) *Mr. Todd's bank*, three quarters of a mile north of Hookstown, Greene township, Beaver county. *Upper part of bed.*

Coal compact, bright, with pyrites in scales. (D. McCreath.)

(*172*) *Mr. Swearingen's bank*, one mile north from Hookstown, Greene township, Beaver county. See Report K, p. 347.

Coal exceedingly firm and compact; bright, pitchy appearance; carries considerable mineral charcoal and some pyrites in thin partings.

(*174*) *Mr. Wilson's bank*, near Shippingport, Greene township, Beaver county. See K, p. 347.

Coal very compact; bright, pitchy luster; shows a few thin partings of pyrites.

(*171*) *Mr. Cotter's bank*, near Service Creek Church, two and a half miles north-east of Mechanicsburg, Raccoon township, Beaver county.

Coal compact, bright; contains numerous thin partings of pyrites.

Butler County.

	(932) *Unionville Coal Bank.**
Water @ 225°,	2.110
Volatile matter,	37.570
Fixed carbon,	51.248
Sulphur,	1.894
Ash,	7.178
	100.000
Coke, per cent.,	60.320
Color of ash,	cream.
Fuel ratio,	1:1.36

(*932*) *Unionville Coal bank*, Centre township, Butler county. D. Heck & Eli Eagle, owners. *Middle bench of bed.*

Coal compact, bright, pitchy; shows numerous thin partings of pyrites.

Indiana County.

	(688) *Groft Bros.*	(678) *Beatty.*	(682) *Hazlett.*
Water @ 225°,	.950	.990	1.180
Volatile matter,	31.420	31.760	26.500
Fixed carbon,	55.215	52.190	56.697
Sulphur,	1.215	4.625	.671
Ash,	11.200	10.435	14.970
	100.000	100.000	100.000
Coke, per cent.,	67.630	67.250	72.320
Color of ash,	dirty grey.	lilac.	grey.
Fuel ratio,	1:1.75	1:1.64	1:2.13

(*688*) *Groft Bros. bank*, one mile east of Chambersville, Indiana county. *Lower bench.* See Report HHHH, p. 254.

Coal bright, shining, tender; carries numerous thin partings of charcoal and pyrites; also some bands of slaty coal.

* The identification of this specimen of coal is not complete; but it is supposed to represent the Freeport Upper bed.

(*673*) *James Beatty's bank*, one mile north-west from Decher's Point, Indiana county. *Specimen from center of bed.* See HHHH, p. 226.

Coal bright, shining, very compact; carries numerous partings of pyrites and slate.

(*682*) *S. C. Hazlett's bank*, one and a quarter miles south-west of Jacksonville, Indiana county. *Upper bench.* See HHHH, p. 249.

Coal bright, shining, compact; carries seams of slaty coal and mineral charcoal.

	(*621*) *Griffith.* [*Upper bench.*]	(*619*) *Griffith.* [*Lower bench.*]	(*620*) *Indiana.* [*Lower bench.*]	(*678*) *Waddle.*
Water @ 225°,	.590	.700	.800	1.220
Volatile matter,	28.710	29.680	25.770	32.570
Fixed carbon,	52.488	63.766	70.224	59.689
Sulphur, .	5.462	1.719	.621	2.151
Ash, . .	12.750	4.135	2.585	4.370
	100.000	100.000	100.000	100.000
Coke, per cent., .	70.700	69.620	73.430	66.210
Color of ash,	reddish grey.	cream.	red.	grey, yellow tinge.
Fuel ratio, .	1:1.82	1:2.14	1:2.72	1:1.83

(*621*) *D. B. Griffith's bank*, one and a half miles north north-east of Homer, Indiana county. *Upper bench.* See HHHH, p. 203.

Coal very tender; luster resinous generally; with numerous thin partings of mineral charcoal and pyrites.

(*619*) *D. B. Griffith's bank*, one and a half miles north north-east of Homer, Indiana county. *Upper part of lower bench.*

Coal bright and tender; seamed with mineral charcoal and iron pyrites.

(*620*) *Indiana Coal Co.'s bank*, one and a quarter miles south-east of Homer, on Bracken farm, Indiana county. *Lower part of lower bench.* See HHHH, pp. 198, 203.

Coal bright and tender; somewhat coated with iron oxide; with numerous partings of mineral charcoal.

(*678*) *S. Waddle's bank*, one third of a mile north-east from Kelly's Station. W. P. R. R., Indiana county.

Coal bright and tender; with numerous thin partings of mineral charcoal and pyrites. Carries quite an appreciable amount of *calcite* in thin scales.

	(616) *Snyder.*	(615) *Ragar.*	(617a) *Harris.* [*Upper part.*]	(617b) *Harris.* [*Lower part.*]
Water @ 225°, .	.770	.600	.660	.450
Volatile matter,	27.800	26.531	24.467	24.215
Fixed carbon,	67.537	61.525	71.900	60.947
Sulphur,	.718	.629	.588	1.173
Ash, . . .	3.175	10.715	2.385	13.215
	100.000	100.000	100.000	100.000
Coke, per cent.,	71.430	72.869	74.873	75.335
Color of ash, . .	cream.	grey.	cream.	reddish grey.
Fuel ratio, .	1:2.42	1:2.31	1:2.93	1:2.51

(*616*) *Wm. Snyder's bank*, four miles east north-east of Blairsville, Indiana county.

Coal bright and tender; fracture uneven, as if from oblique strains.

(*615*) *H. Ragar's bank*, five miles north-east from Blairsville, Indiana county.

Coal firm and compact; luster dull; coated with iron oxide. Fresh fracture shows bright shining luster; numerous thin bands of slaty coal.

(*617a*) *D. Harris' bank*, one mile south-east of Lockport, Indiana county. *Upper part of main bench.*

Coal compact, bright, shining; seems generally free from slate and pyrites; fracture shows oblique faces.

(*617b*) *D. Harris' bank*, one mile south-east of Lockport, Indiana county. *Lower part of main bench.*

Coal generally bright and tender; carries considerable slaty coal and some iron pyrites.

	(687) *Marlin.**
Water @ 225°, . .	1.100
Volatile matter, . .	31.890
Fixed carbon, ...	60.736
Sulphur, .	1.279
Ash, .	4.995
	100.000

* This specimen is supposed to represent the Freeport Upper Coal, but its identification is not complete. See HHHH, pp. 280 and 281.

Coke, per cent.,	67.010
Color of ash,	cream.
Fuel ratio,	1:1.90

(*687*) *D. Marlin's bank*, half a mile west of Five Points, Indiana county.

Coal bright, shining, tender; carries numerous thin partings of mineral charcoal and iron pyrites.

Westmoreland County.

	(*940*) *Kier Bros.*	(*478*) *Snodgrass.*	(*691*) *Lyon.*
Water @ 225°,	1.060	.890	.770
Volatile matter,	33.955	34.100	23.910
Fixed carbon,	54.392	56.088	64.526
Sulphur,	1.058	3.932	4.789
Ash,	9.535	4.990	6.005
	100.000	100.000	100.000
Coke, per cent.,	64.985	65.010	75.320
Color of ash,	grey.	cream.	pink.
Fuel ratio,	1:1.60	1:1.64	1:2.69

(*940*) *Kier Bros.' mine*, at Salina Station, Westmoreland side of Kiskiminetas river, Westmoreland county.

Coal generally firm and compact, with deep black luster; carries thin seams of slaty coal and charcoal.

(*478*) *J. Snodgrass' bank*, about two miles south from Saltzburg, Loyalhanna township, Westmoreland county. See Report KK, pp. 320, 321.

Coal bright and tender, showing numerous thin partings of pyrites; carries an unusually large amount of *carbonate of lime*, and some *sulphate of lime.*

(*691*) *Mr. Lyon's bank*, on southern border of Cook township, south-east of Ligonier. Westmoreland county.

Coal bright, shining, tender; carries an unusually large amount of pyrites in the form of thin knife edges.

Fayette County.

	(*696*) *Potter.*	(*695b*) *Fayette Furnace.*
Water @ 225°,	.870	.930
Volatile matter,	27.255	24.545
Fixed carbon,	61.759	69.956
Sulphur,	2.031	1.414
Ash,	8.085	3.155
	100.000	100.000

Coke, per cent.,	71.875	74.525
Color of ash,	grey.	grey.
Fuel ratio,	1:2.26	1:2.85

(*696*) *Samuel Potter's bank*, on Meadow run, one mile south of Ohiopyle Falls, Fayette county.

Coal of a deep black luster generally; has numerous bands of bright crystalline coal running through it; it also carries thin partings of charcoal, slate and pyrites.

(*695b*) *Fayette Furnace bank*, two miles east from Springfield, Springfield township, Fayette county.

Coal of deep black luster and tender; carries numerous thin partings of charcoal and some iron pyrites in minute crystals.

Somerset County.

	(*398*) Somerset and Mineral Point.
Water @ 225°,	.860
Volatile matter,	16.885
Fixed carbon,	66.055
Sulphur,	.585
Ash,	15.615
	100.000
Coke, per cent,,	82.255
Color of ash,	grey.
Fuel ratio,	1:3.91

(*398*) *Somerset and Mineral Point Railroad Co.'s mines*, half a mile south of Somerset, Somerset county. [Specimen forwarded by Mr. Isaac Hugus.] See HHH, p. 163.

Coal bright, tender, slaty; with an unusually large amount of mineral charcoal, and only a small quantity of pyrites in the form of scales.

Cambria County.

	(*375*) Kindport.	(*374*) Garman.	(*192*) Dysart & Co.
Water @ 225°,	.880	1.260	.715
Volatile matter,	24.630	25.185	22.250
Fixed carbon,	68.333	66.797	70.518
Sulphur,	1.227	.568	1.459
Ash,	4.930	6.190	5.058
	100.000	100.000	100.000
Coke, per cent..	74.490	73.555	77.030
Color of ash,	yellow.	grey.	cream.
Fuel ratio,	1:2.77	1:2.65	1:3.16

(*375*) *Porter Kindport's mine*, near Cherry Tree, Cambria county. See HH, p. 174.

Coal very tender, with numerous partings of mineral charcoal and pyrites; considerable efflorescence of sulphate of iron.

(*374*) *Peter Garman's mine*, three quarters of a mile east of Cherry Tree, Cambria county.

Coal bright, brittle, with numerous seams of charcoal. (D. McCreath.)

(*192*) *J. H. Dysart & Co.'s mine*, near Lilly's Station, Cambria county. "*Lemon seam.*" See HH, p. 33.

Coal bright, shining, tender; carries numerous thin partings of charcoal and pyrites.

Blair County.

	(*302*) *Dennison, Porter & Co.*	(*309*) *Kittanning. Coal Co.*
Water @ 225°,	.960	1.190
Volatile matter,	26.400	26.975
Fixed carbon,	65.586	64.357
Sulphur,	2.274	2.728
Ash,	4.780	4.750
	100.000	100.000
Coke, per cent.,	72.640	71.835
Color of ash,	grey, red specks.	red.
Fuel ratio,	1:2.48	1:2.38

(*302*) *Dennison, Porter & Co.'s mines*, about three miles south west of Bennington, Blair county. "*Lemon seam.*" See Report of Progress HH, p. 23.

The coal has a bright shining luster; is rather tender, and carries numerous thin partings of mineral charcoal and iron pyrites.

(*309*) *Kittanning Coal Co.'s mine*, one and a half miles west of Bennington, Blair county. "*Lemon seam.*" See HH, p. 22.

Coal bright, and very tender; seamed with charcoal and pyrites.

Lycoming County.

	(806) McIntyre mines.✠	(805) McIntyre mines.✠
Water @ 225°,	.950	1.170
Volatile matter,	17.940	17.120
Fixed carbon,	71.151	73.682
Sulphur,	.834	.843
Ash,	9.125	7.185
	100.000	100.000
Coke, per cent.,	81.110	81.710
Color of ash,	grey, red tinge.	grey, red tinge.
Fuel ratio,	1:3.96	1:4.30

(*806*) *McIntyre Coal Co.'s mines*, at Ralston, Lycoming county. *Drift No. 2; Bed E.*

The coal has a deep black glossy luster, and is seamed with greyish black, compact coal; it carries a few thin knife edges of slate, but seems in the main free from pyrites.

(*805*) *McIntyre Coal Co.'s mines*, at Ralston, Lycoming county. *Drift No. 4; Bed E.*

The coal, which is rather tender, has a deep black shining luster, and carries seams of greyish black, compact coal. The specimen shows but little pyrites.

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§ *13. Freeport Lower Coal Bed.* (*D'*.)

This underlies the Freeport Upper Coal bed, from thirty to seventy feet, in all parts of Western Pennsylvania where the latter has been preserved from erosion as described in § 12, but is usually a much less important bed.

In Reports of Progress H and HH this bed has been named "Middle Freeport," not by an error of identification, but by an error of classification to be explained in § 14. The lettering D' is unfortunate, as it should have been lettered E, and the Freeport Upper bed E'. But this last bed was lettered E in 1848, and it would have produced great confusion to change E to E', in the Reports of the Second Survey.

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*The identification of this bed with the Freeport Upper Coal Bed of Western Pennsylvania is probable, but not proved.

The descriptions of the "Lower Freeport bed" in H must be understood as not applying to this bed, but to the bed below it, the Darlington or Upper Kittanning. See § 14.

	Butler County. (485) *Schantz.*	*Armstrong County.* (946) *Pine Creek Fur.*
Water @ 225°, .	2.290	1.820
Volatile matter, .	33.580	34.185
Fixed carbon, .	55.772	58.301
Sulphur, . . .	1.158	.989
Ash, .	7.200	4.705
	100.000	100.000
Coke, per cent., .	64.130	63.995
Color of ash, . . .	grey.	cream.
Fuel ratio, ...	1:1.66	1:1.70

(*485*) *Mr. Shantz' mine*, near Ziegler's mill; one and a half miles east of Harmony, Jackson township, Butler county. See Q, p. 114.

Appearance bright, pitchy; generally compact; numerous partings of mineral charcoal; considerable pyrites in scales.

(*946*) *Pine Creek Furnace property bank*, six miles north-east of Kittanning, Armstrong county.

Coal of deep black luster; with numerous thin partings of charcoal. Specimen seems in the main free from pyrites.

	Indiana County.		*Fayette County.*
	(*689*) *Brady.*	(*681*) *Forsythe.*	(*693*) *Mitchell.*
Water @ 225°, .	.920	1.010	.700
Volatile matter,	31.320	28.505	25.470
Fixed carbon,	57.266	55.380	54.673
Sulphur,	2.669	.700	3.673
Ash,	7.825	14.405	15.485
	100.000	100.000	100.000
Coke, per cent.,	67.760	70.485	73.83
Color of ash, ...	grey, pink tinge.	grey.	grey, pink tinge.
Fuel ratio, . .	1:1.82	1:1.94	1:2.14

(*689*) *J. Brady's mine*, at Marion, Indiana county. See HHHH, p. 258.

Coal bright, shining, iridescent, tender; with numerous thin partings of charcoal and pyrites.

(*681*) *J. Forsythe's bank*, one and a half miles north north-west of Jacksonville, Indiana county.

Coal with dull luster generally; numerous bands of bright, pitchy coal; carries considerable slaty coal; fracture uneven, as if from oblique strains.

(*693*) *Martin Mitchell's bank*, three miles north of Ohiopyle Falls, Stewart township, Fayette county.

Coal compact, with dull luster generally; shows numerous bands of slaty coal and iron pyrites.

	Somerset County.		*Cambria County.*
	(*383*) *Reitz.*	(*371*) *Garrett.*	(*373*) *Luly.*
Water @ 225°,	.940	1.020	.800
Volatile matter,	19.060	17.135	24.635
Fixed carbon,	70.659	66.679	72.436
Sulphur,	1.291	.676	.559
Ash,	8.050	14.490	1.570
	100.000	100.000	100.000
Coke, per cent.,	80.000	81.845	74.565
Color of ash,	red.	grey.	cream.
Fuel ratio,	1:3.70	1:3.89	1:2.93

(*383*) *Geo. Reitz's bank*, near Friedensburg, Somerset county. See HHH, p. 331.

Coal bright, exceedingly tender, and seamed with charcoal and pyrites. (D. McC.)

(*371*) *Garrett Coal Co.'s bank*, one mile from Garrett, Somerset county.

Coal bright, compact; seamed with charcoal, and shows a few thin scales of iron pyrites. (D. McCreath.)

(*373*) *Adam Luly's bank*, one and a half miles south of Cherry Tree, Cambria county. See HH, p. 175,

Coal bright, friable; carries a few thin partings of mineral charcoal and iron pyrites. (D. McCreath.)

§ 14. *Kittanning Upper (Darlington) Coal Bed. (D.)*

This bed is lettered (C′) instead of (D) in the Report of Progress Q on North Beaver, North Allegheny, and South Butler.*

It is the Ohio coal No. IV; the "Strip vein" of the Yellow Creek country, west of the Ohio State Line, on the Ohio river.

It is typical at Darlington, in Beaver county, and was formerly supposed to be the equivalent of the Kittanning bed at Kittanning, in Armstrong county.

It is the "Freeport Lower coal" of Reports H, HH; an error due to a mistake at the commencement of the survey, in Jefferson county, in making the Freeport group *triple*, so as to include the top bed of the Kittanning group.

It underlies the Massive Freeport (Lower) Sandstone, either immediately, or by an interval of five to forty feet; as the Freeport Upper coal underlies the Mahoning Sandstone.

It underlies the Freeport Lower coal by an interval of from fifty to eighty feet in the country north of the Ohio river, rising from the Ohio river near Freedom, and from the Allegheny river near Kittanning.

Its area is of course a little greater than that of the coals above it, extending somewhat further north and east; so that outlying patches of it appear on the hill tops of Lawrence county between the Mahoning and Shenango rivers, and between the Shenango and Neshannock;—and on others in Butler county, as far north as Washington township.

Its thickness is very variable; one to two feet in south Butler; two and a half feet along the Connoquenessing; three feet at one place on the Beaver; and three and a half feet at Darlington, where it is covered in one remarkable locality by twelve feet of cannel.

Its floor is a bed of shale crowded with fossil plants, from which Mr. I. F. Mansfield has made his admirable collec-

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*The recent discovery of a third or *middle* persistent bed in the Kittanning Series, compels us to assign C′ to *it*, or else to change the long established lettering of the Kittanning Lower bed C. The Kittanning Upper Coal should be lettered C″, to make the system uniform.

tions, studied and described by Mr. Lesquereux, and published as Report of Progress P, two volumes, text and atlas, entitled "The Coal Flora of Pennsylvania, and other Carboniferous Areas of the United States, 1879." A list of those discovered up to 1878 is given in Q, pp. 54, 55.

In Lawrence, Beaver and Butler counties it is a gas coal remarkably rich in volatile matters, showing percentages varying from 35.70 to 43.25.

Its qualities along the Allegheny river will be stated in the forthcoming Reports of Progress H^5 on Armstrong county, and V on North Butler.

In Indiana county it is four feet thick along the Black Lick Valley (HHHH, p. 70); one and a half feet at Lockport; three and a half feet on Little Yellow creek; four and a half feet at Wilkin's mine (HHHH, p. 123); five and a half feet at Rowley's mine on Chestnut Ridge; and two and a half feet thick near Decher's Point, on Mr. Lowry's property, where it is overlaid by eight feet of laminated cannel slates. (HHHH, pp. 228, 229, 230.)

In southern Clarion and eastern Jefferson counties (see H, pp. 144 to 146, 164, 195, 238) it has a remarkable development; for on Red Bank creek opposite New Bethlehem, on the north Armstrong line, it is two feet thick, carrying eight feet of cannel and a cannel slate roof; but the deposit, as at Darlington, is very local.

East of New Bethlehem it is six and seven and even nine feet thick, with sometimes as high as 40.80 per cent. of volatile matter, (H, pp. 229, 230, 231.)

At Reynoldsville and Punxatawny it reaches ten and twelve feet in thickness, and equals in importance and quality the Pittsburgh bed in the Connellsville district of Fayette and Westmoreland counties, furnishing a gas coal with percentages of volatile matters ranging from 30.00 to 35.87 per cent. (See the seventeen analyses of it published in H, on various pages from 149 to 179.)

Whether this be the gas coal of the Johnson Run basin in McKean county is not yet decided; nor is its identification with one or other of the Tioga, Bradford and Sullivan coals determined.

Along the Allegheny Mountain in Cambria and Somerset, and on both flanks of Laurel Hill and Chestnut Ridge in Fayette, Westmoreland and Indiana counties, this bed has been recognized and mined in many places, as may be seen by reference to the indices of Reports HH, HHH, HHHH, and KKK; but there is some confusion in the descriptions and references to the bed in the text of HH which should make the reader careful; for it is everywhere called (wrongly) the Freeport Lower bed D; and the bed above it is called the Freeport Middle bed D′. It is often four feet thick, as at Fairview, Cambria county.

Lawrence County.

	(623) *McConnell.*✠	(630) *Woolley.*✠	(632) *Granniss.*✠
Water @ 225°,	1.950	2.340	2.100
Volatile matter,	40.860	39.480	41.210
Fixed carbon,	53.531	55.774	54.163
Sulphur,	1.199	.741	.587
Ash,	2.460	1.665	1.940
	100.000	100.000	100.000
Coke, per cent.,	57.190	58.180	56.690
Color of ash,	reddish brown.	cream.	cream.
Fuel ratio,	1:1.31	1:1.41	1:1.31

(623) *Mr. McConnell's bank*, Shenango township, Lawrence county.

The coal is very compact, with resinous luster generally; it is somewhat coated with iron oxide, and carries partings of mineral charcoal and pyrites.

(630) *Mr. Woolley's bank*, four miles from New Castle, Shenango township, Lawrence county.

The coal is bright, pitchy, with numerous partings of charcoal.

(632) *Mr. Granniss' mines*, Shenango township, Lawrence county.

The coal is compact, brittle, pitchy, with numerous partings of charcoal.

* There is a possibility that these coals may be found hereafter to represent the Kittanning Middle bed. Mr. White reports them as Darlington.

	(627) Lee & Patterson.	(624) Armstrong.	(629) Rogers.
Water @ 225°,	2.170	1.660	1.990
Volatile matter,	39.610	40.760	39.990
Fixed carbon,	55.591	50.008	52.286
Sulphur,	.789	2.572	1.734
Ash,	1.840	5.000	4.000
	100.000	100.000	100.000
Coke, per cent.,	58.220	57.580	58.120
Color of ash,	cream.	lilac.	reddish brown.
Fuel ratio,	1:1.40	1:1.22	1:1.30

(*627*) *Lee & Patterson's mines*, near Wampum, Lawrence county.

The coal is bright, pitchy, brittle, with partings of mineral charcoal and iron pyrites.

(*624*) *Mr. Armstrong's bank*, near Wurtemburgh, Perry township, Lawrence county.

The coal is compact, bright, pitchy; somewhat coated with silt, and seamed with charcoal and pyrites.

(*629*) *Mr. Rogers' bank*, two miles west of Rose Point, Slippery Rock township, Lawrence county.

Compact, brittle, pitchy; somewhat coated with silt.

	(625) Brown. [Upper bench.]	(631) Brown. [Lower bench.]
Water @ 225°,	2.710	3.055
Volatile matter,	39.220	38.260
Fixed carbon,	55.693	53.585
Sulphur,	.567	.675
Ash,	1.810	4.425
	100.000	100.000
Coke, per cent.,	58.070	58.685
Color of ash,	cream.	grey.
Fuel ratio,	1:1.42	1:1.40

(*625*) *Mr. Brown's bank*, near Plain Grove, Lawrence county. *Upper bench.*

The coal is compact, bright, pitchy, generally; but with seams of dull resinous coal. It is very brittle, and carries a large amount of mineral charcoal and a few scales of pyrites.

(*631*) *Mr. Brown's bank*, near Plain Grove, Lawrence county. *Lower bench.*

The coal is compact, bright, pitchy, brittle, and shows a few scales of pyrites.

Beaver County.

	(175) *Diehl.*	(176) *Bryan.*
Water @ 225°,	1.770	2.090
Volatile matter,	38.620	35.700
Fixed carbon,	56.333	59.685
Sulphur,	.717	.580
Ash,	2.560	1.945
	100.000	100.000
Coke, per cent.,	59.610	62.210
Color of ash,	reddish grey.	cream.
Fuel ratio,	1:1.45	1:1.67

(*175*) *Mr. Diehl's bank*, half a mile west of Georgetown, Greene township, Beaver county. See K, pp. 86, 383.

Coal compact, bright, clean looking; with a small amount of pyrites in minute crystals.

(*176*) *Mr. Bryan's bank*, one and a half miles south-west of Georgetown, Greene township, Beaver county. See K, pp. 86, 383.

Coal bright, clean looking; seems in the main free from slate and pyrites.

	(507) *Dougherty.*	(486a) *Mansfield.* [*Bituminous.*]	(486b) *Mansfield.* [*Cannel coal.*]	(513) *Middleton.*
Water @ 225°,	3.090	1.780	1.160	2.680
Volatile matter,	37.915	40.760	48.015	36.205
Fixed carbon,	56.980	49.391	38.241	53.804
Sulphur,	.495	3.379	.599	2.391
Ash,	1.520	4.690	11.985	4.920
	100.000	100.000	100.000	100.000
Coke, per cent.,	58.995	57.460	51.985	61.115
Color of ash,	cream.	grey, red tinge.	grey.	reddish grey.
Fuel ratio,	1:1.50	1:1.21	1:0.79	1:1.48

(*507*) *Mr. Dougherty's bank*, three miles north of New Brighton, North Sewickley township, Beaver county. See Q, p. 207.

Coal compact; seems unusually free from slate and pyrites, only a few specks being visible; has generally a bright, shining luster.

(*486a*) *I. F. Mansfield's mine*, near Cannelton, three miles south from Darlington, Darlington township, Beaver county. See Q, p. 232.

Coal compact, luster, bright, shining; specimens received carry an unusual amount of thin partings of pyrites.

(*486b*) *I. F. Mansfield's mine*, near Cannelton, three miles south of Darlington, Darlington township, Beaver county. See Q, p. 232.

Cannel coal; compact; fracture conchoidal, luster dull; carries very thin seams of bright crystalline coal.

(*513*) *Mr. Middleton's mine*, on Brady's run, one mile west from New Brighton, New Brighton township, Beaver county. See Q, p. 251.

The coal has a dull luster generally, being considerably coated with a yellowish white silt; it is rather tender, and carries considerable mineral charcoal and iron pyrites.

Butler County.

	(*502*) *Fiedler.*	(*470*) *Melvin.*	(*487*) *Bieber.*	(*934*) *McGarvey.*
Water @ 225°,	1.390	1.455	1.300	1.610
Volatile matter,	41.265	43.250	40.220	40.300
Fixed carbon,	48.029	49.716	42.661	49.456
Sulphur,	3.061	2.109	2.404	.739
Ash,	5.715	3.470	13.415	7.895
	100.000	100.000	100.000	100.000
Coke, per cent.,	57.345	55.295	58.480	58.090
Color of ash,	pink.	reddish grey.	reddish grey.	cream.
Fuel ratio,	1:1.16	1:1.14	1:1.06	1:1.22

(*502*) *Mr. Fiedler's mine*, near Ziegler's mill, one mile east of Harmony, Jackson township, Butler county. See pp. 115, 116, Q.

Generally compact; seamed with bright pitchy looking coal; carries considerable mineral charcoal and pyrites.

(*470*) *Mr. Melvin's mine*, on west branch Yellow creek, three and a half miles south-east from Portersville, Lancaster township, Butler county. See p. 118, Q.

Appearance fatty; numerous thin bands of bright crystalline coal; generally compact and clean looking, but shows considerable pyrites.

(*487*) *Mr. Bieber's mine*, one and a half miles above the mouth of Yellow creek, Lancaster township, Butler county. See p. 120, Q.

Somewhat slaty; luster bright, resinous; seams of bright crystalline coal run through it.

(*934*) *Mr. McGarvey's bank*, North Washington, Washington township, Butler county. *Cannel coal.*

Luster deep black, rather dull; structure laminated; fracture irregular, somewhat conchoidal. *Coal yields a moderately coherent coke.*

Clarion County.

	(*44*) *Fairmount.**
Water @ 225°,	2.375
Volatile matter,	32.565
Fixed carbon,	49.955
Sulphur,	1.960
Ash,	13.145
	100.000
Coke, per cent.,	65.060
Color of ash,	dirty grey, red tinge.
Fuel ratio,	1:1.53

(*44*) *Fairmount Coal and Coke Co.'s* mine, on north side of Red Bank creek, one mile east of New Bethlehem, Clarion county. *Slack coal.*

The coal is bright, shining, friable, with a large amount of slate and considerable pyrites.

Jefferson County.

	(*42*) *Diamond.**
Water @ 225°,	1.550
Volatile matter,	34.500
Fixed carbon,	57.386
Sulphur,	1.118
Ash,	5.446
	100.000

*Called Lower Freeport or D (*i. e.* the lowest of three beds called Freeport) by Mr. F. Platt in Report of Progress H, 1874-5, (See pp. 230, 231, H.)

Coke, per cent.,	63.950
Color of ash,	cream.
Fuel ratio,	1:1.66

(*42*) *Diamond Gas Coal Co.'s mine*, one mile north of Reynoldsville, Jefferson county. See H, pp. 151, 152, 153.

Coal bright, compact; contains numerous thin partings of charcoal and pyrites.

Clearfield County.

	(*727*) *Hughes & Co.*✠
Water @ 225°,	1.240
Volatile matter,	24.450
Fixed carbon,	67.045
Sulphur,	1.320
Ash,	5.945
	100.000
Coke, per cent.,	74.310
Color of ash,	cream.
Fuel ratio,	1:2.74

(*727*) *Richard J. Hughes & Co.'s mine*, one and a half miles north-west of Osceola, on Shimmel's Run, Clearfield county.

Coal deep black, shining, tender; with numerous thin partings of mineral charcoal and iron pyrites in minute crystals.

Indiana County.

	(*674a*)✠✠ *Lowry.* [*Upper bench.*]	(*674b*)✠✠ *Lowry.* [*Middle.*]	(*674c*)✠✠ *Lowry.* [*Lower.*]
Water @ 225°,	.880	.870	1.320
Volatile matter,	23.375	24.485	30.320
Fixed carbon,	50.324	52.964	66.083
Sulphur,	.621	.621	.654
Ash,	24.800	21.060	1.623
	100.000	100.000	100.000
Coke, per cent.,	75.745	74.645	68.360
Color of ash,	yellowish brown.	yellowish brown.	brown.
Fuel ratio,	1:2.15	1:2.16	1:2.17

* Called Lower Freeport or D (*i. e.* the lowest of three beds called Freeport) by Mr. F. Platt in Report of Progress H, 1874-5.

** Bed D of Report HHHH.

(*674a*) *S. S. Lowry's bank*, one and a half miles north north-west of Decher's Point, Indiana county. *Upper bench.* See HHHH, pp. 229, 230, 231.

Coal compact, greyish black, cannel like; fracture conchoidal.

(*674b*) *S. S. Lowry's bank*, one and a half miles north north-west of Decher's Point, Indiana county. *Middle bench.*

Coal compact, greyish black, cannel like; exceedingly brittle, breaking up into plates with smooth even surface. *It may be interesting to note that analyses of several of the plates show them to be of practically the same composition.*

(*674c*) *S. S. Lowry's bank*, one and a half miles north north-west of Decher's Point, Indiana county. *Lower bench.*

Coal deep black, shining, tender; with thin partings of pyrites.

	(*686*)* *Jeffries.*	(*676*)* *Walker.* [*Upper.*]	(*675*)* *Walker.* [*Lower.*]
Water @ 225°,	.860	1.270	1.240
Volatile matter,	31.535	28.930	29.630
Fixed carbon,	59.093	60.175	65.172
Sulphur,	3.162	.950	.503
Ash,	5.350	8.675	3.455
	100.000	100.000	100.000
Coke, per cent.,	67.605	69.800	69.130
Color of ash,	reddish grey.	reddish grey.	brown.
Fuel ratio,	1:1.87	1:2.08	1:2.19

(*686*) *N. Jeffries' bank*, two thirds of a mile south-west of Richmond, Indiana county.

Coal deep black luster; tender; shows considerable mineral charcoal and a large amount of pyrites in thin knife edges.

(*676*) *D. Walker's bank*, three miles north-west of Gettysburgh, Indiana county. *Upper bench.*

*Bed D of Report HHHH.

Coal bright, shining, compact; with thin seams of slaty coal.

(675) *D. Walker's bank*, three miles north-west of Gettysburgh, Indiana county. *Lower bench.*

Coal bright, shining, compact; with thin seams of mineral charcoal.

Cambria County.

	(439b) *Ramsey.*✠	(2) *Cambria Iron Co.*✠
Water @ 225°,	1.745	1.140
Volatile matter,	23.590	17.180
Fixed carbon,	68.805	73.424
Sulphur,	.535	1.408
Ash,	5.325	6.848
	100.000	100.000
Coke, per cent.,	74.665	81.680
Color of ash,	grey, yellow tinge.	cream.
Fuel ratio,	1:2.91	1:4.27

(439b) *Jos. Ramsey, Jr.'s mines*, Fallen Timber run, Cambria county. See HH, p. 91.

Coal bright, tender; carries an unusually large amount of mineral charcoal, and a small amount of pyrites in thin scales.

(2) *Cambria Iron Co.'s mines*, at Johnstown, Cambria county. *Cement seam.* See HH, pp. 109, 110.

Coal bright, shining, tender; carries considerable iron pyrites in thin scales; also scales of *calcite.*

Somerset County.

	(397) *Beam.*✠✠	(446) *Trevorrow.*✠✠	(401) *Wilt.*✠✠	(314) *Pile.*✠✠	(447) *Wigle.*✠✠
Water @ 225°,	.820	.670	.600	.950	.850
Volatile matter,	17.235	14.530	15.415	16.540	16.850
Fixed carbon,	74.881	74.800	70.632	71.206	69.578
Sulphur,	.519	.635	1.748	2.409	2.587
Ash,	6.545	9.365	11.605	8.895	10.135
	100.000	100.000	100.000	100.000	100.000
Coke, per cent.,	81.945	84.800	83 985	82.510	82.300
Color of ash,	cream.	white.	grey.	grey.	grey.
Fuel ratio,	1:4.34	1:5.14	1:4.58	1:4.30	1:4.12

* Bed D of Report HH.

** Bed D of Report HHH.

(*397*) *J. W. Beam's mine*, at Jenner Cross Roads, Jenner township, Somerset county. See HHH, p. 229.

Coal bright, shining, tender; seems generally free from pyrites.

(*446*) *Mr. Trevorrow's mine*, at Davidsville, Conemaugh township, Somerset county. See HHH, p. 117.

Coal very compact; luster generally dull, with seams of bright crystalline coal running through it; commonly free from pyrites. (D. McCreath.)

(*401*) *Mr. Wilt's mine*, at Stoystown, Quemahoning township, Somerset county.

Coal bright, tender, slaty; seamed with charcoal and pyrites.

(*314*) *J. J. Pile's mine*, near Sipesville, Somerset township, Somerset county.

Coal bright, tender; shows considerable mineral charcoal, thin slate seams and pyrites.

(*447*) *Mr. Wigle's mine*, one mile north of Garrett, Brother's Valley township, Somerset county.

Coal bright, tender; seamed with slate and pyrites. (D. McCreath.)

Huntingdon County.

	(*75*) *Robertsdale.** [*Upper bench.*]	(*76*) *Robertsdale.** [*Lower bench.*]
Water @ 225°,	.450	.535
Volatile matter,	16.210	15.910
Fixed carbon,	70.601	71.898
Sulphur,	4.170	3.434
Ash,	8.569	8.223
	100.000	100.000
Coke, per cent.,	83.340	83.555
Color of ash,	reddish grey.	grey, red tinge.
Fuel ratio,	1:4.35	1:4.51

(*75*) *Robertsdale colliery* of the Rockhill Iron and Coal Co., Trough Creek basin, Carbon township, Huntingdon county. *Mine C'; upper bench.* See F, p. 187.

* Coal bed D of East Broad Top. Ashburner, Report of Progress, F.

Coal bright, shining, tender; carries considerable mineral charcoal and iron pyrites in thin partings.

(76) *Robertsdale colliery* of the Rockhill Iron and Coal Co., Trough Creek basin, Carbon township, Huntingdon county. *Mine C'; lower bench.*

Coal bright, shining, rather compact; carries numerous partings of mineral charcoal and iron pyrites.

The following analyses of the coals from the Robertsdale collieries of the Rockhill Iron and Coal Co., were made by Mr. J. Blodgett Britton, of Philadelphia, and they are published here for comparison by the kind permission of Mr. Wm. A. Ingham, President.

	*Bed D.**	
	[*Upper bench.*]	[*Lower bench.*]
Moisture,	1.31	1.58
Volatile matter,	15.15	14.30
Ash,	7.83	6.97
Fixed carbon,	75.71	77.15
	100.00	100 00
Sulphur,	2.416	1.475
Coke, per cent.,	83.540	84.120
Per cent. sulphur in coke,	1.438	1.057

Tioga County.

	(672) *Fall Brook.***	(669) *Blossburg Coal Co.***	(665) *Morris Run.***	(654) *Fall Brook.***
Water @ 225°,	1.460	1.180	.950	1.970
Volatile matter,	21.600	21.586	19.830	20.105
Fixed carbon,	65.120	71.574	60.759	68.360
Sulphur,	2.820	.907	6.856	1.795
Ash,	9.000	4.753	11.605	7.770
	100.000	100.000	100.000	100.000
Coke, per cent.,	76.940	77.234	79.220	77.925
Color of ash,	reddish grey.	reddish grey.	deep pink.	lilac.
Fuel ratio,	1:3.01	1:3.31	1:3.06	1:3.40

(672) *Fall Brook Coal Co.'s mines*, at Antrim, eight miles west from Arnot, Tioga county. See G, p. 187.

Coal, of a bright, black luster, is very tender and carries

* Worked in "Mine C."

** Seymore bed. Bed D. F. Platt. Report of Progress G.

numerous thin partings of mineral charcoal and knife edges of slate.

(*669*) *Blossburg Coal and Coke Co.'s mines*, at Arnot, Tioga county. See G, p. 179.

The coal is bright, shining, and very tender; it carries numerous thin partings of iron pyrites and an unusually large amount of mineral charcoal.

(*665*) *Morris Run Coal Co.'s opening*, on Morris Run, two miles west of Fall Brook and three miles east of Blossburg, Tioga county. See G, pp. 173, 174.

The coal has a deep black luster, is very tender, and contains an unusually large number of thin partings of iron pyrites. These are generally nothing more than mere knife edges; but the number present in the specimen examined is very unusual.

It should be stated here that this coal is not mined for shipment to market.

(*654*) *Fall Brook Coal Co.'s mines*, at Fall Brook, Tioga county. See G, pp. 166, 167.

The coal is bright, shining, tender; somewhat columnar structure and cubical fracture. It contains numerous thin partings of mineral charcoal and iron pyrites.

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§ *15. Kittanning Middle Coal Bed. C'.*

A third member of the Kittanning group, the Kittanning Middle coal bed, has been identified by Mr. Chance in his survey of Northern Butler county. See Report of Progress, V, 1879.

Its identification in other parts of the State is not yet satisfactory, so that its approximate area cannot be positively stated.

The following analyses will represent the character of the coal in the district where the bed has been identified:

Butler County.

	(933) Studebaker.	(935) Mercer Co. [Upper bench.]	(936) Mercer Co. [Lower bench.]
Water @ 225°,	2.270	2.430	2.920
Volatile matter,	40.990	36.735	38.495
Fixed carbon,	46.794	47.858	54.138
Sulphur,	1.871	.767	.842
Ash,	8.075	12.210	3.605
	100.000	100.000	100.000
Coke, per cent.,	56.740	60.835	58.585
Color of ash,	grey.	grey, red tinge.	cream.
Fuel ratio,	1:1.14	1:1.30	1:1.40

(*933*) *Studebaker's bank*, Worth township, Butler county. *Middle bench of bed.*

Luster deep black, shining; carries considerable pyrites and small lenticular masses of slate.

(*935*) *Mercer Mining and Manufacturing Co.'s coal*, Mercer township, Butler county. *Harrisville coal; upper part of bed with some draw slate attached.*

Coal generally compact; alternating bands of bright, crystalline coal and dull black slaty coal.

(*936*) *Mercer Mining and Manufacturing Co.'s coal*, Mercer township, Butler county. *Harrisville coal; lower bench.*

Coal compact; luster deep black, shining; brittle; generally free from pyrites.

§ *16. Kittanning Lower Coal Bed.* (*C.*)

This is the bed always known as simply the Kittanning, the first bed *above* the Ferriferous Limestone wherever this exists, namely: in Beaver, Lawrence, Butler, Allegheny, Armstrong, Western Indiana, Clarion, Jefferson, Clearfield, Forest, Elk, and McKean.

The "Gas Coal" of Johnson Run basin in McKean county, lies fifty feet above a limestone which is probably the Ferriferous; which, if true, makes the "Gas Coal" the Kittanning Lower.

To the east and south-east of the area mentioned above no Ferriferous Limestone was deposited; but the Kittanning Lower coal bed was, and has been identified as far east as the Allegheny mountain and as far south as the State Line; never as a large bed, but often of workable thickness.

Its area is approximately defined by the blue line of the Ferriferous Limestone outcrop on the county maps accompanying the reports.

It may be the coal bed lettered B′ around Blossburg in Tioga county, at Fall Brook, Arnot, and Antrim. This "Bloss" bed furnishes most of the coal for the output of the Arnot mines for steam and blacksmith use. For its coking qualities see Report of Progress G, pp. 180, 183, &c.

Upper Bench of Kittanning Lower Coal.

Beaver County.

	(511a) Mendenhall.	(515a) Couch.	(509a) Hulmes.
Water @ 225°,	1.850	2.080	2.200
Volatile matter,	41.260	39.250	39.440
Fixed carbon,	43.263	48.818	50.705
Sulphur,	4.177	1.927	.825
Ash,	9.450	7.925	6.830
	100.000	100.000	100.000
Coke, per cent.,	56.890	58.670	58.360
Color of ash,	grey, pink tinge.	grey, red tinge.	dirty grey.
Fuel ratio,	1:1.04	1:1.24	1:1.28

(511a) *Mendenhall & Chamberlin's mines*, near New Brighton, Pulaski township, Beaver county. See p. 194, Q.

Coal bright, compact; carries an unusually large number of thin partings of iron pyrites.

(515a) *Mr. Couch's mine*, near New Brighton, Pulaski township, Beaver county. See p. 196, Q.

Coal generally compact, has a bright, resinous luster; carries numerous thin partings of pyrites.

(*509a*) *Mr. Hulmes' mines*, near Beaver Falls, Patterson township, Beaver county. See p. 247, Q.

The coal has a resinous luster; with seams of bright, pitchy coal. Specimen seems generally free from pyrites.

Lower Bench of Kittanning Lower Coal.

Beaver County.

	(*511b*) *Mendenhall.*	(*514*) *Fish.*	(*515b*) *Couch.*	(*509b*) *Hulmes.*
Water @ 225°, ...	2.270	2.160	2.370	2.400
Volatile matter, . .	38.870	40.885	36.470	38.110
Fixed carbon, . .	50.173	49.488	51.845	54.619
Sulphur, ...	2.322	1.767	1.770	.791
Ash, ...	6.365	5.700	7.545	4.080
	100.000	100.000	100.000	100.000
Coke, per cent., . . .	58.860	56.955	61.160	59.490
Color of ash, ...	grey.	grey.	grey, red tinge.	grey.
Fuel ratio, . . .	1:1.29	1:1.21	1:1.42	1:1.43

(*511b*) *Mendenhall & Chamberlin's mines*, near New Brighton, Pulaski township, Beaver county. See p. 194, Q.

Coal bright and compact; shows considerable iron pyrites in thin partings.

(*514*) *Mr. Fish's mine*, on Blockhouse run, one mile north of New Brighton, Pulaski township, Beaver county. See p. 196, Q.

The coal has a resinous luster generally, but carries numerous bands of bright, pitchy coal. It shows considerable iron pyrites, part of which exists as beautiful stalactitic prolongations of pyrite.

(*515b*) *Mr. Couch's mine*, near New Brighton, Pulaski township, Beaver county. See p. 196, Q.

The coal is compact, with heavy, bright, pitchy luster. It is seamed with thin partings of pyrites.

(*509b*) *Mr. Hulmes' mines*, near Beaver Falls, Patterson township, Beaver county.

The coal is compact, and has a bright, pitchy appearance. It seems generally free from slate and pyrites.

Kittanning Lower Coal—Bench not stated.

Lawrence County.

	(628) Sharpless & Kincaid.	(637) Nelson.
Water @ 225°,	2.670	1.930
Volatile matter,	38.790	42.445
Fixed carbon,	54.994	49.823
Sulphur,	.956	1.832
Ash,	2.590	3.970
	100.000	100.000
Coke, per cent.,	58.540	55.625
Color of ash,	reddish brown.	reddish grey.
Fuel ratio,	1:1.41	1:1.17

(628) *Sharpless and Kincaid's mine*, three miles north of New Castle, Lawrence county.

Coal, of a deep black luster, is very compact and brittle and carries considerable mineral charcoal.

(637) *Mr. Nelson's mine*, Slippery Rock township, Lawrence county.

Coal compact, brittle, with resinous luster generally; is somewhat coated with iron oxide.

Beaver County.

	(510) Fell's Drift.	(508) Ross & Smith.
Water @ 225°,	1.450	1.620
Volatile matter,	34.270	39.385
Fixed carbon,	36.193	43.603
Sulphur,	3.357	2.822
Ash,	24.730	12.570
	100.000	100.000
Coke, per cent.,	64.280	58.995
Color of ash,	grey, pink tinge,	dirty grey, pink tinge.
Fuel ratio,	1:1.05	1:1.10

(510) *Mr. Fell's drift*, at Rochester, Rochester township, Beaver county. See p. 196, Q.

Coal of dull resinous appearance generally, shows numerous thin partings of slate and iron pyrites.

(508) *Ross and Smith's bank*, near Beaver Falls, Patterson township, Beaver county. See p. 247, Q.

Coal of resinous luster generally, carries numerous thin bands of bright crystalline coal; and shows some slate partings and considerable pyrites.

	Fayette County. (695a) Fayette.	*Westmoreland County. (692) Hall.*	*Cambria County. (439a) Ramsey.**
Water @ 225°,	.860	.780	1.355
Volatile matter,	21.815	20.405	24.581
Fixed carbon,	59.417	69.570	63.101
Sulphur,	4.398	3.285	.643
Ash,	13.510	5.960	10.320
	100.000	100.000	100.000
Coke, per cent.,	77.325	78.815	74.061
Color of ash,	grey, pink tinge.	pink.	grey, yellow tinge.
Fuel ratio,	1:2.72	1:3.40	1:2.56

(695a) *Fayette Furnace bank*, two miles east from Springfield, Springfield township, Fayette county.

Coal, of a deep black luster generally, carries numerous bands of bright crystalline coal. The specimen shows an unusually large amount of pyrites, present generally in thin knife edges; also bands of slaty coal.

(692) *Robt. Hall's mine*, near Laughlinstown, and four miles east of Ligonier, Ligonier township, Westmoreland county.

Coal, deep black, tender, iridescent, carries numerous thin partings of pyrites.

(439a) *Jos. Ramsey Jr.'s Coal mine*, at Fallen Timber, Cambria county. See HH, p. 91.

Coal bright, shining, tender; carries an unusually large amount of mineral charcoal and a few thin partings of pyrites.

Huntingdon County.

	*(77) Robertsdale.*** *[Upper bench.]*	*(78) Robertsdale.*** *[Lower bench.]*
Water @ 225°,	.395	.560
Volatile matter,	16.140	16.002
Fixed carbon,	72.942	73.091
Sulphur,	2.483	1.115
Ash,	8.040	9.232
	100.000	100.000

* Called bed C. in Report HH.

** Bed C of Ashburner. Report of Progress, F.

Coke, per cent.,	83.465	83.438
Color of ash,	reddish grey.	dirty grey.
Fuel ratio,	1:4.51	1:4.56

(77) *Robertsdale colliery* of the Rockhill Iron and Coal Co., Trough Creek basin, Carbon township, Huntingdon county. *Mine B′; upper bench.* See F, p. 187.

The coal has a bright, shining luster, is rather tender, and carries considerable mineral charcoal and iron pyrites.

(78) *Robertsdale colliery* of the Rockhill Iron and Coal Co., Trough Creek basin, Carbon township, Huntingdon county. *Mine B′; lower bench.*

Coal bright, generally compact, with considerable mineral charcoal and some iron pyrites.

The following analyses of the coals from the Robertsdale collieries of the Rockhill Iron and Coal Co., were made by Mr. J. Blodgett Britton, of Philadelphia; and they are published here for comparison by the kind permission of Mr. Wm. A. Ingham, President:

*Bed C.**

	[*Upper bench.*]	[*Lower bench.*]
Moisture,	.91	1.13
Volatile matter,	15.83	15.56
Ash,	10.27	8.58
Fixed carbon,	72.99	74.73
	100.00	100.00
Sulphur,	2.431	.762
Coke, per cent.,	83.260	83.31
Per cent. sulphur in coke,	1.974	.466

	(206) *Alloway.***
Water @ 225°,	.250
Volatile matter,	14.510
Fixed carbon,	77.042
Sulphur,	1.338
Ash,	6.860
	100.000
Coke, per cent.,	85.240
Color of ash,	grey.
Fuel ratio,	1:5.30

* Worked in "Mine B′."

** Bed C.

(*206*) *Alloway colliery*, Trough Creek basin, Carbon township, Huntingdon county. Owner, Mr. E. L. Anderson; operator, Mr. W. T. Pearson. See F, p. 189.

Coal bright, friable, with thin seams of charcoal and pyrites. Laminæ very distinct in some pieces. (D. McC.)

McKean County.

	(*720a*)* Coal pit bed. [Top bench.]	(*720b*)* Coal pit bed. [Bottom bench.]
Water @ 225°,	5.960	7.710
Volatile matter,	36.385	33.705
Fixed carbon,	51.673	55.868
Sulphur,	.677	.802
Ash,	5.305	1.915
	100.000	100.000
Coke, per cent.,	57.655	58.585
Color of ash,	cream.	cream.
Fuel ratio,	1:1.42	1:1.65

(*720a*) *Coal pit bed opening*, four miles east of Norwich Corners, McKean county. *Top bench;* two feet five inches thick. "*Dagus Bed.*"

The coal, of a deep black to brownish black color, is generally very compact and brittle, with irregular fracture. It carries numerous thin partings of mineral charcoal, and *yields a coke which is only slightly coherent.*

(*720b*) *Coal pit bed opening*, four miles east of Norwich Corners, McKean county. *Bottom bench;* two feet one inch thick. "*Dagus Bed.*"

The coal has the same general appearance as that from the top bench. *It yields a coke only slightly coherent.*

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§ 17. *Clarion Upper Coal Bed.* (*B.*)

Immediately underneath the Ferriferous Limestone comes the Scrubgrass coal bed in northern Butler county; and from ten to thirty feet beneath it the Clarion coal bed.

There is good reason for believing (See Report of Progress, V, 1879) that the Scrubgrass is a split from the Clarion, or,

* Not yet certainly identified with Kittanning Lower coal.

in other words, its top bench removed to a considerable distance from the lower bench.

In all the counties mentioned in §16 we recognize the Clarion bed, under the Ferriferous Limestone where that exists, or its rightful place where it ought to exist.

It is usually a small bed, seldom three feet thick, but often yielding excellent coal.

In McKean county it is the Clermont coal bed of the Johnson run and Bishop Summit basin, provided the limestone over it (30± feet) be really the Ferriferous; and it is here extensively and profitably mined. See Report of Progress, R, 1879.

This may be the Barclay coal bed, B, of Bradford county, at Miller's & Gatiss's openings, where it reaches a thickness of ten feet, and has a coal twenty feet above it, like the Scrubgrass; but the absence of any limestone makes absolute identification impossible. See Report of Progress, G, pp. 123, 125.

Bed B at Bell's run in Cambria county is ten feet thick; but sinks to about four feet at the Bennington mines in Blair county. HH, p. 15, &c.

Fayette County.

	(694) *Potter.*
Water @ 225°,	.860
Volatile matter,	26.490
Fixed carbon,	65.570
Sulphur,	2.025
Ash,	5.055
	100.000
Coke, per cent.,	72.650
Color of ash,	red.
Fuel ratio,	1:2.47

(694) Geo. Potter's pit, near Meadow Run, three miles south of Ohiopyle Falls, Stewart township, Fayette county. See KKK, p. 85.

Coal generally compact, with bright, shining luster; carries numerous thin partings of mineral charcoal and iron pyrites.

Somerset County.

	(400) Liston Bros.	(382) Zimmerman.	(381) Clark.
Water @ 225°,	.910	.630	.770
Volatile matter,	21.960	15.565	15.870
Fixed carbon,	64.597	67.420	76.925
Sulphur,	2.298	3.590	.690
Ash,	10.235	12.795	5.745
	100.000	100.000	100.000
Coke, per cent.,	77.130	83.805	83.360
Color of ash,	grey.	grey.	grey.
Fuel ratio,	1:2.94	1:4.33	1:4.84

(*400*) *Liston Bros'. mine*, at Listonville, four miles south of Ursina, Addison township, Somerset county.

Coal bright and tender; seamed with mineral charcoal, slate and pyrites.

(*382*) *Mr. Zimmerman's mine*, one mile south of Fairview village, Somerset township, Somerset county.

Coal very tender; luster resinous; seamed with pyrites. (D. McC.)

(*381*) *G. W. Clark's mine*, at Hooversville, Shade township, Somerset county. See HHH, pp. 119, 120, 121.

Coal bright and very tender; shows a few specks of pyrites and a slight efflorescence of sulphate of iron. (D. McC.)

Indiana County.

	(618) Indiana Coal Co.
Water @ 225°,	.920
Volatile matter,	24.356
Fixed carbon,	62.218
Sulphur,	4.916
Ash,	7.590
	100.000
Coke, per cent.,	74.724
Color of ash,	brick red.
Fuel ratio,	1:2.55

(*618*) *Indiana Coal Co.'s mine*, Bracken farm, one and a half miles south-east of Homer, Indiana county. See HHHH, pp. 198, 201.

The coal is exceedingly tender, and has a dull luster, being very much coated with iron oxide; it carries numerous thin partings of mineral charcoal, and a large amount of iron pyrites.

Clearfield County.

	(70) *Franklin.*	(4) *Beaver Run.*
Water @ 225°,	.670	.920
Volatile matter,	21.360	21.550
Fixed carbon,	74.284	74.009
Sulphur,	.435	.631
Ash,	3.251	2.890
	100.000	100.000
Coke, per cent.,	77.970	77.53
Color of ash,	cream.	cream.
Fuel ratio,	1:3.47	1:3.43

(*70*) *Franklin colliery* of Kittanning Coal Co., at Houtzdale, five and a half miles south-west of Osceola, Clearfield county. See Report H, p. 30.

The coal has a resinous luster generally, but with seams of bright crystalline coal running through it; it carries numerous thin partings of mineral charcoal and a few specks of partially decomposed pyrites; also, some scales of *calcite.* This specimen of coal was forwarded by Mr. Shillingford, secretary of the Kittanning Coal Co.; it had been kept in their office for three months previous to analysis.

(*4*) *Beaver Run No. 1 colliery*, three quarters of a mile south-west of Houtzdale, Clearfield county. *Kendrick & Co.* See H, p. 34.

The coal is bright, shining, resinous, with somewhat columnar structure; it contains numerous thin partings of mineral charcoal, and shows but little pyrites.

Cambria County.

	(1) *Cambria.*	(307) *Cambria.*	(316) *Martin.*	(191) *Dysart & Co.*
Water @ 225°,	1.185	1.100	.840	.615
Volatile matter,	16.540	17.240	18.535	17.935
Fixed carbon,	74.456	73.145	77.132	76.503
Sulphur,	1.860	2.352	.573	.602
Ash,	5.959	6.163	2.920	4.345
	100.000	100.000	100.000	100.000
Coke, per cent.,	82.275	81.660	80.625	81.450
Color of ash,	cream.	cream.	cream.	cream.
Fuel ratio,	1 : 4.50	1 : 4.24	1 : 4.16	1 : 4.26

(*1*) *Cambria Iron Co.'s mines*, at Johnstown, Cambria county. See HH, p. 105.

Coal bright, shining, friable; contains numerous partings of pyrites. Fracture uneven, as if from oblique strains.

(*307*) *Cambria Iron Co.'s mines*, at South Fork, Cambria county. *Upper bench.* See HH, p. 44.

Coal bright, tender; seamed with mineral charcoal and pyrites. Fracture shows oblique faces.

(*316*) *J. C. Martin's mine*, on Trout run, Cambria, county. "*Sample taken twenty yards from mouth of drift.*" See HH, pp. 55, 56.

Coal bright, clean looking, tender; shows but little pyrites.

(*191*) *Dysart & Co.'s mine*, on Ben's creek, Cambria county. "*Sonman vein.*" See HH, p. 49.

Coal bright, clean looking, firm; shows a few thin partings of charcoal and slaty coal, and only a small amount of pyrites in thin scales. Fracture shows oblique faces.

	(*311*) *Mellon.*	(*425*) *Mellon.*	(*313*) *Wirtner.*
Water @ 225°,	.850	.880	.750
Volatile matter,	22 590	22.755	21.930
Fixed carbon,	66.694	68.340	61.597
Sulphur,	3.126	1.905	2.253
Ash,	6.740	6.120	13.470
	100.000	100.000	100 000
Coke, per cent.,	76.560	76.365	77.320
Color of ash,	cream.	grey, red tinge.	grey, red tinge.
Fuel ratio,	1:2.95	1:3.00	1:2.80

(*311*) *James Mellon's mine*, at Carrolltown, Cambria county. See HH, pp. 141, 142.

Coal bright, clean looking, tender; shows considerable mineral charcoal and iron pyrites in thin partings.

(*425*) *James Mellon's mine*, at Carrolltown, Cambria county. *Second sample.*

Coal bright, tender; seamed with charcoal and pyrites.

(*313*) *Benjamin Wirtner's mine*, at Carrolltown, Cambria county.

Coal bright, tender; somewhat coated with iron oxide and seamed with slate and iron pyrites.

	(304) *Bell's Gap R. R.* [*Upper bench.*]	(305) *Bell's Gap R. R.* [*Middle bench.*]	(306) *Bell's Gap R. R.* [*Lower bench.*]	(348) *Brotherline.*
Water @ 225°,	.630	.710	.970	1.340
Volatile matter,	24.230	26.065	26.130	25.425
Fixed carbon,	59.216	64.806	63.624	64.541
Sulphur,	2.239	1.509	2.581	.731
Ash,	13.685	6.910	6.695	7.930
	100.000	100.000	100 000	100.000
Coke, per cent.,	75.140	73.225	72.900	73.235
Color of ash,	grey.	grey.	grey, pink tinge.	reddish grey.
Fuel ratio,	1:2.44	1:2.48	1:2.43	1:2.53

(*304*) *Bell's Gap Railroad Co.'s mines*, at Lloydsville, Cambria county. *Upper bench.* See HH, pp. 84, 85, 86, 87.

Coal bright, shining; carries an unusually large number of thin partings of mineral charcoal and iron pyrites; also some slate partings.

(*305*) *Bell's Gap Railroad Co.'s mines*, at Lloydsville, Cambria county. *Middle bench.*

Coal bright, *exceedingly tender;* carries a large amount of mineral charcoal, and considerable iron pyrites; also, some sulphate of iron.

(*306*) *Bell's Gap Railroad Co.'s mines*, at Lloydsville, Cambria county. *Lower bench; "slip coal."*

This coal has the general appearance of that from the middle bench. Its fracture is very uneven, as if from oblique strains.

(*348*) *Mr. Brotherline's mine*, on Allegheny mountain, five miles north-east of Bennington.

Coal of dull aspect generally, is strongly iridescent, and carries considerable mineral charcoal and some pyrites.

Blair County.

	(3) *Cambria Iron Co.*	(303) *Dennison, Porter & Co.*
Water @ 225°,	1.400	.910
Volatile matter,	27.225	26.340
Fixed carbon,	61.843	61.373
Sulphur,	2.602	1.792
Ash,	6.930	6.585
	100.000	100.000

Coke, per cent.,	71.375	72.750
Color of ash,	grey.	grey.
Fuel ratio,	1:2.27	1:2.44

(*3*) *Cambria Iron Co.'s mine*, at Bennington, Blair county. See HH, p. 16.

Coal bright, friable; carries considerable pyrites.

(*303*) *Dennison, Porter & Co.'s mine*, near Bennington, Blair county. See HH, pp. 17, 18.

Coal bright, shining, tender; carries numerous thin partings of mineral charcoal and iron pyrites.

	(*411*) *Glen White.* [*Upper.*]	(*412*) *Glen White.* [*Lower.*]	(*308*) *Baker.* [*Upper.*]	(*384*) *Baker.* [*Lower.*]
Water @ 225°,	.940	1.040	.950	.900
Volatile matter,	29.660	28.010	28.915	25.630
Fixed carbon,	59.912	49.244	63.462	51.305
Sulphur,	.978	4.501	.983	4.400
Ash,	8.510	17.205	5.690	17.765
	100.000	100.000	100.000	100.000
Coke, per cent.,	69 406	70.950	70.135	73.470
Color of ash,	white.	pink.	grey.	pink.
Fuel ratio,	1:2.01	1:1.75	1:2.19	1:2.00

(*411*) *Glen White Coal and Lumber Co.'s mine*, three miles north-west of Kittanning Point, Blair county. *Upper bench.* See HH, pp. 11, 12.

Coal bright, shining, tender, seamed with mineral charcoal. (D. McCreath.)

(*412*) *Glen White Coal and Lumber Co.'s mine*, three miles north-west of Kittanning Point, Blair county. *Lower bench.*

The coal is bright and very compact, and carries numerous thin partings of mineral charcoal, slate and iron pyrites.

(*308*) *Dr. Baker's mine*, three miles north north-west of Kittanning Point, Blair county. *Upper bench.*

Coal bright, compact, seamed with mineral charcoal and pyrites.

(*384*) *Dr. Baker's mine*, three miles north north-west of Kittanning Point, Blair county. *Lower bench.*

Coal bright, very tender, with numerous partings of mineral charcoal, slate and pyrites.

McKean County.

	(715) *Buffalo.**
Water @ 225°,	1.470
Volatile matter,	38.710
Fixed carbon,	44.561
Sulphur,	4.839
Ash,	10.420
	100.000
Coke, per cent.,	59.820
Color of ash,	pink.
Fuel ratio,	1:1.15

(*715*) *Buffalo Coal Co.'s mine*, Clermont, McKean county. The coal, generally compact and brittle, has a deep black luster, and carries numerous thin partings of mineral charcoal and iron pyrites.

Potter County.

	(*704a*) *West Branch Pine Creek.***	(*704b*) *West Branch Pine Creek.***
Water @ 225°,	3.070	.950
Volatile matter,	30.970	31.700
Fixed carbon,	55.140	56.500
Sulphur,	.975	1.000
Ash,	9.845	9.850
	100.000	100.000
Coke, per cent.,	65.96	67.350
Color of ash,	cream.	—
Fuel ratio,	1:1.78	1:1.78

(*704a*) *West Branch Pine Creek*, five miles from Pikes Mills P. O., Potter county. See G, pp. 230, 231, 234.

Coal generally coated with silt, has a deep black luster on fresh fracture. It is firm and compact and carries a few thin partings of slaty coal. Specimen very wet; probably due to its being soaked with water in transitu.

(*704b*) *West Branch Pine Creek*, five miles from Pikes Mills P. O., Potter county.

Coal from same opening analysed by Prof. C. F. Chandler,

* Clermont coal. Ashburner. Report of Progress, R. Identification not yet established.

** Bed B.—F. Platt, R. of Prog. G.

February 10, 1876. These two analyses are almost identical; No. (704b) showing the normal amount of water present in the coal. The proportion of volatile matters to fixed carbon is the same in each analysis, viz: 1:1.78.

	(1000)* McLean.
Water @ 225°,	1.150
Volatile matter,	34.185
Fixed carbon,	54.276
Sulphur,	1.059
Ash,	9.330
	100.000
Coke, per cent.,	64.665
Color of ash,	grey.
Fuel ratio,	1:1.58

(*1000*) *McLean's coal opening*, three and a half miles west of Coudersport, Potter county.

Coal somewhat coated with infiltrated silt, is compact and brittle, with deep black luster.

Tioga County.

	(706) Bache.** [Soft Coal.]	(707) Bache.** [Hard Coal.]	(705) Mitchell.**
Water @ 225°,	2.240	2.380	1.810
Volatile matter,	20.045	20.005	20.350
Fixed carbon,	70.357	70.055	68.126
Sulphur,	.588	.565	.569
Ash,	6.770	6.995	9.145
	100.000	100.000	100.000
Coke, per cent.,	77.715	77.615	77.840
Color of ash,	grey, red tinge.	reddish grey.	reddish grey.
Fuel ratio,	1:3.50	1:3.50	1:3.34

(*706*) *Bache mine*, Morris township, ten miles south from Wellsboro', Tioga county. See G, p. 190.

The coal, clean looking generally, has a deep black luster; it is moderately firm and compact and shows numerous thin partings of mineral charcoal. It breaks with irregular fracture.

(*707*) *Bache mine*, Morris township, ten miles south from Wellsboro' Tioga county.

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* Bed B.—F. Platt, R. of Prog. G.

** Bloss bed. Bed B'. F. Platt, Report of Progress, G.

The coal, considerably coated with an orange yellow silt, is unusually firm and compact and has a deep black luster on fresh fracture. It shows numerous thin partings of mineral charcoal and breaks with somewhat cubical fracture.

(*705*) *Mitchell's mine*, eight and a half miles from Wellsboro', Tioga county. See G, p. 192.

The coal, considerably coated with silt, has a dull, dead luster on fresh fracture. It is generally compact; carries numerous thin partings of mineral charcoal, and seems in the main free from iron pyrites.

	(*671*) *Fall Brook.**	(*601a*) *Blossburg.** [*Upper.*]	(*601c*) *Blossburg.** [*Middle.*]	(*601b*) *Blossburg.** [*Lower.*]
Water @ 225°,	2.260	1.190	.940	1.110
Volatile matter,	20.240	20.755	20.640	18.790
Fixed carbon,	71.847	71.697	64.306	63.428
Sulphur,	.548	1.023	.914	.602
Ash,	5.105	5.335	13.200	16.070
	100.000	100.000	100.000	100.000
Coke, per cent.,	77.500	78.055	78.420	80.100
Color of ash,	grey.	grey.	grey.	grey.
Fuel ratio,	1:3.54	1:3.45	1:3.11	1:3.37

(*671*) *Fall Brook Coal Co.'s mines* at Antrim, Tioga county. See G, pp. 187, 188.

The coal has a deep black luster generally, with seams of bright crystalline coal running through it. It is rather tender, is free from slaty coal, and carries only a small amount of iron pyrites.

(*601a*) *Blossburg Coal Co.'s mines* at Arnot, Tioga county. *Upper bench.* See G, pp. 180, 181.

Coal rather tender, with resinous luster generally; carries thin seams of bright crystalline coal through it. It shows considerable mineral charcoal and iron pyrites in thin partings.

(*601c*) *Blossburg Coal Co.'s mines* at Arnot, Tioga county. *Middle bench.*

Coal rather compact, and somewhat slaty; has a bright

* Bloss bed. Bed B'. F. Platt, Report of Progress G.

resinous luster, and shows numerous thin partings of mineral charcoal, and considerable pyrites existing in scales.

(*601b*) *Blossburg Coal Co.'s mines* at Arnot, Tioga county. *Bottom bench.*

Coal generally compact, with bright resinous luster; carries numerous bands of bright crystalline coal through it; also, some bands of slaty coal. Specimen seems in the main free from pyrites.

	(*664*) *Morris Run.**	(*657a*) *Fall Brook.** [*Average.*]	(*657b*) *Fall Brook.** [*Crystalline coal.*]	(*657c*) *Fall Brook.** [*Cannel-like coal.*]
Water @ 225°, .	1.120	1.050	1.000	1.200
Volatile matter,	18.570	18.540	20.830	17.110
Fixed carbon, .	72.097	69.934	70.854	66.212
Sulphur,	.583	.661	.796	.568
Ash, . . .	7.630	9.815	6.520	14.910
	100.000	100.000	100.000	100.000
Coke, per cent.,	80.330	80.410	78.170	81.690
Color of ash, . .	grey.	grey.	grey.	grey.
Fuel ratio, . .	1:3.88	1:3.77	1:3.40	1:3.86

(*664*) *Morris Run Coal Co.'s mines*, on Morris Run, three miles east of Blossburg, Tioga county. See G, p. 176.

Coal is generally bright, tender and columnar; it shows a few thin seams of cannel-like coal and mineral charcoal, and only a small amount of pyrites.

(*657a*) *Fall Brook Coal Co.'s mines*, at Fall Brook, Tioga county. See G, pp. 170, 171.

The specimen contains bright crystalline, tender coal, with columnar structure and cubical fracture; also, bright, resinous, slaty, cannel-like coal, having a somewhat conchoidal fracture.

(*657b*) *Fall Brook Coal Co.s mine*, at Fall Brook, Tioga county.

Selected bright crystalline coal, from No. (657a.)

(*657c*) *Fall Brook Coal Co.'s mine*, at Fall Brook, Tioga county.

Selected cannel-like coal, from No. (657a;) yields a coke which is only slightly coherent.

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* Bloss bed. Bed B. F. Platt, Report of Progress G.

	(703) *Knox & Billings.* *
Water @ 225°,	3.260
Volatile matter,	27.860
Fixed carbon,	61.421
Sulphur,	.804
Ash,	7.655
	100.000
Coke, per cent.,	68.880
Color of ash,	reddish grey.
Fuel ratio,	1:2.16

(*703*) *Knox & Billing's coal bed*, near Gaines P. O., sixteen miles from Wellsboro', Tioga county. See G, p. 221.

The coal, generally coated with a yellowish white silt, has a deep black, shining luster on fresh fracture. It is rather compact and shows numerous partings of mineral charcoal.

Coal when analysed was very wet; so that the high percentage of water given above is most probably due to the specimen having been soaked in transitu.

Bradford County.

	(660) *Barclay.* [*Upper bench.*]	(661a) *Barclay.* [*Middle bench.*]	(662a) *Barclay.* [*Lower bench.*]	(663) *Barclay.* * [*Average.*]
Water @ 225°,	.730	.760	.880	.770
Volatile matter,	17.220	16.405	16.660	17.110
Fixed carbon,	69.840	62.172	73.257	70.744
Sulphur,	.795	.613	.643	.776
Ash,	11.415	20.050	8.560	10.600
	100.000	100.000	100.000	100.000
Coke, per cent.,	82.050	82.835	82.460	82.120
Color of ash,	grey.	grey, yellow tinge.	grey.	grey.
Fuel ratio,	1:4.05	1:3.78	1:4.39	1:4.13

(*660*) *Barclay Railroad and Coal Co.'s mines*, at Barclay, Bradford county. Mine No. 2; *upper bench*. See G, pp. 131, 132, 133.

Coal generally bright and crystalline, but with thin seams of slaty coal; rather tender, with numerous thin partings of mineral charcoal.

(*661a*) *Barclay Railroad and Coal Co.'s mines*, at Barclay, Bradford county. Mine No. 2; *middle bench.*

* Bed B ? F. Platt. Report of Progress G.

Coal generally bright and columnar, with numerous bands of slaty coal. It also carries considerable slate in lenticular masses. See analysis No (661b.)

(*662a*) *Barclay Railroad and Coal Co.s mines*, at Barclay, Bradford county. Mine No. 2; *lower bench.*

The specimen contains bright, crystalline, columnar coal; also greyish black, cannel-like coal. See analyses Nos. (662b) and (662c).

(*663*) *Barclay Railroad and Coal Co.'s mines*, at Barclay, Bradford county. *Average.*

The specimen consists of bright, crystalline, columnar coal, seamed with mineral charcoal and slate; also of compact, greyish black, cannel-like coal with conchoidal fracture.

	(*661b*) *Barclay.* [*Selected specimen.*]	(*662b*) *Barclay.* [*Crystalline coal.*]	(*662c*) *Barclay.** [*Cannel-like coal.*]
Water @ 225°, ...	.750	.850	.900
Volatile matter, . .	17.070	17.080	15.050
Fixed carbon, . . .	71.969	75.939	71.396
Sulphur, ...	.661	.681	.544
Ash, ...	9.550	5.450	12.110
	100.000	100.000	100.000
Coke, per cent., .	82.180	82.070	84.050
Color of ash, ...	grey.	grey.	grey.
Fuel ratio, ...	1:4.21	1:4.44	1:4.74

(*661b*) *Barclay Railroad and Coal Co.'s mines*, at Barclay, Bradford county. Mine No. 2; *selected specimen from middle bench.* See analysis No. (661a.)

Coal bright, crystalline, columnar.

(*662b*) *Barclay Railroad and Coal Co.'s mines*, at Barclay, Bradford county.

Bright, *crystalline*, columnar coal, selected from *middle bench*, Mine No. 2. See analysis No. (662a.)

(*662c*) *Barclay Railroad and Coal Co.'s mines*, at Barclay, Bradford county.

Greyish black, *cannel like* coal, selected from *middle bench*, Mine No. 2. See analysis No. (662a.)

* Bed B. F. Platt. Report of Progress, G.

This specimen yields a coke which is only slightly coherent.

	(668a) Schroeder.* [Middle bench.]	(668b) Schroeder.* [Lower bench.]
Water @ 225°,	.940	.850
Volatile matter,	17.845	16.755
Fixed carbon,	72.155	69.390
Sulphur,	.670	.715
Ash,	8.390	12.290
	100.000	100.000
Coke, per cent.,	81.215	82.495
Color of ash,	grey, yellow tinge.	grey, yellow tinge.
Fuel ratio,	1:4.04	1:4.14

(668a) *Schroeder mine*, of the Carbon Run Coal Company, about one and a half miles west of Barclay, Bradford county. *Middle bench.* See G, p. 134.

The specimens consist of bright, crystalline, columnar coal, and greyish black, cannel-like coal.

(668b) *Schroeder mine*, of the Carbon Run Coal Company, about one and a half miles west of Barclay, Bradford county. *Lower bench.*

Coal of same general character as No. (668a), but with more slaty coal throughout it.

Sullivan County.

Semi-Anthracite Coals.

	(315) Bernice. [Average.]	(666a) Bernice. [Upper.]	(666b) Bernice. [Middle.]	(666c) Bernice. [Lower.]	(666d) Bernice.** [Cannel-like.]
Water @ 225°,	1.295	1.840	1.800	2.220	1.950
Volatile matter,	8.100	9.835	9.650	9.405	9.030
Fixed carbon,	83.344	76.788	82.373	81.267	63.795
Sulphur,	1.031	.647	.622	.618	.585
Ash,	6.230	10.890	5.555	6.490	24.640
	100.000	100.000	100.000	100.000	100.000
Color of ash,	grey.	cream.	grey.	cream.	cream.
Fuel ratio,	1:10.28	1:7.87	1:8.53	1:8.64	1:7.06

(315) *State Line and Sullivan Railroad Co.'s mines*, at Bernice, Sullivan county. *Average;* sampled in 1876.

* Bed B. F. Platt. Report of Progress, G.

** Bed B.—F. Platt, Report of Prog. GG.

Coal compact, bright, shining; seamed with mineral charcoal and pyrites. Has the general appearance of an ordinary bituminous coal.

(666a) *State Line and Sullivan Railroad Co.'s mines*, at Bernice, Sullivan county. *Upper bench;* sampled in 1878.

Coal firm and compact, has a deep black, shining luster generally; it is seamed with bright crystalline coal and greyish black cannel-like coal. It carries considerable mineral charcoal in thin partings; only a few scales of pyrites.

(666b) *State Line and Sullivan Railroad Co.'s mines; middle bench.*

Coal bright, firm, compact; with only a few scales of pyrites.

(666c) *State Line and Sullivan Railroad Co.'s mines; bottom bench.*

Coal bright, compact; with little pyrites.

(666d) *State Line and Sullivan Railroad Co.'s mines; cannel-like coal from top bench.*

Greyish black, compact, cannel-like.

These coals do not have the slightest tendency to form a coherent coke.

	(937) Bernice.*
Water @225°,	2.340
Volatile matter,	8.440
Fixed carbon,	80.949
Sulphur,	.726
Ash,	7.545
	100.000
Color of ash,	cream.
Fuel ratio,	1:9.59

(937) *State Line and Sullivan Railroad Co.'s coal opening*, four miles east of Bernice, Sullivan county. See analyses of this bed at Bernice; Nos. (315,) (666a,) (666b,) (666c,) page 82.

The coal has a dull luster generally, being for the most part coated with infiltrated silt; on fresh fracture the luster is bright, shining. It is very firm and compact and shows

* Bed B. F. Platt. Report of Progress, G.

but little pyrites. It breaks with rough irregular fracture and has the general appearance of an ordinary bituminous coal.

	(812a) *Lippincott & Mercur.*✠ [*Upper part.*]	(812b) *Lippincott & Mercur.*✠ [*Lower part.*]
Water @ 225°,	.930	.810
Volatile matter,	12.410	13.060
Fixed carbon,	75.611	71.679
Sulphur,	.574	.581
Ash,	10.475	13.870
	100.000	100.000
Color of ash,	grey.	grey.
Fuel ratio,	1:6.09	1:5.48

(812a) *Lippincott & Mercur's mines*, three and a half miles south-west of Forksville, Sullivan county. *Upper part of bed.*

Coal, with deep black, shining luster generally, is rather tender and carries numerous thin bands of bright crystalline coal and slate; it seems in the main free from iron pyrites. *The gases burn with a bright yellow flame, but the coal is non-coking.*

(812b) *Lippincott & Mercur's mines*, three and a half miles south-west of Forksville, Sullivan county. *Lower part of bed.*

The coal is compact and brittle, with deep black to greyish black luster; it carries numerous thin bands of slaty coal but seems in the main free from pyrites. *Volatile matters burn with bright yellow flame, but the coal does not yield a coke.*

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§ *18. Brookville (or Clarion Lower) Coal Bed.* (*A.*)

This is the lowest workable coal bed of the Allegheny River Series, over the Pottsville Conglomerate, No. XII.

* Bed B. F. Platt. Report of Progress, GG.

It is recognized everywhere west and north of the Allegheny Mountain; in the Cumberland basin of Maryland; in the Broad Top basin in Huntingdon county; and probably in the Anthracite basins.

In Blair, Cambria and Somerset counties it is usually a thin bed and so full of sulphur as to be worthless. See HH, pp. 5, 9.

It is thin also around Brookville in Jefferson county, where it received its name. (H, pp. 18, 143, 209, 224.)

It outcrops upon the Conglomerate on both sides of Negro Mountain in Somerset, and Laurel Hill and Chestnut Ridge in Fayette, Westmoreland, Indiana, Cambria and Clearfield counties; it lies of course deeply buried below water level in South-Western Pennsylvania west of Chestnut Ridge.

It is probably the Alton bed of McKean county, (Report of Progress, R, 1879,) called the Twin at Clermont.

There is a bed A in the Tioga and Bradford fields which may or may not be the same.

Indiana County.	*(622) Meldron.*
Water @ 225°,	.560
Volatile matter,	27.880
Fixed carbon,	61.920
Sulphur,	3.610
Ash,	6.030
	100.000
Coke, per cent.,	71.560
Color of ash,	lilac.
Fuel ratio,	1:2.22

(*622*) *E. J. Meldron's mine*, half a mile south-east of Bell's Mills, Indiana county. Used in works of Black Lick Manufacturing Co. See HHHH, p. 192.

Coal bright, and *exceedingly* tender; carries a large amount of iron pyrites in thin partings.

Cambria County.

	(444) Shoemaker. [Upper.]	(445) Shoemaker. [Lower.]	(376) Moore. [Upper.]	(312) Moore. [Lower.]	(310) Cambria.
Water @ 225°,	1.360	.840	.690	.340	1.470
Volatile matter,	23.480	22.710	20.595	17.360	17.930
Fixed carbon,	69.945	49.417	74.690	58.294	75.508
Sulphur,	.955	8.853	.850	1.806	.567
Ash,	4.260	18.180	3.175	22.200	4.525
	100.000	100.000	100.000	100.000	100.000
Coke, per cent.,	75.160	76.450	78.715	82.300	80.600
Color of ash,	grey, red tinge.	pink.	grey.	grey.	reddish brown.
Fuel ratio,	1:2.55	1:2.17	1:3.62	1:3.35	1:4.21

(*444*) *S. A. Shoemaker's mine*, near Carrolltown, Cambria county. *Upper bench.*

Coal bright, shining, tender, with a few thin partings of pyrites. (D. McC.)

(*445*) *S. A. Shoemaker's mine*, near Carrolltown, Cambria county. *Lower bench.* See HH, p. 167.

Coal very compact, with dull resinous luster; carries an unusually large amount of iron pyrites. (D. McCreath.)

(*376*) *Mr. Moore's mine*, at Big Bend, Black Lick, Cambria county. *Upper bench.* See HH, p. 159.

Coal bright, tender, seamed with charcoal and pyrites. (D. McCreath.)

(*312*) *Mr. Moore's mine*, at Big Bend, Black Lick, Cambria county. *Lower bench.*

Coal compact, cannel-like; somewhat coated with silt; slightly iridescent.

(*310*) *Cambria Iron Co.'s mine*, near Conemaugh Station, Cambria county. See HH, p. 101.

Coal bright, compact, shows only a small amount of partially decomposed iron pyrites. [Coal forwarded by Mr. John Fulton, Engineer, who stated that specimen had been "weathered" for some time.]

Somerset County.

	(377) *Heinemeyer.*
Water @ 225°,	.600
Volatile matter,	26.000
Fixed carbon,	55.683
Sulphur,	2.167
Ash,	15.550
	100.000
Coke, per cent.,	73.400
Color of ash,	grey.
Fuel ratio,	1:2.14

(377) *C. Heinemeyer's mine*, one and a half miles west south-west of Buckstown, Stony Creek township, Somerset county. See HHH, pp. 14, 15.

Coal bright, very tender, seamed with slate and mineral charcoal. (D. McCreath.)

Bradford County.

	(659) *Barclay.**
Water @ 225°,	.850
Volatile matter,	16.625
Fixed carbon,	67.292
Sulphur,	.498
Ash,	14.735
	100.000
Coke, per cent.,	82.525
Color of ash,	grey.
Fuel ratio,	1:4.04

(659) *Barclay Railroad and Coal Co.'s opening*, on Fall creek, Bradford county. See G, pp. 138, 139.

The coal is very compact, with dull resinous luster. It breaks with conchoidal fracture, and has the general appearance of a cannel coal. *It yields a coke which is only slightly coherent.*

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* Bed A. F. Platt. Report of Progress, G.

§ 19. *Clarion Group; undetermined Beds.*

There was a preliminary survey of Clearfield and Jefferson counties in 1874, published as Report of Progress H, which left much to be desired in the way of identification of the lowest coal beds of the Productive Measures.

At that time there had been no comprehensible differentiation of the Pottsville Conglomerate into its numerous members; nor any clear distinction drawn between its top member and certain massive sand and gravel deposits with intervening coal beds (A, A′, B, B′) above.

Much still remains to be done towards clearing up this difficulty, especially in the wild region between Warren and McKean on the north, and Indiana and Cambria on the south.

The following are analyses of well known and important coals from beds the identification of which with the type beds on the Allegheny River is not yet made out.

Clearfield County.

	(414) *Reed.*	(415) *Reed.*
Water @ 225°,	.980	.740
Volatile matter,	22.585	23.985
Fixed carbon,	69.964	62.171
Sulphur,	.836	.734
Ash,	5.635	12.370
	100.000	100.000
Coke, per cent.,	76.435	75.275
Color of ash,	yellow.	grey.
Fuel ratio,	1:3.09	1:2.59

(*414*) *Mr. Reed's bank*, near Curwensville, Clearfield county. "*Three foot vein.*" See H, pp. 95 and 96.

Coal tender, bright, brittle, iridescent, seamed with mineral charcoal and iron pyrites. (D. McCreath.)

(*415*) *Mr. Reed's bank*, near Curwensville, Clearfield county. "*Four and a half foot vein.*"

Coal bright, tender; contains thin partings of mineral charcoal and slate and some iron pyrites. (D. McCreath.)

Blair County.

	(402) Woodcock.*
Water @ 225°,	1.260
Volatile matter,	26.290
Fixed carbon,	66.133
Sulphur,	.567
Ash,	5.750
	100.000
Coke, per cent.,	72.450
Color of ash,	grey.
Fuel ratio,	1:2.51

(402) S. Woodcock's mine, one and a half miles southwest of Bennington, Blair county. See Report HH, p. 9.

The coal, bright, shining, tender, is seamed with mineral charcoal, and is in the main free from pyrites.

Huntingdon County.

	(187) Savage.**	(188) Taylor.**	(814) Dougherty.**
Water @ 225°,	.390	1.020	.210
Volatile matter,	18.165	17.840	17.540
Fixed carbon,	75.421	74.623	67.154
Sulphur,	.994	.797	1.496
Ash,	5.030	5.720	13.600
	100.000	100.000	100.000
Coke, per cent.,	81.445	81.140	82.250
Color of ash,	cream.	cream.	reddish grey.
Fuel ratio,	1:4.15	1:4.18	1:3.82

(187) Savage (Curfman) opening, Rocky Ridge Basin, Todd township, Huntingdon county. Mr. John Weist, owner and operator. See F, p. 190.

Coal bright, shining, tender; carries considerable pyrites in thin scales. Fracture rather even.

(188) Taylor (Petriken) opening, Rocky Ridge Basin, Todd township, Huntingdon county. Owner, Hon. R. B. Petriken; operator, Mr. John Whitney.

Coal, hard, brittle, dull, somewhat coated with silt. Laminæ very distinct; fracture irregular.

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*Probably Bed A.

** Undetermined beds, on the general horizon of beds A, A', B, in Blair and Cambria. Ashburner, Report of Progress, F.

(*814*) *John Dougherty's opening*, Rocky Ridge Basin, Todd township, Huntingdon county. See F, p. 190.

Coal, deep black, rather firm and compact; carries numerous thin knife edges of slate; also bands of greyish black, ashy coal; considerable pyrites in thin scales. (S. S. Hartranft.)

McKean County.

	(*717*) *Spring bed.**
Water @ 225°,	1.780
Volatile matter,	36.270
Fixed carbon,	47.791
Sulphur,	5.069
Ash,	9.090
	100.000
Coke, per cent.,	61.950
Color of ash,	pink.
Fuel ratio,	1:1.31

(*717*) *Spring Bed opening*, three miles east of Norwich Corners, McKean county. Bed two feet thick.

The coal has a dull, dead luster; on fresh fracture it is deep black, shining; brittle, with irregular fracture; contains a large amount of iron pyrites partially decomposed.

	(*718*) *Rochester.**
Water @ 225°,	1.330
Volatile matter,	27.170
Fixed carbon,	26.906
Sulphur,	10.259
Ash,	34.335
	100.000
Coke, per cent.,	71.500
Color of ash,	lilac.
Fuel ratio,	1:0.99

(*718*) *Rochester cannel bed opening*, five miles east of Norwich Corners, McKean county. Bed two feet thick.

Coal has a deep black luster; is very brittle, with irregular fracture. It shows an unusually large amount of iron pyrites, partially decomposed. The coal, treated with water, gives a strong acid reaction. *Coke slightly coherent.*

* Brookville? Bed A. Ashburner. Report of Progress R. Identification not yet certain.

	(614a) Bond Vein.* [Top bench.]	(614b) Bond Vein. [Middle bench.]	(614c) Bond Vein. [Bottom bench.]
Water @ 225°,	.670	1.030	.710
Volatile matter,	36.065	37.630	32.980
Fixed carbon,	48.417	51.237	46.867
Sulphur,	1.058	1.553	2.943
Ash,	13.790	8.550	16.500
	100.000	100.000	100.000
Coke, per cent.,	63.265	62.370	66.310
Color of ash,	grey.	grey.	grey, red tinge.
Fuel ratio,	1:1.34	1:1.36	1:1.42

(*614a*) *Bond vein*, (Gillesville,) McKean county. *Top bench;* two feet thick.

Coal very compact and brittle; luster generally resinous, with thin seams of bright crystalline coal running through the mass; shows considerable slate partings.

(*614b*) *Bond vein*, (Gillesville,) McKean county. *Middle bench;* fourteen inches thick.

Coal compact, brittle; generally like (614a), but carries fewer slate partings.

(*614c*) *Bond vein*, (Gillesville,) McKean county. *Bottom bench;* one foot thick.

Coal compact, brittle; carries numerous partings of slate and pyrites.

	(716a) Hamlin bed.* [Top bench.]	(716b) Hamlin bed.* [Bottom bench.]
Water @ 225°,	1.210	1.060
Volatile matter,	36.895	28.990
Fixed carbon,	52.593	35.588
Sulphur,	2.037	.977
Ash,	7.265	33.385
	100.000	100.000
Coke, per cent.,	61.895	69.950
Color of ash,	reddish grey.	yellowish white.
Fuel ratio,	1:1.42	1:1.22

(*716a*) *Hamlin bed opening*, three miles east of Norwich Corners, McKean county. *Top bench;* two feet three inches thick.

The coal, for the most part coated with silt, has a deep

* Brookville ? Bed A. Ashburner. Report of Progress R. Identification not yet certain.

black luster on fresh fracture; it is very hard and compact, and shows considerable pyrites in minute crystals.

(*716b*) *Hamlin bed opening*, three miles east of Norwich Corners, McKean county. *Bottom bench;* sixteen inches thick.

The coal has a dull, dirty appearance, being for the most part coated with silt and iron oxide. It carries considerable slate and small lenticular masses of white sand rock.

	(*719*) *Rock seam.**
Water @ 225°,	1.860
Volatile matter,	34.630
Fixed carbon,	47.304
Sulphur,	2.491
Ash,	13.715
	100.000
Coke, per cent.,	63.510
Color of ash,	red.
Fuel ratio,	1:1.36

(*719*) *Rock bed opening*, three miles east of Norwich Corners, McKean county. Bed three feet five inches thick.

Coal generally coated with silt; has a dull black luster on fresh fracture; it shows numerous thin partings of slate and iron pyrites.

Tioga County.

	(*658a*) *Fall Brook.*** [*Average.*]	(*658b*) *Fall Brook.*** [*Crystalline coal.*]	(*658c*) *Fall Brook.*** [*Cannel-like coal.*]
Water @ 225°,	.790	.770	.800
Volatile matter,	20.965	22.180	15.720
Fixed carbon,	65.465	67.191	59.299
Sulphur,	.725	.799	.471
Ash,	12.055	9.060	23.710
	100.000	100.000	100.000
Coke, per cent.,	78.225	77.050	73.480
Color of ash,	grey.	grey.	grey.
Fuel ratio,	1:3.12	1:3.02	1:3.77

(*658a*) *Fall Brook Coal Co.'s mines*, at Fall Brook, Tioga county. *Average.* See G, p. 172.

* Brookville? Bed A. Ashburner. Report of Progress R. Identification not yet certain.

** Bear Creek Coal Bed on the general horizon of A, A′, B, of Western Pennsylvania. F. Platt. R. of Prog. G.

The specimen consisted of bright, crystalline, columnar coal, with numerous thin partings of mineral charcoal and some iron pyrites; also compact, greyish black, cannel-like coal with conchoidal fracture.

(*658b*) *Fall Brook Coal Co.'s mines*, at Fall Brook, Tioga county.

Bright, crystalline, columnar coal selected from specimen No. (658a.)

(*658c*) *Fall Brook Coal Co.'s mines*, at Fall Brook, Tioga county.

Greyish black, cannel-like coal from specimen No. (658a.) Yields a coke only slightly coherent.

	(*655*) *Fall Brook.* *"Monkey Vein."* *
Water @ 225°,	1.560
Volatile matter,	20.740
Fixed carbon,	66.587
Sulphur,	.773
Ash,	10.340
	100.000
Coke. per cent.,	77.700
Color of ash,	reddish grey.
Fuel ratio,	1:3.21

(*655*) *Fall Brook Coal Co.'s mines*, at Fall Brook, Tioga county. See G. p. 168.

The coal has a dull, dirty appearance, being for the most part coated with infiltrated silt; on fresh fracture it shows bands of bright crystalline coal and considerable slaty coal. It carries numerous thin partings of mineral charcoal and some iron pyrites.

	(*656*) *Fall Brook.* *"Morgan or Dirty Vein."* *
Water @ 225°,	2.820
Volatile matter,	17.975
Fixed carbon,	71.326
Sulphur,	.634
Ash,	7.245
	100.000

* Coal Bed on the general horizon of A, A', B, of Western Pennsylvania. F. Platt. R. of Prog. G.

Coke, per cent.,	79.205
Color of ash,	reddish grey.
Fuel ratio,	1:3.96

(656) *Fall Brook Coal Co.'s mines*, at Fall Brook, Tioga county. See G. p. 169.

The coal has a dull, dead luster, being generally coated with silt; on fresh fracture the coal is bright, crystalline and columnar. It carries numerous thin partings of mineral charcoal and some iron pyrites.

Sullivan County.

	(667) *Bernice**.	(803) *Bernice**.	(938) *Bernice.* [*Top bench.*	(939) *Bernice.* [*Bottom bench.*]
Water @ 225°,	5.815	4.130	7.930	2.910
Volatile matter,	15.085	15.270	21.410	11.780
Fixed carbon,	62.329	67.362	54.099	81.672
Sulphur,	.474	.523	.551	.598
Ash,	16.297	12.715	16.010	3.040
	100.000	100.000	100.000	100.000
Color of ash,	reddish grey.	reddish grey.	cream.	cream.
Fuel ratio,	1:4.13	1:4.41	1:2.52	1:6.93

(667) *State Line and Sullivan Railroad Co.'s mines*, at Bernice, Sullivan county. *Coal about sixty feet below bed B.*

Coal, for the most part coated with iron oxide and infiltrated silt, has a dull, dead luster; is compact and brittle, with very irregular fracture. It yields gases which burn with a feebly luminous flame, but has not the slightest tendency to yield a coherent coke. *See remarks at end of this section.*

(803) *State Line and Sullivan Railroad Co.'s mines*, at Bernice. Same coal as the above, but from a different part of the mine.

(938) *State Line and Sullivan Railroad Co.'s coal opening*, one and a half miles east of Bernice. *Top bench.*

Coal has a dull, dead, brownish-black luster; is *very soft* and crumbling, and has the general appearance of a soft cannel shale, with laminated structure. It yields gases burning with a feebly luminous flame, but is non-coking.

* Bed A ?; sixty feet below bed B, of F. Platt's Report of Progress GG.

(*939*) *State Line and Sullivan Railroad Co.'s coal opening*, one and a half miles east of Bernice. *Bottom bench.*

The coal has a deep black, shining luster; is very hard and brittle, breaking with a rough irregular fracture. It has the general appearance of an ordinary bituminous coal. *See remarks at end of this section.*

	(*813*) *Hall**.
Water @ 225°,	6.830
Volatile matter,	21.930
Fixed carbon,	55.413
Sulphur,	.387
Ash,	15.440
	100.000
Color of ash,	red.
Fuel ratio,	1:2.52

(*813*) *S. Hall's coal drift*, one mile south of Laporte, Sullivan county.

Coal of a deep black, dull luster; is rather friable, and shows considerable bony coal. The volatile matters burn with a feebly luminous flame, but the coal does not yield a coherent coke.

REMARKS.—The Sullivan county coals of which the analyses are given in this section, present such unusual characteristics that it seems proper here to describe some of them. They are comparatively dry-looking coals, yet they all contain an unusually large percentage of water. After being thoroughly dried at 225° F., and then exposed to the ordinary atmosphere, they absorb water with great rapidity, so that in a few hours they have re-absorbed about sixty per cent. of the amount of water originally present; and this amount is not materially increased by longer exposure. The following experiments were made with specimen No. 803, containing 4.13 per cent. water:

On drying at	225° F.	the coal loses,	. . .	4.13 per cent.
" "	245° F.	" "	. . .	the same.
" "	260° F.	" "	. . .	4.19 per cent.
" "	340° F.	" "	. . .	4.50 per cent.

* Low bed not identified. Perhaps local. Probably not bed A. F. Platt. Report of Progress GG.

On drying at 460° F. the coal loses, . . . 4.69 per cent.
At a dull red heat " " . . . 12.59 per cent.

But in all these experiments the amount of water re-absorbed—after exposure for a few hours to the ordinary atmosphere—remains practically constant; that is, the coal re-absorbs about 2.48 parts of water; and this property of of absorbing water is not destroyed even after all the volatile matters have been driven off by heat. These 2.48 parts of water might therefore be termed *water of constitution*, and the remainder of the water—1.65 parts—*hygroscopic moisture* or *pit water*. And it is to be noticed that this latter amount of water corresponds very closely with the average percentage found in the general run of the coals from this basin.

In order to ascertain whether the total absorption was due to water, the following experiment was made: A portion of the coal was put into a flask, and after being thoroughly dried the whole was weighed; the flask was then tightly fitted with a chloride of calcium tube (to prevent the absorption of water,) and allowed to stand in the ordinary atmosphere for twelve hours. It was again weighed; but no appreciable increase in weight was noticed. It was now allowed to stand for a few hours without the chloride of calcium tube attached; and when again weighed it was found that a considerable increase in weight had taken place, evidently due to the absorption of water. This property of absorbing water with such remarkable rapidity has been noticed in only a very few cases.

These coals yield quite a large percentage of volatile matters which burn with a *very feebly luminous flame;* but not one of them has the slightest tendency to form a coherent coke. And in this respect also they differ from most of the other coals examined. It seems safe, therefore, to assume that they result from a peculiar kind of vegetation, deficient in illuminating hydro-carbons and different in many respects from that forming the great bulk of the bituminous coals of this State.

Another very interesting point may here be noted. In the coal opening one and a half miles east of Bernice (analyses Nos. 938 and 939) we find in the same mine—separated from each other by only six inches of slate—a bituminous coal (upper bench) with a fuel ratio of 1 : 2.52, and a semi-anthracite (lower bench) with a fuel ratio of 1 : 6.93. Or, taking the sum of the volatile combustible matters and fixed carbon as 100, we have the ignitible constituents in the following proportions :

	Upper bench.	*Bottom bench.*
Volatile combustible matters,	28.36	12.61
Fixed carbon,	71.64	87.39
	100.00	100.00

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§ *20. Mercer Upper Coal Bed.*

There are two coal beds and two limestones, all small, making the Mercer group, lying between the Homewood (Tionesta) and Connoquenessing Sandstones, in Beaver, Lawrence, Mercer and Butler counties; as described in Reports of Progress, QQ, QQQ, and V.

Only one specimen has thus far been analysed from one of these coal beds, the Mercer Upper Coal.

Lawrence County.

	(636) Miller.
Water @ 225°,	1.190
Volatile matter,	48.140
Fixed carbon,	44.084
Sulphur,	1.951
Ash,	4.635
	100.000
Coke, per cent.,	50.670
Color of ash,	reddish grey.
Fuel of ratio,	1 : 0.91

(*636*) *Mr. Miller's bank*, near Mahoningtown, Lawrence county.

The coal is compact and brittle, with dull, pitchy luster generally ; it carries numerous bands of bright crystalline coal and shows some pyrites in scales.

§ 21. *Quakertown Coal Bed.*

This bed lies between the Connoquenessing Upper and Lower Sandstones, in the body of the Pottsville Conglomerate, No. XII.

Whether it be the Mount Savage bed in Maryland or not remains to be seen.

It was named from its principal locality in Lawrence county. (See Report of Progress, QQ.) But it has a wide expanse over Western Pennsylvania, although it is often a mere bed of black shale, and has been nowhere seen large.

It is one of the representatives of Fontaine's Interconglomerate coals of Virginia; of the Mt. Savage coal of Maryland (?); of certain black slates and coals in McKean, Potter, Tioga, Lycoming, Bradford and Sullivan counties, enclosed in the Conglomerate; and probably of the Lykens Valley Large coal bed of the Anthracite First Field, with numerous small coals above it in the body of the Pottsville Conglomerate.

As yet we have only one analysis from this bed to report.

Lawrence County.

	(633) *Brown.*
Water @ 225°,	2.030
Volatile matter,	42.147
Fixed carbon,	44.233
Sulphur,	4.087
Ash,	7.503
	100.000
Coke, per cent.,	55.823
Color of ash,	red.
Fuel ratio,	1:1.04

(*633*) *Mr. Brown's bank*, one mile north-east from Quakertown, Lawrence county.

The coal is compact and brittle, with dull luster; for the most part coated with infiltrated silt. It carries numerous thin partings of pyrites.

§ 22. *Sharon (or Block) Coal Bed.*

This most important bed for the Iron Works of the State of Ohio, passes the Pennsylvania Line into Mercer county, as a four foot workable bed, around Sharon; but soon thins away eastward and southward, and is often quite absent; but sometimes underlies the bottom layer of the Pottsville Conglomerate (No. XII) as a one or even two foot coal bed; but frequently, as at Ralston in Lycoming county, and in the gaps of the Conemaugh river, as a deposit of bituminous shale interstratified with iron-stone layers, &c.

It is not impossible, though improbable, that the Lykens Valley coal may be this bed; and that the fifty feet of Conglomerate under it may thin away and disappear going west and north.

Mercer County.

	(634) *Williams.*
Water @ 225°,	3.790
Volatile matter,	35.300
Fixed carbon,	53.875
Sulphur,	.675
Ash,	6.360
	100.000
Coke, per cent.,	60.910
Color of ash,	grey.
Fuel ratio,	1 : 1.52

(*634*) *Mr. Williams' bank*, near New Bedford, adjoining the Lawrence County line, Mercer county.

The coal is bright, pitchy, brittle, with very irregular fracture.

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§ 23. *Coal Beds of Pocono Sandstone, No. X.*

Under the Pottsville Conglomerate, No. XII, are two thousand to three thousand feet of Mauch Chunk Red Shale, No. XI, in Eastern Pennsylvania; and under the Red Shale two thousand or more feet of Pocono grey sandstone, No. X.

Several hundred feet down from the top of No. X, is a coal bed near Duncannon, on the Susquehanna river, about twelve miles above Harrisburg.

Anthracite miners suppose this to be the westward extension of the Lykens Valley coal bed, which in reality *it underlies* by several thousand feet; the whole of the Red Shale formation coming in between the two beds.

The bed near Duncannon is from two to four feet thick, extreme measurement, and although curious and interesting is undoubtedly worthless.

In the tunnel by which the East Broad Top Railroad passes through under the crest of Sideling Hill, in Huntingdon county, a dozen very small coal beds were discovered in No. X, as described in Report of Progress F. One of these, if continuous, would be the Duncannon coal bed.

Two beds, two or three feet thick each, much crushed, and yielding no good coal, have been opened in several of the ravines in the Allegheny Mountain, in Blair county. They belong to this horizon.

Such beds have also been opened in Maryland; and the same series is no doubt represented in the South by those of Montgomery and Wythe counties, at Augusta Springs and in other localities in Virginia.

Perry County.

	(697a) *Cove Mountain.*	*(697b)* *Cove Mountain.*
Water @ 225°,	.570	.320
Volatile matter,	14.380	15.500
Fixed carbon,	48.285	50.709
Sulphur,	.320	.206
Ash,	36.445	33.265
	100.000	100.000
Coke, per cent.,	85.050	84.180
Color of ash,	grey.	grey.
Fuel ratio,	1:3.35	1:3.27

(*697a*) *Coal from opening on Cove Mountain*, near Duncannon, Perry county. Specimens brought to the Laboratory by Mr. Wm. C. McFadden, Harrisburg. 1876.

The coal is generally very compact, with dull black luster, and smooth, polished surface; it has numerous thin bands of bright crystalline coal running through it, and seems in the main free from iron pyrites. It is very brittle, breaking with irregular fracture; some of the pieces have a slightly conchoidal fracture. It yields gases which burn with a bright luminous flame and produces a coke which is only slightly coherent.

(*697b*) *Coal from same opening.* Selected by myself in 1877.

It has the same general appearance as the above.

Huntingdon County.

	(*71*) *Sideling Hill.*	(*72*) *Sideling Hill.*	(*73*) *Sideling Hill.*
Water @ 225°,	.340	.350	.470
Volatile matter,	13.660	16.290	21.340
Fixed carbon,	53.295	61.785	51.972
Sulphur,	.465	7.180	1.033
Ash,	32.240	14.395	25.185
	100.000	100.000	100.000
Color of ash,	grey.	red.	reddish grey.
Fuel ratio,	1:3.90	1:3.79	1:2.43

(*71*) *Coal from Sideling Hill Tunnel*, East Broad Top Railroad, Clay township, Huntingdon county. See Report F, pp. 206–213. *No. 5 of section.*

The coal, generally slaty in appearance, has a bright shining luster and breaks with conchoidal fracture.

(*72*) *Coal from Sideling Hill Tunnel. No. 10 of section.*

The coal has a bright luster and conchoidal fracture, and shows a large amount of iron pyrites.

(*73*) *Coal from Sideling Hill Tunnel. No. 17 of section.*

The coal is generally bright, with laminated, slaty structure. It shows considerable pyrites, partially decomposed.

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§ *24. Lower Devonian Coal.*

In Perry county a series of small coal-beds are seen crossing the Lower Juniata River, which belong to the Hamilton group, part of No. VIII. They are a few inches thick (one of them reaches a thickness of over twelve inches) and are entirely worthless, as many attempts to open them for practical mining in the last forty years have abundantly proved. But in a geological sense they are extremely interesting for their great antiquity, lying as they do fifteen thousand feet more or less beneath the Lykens Valley Anthracite coal bed. They have not yet been carefully studied by the current Survey; nor as yet by the Fossil Botanist of the Survey; nor have any analyses been made of the coal which they contain.

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§ 25. *Silurian Coal.*

In the Hudson River slate formation, No. III, are found in many places along its numerous outcrops—both along the north side of the Great or Cumberland Valley, and along the border slopes of the Kishocoquillas, Nittany, and Nippenose Valleys, and Morrison's, Milliken's, Friend's, and McConnellsburg coves—small lenticular or nodular pieces of a substance resembling in appearance anthracite, but of an entirely different chemical constitution, and of unknown vegetable or animal origin, perhaps connected with one of the graptolite zones of black slate of that early age.

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§ 26. *Triassic Coal.*

The workable Triassic coal beds of the Richmond, Danville and Deep river basins in Virginia and North Carolina are represented at Frederick in Maryland and at Phœnixville and Gwynedd in Pennsylvania by a bed of carbonaceous shale connected with animal and vegetable remains.

No doubt this deposit is more or less restricted to localities or areas in detail, but is co-extensive with the Triassic Formation, and on a little search might be found in many places, like the one in York county mentioned by Prof.

Frazer in Report of Progress CCC, on Lancaster County, 1879, page 259, the analysis of which is given underneath.

York County.	(559) *Gross.*
Water @ 225°,	4.310
Volatile matter,	18.482
Fixed carbon,	74.358
Sulphur,	.528
Ash,	2.322
	100.000
Color of ash,	reddish brown.
Fuel ratio,	1:4.02

(*559*) *B. Gross' property*, on Liverpool road, three quarters of a mile north of Liverpool, on Little Conewago Creek, York county.

Coal generally of a deep black color, with somewhat pitchy appearance; is very brittle, with conchoidal fracture. It yields volatile matters which burn with a non-luminous flame, but it has not the slightest tendency to form a coherent coke. The dried coal absorbs water with great avidity, so that in a few hours it has re-absorbed about sixty-three per cent. of the amount of water originally present. *See remarks at end of* § *19.*

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§ *27. Anthracite.*

The survey of the Anthracite Coal Fields by the Second Survey of the State has not yet been commenced; but a very thorough preliminary survey was made of them in the years 1838, '39, '40, '41 and 1851, and published in the Geology of Pennsylvania, by H. D. Rogers, 1858; since which, numerous private surveys ordered by coal companies have been made, and the generalizations of the geologists of 1838–1851 in a great measure confirmed, but also in many points modified or changed, especially as to the underground structure along the axes of the troughs.

It remains as true now as in 1840 that the Anthracite

Coal Measures of Eastern Pennsylvania are identically the same in a geological sense as the Bituminous Coal Measures of Western and Northern Pennsylvania, the coal beds having in some instances, if not in all, originally extended from the Lehigh and Lackawanna to the Allegheny and Monongahela rivers across the now eroded regions in the center of the State.

It remains true that a regular gradation of the percentage relation of fixed carbon to volatile matters, or of natural coke to gas, in going westward—from two to five per cent. of volatile matters on the Lehigh, to thirty to thirty-five per cent. at Pittsburgh—exists; but that this gradation corresponds with any observable gradation of amount of disturbance (on which correspondence Mr. Rogers' theory of the origin of the change of the coal in the beds from bituminous to anthracite was based) is not true. All that can be affirmed is, that the high anthracite coals lie in beds very much folded or overturned, and that the high bituminous coals are mined from almost horizontal and undisturbed beds; but there is no graduated disturbance to correspond with the graduated percentage.

Some other and still unknown factor must be introduced; and partly with this object in view the analyses in this volume have been classified in an order both vertical and horizontal, *i. e.*, both geological and geographical. Results are not yet satisfactory, because the data are not yet sufficiently numerous. But there is the first appearance of a probable hypothesis, viz: not only that the coal beds suffered metamorphism from their original bituminous to their present anthracite condition by virtue of physical disturbance of the crust of the earth; but also that there was a certain amount of aboriginal difference in each coal deposit itself in different parts of its geographical area, due perhaps to difference of vegetation.

The few analyses of anthracite given here were made in connection with certain experiments to test the possibility of making a good furnace coke from anthracite slack coal with certain proportions of bituminous coal.

	(88) Lykens Valley. [Lump coal.]	(441) Lykens Valley. [Slack coal.]	(87) Schuylkill.
Water @ 225°,	2.270	1.930	2.980
Volatile matter,	8.830	7.253	3.380
Fixed carbon,	78.831	82.010	87.127
Sulphur,	.676	.525	.657
Ash,	9.393	8.273	5.856
	100.000	100.000	100.000
Color of ash,	red.	red.	cream.
Fuel ratio,	1:8.91	1:11.30	1:25.77

(*88*) *Lykens Valley coal,* Williamstown colliery, Dauphin county. *Lump coal.*

(*441*) *Lykens Valley coal,* Williamstown colliery, Dauphin county. *Slack coal.*

(*87*) *Schuylkill coal,* Gilberton colliery, mammoth vein, Schuylkill county.

	(403) Cameron. [Lump coal.	(421) Cameron. [Slack coal.]	(437) Cameron. [Slack coal.]
Water @ 225°,	1.815	2.280	3.170
Volatile matter,	6.180	6.620	6.842
Fixed carbon,	86.748	75.725	76.636
Sulphur,	.755	1.195	1.355
Ash,	4.502	14.180	11.997
	100.000	100.000	100.000
Color of ash,	Reddish grey.	Reddish grey.	Reddish grey.
Fuel ratio,	1:14.03	1:11.43	1:11.20

(*403*) *Mineral Railroad and Mining Co.'s coal,* Cameron colliery, Northumberland county. *Lump coal.*

(*421*) *Mineral Railroad and Mining Co.'s coal,* Cameron colliery, Northumberland county. *Slack coal.*

(*437*) *Mineral Railroad and Mining Co.'s coal,* Cameron colliery, Northumberland county. *Slack coal.*

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§ *28. Mineral Charcoal.*

In almost every variety of coal there may be observed thin layers or patches of a dull black granular, or silky fibrous substance running between the laminae or along the planes of bedding of the coal. This material is commonly known as *mineral charcoal*, from its resemblance in outward appearance to ordinary charcoal. It has in all probability been derived from the leaves or leaf-stalks of the coal-forming plants; and it differs very much in composition from the adjoining bituminoid portions of the coal, the proportion of volatile matter being much less. The following tables show the proximate composition of twelve specimens selected from different varieties of coal:

	(1015a)	(1015b)	(1015c)	(1015d)	(1015e)	(1015f)
Water @ 225°,	1.00	1.17	.75	2.39	.52	.52
Volatile matter,	30.74	19.77	20.36	12.40	11.36	14.32
Fixed carbon, .	59.40	72.13	71.07	75.34	82.94	64.03
Ash, .	8.86	6.93	7.82	9.87	5.18	21.13
	100.00	100.00	100.00	100.00	100.00	100.00
Color of ash,	cream.	white.	brown.	yellowish br'n.	white.	pink.
Fuel ratio, ...	1:1.93	1:3.64	1:3.49	1:6.07	1:7.30	1:4.47

(*1015a*) *Miller's bank;* Tionesta coal bed.

Steel grey, with long, delicate fibers.

(*1015b*) *Miller's bank;* Brush Creek coal bed; upper bench.

Steel grey, with long fibers.

(*1015c*) *Todd's bank;* Freeport Upper coal bed; upper bench.

Deep black; fibrous.

(*1015d*) *R. R. George's bank;* Pittsburgh bed.

Deep black; fibers much broken.

(*1015e*) *S. S. Hazlett's bank;* Freeport Upper coal bed.

Deep black; fibers much broken.

(*1015f*) *Glen White Coal Co.'s mine*, Bed B.; bottom bench.

Steel grey; fibrous.

	(1016a)	(1016b)	(1016c)	(1016d)	(1016e)	(1016f)
Water @ 225°, .	.55	.57	.85	.85	1.41	1.22
Volatile matter, . .	9.92	20.98	8.36	10.49	6.40	8.60
Fixed carbon,	81.37	70.37	87.64	84.01	87.11	82.56
Ash, ...	8.16	8.08	3.15	4.65	5.08	7.62
	100.00	100.00	100.00	100.00	100.00	100.00

Color of ash, . .	steel grey.	white.	reddish grey.	grey.	cream.	brown.
Fuel ratio, ...	1:8.20	1:3.35	1:10.48	1:8.00	1:13.61	1:9.60

(*1016a*) *James Wigle's bank*, Coal Bed D.

Deep black; rather earthy.

(*1016b*) *Barclay Coal Co.'s mines;* Barclay Bed B; average.

Steel grey; fibrous.

(*1016c*) *Blossburg Coal Co.'s mines;* Bloss Bed B; upper bench.

Steel grey; rather fibrous.

(*1016d*) *Schraeder mines;* Bed B; middle bench.

Deep black; rather granular.

(*1016e*) *State Line and Sullivan Railroad Co.'s mines;* Bed B; top bench.

Deep black; granular.

(*1016f*) *Lykens Valley anthracite.*

Steel grey; fibers much broken.

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§ 29. *Cokes.*

The manufacture of coke for use in the blast furnace has become a most important industry in this State. Mr. John Fulton, General Mining Engineer for the Cambria Iron Company at Johnstown, has discussed the subject of coking in such a thorough manner (See Reports L and G) that nothing remains to be added here; and the following analyses of coke are therefore given without comment.

	(*48a*) *Connellsville. Frick & Co.*	(*48b*)* *Connellsville. J. F. Dravo.*	(*48c*)* *Connellsville. J. F. Dravo.*
Water @ 225°, ...	.030	.040	.110
Volatile matter, ...	.460	.352	.471
Fixed carbon, ...	89.576	88.906	88.403
Sulphur, ...	.821	.771	.838
Ash, ...	9.113	9.931	10.178
	100.000	100.000	100.000

* Private analyses made by me for the Champion Iron Co., Boston; and published here through the courtesy of W. P. Fay, Treasurer.

Color of ash,	reddish brown.	reddish brown.	reddish brown.
Phosphorus,	.014	.014	.013

(*48a*) *Connellsville coke*, Frick & Co., Broad Ford, Fayette county.

Bright, silvery; very compact and close grained; small lenticular masses of slate.

(*48b*) *Connellsville coke*, used at Grafton Iron Works, Leetonia, Ohio; supplied from the ovens of J. F. Dravo. Ash contains 5.38 parts silica.

Generally firm and rather close grained; steel grey; carries small lenticular pieces of slate.

(*48c*) *Connellsville coke*, used at Neshannock Iron Works, New Castle, Pa., and supplied from the ovens of J. F. Dravo. Ash contains 5.63 parts silica. Has the same general appearance as previous specimen.

	(*516*) *Hulmes.*	(*512*) *Kendall.*
Water @ 225°,	.010	1.410
Volatile matter,	.633	1.580
Fixed carbon,	84.727	82.801
Sulphur,	1.994	.969
Ash,	12.636	13.240
	100.000	100.000
Color of ash,	red.	reddish grey.

(*516*) *Hulmes' coke*, Beaver Falls, Patterson township, Beaver county. See Report Q, p. 247.

Generally very compact; bright, silvery luster; carries small particles of intermingled slate.

(*512*) *J. P. Kendall's coke*, one and a half miles south from McClellandstown, Fayette county.

Rather compact; appearance dull, dirty; carries considerable intermingled slate.

	(*43*) *Diamond.*	(*45*) *Fairmount.*	(*47*) *P. & B. C. Co*	(*408*) *P. & B. C. Co.*
Water @ 225°,	.520	2.045	.930	.160
Volatile matter,	.575	1.961	1.585	2.000
Fixed carbon,	86.056	80.600	86.620	86.824
Sulphur,	1.027	1.111	2.259	2.701
Ash,	11.822	14.283	8.606	8.315
	100.000	100.000	100.000	100.000
Color of ash,	red, white specks.	red, white specks.	red.	red.

(*43*) *Diamond Gas Coal Co.'s Coke*, one mile north of Reynoldsville.

Bright, shining; rather porous; with particles of slate throughout.

(*45*) *Fairmount Coal Co.'s Coke*, one mile east of New Bethlehem.

Generally dull; very porous and open; shows considerable slate particles.

(*47*) *Pittsburgh and Baltimore Coal Co.'s Coke*, near Ursina. See Report HHH, pp. 251, 252, 253.

Very dull, dirty appearance; porous; loose particles of slate.

(*408*) *Pittsburgh and Baltimore Coal Co.'s Coke*, near Ursina.

Dull, dirty appearance; porous; slaty. (D. McC.)

	Cambria Iron Company.		
	(*517*)	(*519*)	(*518*)
Water @ 225°,	.050	.090	.060
Volatile matter,	.337	.542	.270
Fixed carbon.	88.773	89.931	90.260
Sulphur,	1.328	1.300	1.145
Ash,	9.512	8.137	8.265
	100.000	100.000	100.000
Color of ash,	reddish grey.	reddish grey.	reddish grey.

(*517*) *Cambria Iron Co.'s coke*, at Johnstown. *Quenched with water.* (D. McC.)

(*519*) *Cambria Iron Co.'s coke*, at Johnstown. *Quenched with steam.* (D. McC.)

(*518*) *Cambria Iron Co.'s coke*, at Johnstown. *Cooled in the air.* (D. McC.)

	(*342*) *Robertsdale.*	(*343*) *Robertsdale.*	(*344*) *Riddlesburg.*
Water @ 225°,	.350	.400	.150
Volatile matter,	.930	.750	.780
Fixed carbon,	86.136	88.162	86.734
Sulphur,	1.824	1.318	1.452
Ash,	10.760	9.370	10.884
	100.000	100.000	100.000
Color of ash,	reddish grey.	reddish grey.	reddish grey.

(*342*) *Rockhill Iron and Coal Co.'s coke;* Robertsdale collieries; Broad Top coal. *Mines B′ and C′ mixed.* See Report F, p. 189.

Compact, firm; dull grey; with small masses of slate.

(*343*) *Rockhill Iron and Coal Co.'s coke;* Robertsdale collieries. *Mine C′ alone.*

Generally firm; dull grey; with small particles of slate.

(*344*) *Riddlesburg coke; Broad Top coal; Kelly seam. Coke made from washed coal.*

Bright, silvery; generally very firm; with some intermingled slate.

	Blossburg Coal Company.				
	(*581*)	(*579*)	(*580*)	(*670*)	(*1009*)
Water @ 225°, . .	.220	.590	.240	1.150	.175
Volatile matter, . .	.625	.845	.572	1.732	.722
Fixed carbon, . .	90.650	83.371	83.922	80.927	84.760
Sulphur, . . .	.850	.644	.679	.764	.998
Ash,	7.655	14.550	14.587	15.427	13.345
	100.000	100.000	100.000	100.000	100.000
Color of ash, . .	grey, red tinge.	grey.	grey.	reddish grey.	reddish grey.

(*581*) *Blossburg Coal Co.'s coke*, at Arnot. *Seymour vein.*

Compact; firm; dull grey. (D. McC.)

(*579*) *Blossburg Coal Co.'s coke*, at Arnot. *Bloss vein; north drift.*

Firm; cells very open; dull grey, with intermingled slate. (D. McC.)

(*580*) *Blossburg Coal Co.'s coke*, at Arnot. *Bloss vein.*

Firm; cells very open; dull grey; with intermingled slate. (D. McC.)

(*670*) *Blossburg Coal Co.'s coke*, at Arnot. *Bloss vein; fine coal screened from market sales.*

Generally firm throughout; rather open grained in center; bright steel grey; carries considerable slate in lenticular masses.

(*1009*) *Blossburg Coal Co.'s coke*, at Arnot. *Bloss vein; washed coal.*

Compact, firm, with small lenticular masses of slate; steel grey color.

	(89) Alabama.	(493) Colorado.
Water @ 225°,	.030	.125
Volatile matter,	.730	1.055
Fixed carbon,	93.253	84.376
Sulphur,	.601	.719
Ash,	5.380	13.725
	100.000	100.000
Color of ash,	grey.	reddish grey.

(*89*) *Oxmoor Iron Works coke*, Alabama. *Cahawba basin coal.*

Compact, bright, silvery; generally free from slate particles.

(*493*) *Colorado coke*, made from Colorado tertiary coal, and analysed for comparison at the request of Mr. Franklin Platt.

Bright, shining; rather open and porous, with some intermingled slate.

"*Anthracite Cokes.*"

	(422a)	(422b)	(434a)	(434b)	(504)
Water @ 225°,	2.352	.230	.260	.200	.250
Volatile matter,	.997	.559	.754	.584	.490
Fixed carbon,	80.703	84.419	83.756	85.697	88.420
Sulphur,	1.187	1.021	1.398	1.050	.855
Ash,	14.761	13.771	13.832	12.469	9.985
	100.000	100.000	100.000	100.000	100.009

(*422a*) Coke made from sixty per cent. anthracite slack coal, (Cameron colliery;) thirty-five per cent. Latrobe slack coal, (M. Saxman, Jr., & Co.,) and five per cent. pitch.

(*422b*) Coke made from fifty per cent. anthracite slack coal, (Cameron colliery,) and fifty per cent. Latrobe slack coal.

(*434a*) Coke made from sixty per cent. anthracite slack coal, and forty per cent. Latrobe bituminous coal.

(*434b*) Coke made from same proportions as No. (434a), but with the materials finely pulverized and intimately mixed.

(*504*) Coke made from fifty per cent. Lykens Valley slack coal, and fifty per cent. Connellsville coal.

All of the above cokes are moderately firm and compact. The particles of anthracite are well cemented together, but they seem to retain their original size and shape, and are easily recognizable throughout the mass.

Cokes made in the Laboratory of the Survey by coking the coal in a platinum crucible.

	I.	*II.*	*III.*	*IV.*	*V.*
Fixed carbon,	89.233	89.237	92.554	88.112	86.479
Sulphur, . .	1.620	.579	.732	1.808	3.590
Ash, ...	9.147	10.184	6.714	10.080	9.931
	100.000	100.000	100.000	100.000	100.000

I. Coke from Mr. Miller's coal; Tionesta coal bed.

II. Coke from J. White's coal, upper bench; Pittsburgh bed.

III. Coke from L. Vernon's coal, main bench; Pittsburgh bed.

IV. Coke from Daniel Miller's coal, main bench; Pittsburgh bed.

V. Coke from Pittsburgh and Baltimore Coal and Iron Co.'s coal; Rose bed.

	VI.	*VII.*	*VIII.*	*IX.*	*X.*
Fixed carbon,	95.129	96.129	94.736	87.259	90.414
Sulphur, . .	.577	.711	.840	.746	1.070
Ash, . . .	4.294	3.160	4.424	11.995	8.516
	100.000	100.000	100.000	100.000	100.000

VI. Coke from Mr. Diehl's coal; Kittanning Lower coal bed.

VII. Coke from Lee & Patterson's coal; Kittanning Lower coal bed.

VIII. Coal from Sharpless & Kincaid's coal; Kittanning bed.

IX. Coke from Frick & Co.'s Connellsville coal; Pittsburgh bed.

X. Coke from Diamond Gas Coal Co.'s coal; Bed D.

	XI.	*XII.*	*XIII.*	*XIV.*	*XV.*
Fixed carbon,	90.532	87.254	88.348	89.558	90.685
Sulphur, . .	2.057	2.905	2.008	1.391	1.768
Ash, . . .	7.411	9.841	9.644	9.051	7.547
	100.000	100.000	100.000	100.000	100.000

XI. Coke from Saltsburg Coal Co.'s coal; Pittsburgh bed.

XII. Coke from Rockhill Iron and Coal Co.'s coal, lower bench; Bed D.

XIII. Coke from Rockhill Iron and Coal Co.'s coal, upper bench; Bed C.

XIV. Coke from Dennison, Porter & Co.'s coal; Bed B.

XV. Coke from Cambria Iron Co.'s coal; Bed B.

	XVI.	*XVII.*	*XVIII.*	*XIX.*	*XX.*
Fixed carbon,	89.885	87.098	86 405	88.461	83.918
Sulphur, . .	.618	.696	.688	1.568	.672
Ash, ...	9.497	12.206	12.907	9.971	15.410
	100.000	100.000	100.000	100.000	100.000

XVI. Coke from Morris Run Coal Co.'s coal; Bloss B.

XVII. Coke from Fall Brook Coal Co.'s coal; Bloss B.

XVIII. Coke from Barclay Coal Co.'s coal; Barclay bed.

XIX. Coke from Fall Brook Coal Co.'s coal; Seymour bed.

XX. Coke from Fall Brook Coal Co.'s coal; Bear Creek coal.

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§ *30. Weatherwaste.*

This term is applied to the changes which a coal undergoes by exposure to the air; and the extent of the weatherwaste depends on the ability of the coal to absorb oxygen, part of which combines with the carbon and hydrogen to form carbonic acid and water respectively, while another portion is consumed in oxidizing the iron pyrites invariably present. It had been hoped that a sufficient number of independent experiments could have been made in the Laboratory of the Survey to allow a thorough discussion of this important subject from the results obtained by such experiments alone; but the numerous analyses required for the different Reports have completely occupied the time of the Laboratory so that nothing has been attempted aside from the *proximate analyses* of a few typical coals.

Dr. Percy has given an excellent résumé of the results obtained by different observers in Europe, and the following summary of his conclusions will be here in place.*

It would appear from the experiments of Richters and Reder that when there is no rise in the temperature of coal piled in heaps and left exposed to the air during nine or twelve months it undergoes no sensible change in any respect; and that, on the other hand, when the coal becomes heated it suffers precisely the same kind of change as was found by Richters to be effected in coal by heating it in contact with atmospheric air to a comparatively low temperature, namely: loss of carbon and hydrogen, by oxidation, and increase of the absolute weight of the coal, owing to the fixation of oxygen.

Richters ascertained that twenty grammes of various freshly-gotten coals of the Carboniferous System, when in the state of powder freed from dust by means of a sieve, absorbed from two to nine cubic centimeters of oxygen, from moist atmospheric air, in the course of twenty-four hours. Absorption begins very soon, and proceeds with proportionate rapidity. Varrentrap had previously shown that carbonic acid is formed by passing a current of atmospheric air over coal at ordinary atmospheric temperatures. The change which coal undergoes by exposure to the air is greatest at first; and although, according to Richters, the power possessed by coal of absorbing oxygen becomes continually weaker by time, yet it never entirely ceases. It follows therefore, that freshly-gotten coal should absorb oxygen more vigorously and more quickly than such as has been long exposed to the air.

*Percy's Metallurgy; Refractory Materials and Fuel, 1875. A most valuable work, and one which should be in the hands of every one interested in metallurgy.

The action of oxygen upon coal is much promoted by heat, even at temperatures not exceeding 70° or 80° C.; and evidence of this fact is obtained from the results of Richters' experiments given in the following table:

TABLE A—*Showing the changes which take place in coal, when it is heated to from 70° to 80° C., in contact with atmospheric air and with moisture:*

TREATMENT TO WHICH THE COAL WAS SUBJECTED.		Chemical composition of the coal per cent., calculated exclusive of ash. Carbon.	Hydrogen.	Oxygen and nitrogen.	Ash per cent. in the coal.
I.	(a) Before heating,	82.90	5.25	11.85	5.70
	(b) After heating in a water-bath during 14 days, from 70° to 80° C.,	81.94	5.06	13.00	5.37
	(c) After heating during 14 days in a water-bath, but during the day kept constantly moist,	82.02	5.09	12.89	5.59
II.	(a) Before heating,	84.44	5.07	10.49	2.90
	(b) After heating, as in No. I, (b)	83.49	4.85	11.66	2.90
	(c) After heating moist, as in No. I, (c)	83.81	4.90	11.29	2.91
III.	(a) Before heating,	90.73	4.25	5.02	9.87
	(b) After heating, as in No. I, (b)	88.80	4.07	7.13	9.31
	(c) After heating moist, as in No. I, (c)	89.01	3.96	7.03	9.28

Remarks on the preceding table.

Nos. I and II were caking coals, but No. III was non-caking (Sandkohle) and did not yield coke, properly so called.

The caking power of No. I (a) being estimated at 1.4, that of No. I (b) was 1.1.*

* In estimating the relative caking power of coal, Richters used the following method: One gramme of finely-pounded and air-dried coal is mixed with a definite weight of silica in the state of ground flints, such as is prepared for potters, and put loosely into a platinum crucible, about three centimeters deep and as many wide, which, with its cover adjusted, is heated in the coal-gas flame of a single Bunsen burner, so that its bottom may be about six centimeters above the orifice of the jet; and the height of the flame should be about eighteen centimeters. Heating is to be continued until flame-producing gases cease to be evolved; and when this is the case, the coke is to be carefully placed with its bottom downwards upon a piece of sheet-iron. A weight of 0.5 kilogramme is then to be cautiously applied to the top of the coke,

The caking power of No. II (a) being estimated at 2.0, that of No. II (b) was 1.6.

Nos. I (b, c) II (b, c) and No. III (b, c) did not sensibly differ from Nos. I (a) II (a) and III (a) respectively either in the yield of coke or specific gravity.

It will be seen from the above table that coal was kept heated, dry as well as moist, during a certain period in contact with atmospheric air, and its composition was ascertained before and after that treatment; and in order to demonstrate that increase of temperature did promote oxidation, portions of the same specimens of coal as those operated upon were left exposed to the air at the ordinary temperature during the experiments on heating, and then analysed, by which it was proved that they had undergone no sensible change in composition by such exposure.

Richters has endeavored to ascertain whether there is any relation between the power of coal to absorb oxygen and its power to absorb moisture from the atmosphere, and has made more than a hundred experiments upon this point. Different kinds of coal were dried at 100° C. and were afterwards left in contact with atmospheric air, saturated with moisture at 15° C.; and it was found that they absorbed from 2 to 7.5 per cent. of water, and that this property was in no degree dependent, as is commonly supposed, upon the structure of the coal. Thus, compact bright coals (Glanz kohlen) not seldom absorb three times as much water as very loose, soft, and tender schistose coals (Schiefer kohlen) of an almost lamellar structure. But coal from the same seam over a wide extent absorbs the same proportion of water, or shows only very slight difference in its capacity for absorption.

Now, Richters found that the quantity of oxygen ab-

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which will either be crushed or resist the pressure and remain entire. If the former should occur, the experiment is to be repeated with mixtures containing always the same weight of coal and, say, 0.1 gramme less silica each time, until one is found which yields a coke just capable of resisting the weight of 0.5 kilogramme; but if the latter should occur the same course is to be followed, except that the silica is increased by 0.1 gramme each time. The strongest caking coal of the Waldenburg district required the addition of 2.8 grammes of silica to 1 gramme of coal in order to produce a coke of the necessary quality, and its caking power is therefore indicated by the number 2.8.

sorbed by different coals, under the same conditions, is proportionate to the quantity of water which they absorb. It is regarded as more than probable that in the first stages the absorption of oxygen is purely physical, like that of moisture, and that the condensation of the gas precedes its combination with the substance of the coal.

The products of the oxidation of the organic substance of coal by atmospheric air are carbonic acid and water; and any iron pyrites which the coal may contain will also be oxidized, with the formation of ferrous and ferric sulphate.

Richters found that coal poor in sulphur absorbed less oxygen in the moist than in the air-dried state; and, on the contrary, that coal rich in sulphur absorbed less in the air-dried state than in the moist state.

Judging from Richters experiments, therefore, it would seem as if the oxidation of the organic substance of a coal is generally impeded rather than promoted by the presence of moisture; but, on the other hand, the oxidation of iron pyrites is greatly favored by moisture, if, indeed, moisture be not absolutely essential to that action at ordinary temperatures.

The product of the first stage in the atmospheric oxidation of iron pyrites, that is, sulphate of the protoxide of iron (ferrous sulphate) usually makes its appearance in the form of delicate, apparently colorless fibers, protruding here and there from the surface of the coal; and as the volume of the oxidized products in question greatly exceeds that of the original pyrites, the oxidation of the latter in coal will tend to produce disintegration; and when iron pyrites is present in considerable quantity disintegration may take place to such an extent as to render the coal comparatively worthless after exposure to the air during a certain time. The oxidation of the iron pyrites tends to promote the oxidation of the organic substance of coal, because it is attended with a considerable development of heat, and by swelling, it splits up the coal and so renders the mass more pervious throughout to oxygen. And this point has an important bearing on the question of the spontaneous ignition of coal. It has generally been believed that coals carrying a large amount of iron pyrites were more liable to spontaneous ignition than others which were comparatively free from this compound. But it has been demonstrated that many coals which are moderately free from iron pyrites are yet readily self-inflammable. On this point, Dr. Percy, in a lecture delivered in 1864, and when speaking about coal says: "I am disposed to believe that there is another cause of spontaneous ignition (besides iron pyrites) similar to that which determines the spontaneous combustion of cotton waste, namely, the absorption of oxygen by coal reduced to a fine state of division." But, as Dr. Percy says, it was reserved for Richters to substitute fact for opinion, and to demonstrate by experiments, that, generally the spontaneous ignition of coal is due to the heat developed by atmospheric oxidation of the organic substance of coal, and not to that resulting from the oxidation of iron pyrites. He has shown that coal most liable to spontaneous ignition is not that which contains most iron pyrites; and of this proof is afforded by the accompanying table B, in which he has arranged eleven varieties of coal from the carboniferous system in three classes, according to the degree of their self inflammability:

TABLE B.—*Of coals arranged according to degree of self-inflammability.*

Degree of self-inflammability.		Iron pyrites, per ct.	Water, per ct.	Character of the Coal.
Class I — Difficulty self-inflammable,	1	1.13	2.45	Easily friable.
	2	from 1.01 to 3.04	2.75	Very compact.
	3	1.51	3.90	Very compact.
Class II—Of medium self-inflammability,	4	1.20	4.50	Firm, schistose, bright.
	5	1.08	4.55	Hard, but very brittle.
	6	1.15	4.75	Moderately tender.
Class III—Readily self-inflammable,	7	1.12	4.85	Outwardly very like No. 1.
	8	1.00	9.01	Moderately tender, schistose
	9	0.83	5.30	Moderately soft, schistose.
	10	1.35	4.85	Do.
	11	0.84	5.52	Not stated; yielded only 2.5 per cent. of ash. From the same pit as No. 10, but from a different seam, remarkable for its great self-inflammability.

Atmospheric oxidation of iron-pyrites is always a comparatively slow process, and consequently there must be much loss of heat. It is not, however, asserted that iron-pyrites may not, when present in coal in considerable quantity, develop sufficient heat during its oxidation by atmospheric air to set the coal on fire.

The coking qualities of some kinds of coal are completely destroyed by weathering. Some coals which when freshly mined yield a firm, coherent coke, after they have been exposed to the weather for a certain time, either do not coke at all or yield a coke which is only slightly coherent, and generally of inferior quality. The loss of the coking quality will probably be found to depend on the escape of something from the coal, or on the oxidizing action of the atmosphere upon the coal.

Prof. W. Stein, of the Polytechnic School of Dresden, has made a series of experiments on the coals of Saxony; and from his researches it would seem that coking and non-coking coals may sometimes have the same *ultimate* composition. Accepting the accuracy of these results, it would appear that the coking qualities depended upon the *proximate* constitution of a coal—that is, upon the *manner* in which the elements, exclusive of those constituting the so-called inorganic or earthy part, are combined.

The analyses of some Pennsylvania coals tested for weatherwaste are given in the following tables. It will be noticed that while some of the coals do not seem to have deteriorated appreciably, others have suffered a considerable loss in volatile matter. The coking qualities of some of them have been considerably affected; and especially is this the case with the coal from the Cambria Iron Company's Mines. When freshly mined, this coal yields a firm coherent coke of excellent quality; after exposure to the weather for about a year it yields a coke only slightly coherent and generally of inferior quality; and after three years' exposure the coke made from it is only slightly fritted and utterly worthless. That this same result has been experienced in the practical working of this coal will be seen from the following abstract of a letter received from Mr. John Fulton, Mining Engineer at the Cambria Iron Works: "You are absolutely correct in your estimate of the effect of weatherwaste on the coking qualities of the Cambria Coal. At best it is rather dry. In the mine from which the Coke Ovens are supplied I am drawing back coal pillars that have been standing for two or three years. When the drawing began our Coker detected the trouble at once; his coke would not 'stick,' and his ovens got cold. I had to open a new section of mine so as to mix fresh coal with the weathered pillar coal."

Without an *ultimate* analysis of the coal it is impossible to determine in what respect it has changed in its chemical composition. The difference in the *percentage of the volatile matters* being insufficient to account for any change in its coking qualities, it would seem as if the deterioration must either be due to an alteration in the physical structure of the coal or to a difference in the *chemical composition of the volatile matters*. Although the percentage of sulphur has diminished to the extent of .546 per cent., equal to 1.024 per cent. iron pyrites, the amount of ash remains nearly constant; and the relationship between the volatile matters and the fixed carbon has not changed appreciably. The freshly mined coal gives a fuel ratio of 1:4.50, and after exposure for three years the fuel ratio is 1:4.42. These experiments therefore merely indicate the fact that the coal has deteriorated in its coking qualities without showing precisely the cause of this deterioration.

The famous coking coal from the Connellsville district seems to have suffered quite an appreciable loss in volatile matters; and the coking qualities of this coal have likewise been materially impaired, although not to any very great extent.

The Richmond gas coal has also suffered a similar loss in volatile matters; but in this case the coking qualities of the coal do not seem to have deteriorated in any way.

The results of these experiments seem to indicate the following facts:

I. That some coals do not seem to deteriorate by weather-waste, either in respect to volatile matter or coking qualities. [Coal analysis No. IV.]

II. That the coking qualities of some coals which *seemingly* suffer no loss in the *percentage* of volatile matters, are completely destroyed. [Coal analysis No. III.]

III. That some coals suffer a considerable loss in volatile matter but yet retain the quality of yielding a firm coherent coke. [Coal analysis No. VI.]

The general conclusion to be drawn from these experiments is that, as a rule, better results will be obtained by using freshly-mined coal—whether it be in the manufacture of illuminating gas, the production of coke, or in the blacksmith's fire.

I. Gilberton Coal, Schuylkill County.

Date of Analysis.	February, 1876.	December, 1876.	December, 1878.
Water @ 225°,	2.980	3.320	2.220
Volatile matter,	3.380	3.410	3.500
Fixed carbon,	87.127	86.881	87.999
Sulphur,	.657	.639	.626
Ash,	5.856	5.750	5.655
	100.000	100.000	100.000
Fuel ratio,	1:25.77	1:25.48	1:25.14

II. Lykens Valley Coal, Dauphin County.

Date of Analysis.	March, 1876.	December, 1876.	December, 1878.
Water @ 225°,	2.270	2.155	1.430
Volatile matter,	8.830	8.670	8 435
Fixed carbon,	78.831	79.290	80.311
Sulphur,	.676	.649	.659
Ash,	9.393	9.236	9.165
	100.000	100 000	100.000
Fuel ratio,	1:8.92	1:9.14	1:9.52

III. Cambria Iron Co.'s Coking Coal, Cambria County.

DATE OF ANALYSIS.	July, 1875.	December, 1876.	December, 1878.
Water @ 225°,	1.185	1.475	.450
Volatile matter,	16.540	16.240	17.020
Fixed carbon,	74.456	74.920	75.335
Sulphur,	1.860	1.535	1.314
Ash,	5.959	5.830	5.881
	100.000	100.000	100.000
Quality of coke,	good.	inferior.	worthless.
Fuel ratio,	1:4.50	1:4.61	1:4.42

IV. Coal from Franklin Colliery, Clearfield County.

DATE OF ANALYSIS.	April, 1875.	September, 1875.	December, 1876.	December, 1878.
Water @ 225°,	1.942	1.060	2.785	.520
Volatile matter,	22.720	22.700	22.355	22.405
Fixed carbon,	71.018	72.075	70.640	72.326
Sulphur,	.543	.515	.525	.549
Ash,	3.777	3.650	3.695	3.800
	100.000	100.000	100.000	100.000
Quality of coke,	good.	good.	good.	good.
Fuel ratio,	1:3.12	1:3.17	1:3.15	1:3.22

V. Connellsville Coal, Fayette County.

DATE OF ANALYSIS.	October, 1875.	December, 1876.	December, 1878.
Water @ 225°,	1.260	1.450	.860
Volatile matter,	30.107	28.790	28.700
Fixed carbon,	59.616	60.274	60.676
Sulphur,	.784	.751	.679
Ash,	8.233	8.735	9.085
	100.000	100.000	100.000
Quality of coke,	good.	good.	fair.
Fuel ratio,	1:1.98	1:2.09	1:2.11

VI. Richmond Gas Coal, Virginia.

Date of Analysis.	July, 1875.	September, 1875.	December, 1876.	December, 1878.
Water @ 225°,	1.030	.810	1.500	.760
Volatile matter	38.230	38.520	37.350	36.942
Fixed carbon,	52.561	52.350	52.693	54.183
Sulphur,	1.709	1.690	1.544	1.405
Ash,	6.470	6.630	6.913	6.710
	100.000	100.000	100.000	100.000
Quality of coke,	good.	good.	good.	good.
Fuel ratio,	1:1.37	1:1.35	1:1.41	1:1.46

§ 31. *Iron and Sulphur in Coals.*

The accompanying table C shows the percentage of iron and sulphur found in different coals; also the proportion of the sulphur which is combined with the iron as bisulphide of iron, or iron pyrites; and the relationship which the combined and the "free" sulphur bear to the percentage volatilized during the process of coking. It has been assumed that all of the iron in the coals exists in combination with sulphur as iron pyrites, although in all probability in many of them a small proportion of it may be present in the form of a silicate in the slate partings, &c.

It will be noticed that all of the coals examined contain a certain proportion of so-called *free sulphur*—that is, sulphur not combined with iron—and that the per centage of this varies from 1.95 to 75.25 per cent. of the total amount of sulphur present. The question of the volatilization of the sulphur in a coal during the process of coking was briefly discussed in Report M, p. 31; and, from a limited number of experiments made, the conclusion was reached that the condition of the sulphur in a coal bore little or no relation to the per centage of it which was volatilized by coking. And the results of the experiments given in the accompanying table seem to indicate that this conclusion was a correct one; and that the percentage of sulphur in coke produced from a coal containing a large proportion of so-called free sulphur would be just as large as if all of the sulphur had been present in the form of iron pyrites.

TABLE C—*Showing the percentage of Iron and Sulphur is volatilized*

No.	Name of Coal.	Coal bed.
1	L. L. Minor's coal; upper bench,	Waynesburg,
2	James Magee's coal; roof coal,	Pittsburgh,
3	J. White's coal; upper bench,	Pittsburgh,
4	L. Vernon's coal; main bench.	Pittsburgh,
5	Daniel Miller's coal; main bench,	Pittsburgh,
6	Pittsburg and Baltimore Coal and Iron Co.'s coal,	Rose,
7	Mr. Todd's coal; bottom bench.	Freeport Upper,
8	Mr. Diehl's coal,	Kittanning Upper.
9	Lee & Patterson's coal,	Kittanning Upper.
10	Sharpless and Kincaid's coal,	Kittanning Lower,
11	Connellsville coal; Frick & Co.,	Pittsburgh,
12	Diamond Gas Coal Co.'s coal,	Bed D,
13	Fairmount Coal Co.'s coal,	Bed D,
14	Rockhill Iron and Coal Co.'s coal; lower bench,	Bed D,
15	Rockhill Iron and Coal Co.'s coal; upper bench,	Bed C,
16	Dennison, Porter & Co.'s coal,	Bed B,
17	Cambria Iron Co.'s coal; upper bench, South Fork,	Bed B,
18	Morris Run Coal Co.'s coal,	Bloss B,
19	Fall Brook Coal Co.'s coal,	Bloss B,
20	Barclay Coal Co.'s coal,	Barclay B,
21	Fall Brook Coal Co.'s coal,	Seymour,
22	Morris Run Coal Co.'s coal, (not mined,)	Seymour,
23	Fall Brook Coal Co.'s coal,	Bear Creek,
24	Miller's coal; (Tionesta,)	Mercer,
25	Saltzburg Coal Co.'s coal,	Pittsburgh,

It is to be understood, of course, that that portion of the sulphur existing as sulphate of lime or as any other non-volatile sulphate, is not considered in this discussion; but it is believed that the specimens examined were in the main free from such compounds. Seven coals with an average of 63.51 per cent. of their sulphur existing as "free sulphur" lost 34.57 per cent. of the sulphur by coking; on the other hand, eleven coals with an average of only 11.36 per cent. of the sulphur not combined with iron, lost 37.88 per cent. Again, two coals with an average of 74.58 per cent. of the sulphur "free" lost 20.97 per cent. by coking;

in different Coals, and the proportion of the Sulphur which by coking, &c.

Sulphur per cent. in coal.	Iron per cent. in coal.	Sulphur required by iron to form iron pyrites, (Fe S².)	"Free sulphur."	Per centage of sulphur not combined with iron. ("Free sulphur.")	Sulphur left in coke.	Sulphur per cent. in coke.	Percentage of sulphur volatilized by coking.
1.705	1.078	1.232	.473	27 74	1.021	1.555	40.11
7.566	5.390	6.160	1.406	18.58	4.522	7.799	40.23
.643	.329	.376	.267	41.52	.261	.579	43.85
.982	.448	.512	.470	47.86	.452	.732	53.97
1.941	1.155	1.320	.621	31.99	1.098	1.808	43.42
4.037	3.276	3.744	.293	7.25	2.694	3.590	33.26
4.595	3.269	3.736	.859	17.09	2.830	4.827	38.41
.717	.308	.352	.365	50.90	.344	.577	52.02
.789	.252	.288	.501	63.49	.414	.711	47.53
.956	.448	.512	.444	46.44	.492	.840	48.53
.784	.567	.648	.136	17.34	.512	.746	34.69
1.118	.812	.928	.190	16.99	.683	1.070	38.90
1.960	1.673	1.912	.048	2.45	.960	1.470	51.02
3.434	2.828	3.232	.202	5.88	2.428	2.905	29.29
2.483	1.960	2.240	.243	9.78	1.676	2.008	32.50
1.792	1.274	1.456	.336	18.75	1.012	1.391	43.52
2.352	2.018	2.306	.046	1.95	1.444	1.768	38.60
.583	.133	.152	.431	73.92	.497	.618	14.75
.661	.133	.152	.409	61.87	.561	.696	15.12
.776	.168	.192	.584	75.25	.565	.688	27.19
1.795	.882	1.007	.788	43.90	1.222	1.568	31.92
6.856	5.558	6.352	.504	7.35	4.375	5.522	36.18
.725	.245	.280	.445	61.37	.526	.672	27.44
1.951	.721	.824	1.127	57.76	.821	1.620	57.92
2.257	1.267	1.448	.809	35.84	1.305	2.057	42.18

while other two coals with only 2.20 per cent. of the sulphur "free" lost 44.81 per cent. In the face of such results, therefore, it would seem to be impossible to accept the statement that all of the so-called free sulphur passes off with the volatile matters during the process of coking.

In the twenty-five coals examined the percentage of sulphur expelled by coking varies very much, the maximum amount being 57.92 per cent., and the minimum 14.75 per cent. The average percentage is 38.50; and the average per centage of "free sulphur" is 33.79.

The seeming relationship between the volatile matters present in the coal and the proportion of the sulphur which is expelled by coking is a very interesting one. Six coals with an average of 15.27 per cent. volatile matter lost only 25.70 per cent. of their sulphur by coking; while in eleven other coals with an average of 36.64 per cent. volatile matter, 43.65 per cent. of the sulphur was expelled during the process of coking. The results obtained, however, are yet too unsatisfactory to justify any positive conclusions in the matter; yet the whole tendency of the investigation is to point to a general relationship between the percentage of volatile matters in the coal and the percentage of the sulphur expelled by coking. And in this connection it may be stated that—irrespective of the percentage of coke which a coal yields—the percentage of sulphur found in the coke is generally a little less than was present in the coal from which it was made; yet for all practical purposes the amounts may be considered the same. A coal, therefore, rich in sulphur will necessarily yield a coke containing a large amount of this obnoxious element. Twenty-five coals with an average of 2.138 per cent. sulphur yielded cokes containing an average of 1.912 per cent. sulphur.

Where, therefore, a careful handling and subsequent washing of the coal will not remove the excess of sulphur, it is scarcely to be hoped that this can be accomplished by the usual methods of coking in coke ovens. And this important consideration should be borne in mind when selecting coals for the manufacture of coke for use in the blast furnace or foundry.

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§ *32. Phosphorus in Coals and Cokes.*

Special attention is directed to table D, showing the percentage of phosphorus in certain coals and cokes. In many of these it is present in most objectionable quantity, entirely unfitting them for use in the manufacture of pig iron intended for conversion into steel by the Bessemer or open hearth processes.

And it will be noticed that several of the specimens examined from the Pittsburgh coal bed—from which our supply of coal for coking purposes is so largely drawn—contain a most damaging amount. The percentage varies from a mere trace to .1248 per cent., the average of the twenty-four coals from this bed being .0217, equal to .0344 in the coke.

TABLE D.

	Name of Coal.	County.	Coal Bed.	Phosphorus, per cent. in *Coal.*	Phosphorus, per cent. in *Coke.*
1	Henderson's; Buffalo township,	Washington,	Washington,	.1667	.2818
2	Lucas'; Dunkard township,	Greene,	Sewickley,	.0053*	.0084
3	Miller's; Dunkard township,	"	Pittsburgh,	.0025	.0041
4	Magee's; Independence township,	Washington,	"	.0254*	.0438
5	Ashurt's; Chartiers township,	"	"	.0491	.0846
6	Redd's; Fallowfield township,	"	"	.0943*	.1551
7	New Eagle Works; Carrol township,	"	"	.0013*	.0020
8	White's; East Pike Run township,	"	"	.1248	.2003
9	Slocum's; East Pike Run township,	"	"	.0011	.0018
10	Penn Gas Coal Co.'s Youghiogheny shaft,	Westmoreland,	"	.0058	.0095
11	Penn Gas Coal Co.'s, Penn shaft,	"	"	trace	trace
12	Penn Gas Coal Co.'s, Sewickley shaft,	"	"	trace	trace
13	Westmoreland Coal Co.'s, Southside mine,	"	"	.0092	.0150
14	Westmoreland Coal Co.'s, Larimer mine,	"	"	trace	trace
15	Westmoreland Coal Co.'s, Foster mine,	"	"	.0402	.0652
16	Millwood Coal Co.'s; Derry township,	"	"	.0801	.1177
17	Saxman & Co.'s; Derry township,	"	"	.0167	.0247
18	Saltzburg Coal Co.'s; Loyalhanna township,	"	"	.0307	.0452
19	Greensburg Coal Co.'s; Hempfield township,	"	"	.0070	.0107
20	Frick & Co.'s; Connellsville township,	Fayette,	"	.0111	.0161 .0034
21	Townsend's; Perry township,	"	"	.0022	trace
22	McCormack Heirs'; Franklin township,	"	"	trace	trace
23	Swan Heirs; North Union township,	"	"	trace	.0031
24	Kendal's; German township,	"	"	.0020	.0074
25	Saylor Hill; Summit township,	Somerset,	"	.0058	.0156
26	Wilhelm mine; Elk Lick township,	"	"	.0127*	.0135
27	Coleman's; Brothers Valley township,	"	Berlin,	.0105*	.0094
28	Cotter's; Raccoon township,	Beaver,	Bed E,	.0058*	.0688
29	Dysart & Co.'s, Washington township,	Cambria,	"	.0530	
30	Dennison, Porter & Co.'s; Allegheny township,	Blair,	"	.0075	.0103
31	Diehl's; Green township,	Beaver,	Bed D,	trace	trace
32	R. J. Hughes & Co.'s; Decatur township,	Clearfield,	"	.0080	.0107
33	Rockhill Iron and Coal Co.'s; Carbon township,	Huntingdon,	"	trace	trace
34	Jos. Ramsey, Jr.'s; White township,	Cambria,	Bed C,	.0078	.0105
35	Dennison, Porter & Co.'s; Allegheny township,	Blair,	Bed B,	.0053*	.0072
36	Cambria Iron Co.'s; Allegheny township,	"	"	trace	trace
37	Cambria Iron Co.'s; Conemaugh township	Cambria,	"	trace	trace
38	Dysart & Co.'s; Washington township,	"	"	trace	trace
39	Brotherline's; Clearfield township,	"	"	trace	trace
40	Savage Colliery; Todd township,	Huntingdon,	?	.0080	.0098
41	Connellsville Coke; Frick & Co.,	. . . .	Pittsburgh,	. . . .	.0140
42	Connellsville Coke; J. F. Dravo,	. . . .	"	. . . .	.0140
43	Connellsville Coke; J. F. Dravo,	. . . .	"	. . . .	.0180

*Determinations marked with a star were made by David McCreath.

Classification of Coals.

By PERSIFOR FRAZER, JR., *Assistant Geologist.*

A classification of natural objects is usually based either upon some fundamental and permanent attribute of the thing itself, (as in the case of scientific classifications,) or it embraces one or more generalizations convenient for use in ordinary life. Thus, it suffices for the statistician to know that so many tons of fish are annually taken by our fishermen, and that they realize so many thousands of dollars, whereas to the student of natural history the anatomy, habits, and relationships of the animals are of chief interest, as settling their respective places in the scale of animate nature.

Many different classifications of coals have been attempted, as one would naturally anticipate from the immense extent of the coal trade, and the different localities whence the supply was derived.

The English divisions were prevalent up to the date of the publication of the last geological survey of the State, except so far as they were modified by local designations. Indeed Professor H. D. Rogers' classifications made very little alteration in the English nomenclature, as may be seen by comparing the tables given below.

To commence with the different kinds mentioned in Ure's *Dictionary of Arts, Manufactures and Mines* of 1845:

"*1. Cubical Coal.*—Black, shining, compact, moderately hard and easily frangible. Comes out in rectangular masses, of which the smaller portions are cubical. The '*reed*' or lamellæ parallel to the bed-plane on which the coal rests. Of cubical coal there are two varieties—(*a*,) open burning; (*b*,) caking. The latter is available as a fuel, no matter how small its particles may be, and is the true smith coal, forming a vault in front of the bellows. (*a*.) The open burning coal is known as *rough* or *clod coal* from the large masses in which it is taken out, and *cherry coal* from the cheerful blaze with which they spontaneously burn; whereas the caking coals, like some of those from New Castle, require to be frequently poked in the grate.

"*2. Slate or Splint Coal.*—Color, dull black, very compact, much harder and less frangible than the last. Readily fissile, like slate, but powerfully resists the cross fracture, which is conchoidal. Specific gravity, 1.26 to 1.40. In working it separates into large quadrangular sharp-edged masses. It burns without caking, with much flame and smoke, unless judiciously supplied with air, and leaves frequently a considerable bulk of white ashes. Good coal of the Glasgow field Dr. Ure found to have a specific gravity of 1.266, and to consist of 70.9 C; 4.3 H; 24.8 O.

"*3. Cannel Coal.*—Color, between velvet and grayish black; luster resinous; fracture, even; fragments, trapezoidal. Hard as splint coal. Specific gravity, 1.23 to 1.28. In working it is detached in four-sided columnar masses. Often breaks conchoidal, like pitch; kindles very readily, and burns with a bright, white, projective flame. Cannel Coal from Woodhall, near Glasgow, consists, by Dr. Ure's analysis, as follows: Specific gravity, 1.228, C 72.22, H 3.93, O 21.05, (with a little nitrogen, about 2.8 in 100 parts.)

"*4. Glance Coal.*—'Color, iron-black, with an occasional iridescence like that of tempered steel; luster, in general, splendent, shining, and imperfect metallic. It does not soil, is easily frangible, and has flat conchoidal fracture, and sharp-edged fragments. It burns without flame or smell, except when sulphurous, (*sic*) and it leaves a white-colored ash. It produces no soot, and seems indeed to be merely carbon, or coal deprived of its volatile matter and bitumen, *and converted into coke from subterranean calcination,* (*sic*) *frequently from contact with whin dikes.*' Abounds in Ireland under the name of Kilkenny coal. In Scotland it is called 'blind coal,' and in Wales 'malting or stone coal.' It contains 90 to 97 per cent. C, specific gravity, 1.3 to 1.5, increasing with the proportion of earthy impurities."*

* Ure's Dict. Ed. 1845, p. 969.

In Watt's *Dictionary of Chemistry*, vol. I, p. 1032:

"The following appears to be as satisfactory a classification of the more important kinds (of coal) as is possible, together with an indication of their characteristic differences and of the localities whence they are obtained.

"*1. Lignite or Brown Coal* generally maintains its lamellar or woody structure. Yields a powdery coke in the form of the original lumps. Brittle, burns easily, but often contains from 30 to 40 per cent. of water.

"*2. Bituminous or Caking Coals.*—The most extensively diffused and valuable of the English coals. Are of various shades of brown and black; emit much gas on heating.

"*a. Caking Coal.*—Splinters on heating, but the fragments then fuse together into a semi-pasty mass.

"*b. Cherry Coal* or soft coal.—Luster very bright. Does not fuse. Ignites well and burns rapidly.

"*c. Splint, Rough, or Hard Coal.*—Black and of glistening fracture. Does not ignite readily, but burns up to a clear, hot fire, constituting a good house coal.

"*d. Cannel Coal* (Parrot Coal of Scotland).—Of dense, compact, and even fracture, conchoidal in every direction. Takes a polish like jet. Splinters in the fire, and burns clearly and brightly.

"*4. Anthracite, Stone Coal, or Culm.*—The densest, hardest and most lustrous of all varieties. Burns with little flame and no smoke, but gives a great heat. Contains very little volatile matter. Splinters when heated, and ignites with difficulty. Color deep black, fracture lamellar, parallel to bed of deposit. Conchoidal in cross fracture. Applied successfully to smelting, and much valued as a steam coal in the navy.

"*5. Steam Coal.*—Approaches nearly to anthracite. It does not crumble into small pieces under friction, and is hence well adapted for stowage. It also emits little smoke."

The most careful classification yet made, as well as the one which concerns us most nearly from the fact that the types on which the classification is based are from our own district, is that of Prof. H. D. Rogers, p. 983, Vol. II, Part

2, of his "*Geology of Pennsylvania*," published in 1858. He says:

"Subdividing the whole class of substances, which we call coal in accordance with their most natural characters, we find them to arrange themselves into the following four principal groups, in the order of diminishing carbon and augmenting hydrogen.

"Anthracites.—Volatile matters below 6 per cent.

"Semi-anthracites.—Volatile matters below 10 per cent.

"Semi-bituminous.—Volatile matters between 12 and 18 per cent.

"Bituminous.—Volatile matters above 18 per cent.

"These convenient distributions, 'which have crept extensively into use since first proposed by me,' are retained as a basis of a general classification which recognizes three main orders, viz.: *Anthracites*, *Common Bituminous* and *Hydrogenous*."

In the following table will be found a condensed form of the definitions which he applies to the coals:

- **Anthracite.**
  - **Hard or dry.**
    - C, 94 to 90 per cent.
    - H, 1 to 3 "
    - O and N, 1 to 3 "
    - Water, 1 to 2 "
    - Ashes, 3 to 4 "
  - **Semi or gaseons.**
    - C, 84.0 per cent.
    - Volatile inflammable matter, 7.5 "
    - Water expelled at 212°, 2.5 "
    - Earthy matter, 6.0 "
- **Common Bituminous Coal.**
  - **Semi-Bittuminous.**
    - Cherry.
    - Splint.
  - **Bituminous.**
    - Caking.
      - Sp. gr. 1.269; C, 76.0; H, 5.0; Ash, 1.5 — Average proximate analysis of the order.
        - Carbon, 52 to 84 p. c.
        - Volatile H. Cs, 12 to 46 "
        - Earthy matter, 2 to 20 "
        - Sulphur, 1 to 3 "
        - Water @ 212°, 1 to 4 "
    - Cherry.
      - More C and H. than caking coal, and leaves about 10 per cent. of ash.
      - Specific gravity, 1.255.
        - Ultimate analysis.
          - C, 75 to 80 p. c.
          - H, 5 to 6 "
          - N, 1 to 2 "
          - O, 4 to 10 "
          - S, 0.4 to 3 "
          - Ash, 3 to 10 "
    - Splint.
      - Specific gravity, 1.29.
      - 9 per cent. ash is best.
- **Hydrogenous or Gas Coal.**
  - Cannel coal, minimum yield of gas, 9,000 cubic feet per ton.
  - Shaly (Torbanehill.)
  - Asphaltic (Albert Mine.)

This classification of Prof. Rogers, whilst perhaps convenient for commercial purposes, is faulty in theory, and the cause of much confusion in discussing the proper place to which different coals should be assigned, because elements are introduced into the definition which are unessential to the fuel proper, but of which the variation nevertheless will cause an apparent variation in the essential constituents of the coal, *i. e.*, its ignitible constituents.

It is not claimed here that some such definition may not serve a good purpose among coal dealers by implying in one word a number of different ideas, but the inevitable result of an attempt of this kind is, 1st, to enormously increase the vocabulary necessary for transmitting ideas, and, 2d, to prevent the exact expression of slight shades of difference where there happens to be no corresponding word for such shades. Like the Chinese language, it makes a word stand for a whole sentence; but, also like the Chinese, it demands an inordinately large number of words.

As an illustration of some of the bad effects of such a system (at least for systematic classification) let us suppose that we have a pure coal corresponding to each of the limits which Professor Rogers sets for bituminous coals, viz.:

1st. Fixed carbon, 84 per cent.; volatile hydrocarbons, 12; that is to say, one part of volatile hydrocarbons to 7 parts of fixed carbon.

2d. Fixed carbon, 52, and volatile hydrocarbons, 48= 13 : 12.

If we mix the first of these materials with various weights of impurities, we shall have substances whose constitution is expressed in the following table:

		I.	II.	III.	IV.
Impurities,	Per cent.,	20	28	36	44
Fixed carbon,	" "	70	63	56	49
Volatile hydrocarbons,	" "	10	9	8	7

In the second case the table would be:

		I.	II.	III.	IV.
Impurities,	Per cent.,	0	25	50	75
Fixed carbon,	" "	52	39	26	13
Volatile hydrocarbons,	" "	48	36	24	12

Yet the *fuel* portion of all the mixtures in the first table is the same, viz., a bituminous coal of the composition C : V. H-C. : : 87.5 : 12.5, and that of all the mixtures in the second C : V. H-C : : 52 : 48. The foreign impurity is the only item of difference between the analyses of each table.

In other words, if the important allowance be made for impurities, most of which are accidental in the formation of the coal, we see by the first table that one of the coals, reckoned at present to the bituminous series, might descend to the composition of a dry anthracite, by impurities introduced into it after it was mined, if these impurities did not remove it from the catalogue of commercial fuels.

By the second table it is observed that by the same means a fat hydrogeneous coal might be so modified by foreign substances that, if the latter be neglected, it could be placed in the category of a semi-anthracite. Neither is such a large amount of impurity an anomaly, nor does it affect the character of the coal, except commercially. The "bone" and roof shales ought to be able to indicate the character of their coals almost as well as the coals themselves, and though the materials are not here at hand to prove that they would do so, it is nevertheless quite possible that they would.

The true method to be pursued in obtaining comparative data for coals is indicated by Prof. Walter R. Johnson, in his unrivaled report to the United States Government, in 1844, on *American Coals;* and consists in giving the ratio of volatile to fixed combustible matter.

CUMBERLAND COALS.

I. New York and Maryland Mining Co.
II. John Neff's, near Frostburg, above Cumberland.
III. William Easby, "coal in store," Cumberland, Md.
IV. Easby & Smith, "coal in store" mine.
V. Atkinson & Templeman, Dan's Mt.
VI. Cumberland (for Navy Yard use).

PENNSYLVANIA COALS.

VII. Dauphin and Susquehanna.
VIII. Blossburg.
IX. Lycoming County (near Ralston).
X. Queen's Run.
XI. Karthaus.
XII. Cambria County, ten miles from Hollidaysburg.

A synoptical table, containing the analyses, specific gravity, etc., of the above coals, is printed, p. 304 of Prof. Johnson's *Report*, as summing up the information obtained in regard to this class of coals.

The ratios of volatile to fixed combustible matter (*i. e.* the quotient obtained by dividing the percentage of the former into that of the latter) here follows:

	I.	II.	III.	IV.	V.	VI.
Cumberland Coals,	5.971	5.880	5.089	4.786	4.937	5.000
	VII.	VIII.	IX.	X.	XI.	XII.
Pennyslvania Coals, .	5.374	4.946	5.181	4.046	4.110	3.656

Professor Rogers, in his Essay on the "Classification of Coals," in Vol. II, part 2, of his *Geology of Pennsylvania*, (1858,) p. 989, appears in one sentence to recognize the importance of this ratio, though he nowhere makes it an essential factor of his system, unless it be in a table which will be considered shortly. He remarks:

"The distinctive properties of the different kinds of coal are determined mainly, though not altogether, by the relative proportions of solid carbon and volatile matter which they severally contain."

Also: "The essential difference between the bituminous coals and the anthracites is, not that the latter contain no gases or volatile matter, for they sometimes possess as much as 9 or 10 per cent., but that they are destitute of those chemical compounds of the gases and the carbon known as bitumen."

On referring to the analyses of the coals whose ratio of combustibles is thus given, it will be acknowledged that the uniformity of these results is satisfactory, considering that the percentage of fixed carbon varies between 68.438 and 76.688; the volatile substances between 12.309 and 19.019; and the ash between 7.000 and 13.961.

And as to minor differences, be it observed that the necessary connection of these beds with each other has not been made out by Professor Johnson, who only associates them together for temporary convenience.

It is not always easy to simplify the method of stating this ratio to the form adopted in Professor Johnson's table as above, for to be applicable it must include all kinds of coals, including the "Hydrogenous or Gas Coals," whose percentage of volatile is greater than that of fixed combustible matter. In this case a single number, viz.: a quotient of $\frac{\text{C}}{\text{Vol. H-C.}}$ would be a fraction, and this is to be avoided if possible. Of course where the water is also considered the plan of expressing the ratio by a single number is impossible.

Such ratios introduced into the discussions of the natural fuels have the same right of existence, and would fill very nearly the same rôle in such discussions that the silica, protoxide, and sesquioxide ratios do in the analytical formulæ of minerals. It would be too much to say that either method would permit of a rigid division into classes, since there are transition forms which always will prevent such absolute divisions of natural objects; but these cases will form a small portion of the whole number, and the handling of the rest will be much simplified.

In the tables constructed with due regard to the above consideration, the first number indicates the percentage amount of fixed carbon in the proportion. The next number refers to the volatile combustible matter. Here the analogy ceases in most cases, since we have determined above to regard the coal as essentially a mixture of gas, carbon, and impurity, under which latter term we include water, ash, sulphur, phosphorus, and whatever is not a necessary factor of the fuel; whether held in the fossil fiber of the coal-plant or separated by ignition; whether oxidized or volatilized.

A few considerations regarding these impurities will be found further on.

To repeat: In most cases the analogy between the oxygen ratio of minerals and the combustible ratio of the fuels will cease at the second term, or as if there were simply the oxygen of the electro-negative to be compared with that of the electro-positive elements. But just as in this latter case it is found most convenient to separate the electro-positive elements by their quantivalences, or *valences*, and thus to make a proportion of several terms; so it will be found best to add a third term to those expressing the fixed and gaseous combustibles for the purpose of eliminating an error which is likely to occur in estimating the hygroscopic moisture.

All those who have had any experience in the analysis of coals are aware that no operation during the analysis requires so much care as the water determination.

From amidst the mass of testimony from numerous chemists on this subject, I select that of Prof. Wormley, in the *Reports of the Ohio Geological Survey*, who states that a a given sample of coal loses less weight when raised to 240° than at 212°. Mr. A. S. McCreath, the chemist of the present Geological Survey of Pennsylvania, in his description of methods, alluding to this observation (*Report M.*, *Second Geological Survey of Pennsylvania*, 1874-75, p. 28,) adds that "this was not found to be the case with the coals" he "examined from this State, for in every instance was the loss greater *when the coal was dried at* 225° *than at* 212°."

It follows, however, from these observations that the less loss must amount to an increase of weight through oxidation, accompanied very often, also, by an actual disengagement of volatile hydrocarbons by distillation at even these low temperatures.* So that the resultant will be the sum of a number of positive and negative quantities depending upon the character of the coal, and the ease with which its composition is changed by heat. That the actual constitution of the coals is thus changed to a greater or less extent seems undoubted.

If, now, part of the volatile substances which should have been reckoned to the combustible hydrocarbons have been expelled with the moisture, the gas-carbon ratio will be affected by it, and, in cases where the known character of the fuel permits a close approximation to the true amount of its moisture, this correction should be made in the form of a third term to the proportion. When this appears without other explanation, it is understood to refer to the moisture, thus, C: V. H-C.: W=Fixed carbon: volatile hydrocarbons: water.

It is unfortunate that in the coal analyses cited by Professor Rogers, including those of Professor Johnson, no attempt has been made to separate the moisture from the vol-

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* See remark of Varrentrapp, quoted from Rothwell, by McCreath, p. 33.

atile hydrocarbons, all being considered alike volatile matter. This fact vitiates any classification which may be based on such analyses.

A list of sixteen analyses of "hard dry anthracites" from Rogers's final Report, vol. II, part 2, pp. 969, 970, is given in the following table, together with two extra columns showing the percentage of fixed carbon and volatile matter, calculated according to the principles stated above:

TABLE I.—*Hard Dry Anthracites.*

	Rogers's Analyses.				Percentage of Constituents of Fuel.		
	Fixed Carbon.	Volatile Matter.	Ash, Water, and Impurities.	Total.	Fixed Carbon.	Volatile Combustible Matter.	$\frac{C}{V.H\text{-}C.}$
1. Rhode Island,	77.00	3.00	20.00	100	96.25	3.75	25.66
2. Nesquehouing, 10-foot vein,	86.60	6.40	7.00	100	93.11	8.89	13.61
3. Summit Mines of Lehigh County,	88.50	7.50	4.00	100	92.19	7.81	11.80
4. Summit Mines of Lehigh County,	87.70	6.00	5.70	100	93.00	7.00	13.28
5. Tamaqua Coal D., East,	02.07	5.03	2.90	100	94.82	6.18	18.30
6. Tamaqua Coal E., East,	89.20	4.54	6.26	100	98.10	3.90	24.64
7. Tamaqua Coal R., Sharp Mountain,	87.45	7.55	5.00	100	92.05	7.95	11.57
8. Tuscarora,	66 20	7.50	4.30	100	91.38	8.62	10.60
9. Beaver Meadow,	90.20	2.52	7.28	100	97.28	2.72	35.78
10. Schenoweth Bed, E. Norwegian,	94.10	1.40	4.50	100	98.53	1.47	67.02
11. Third Coal, Nealy's Tunnel, near Pottsville,	89.20	6.40	6.40	100	94.29	5.71	16.61
12. Forest Improvement,	90.70	3.07	6.23	100	96.72	3.28	29.48
13. Sharp Mountain, north of Pine Grove,	80.57	7.15	12.28	100	91.85	8.15	11.27
14. Lykens Valley,	63.84	6.88	9.28	100	92.41	7.59	12.17
15. Shamokin,	89.90	6.10	4.00	100	93.64	6.36	14.71
16. Black Spring Gap,	62.47	9.53	8.00	100	89.63	10.37	8.64

No. 1 was analyzed by Hayes; Nos. 2, 3, 4, 5, 6, 7, 8, and 13, by the First Geological Survey of Pennsylvania; Nos. 9, 10, 11, 12, 14, 15, and 16, by Prof. W. R. Johnson.

A similar table, with similar added columns of the semi-anthracites from the same source here follows:

TABLE II.—*Semi-Anthracites.*

	ROGERS'S ANALYSES.			Total.	PERCENTAGE OF CONSTITUENTS OF FUEL.		
	Fixed Carbon.	Volatile Matter.	Ash, Water, and Impurities.		Fixed Carbon.	Volatile Combustible Matter.	C / V. H-C
1. Black Spring Gap, Lea Vein, ...	88.84	8.96	2.20	100	90.83	9.17	9.90
2. Black Spring Gap, Gray Vein, ...	81.62	9.78	8.60	100	89.30	10.70	8.35
3. Lykens Valley, Third Bed, ...	88.25	8.85	2.90	100	90.83	9.17	9.90
4. Zerbe's Run, ...	84.25	7.31	8.44	100	92.01	7.99	11.51
5. Wilkes-Barre, Warden's Bed, . . .	88.90	7.68	?	100	92.04	7.96	11.56
6. Carbondale, ...	90.23	7.07	2.70	100	92.73	7.27	12.75
7. Black Spring Gap, gray band of Gray Vein, ...	81.40	11.40	7.20	100	87.72	12.28	7.14
8. Gold Mine Gap, Peacock Vein, . .	82.15	10.95	6.80	100	88.23	11.77	7.49
9. Gold Mine Gap, Heister Vein, ...	81.47	10.43	8.10	100	88.65	11.35	7.81
10. Rausch Gap, Dauphin, Peacock Vein,	77.23	10.57	12.10	100	87.96	12.04	7.30
11. Yellow Spring Gap, ...	79.55	10.95	9.50	100	87.90	12.10	7.26
12. Rattling Run, Dauphin, ...	74.55	13.75	?	100	84.42	15.58	6.41

Nos. 1 and 2 analyzed by Prof. W. R. Johnson; Nos. 3, 5, 6, 7, 8, 9, 10, 11, 12, First Geological Survey of Pennsylvania; No. 4, Hayes (mean of 6 analyses.)

The following is a list of the semi-bituminous coals from the same source and place:

TABLE III.—*Semi-Bituminous Coals.*

	PRINTED ANALYSES.			Total.	PERCENTAGE OF CONSTITUENTS OF FUEL.		
	Fixed Carbon.	Volatile Matter.	Ash, Water, and Impurities.		Fixed Carbon.	Volatile Combustible Matter.	C / V. H-C.
1. Big Flats, *a*	76.94	15.06	8.00	100	83.63	16.37	5.10
2. Broad Top, Hopewell Mine, *a*	88.80	11.20	0.00*c*	100	88.80	11.20	7.93
3. Blossburg, *a*	73.11	15.27	11.62	100	82.62	17.39	4.75
4. Lycoming Creek, *a*	71.53	14.48	13.99	100	83.16	16.34	5.09
5. N. Y. and Maryland Mining Co., *b* .	73.50	14.10	12.40	100	84.13	15.87	6.30
6. Neff's, *b*	74.53	15.13	10.34	100	83.12	16.88	4.92
7. Easby's Coal in Store, *b*	76.27	15.65	8.08	100	82.97	17.03	4.87
8. Atkinson & Templeman's, *b*	76.69	15.98	7.33	100	82.75	7.25	11.41
9. Easby & Smith's, *b*	74.29	16.42	9.29	100	81.80	18.11	4.52
10. Cumberland, Navy Yard, *b*	68.44	17.28	13.98*d*	100	79.84	20.16	3.96

a Analyzed by Penn. Geol. Survey. *b* Analyzed by Prof. W. R. Johnson.
c An unaccountable blunder in the tables makes this 4 per cent. of impurities, after the 100 per cent. has been accounted for. In many places these analyses of coals of Rogers's Survey show signs of carelessness. This impurity has been stricken out, but this is not probably the right correction.
d An error here of 0.41 per cent. in excess.

The table of bituminous coals, numbering 19, which follows in Rogers's Report, is composed entirely of analyses by Professor W. R. Johnson, and in these the calculation is made on the principle advocated in this paper, viz., by making the fixed carbon and volatile matter together=100. The ash is ascertained directly from the analyses, while these other ratios must have been the subject of after-computation; yet there is nothing to indicate that, in the columns giving volatile matter and fixed carbon in 100 parts, a different system from the foregoing has been introduced.

TABLE IV.—*Bituminous Coal.*

	Johnson's Analyses. Fixed Carbon.	Johnson's Analyses. Volatile Matter.	Johnson's Analyses. Sum.	$\frac{C}{V.H\text{-}C.}$	Earthy Matter in 100 parts of the Coal.
1. Lick Run, Lycoming County,	79.28	20.72	100	3.82	13.07
2. Queen's Run, below Farrandsville,	78.28	21.50	100	3.64	4.80
3. Snow-Shoe Mine,	78.80	21.20	100	3.71	2.07
4. Moshannon Creek, near Philipsburg,	70.50	29.50	100	2.39	6.10
5. Speed's Mine, 16 miles from Philipsburg,	79.60	20.40	100	3.90	a 12.00
6. Leach's Mine, 17½ miles from Philipsburg,	79.68	20.32	100	3.92	11.76
7. Upper part of large bed, Ralston,	79.50	20.50	100	3.88	6.00
8. Karthaus, Lower Seam,	75.20	24.80	100	3.03	4.70
9. Reed's 6-foot vein, Curwinsville,	73.00	27.00	100	2.70	5.80
10. Bear Creek, Blossburg,	68.00	32.00	100	2.12	5.20
11. Warner's 5-foot vein, Caledonia,	63.00	37.00	100	1.70	8.50
12. Warner's 3-foot vein, Caledonia,	61.80	38.20	100	1.61	7.20
13. Blairsville Large Bed,	69.00	31.00	100	2.22	4.00
14. Sandy Ridge, 4 miles from Shippensville,	56.80	43.20	100	1.31	7.00
15. Cannel Coal, 6 miles east of Franklin,	47.22	52.78	100	0.89	17.68
16. Cannel Coal from Greensburg,	64.00	36.00	100	1.77	33.68
17. Conneaut Lake,	61.25	38.75	100	1.50	1.80
18. Near Greenville,	40.50	59.50	100	0.68	1.70
19. Near Orangeville,	56.25	43.75	100	1.28	2.80

a In Rogers's Report this is printed 120, probably intended for 12.0.

[Professor Frazer then copies a group of Mr. McCreath's analyses, of the Waynesburg Main Coal, Upper bench, (Nos. 164, 8, 150, 151, 152); a group of the Waynesburg, Lower bench, (155, 154, 7, 156, 153); another group of the Waynesburg Lower bench, (157, 158, 148, 149); and says:

The following table expresses, in a condensed form, the percentage of hydrocarbons in all the above-mentioned specimens from the Waynesburg Bed, assuming the sum of the fixed carbon and volatile hydrocarbons to be together equal to 100, and neglecting the bench to which each belongs, and omitting fractions.

Numbers,	151	149	8 156 157	150 152 148	154	155 158	164	7 153
Per cent. of Vol. H-Cs. (C+H-C=100)	47	46	44	43	42	41	40	39

In other words, the most gaseous representative of the Upper bench of the Waynesburg coal is No. 151, from Hopewell township, Washington county, Pa., and the least gaseous from the same bench, No. 164, from Jefferson township, Greene county; while that representative of the lower bench richest in volatilizable fuel is No. 149, from Pleasant Valley, Washington county, (very nearly like No. 151,) and the poorest is No. 7, Cumberland township, Greene county, (very nearly the same as No. 164.)

[He then gives the three analyses of the Sewickley bed, (MM, page 9); and thirty-three of those of the Pittsburgh coal, (MM, pages 11 to 29,) "to show the modifications of composition which take place in different parts of the same coal bed, and become very apparent when expressed in the term of fuel ratio."]

On comparing the two first tables it will be observed that Prof. Rogers has slighted his own general classification in the examples he furnishes of its various members; for if a semi-anthracite be characterized by a greater percentage of volatile combustible matter than a hard dry anthracite, then Nos. 1, 3, 4, 5, and 6 of Table II, do not belong there, since No. 16, Table I, has a higher percentage of volatile combustible matter than any of them, according to his own tables.

But it is not in examples of this kind, where superior coals have been selected and submitted to analysis, that the urgency of a better basis on which to arrange them, bebecomes most apparent. It matters not whether the article for which a place in the category is sought be a commercial commodity or not, its relation to the purer varieties of its own kind should be plain. An example will suffice to illustrate this.

A recent examination of the carbonaceous slates, known as the Hudson River group, and which form extensive slopes along the flank of the North or Kittatinny Mountain in this State, rendered it interesting to ascertain the quantity of carbon present in those slates, and also its nature. These slates, lying geologically 7,000 meters below the Carboniferous and the carbon associated with them, with the underlying lower Silurian limestone, and with the still lower Huronian or Laurentian rocks, have generally been considered to be graphitic, or at least anthracitic.

Analysis, however, proved that these black strata contain about 3 per cent. of volatile combustible matter, 5 per cent. of fixed carbon, and 92 per cent. of impurities. If we neglect the latter the slate will by reason of its percentage of volatile hydrocarbons come under the head of the hard anthracites, whereas from the point of view above maintained the carbonaceous matter will be found to have the surprisingly high bituminous character of C 62.5, Vol. H-C. 37.5, a percentage hardly averaged by our best gas coals.

If it be true that a coal bed in its several parts, having been derived from mainly the same kind of vegetation (within reasonable limits of space) and being subjected to the same physical treatment within these limits, preserves a uniformity of composition in the product of that vegetation, some such method as this for withdrawing the accidents of the problem would seem to be an important means of identifying the same bed. For though the woody fibre may change into coal at the same rate in all parts of the same bed, the resulting coal will not be the same according to the presentation of it by the ordinary method of proximate analysis, unless the pressure and the resulting structure of the mass are the same; unless the waters and the infiltrating salts are the same in amount and kind; unless, in fact, all the accidents of a coal bed become essentials, which they never can do.

The argument of basing the definition of coals on the ratio between their percentages of fixed carbon and volatile hydrocarbons, is founded upon the assumption that all other constituents than those of the fuel, *i. e.*, carbon and hydrocarbons, are adventitious and accidental, and liable to be influenced by causes operating after the extraction of the coal from the mine. It is true that the coal-plants themselves probably contained in their tissues silica, sulphur, water, etc., and may have contributed in some cases the larger portion of these substances which are found in the coal, but this does not alter the value of the method proposed. Each kind of vegetation, no doubt, produced its own kind of coal; but, over wide tracts, the resulting mass, from similar conditions of overflowing, imbedding, pressure, and heat, would be practically the same *in the large*, while individual differences might be found in every mine (notably where a horse, a slate-parting, and the like occnrs).

But there is an essential difference in the result between two distinct causes of variation, *i. e.* (1), variation in the nature of the plant (2), variation in the mechanical treatment to which the coal has been subjected. In the former case, the coal is a *different* coal; in the latter, a more impure variety of the *same* coal, as a deduction of its mechanical impurities and its fuel ratio will demonstrate.

If these tables here given may be taken as proper bases of the classification which essays to represent them, the definitions of these classes would be as follows:

An anthracite coal is one in which the ratio of fixed carbon to volatile (combustible) matter may vary between the proportions 99 C: 1 V. H-C (theoretically, of course, 100:0), and 89 C: 11 V. H-C.

A semi-anthracite is a coal in which the ratio of the fixed carbon to the volatile combustible matter may vary between the proportions 93 C: 7 V. H-C, and 84 C: 16 V. H-C.

The semi-bituminous coals are those in which this proportion varies between 84 C: 16 V. H-C. and 81 C: 19 V. H-C.

The bituminous coals are those in which the proportion may vary between 80 C: 20 V. H-C. and 47 C: 53 V. H-C.

To recapitulate:

TABLE V.

Kind of coals.	Between proportions. C V. H-C. C V. H-C.
Anthracite,	99 : 1 and 89 : 11
Semi-anthracite,	93 : 7 and 84 : 16
Semi-bituminous,	84 : 16 and 81 : 19
Bituminous,	80 : 20 and 47 : 53

On viewing this last small table, it will be at once seen that the classes overlap each other, and one is compelled to suppose that the coals which thus intrude on each other have some physical peculiarities which ally them to the class into which they come and separate them from the other. It will be in vain that we look for such distinguishing features, however, and the whole truth is, that the definition is based partly upon geographical and partly upon chemical characteristics. It is a repetition of the old difficulty experienced by mineralogists of defining classes by other than strict chemical characters.

So long as no third term (*i. e.* percentage of water) is employed, the general results of these tables permit a very simple expression on Prof. Johnson's plan of fuel ratios. As a result of the digestion of all the above tables we have, from experiment:

Classes of Coals.	$\frac{C}{V.H\text{-}C.}$		
Hard-dry anthracite,	67.02	to	8.64
Semi-anthracite,	12.75	to	5.41
Semi-bituminous,	11.41	to	4.52
Bituminous,	3.93	to	0.68

(Theoretically, of course, the first term of the left-hand column would be 100, and the last term of the right-hand column, 0.)

In Roger's system, the greatest confusion will be found to exist in the *semis*, a term which of itself implies a subordinate value in the system. First the semi-anthracite encroaches upon the anthracite to the extent of 50 per cent. of its entire range.

But worse than this, the semi-bituminous covers the whole space assigned to the semi-anthracite, and actually encroaches upon the "*hard-dry anthracite*," about 40 per cent. of its entire range.

Such a state of our nomenclature cannot but interfere with that most desirable of all aids in the investigation of truth, a distinct and sharp definition of terms.

Would it not be as well to assign their places to these coals by fuel ratios, thus avoiding the perplexing variations of impurities, somewhat as follows:

Classes of Coals.		$\frac{C}{V.H\text{-}C.}$		
Hard-dry anthracite,	from	100	to	12
Semi-anthracite,	from	12	to	8
Semi-bituminous,	from	8	to	5
Bituminous,	from	5	to	0

It is true that the same objection might be found to this which was raised against the new iron nomenclature: That persons who had previously been selling coal, varying from 12 to 8 $\frac{C}{V.H\text{-}C}$ as anthracite, would resent the prefix of semi. But if, in the rectification of our boundary line, our neighbor's well is found on our land, it may be sad for him, but it is nevertheless an unalterable fact.

It should be remarked, in conclusion, that so long as this point of view is selected for viewing coals, it is indifferent whether the per cent. of C, or the per cent. of V. H-C, or the quotient of one divided by the other, be selected as the best means of classification, since one of the first two data being given, the other two can be calculated; but this is a very different thing from basing the classification upon the percentage of C or V. H-C, when the comparison of their sum with the impurities is neglected.

Note by J. P. Lesley.

The above paper on the classification of coals was written in 1876–7, at my request, by Professor Frazer, for one of the Reports of Progress of the Survey; but delays in publication made it convenient to recast it for communication to the meeting of the American Institute of Mining Engineers, held at Wilkesbarre, in May, 1877. It appeared, therefore, in Vol. VI of the Institute's Transactions; but now comes into its proper place in the Reports of the Geological Survey.

The insufficiency of the four tables given on pages 136, 137 above for furnishing a law for rating coals becomes evident when they are broken up, and their heterogeneous parts treated separately.

Taken as a whole, each table furnishes an average which is false and therefore useless, and in fact deceptive, because the four general averages of the four tables fall into an apparently regular ascending series; whereas, when broken up into special averages, no such *regular* series is observable, inasmuch as the averages in Table 2, overlap those in Table 1, and those of Table 3, overlap those of Table 2, thus:

General average of the whole table.

		Carbon. H.C.
Table 1.	Hard dry anthracite.	20.40 : 1
Table 2.	Semi-anthracite, ...	8.86 : 1
Table 3.	Semi-bituminous, ...	5.78 : 1
Table 4.	Bituminous, ...	2.42 : 1

When broken up, the tables exhibit a very different order, thus :—

Table 1.

		C. H.C.
(1)	No. 10 stands alone with the ratio, ...	67.02 : 1
(2)	Nos. 1, 6, 9, 12 form a group, averaging, ...	28.88 : 1
(3)	Nos. 2 to 5, 7 to 8, 11, and 13 to 15 a group, averaging,	14.44 : 1
(4)	No. 16 stands alone with *1st ratio*, ...	8.64 : 1

Table 2.

(5)	Nos. 4, 5, 6 form a group with an average of, . . .	11.94 : 1
(6)	Nos. 1, 2, 3 form a group with an average of, . . .	9.05 : 1
(7)	Nos. 7 to 11 form a group with an average of, ...	7.40 : 1
(8)	No. 8 stands alone with the ratio, ...	5.41 : 1

Table 3.

(9)	No. 8 stands alone with the ratio, ...	11.41 : 1
(10)	No. 2 stands alone with the ratio, ...	7.93 : 1
(11)	Nos. 1, 3 to 7, 9 and 10 form a group, averaging, . .	4.81 : 1

Table 4.

(12)	Nos. 1, 2, 3, 5, 6, 7 form a group, averaging, ...	3.81 : 1
(13)	Nos. 8 and 9 form a group, averaging, ...	2.86 : 1
(14)	Nos. 10 and 13 form a group, averaging, ...	2.17 : 1
(15)	Nos. 11, 12, 16, 17 form a group, averaging, ...	1.64 : 1
(16)	Nos. 14 and 19 form a group, averaging, ...	1.30 : 1
(17)	No. 15 stands alone with the ratio, ...	0.89 : 1
(18)	No. 18 stands alone with the ratio, ...	0.68 : 1

It is evident that (5) and (6) "Semi-anthracite" coals belong among the "Hard dry anthracites;" *or else* (4) "Hard dry anthracite" ought to be transferred to the "Semi-anthracite" Table 2.

It is evident also that if (5) of Table 2 represents a Semi-anthracite coal, so does (9) of Table 3; and (10) ought to precede (7,) and one or other be transferred from the table in which it stands to the table above or below it.

If now the averages as above given (and it would be possible to arrange the data so as to get quite different ones) be arranged in a regular order, we have the following series:

	C. H.C.	
(1)	67.02 : 1	Extreme of the hard dry anthracites.
(2)	28.88 : 1	
(3)	14.44 : 1	
(5)	11.94 : 1	Semi-anthracite coal.
(6)	9.05 : 1	Semi-bituminous coals.
(4)	8.64 : 1	
(10)	7.93 : 1	
(7)	7.40 : 1	
(8)	5.41 : 1	
(11)	4.81 : 1	
(12)	3.81 : 1	
(13)	2.86 : 1	
(14)	2.17 : 1	
(15)	1.64 : 1	
(16)	1.30 : 1	
(17)	.89 : 1	
(18)	.68 : 1	Extreme of the high bituminous coals.

Any one may draw the lines as they are drawn above, or in any other way according to his judgment or fancy; but with the exception of the space between (1) and (2) and between (2) and (3) there seems to be no sufficiently good reason for drawing lines of sub-division anywhere else in the series. In fact chemical analyses of coals might now be collected to the number of some thousands, and arrayed in a series so perfectly continuous as to defy sub-division.

The original sub-division into anthracite, semi-anthracite, semi-bituminous and bituminous, was a mere convenience, founded upon the *geographical distribution* of 1, hard anthracites on the Lehigh and Lackawanna; 2, soft or semi-anthracites at the western ends of the Pottsville and Shamokin coal fields; 3, free-burning and flaming semi-bituminous coals east of the escarpment of the Allegheny and along that escarpment, and 4, all other smoking and gas coals to the west of that natural limit.

The coal trade will always, or for a long time to come, use these convenient names for the different kinds of coals which reach the sea board: but they have no scientific value.

To show that the assertions made above are justifiable, I have arranged all the fuel ratios—*i. e.*, the proportion of solid carbon to gas (hydro-carbon)—given by Mr. McCreath in the first 100 pages of this volume, in such a way as to show how *absolutely continuous* the series *would* be *if a sufficient number of analyses* were at hand.

The arrangement will also serve another purpose, that of indicating to the eye the *geographical* distribution of the maxima and minima of the fuel ratios; the minima being evidently restricted to the extreme western counties of the State; thus:

No. of specimen.	*Name of Coal bed.*	*Name of County.*	*Fuel Ratio.*
486b	D.,	Beaver,	0.79
636	Mercer Upper,	Lawrence,	0.91

718	?	McKean,	0.99
139	P. C.,	Washington,	1.02
179	P. C.,	Washington,	1.03
633	Quakertown,	Lawrence,	1.04
511a	C,	Beaver,	1.04
510	C,	Beaver,	1.05
487	D,	Butler,	1.06
488	Brush Creek,	Butler,	1.07
508	C,	Beaver,	1.10
151	Waynesburg Main,	Washington,	1.13
933	C,	Butler,	1.14
470	D,	Butler,	1.14
474	P. C.,	Westmoreland,	1.15
715	B (?),	McKean,	1.15
502	D,	Butler,	1.16
637	C,	Lawrence,	1.17
173	E,	Beaver,	1.17
149	Waynesburg Main,	Washington,	1.18
180	P. C.,	Washington,	1.18
147	Washington Main,	Washington,	1.19
160	P. C.,	Greene,	1.19
174	E,	Beaver,	1.20
486a	D,	Beaver,	1.21
514	C,	Beaver,	1.21
934	D,	Butler,	1.22
624	D,	Lawrence,	1.22
716b	?	McKean,	1.22
165	P. C.,	Washington,	1.24
515a	C,	Beaver,	1.24
8	Waynesburg Main,	Washington,	1.27
157	Waynesburg Main,	Washington,	1.27
509a	C,	Beaver,	1.28
511b	Waynesburg Main,	Washington,	1.29
156	C,	Beaver,	1.29
150	Waynesburg Main,	Washington,	1.30
935	C′,	Butler,	1.30
629	D,	Lawrence,	1.30
632	D,	Lawrence,	1.31
623	D,	Lawrence,	1.31
717	(?)	McKean,	1.31
148	Waynesburg Main,	Washington,	1.32
152	Waynesburg Main,	Washington,	1.34
614a	(?)	McKean,	1.34
614b	(?)	McKoan,	1.36
719	(?)	McKoan,	1.36
932	E,	Butler,	1.36
680	P. C.,	Indiana,	1.37
162	P. C.,	Greene,	1.37
144	P. C.,	Washington,	1.38
690a	P. C.,	Washington,	1.38
473b	P. C.,	Westmoreland,	1.38
635	Brush Creek,	Lawrence,	1.38

171	E,	Beaver,	1.38
172	E,	Beaver,	1.38
145	P. C.,	Washington,	1.39
154	Waynesburg Main,	Washington,	1.39
161	P. C.,	Greene,	1.40
476	P. C.,	Westmoreland,	1.40
936	C′,	Butler,	1.40
631	D,	Lawrence,	1.40
627	D,	Lawrence,	1.40
630	D,	Lawrence,	1.41
628	C,	Lawrence,	1.41
690b	P. C.,	Washington,	1.41
155	Waynesburg Main,	Washington,	1.42
158	Waynesburg Main,	Washington,	1.42
505b	P. C.,	Westmoreland,	1.42
677	P. C.,	Indiana,	1.42
626	Brush Creek,	Lawrence,	1.42
625	D,	Lawrence,	1.42
614c	?	McKean,	1.42
716a	?	McKean,	1.42
720a	C (?),	McKean,	1.42
515b	C,	Beaver,	1.42
509b	C,	Beaver,	1.43
182	E,	Beaver,	1.44
146	Redstone,	Washington,	1.44
178	P. C.,	Washington,	1.45
175	D,	Beaver,	1.45
177	P. C.,	Washington,	1.47
473a	P. C.,	Westmoreland,	1.47
473c	P. C.,	Westmoreland,	1.48
513	D,	Beaver,	1.48
164	Waynesburg Main,	Greene,	1.48
507	D,	Beaver,	1.50
138	P. C.,	Washington,	1.50
134	P. C.,	Washington,	1.50
10	Sewickley,	Greene,	1.52
159	P. C.,	Greene,	1.52
634	Sharon block,	Mercer,	1.52
44	D (?)	Clarion,	1.53
500	Sewickley,	Fayette,	1.54
153	Waynesburg Main,	Washington,	1.54
143	P. C.,	Washington,	1.54
136	P. C.,	Washington,	1.55
181	P. C.,	Washington,	1.56
505c	P. C.,	Westmoreland,	1.56
495	P. C.,	Westmoreland,	1.58
1000	B (?)	Potter,	1.58
7	Waynesburg Main,	Washington,	1.59
940	E,	Westmoreland,	1.60
5	Sewickley,	Greene,	1.60
6	P. C.,	Greene,	1.61
683	P. C.,	Indiana,	1.62

690d	P. C.,	Washington,	1.02
166	P. C.,	Washington,	1.62
135	P. C.,	Washington,	1.62
142	P. C.,	Washington,	1.64
673	E,	Indiana,	1.64
478	E,	Westmoreland,	1.64
720b	C (?)	McKean,	1.65
485	D',	Butler,	1.66
42	D (?)	Jefferson,	1.66
489	P. C.,	Westmoreland,	1.66
505a	P. C.,	Westmoreland,	1.67
176	D,	Beaver,	1.67
679	P. C.,	Indiana,	1.68
690c	P. C.,	Washington,	1.68
141	P. C.,	Washington,	1.69
137	P. C.,	Washington,	1.70
946	D',	Armstrong,	1.70
496	P. C.,	Fayette,	1.72
140	P. C.,	Washington,	1.74
482	P. C.,	Westmoreland,	1.74
412	B,	Blair,	1.75
688	E,	Indiana,	1.75
497	P. C.,	Fayette,	1.76
704a	B (?)	Potter,	1.78
704b	B (?)	Potter,	1.78
501	P. C.,	Fayette,	1.79
9	Sewickley,	Greene,	1.80
479	P. C.,	Westmoreland,	1.81
684	P. C.,	Indiana,	1.81
689	D',	Indiana,	1.82
621	E,	Indiana,	1.82
678	E,	Indiana,	1.83
480	P. C.,	Westmoreland,	1.83
499	P. C.,	Fayette,	1.83
686	D,	Indiana,	1.87
440	P. C.,	Fayette,	1.88
475	P. C.,	Westmoreland,	1.90
687	E,	Indiana,	1.90
477	P. C.,	Westmoreland,	1.92
436	P. C.,	Westmoreland,	1.93
498	P. C.,	Fayette,	1.94
681	D',	Indiana,	1.94
685b	P. C.,	Indiana,	1.95
423a	P. C.,	Westmoreland,	1.95
30	P. C.,	Fayette,	1.98
685a	P. C.,	Indiana,	2.00
384	B,	Blair,	2.00
411	B,	Blair,	2.01
503	P. C.,	Westmoreland,	2.02
506	P. C.,	Westmoreland,	2.05
423b	P. C.,	Westmoreland,	2.07
471	P. C.,	Westmoreland,	2.07

481	P. C.,	Westmoreland,	2.08
676	D,	Indiana,	2.08
682	E,	Indiana,	2.13
619	E,	Indiana,	2.14
377	A,	Somerset,	2.14
693	D',	Fayette,	2.14
674a	D,	Indiana,	2.15
674b	D,	Indiana,	2.16
703	B. (?),	Tioga,	2.16
445	A,	Cambria,	2.17
674c	D,	Indiana,	2.17
675	D,	Indiana,	2.19
308	B,	Blair,	2.19
622	A,	Indiana,	2.22
696	E,	Fayette,	2.26
3	B,	Blair,	2.27
638b	P. C.,	Westmoreland,	2.29
615	E,	Indiana,	2.31
309	E,	Blair,	2.38
616	E,	Indiana,	2.42
306	B,	Cambria,	2.43
73	No. X coal,	Huntingdon,	2.43
304	B,	Cambria,	2.44
303	B,	Blair,	2.44
694	B, (?),	Fayette,	2.47
305	B,	Cambria,	2.48
302	E,	Blair,	2.48
402	?	Blair,	2.51
617b	E,	Indiana,	2.51
813	?	Sullivan,	2.52
938	?	Sullivan,	2.52
348	B,	Cambria,	2.53
444	A,	Cambria,	2.55
618	B, (?),	Indiana,	2.55
439a	C, (?),	Cambria,	2.56
415	?	Clearfield,	2.59
483	P. C.,	Westmoreland,	2.60
638a	P. C.,	Westmoreland,	2.60
374	E,	Cambria,	2.65
691	E,	Westmoreland,	2.69
46	Philson,	Somerset,	2.70
695a	C, (?),	Fayette,	2.72
620	E,	Indiana,	2.72
727	D, (?),	Clearfield,	2.74
484	P. C.,	Westmoreland,	2.76
375	E,	Cambria,	2.77
313	B,	Cambria,	2.80
695b	E,	Fayette,	2.85
439b	D,	Cambria,	2.91
351	Philson,	Somerset,	2.91
373	D',	Cambria,	2.93
617a	E,	Indiana,	2.93

400	B (?),	Somerset,	2.94
396	Platt,	Somerset,	2.94
311	B,	Cambria,	2.95
442	Berlin,	Somerset,	2.96
425	B,	Cambria,	3.00
672	D (?),	Tioga,	3.01
658b	?,	Tioga,	3.02
665	D (?),	Tioga,	3.06
456	P. C.,	Somerset,	3.07
410	Berlin,	Somerset,	3.09
414	?,	Clearfield,	3.09
601o	B (?),	Tioga,	3.11
658a	?,	Tioga,	3.12
461	Berlin,	Somerset,	3.12
192	E,	Cambria,	3.16
443a	P. C.,	Somerset,	3.18
655	?,	Tioga,	3.21
399	Elk Lick,	Somerset,	3.21
350	Redstone,	Somerset,	3.22
457	P. C.,	Somerset,	3.23
443b	P. C.,	Somerset,	3.26
459	P. C.,	Somerset,	3.27
697b	No. X coal,	Perry,	3.27*
458	P. C.,	Somerset,	3.28
669	D (?),	Tioga,	3.31
428	Berlin,	Somerset,	3.32
705	B (?),	Tioga,	3.34
460	P. C.,	Somerset,	3.35
312	A,	Cambria,	3.35
697a	No. X coal,	Perry,	3.35†
601b	B (?),	Tioga,	3.37
372	Price,	Somerset,	3.39
692	C (?),	Westmoreland,	3.40
654	D (?),	Tioga,	3.40
657b	B (?),	Tioga,	3.40
4	B (?),	Clearfield,	3.43
601a	B (?),	Tioga,	3.45
70	B (?),	Clearfield,	3.47
706	B (?),	Tioga,	3.50
707	B (?),	Tioga,	3.50
671	B (?),	Tioga,	3.54
379	Price,	Cambria,	3.55
349	P. C.,	Somerset,	3.58
376	A,	Cambria,	3.62
378	Price,	Cambria,	3.66
383	D',	Somerset,	3.70
657a	B (?),	Tioga,	3.77
658c	?,	Tioga,	3.77
661a	B (?),	Bradford,	3.78
72	No. X coal,	Huntingdon,	3.79

* Ash 33.265.

† Ash 36.445.

814	?	Huntingdon	3.82
657c	B (?)	Tioga	3.86
664	B (?)	Tioga	3.88
371	D′	Somerset	3.89
71	No. X Coal	Huntingdon	3.90
398	E	Somerset	3.91
656	?	Tioga	3.96
806	E (?)	Lycoming	3.96
559	Trias Coal	York	4.02*
659	A (?)	Bradford	4.04
668a	B (?)	Bradford	4.04
660	B (?)	Bradford	4.05
447	D	Somerset	4.12
667	?	Sullivan	4.13
663	B (?)	Bradford	4.13
668b	B (?)	Bradford	4.14
187	?	Huntingdon	4.15
316	B	Cambria	4.16
188	?	Huntingdon	4.18
661b	B (?)	Bradford	4.21
310	A	Cambria	4.21
307	B	Cambria	4.24
191	B	Cambria	4.26
2	D	Cambria	4.27
314	D	Somerset	4.30
805	E (?)	Lycoming	4.30
382	B (?)	Somerset	4.33
397	D	Somerset	4.34
75	D (?)	Huntingdon	4.35
662a	B (?)	Bradford	4.39
803	?	Sullivan	4.41
662b	B (?)	Bradford	4.44
1001c	P. C. (?)	Cumberland, Md.	4.47
1	B	Cambria	4.50
77	C (?)	Huntingdon	4.51
76	D (?)	Huntingdon	4.51
78	C (?)	Huntingdon	4.56
401	D	Somerset	4.58
(Page 68)	C (?)	Huntingdon	4.61
662c	B (?)	Bradford	4.74
1001a	P. C. (?)	Cumberland, Md.	4.75
1001b	P. C. (?)	Cumberland, Md.	4.78
(Page 68)	C (?)	Huntingdon	4.80
381	B (?)	Somerset	4.84
446	D	Somerset	5.14
206	C (?)	Huntingdon	5.30
812b	B (?)	Sullivan	5.48
812a	B (?)	Sullivan	6.09
939	?	Sullivan	6.93
666d	B (?)	Sullivan	7.06

* Ash, 2.000.

666a	B (?),	Sullivan,	7.87
666b	B (?),	Sullivan,	8.53
666c	B (?),	Sullivan,	8.64
88	Lykens Valley,	Dauphin,	8.91
937	B (?),	Sullivan,	9.59
315	B (?),	Sullivan,	10.28
437	Cameron Colliery,	Northumberland,	11.20
441	Lykens Valley,	Dauphin,	11.30
421	Cameron Colliery,	Northumberland,	11.43
403	Cameron Colliery,	Northumberland,	14.03
87	Gilberton Colliery,	Schuylkill,	25.77

Let us now pick out the Pittsburgh Coal bed and see how its ratios will arrange themselves geographically.

139	P. C.,	Washington,	1.02
179	P. C.,	Washington,	1.03
474	P. C.,	Westmoreland,	1.15
180	P. C.,	Washington,	1.18
160	P. C.,	Greene,	1.19
165	P. C.,	Washington,	1.24
680	P. C.,	Indiana,	1.37
162	P. C.,	Greene,	1.37
144	P. C.,	Washington,	1.38
690a	P. C.,	Washington,	1.38
473b	P. C.,	Westmoreland,	1.38
145	P. C.,	Washington,	1.39
161	P. C.,	Greene,	1.40
476	P. C.,	Westmoreland,	1.40
690b	P. C.,	Washington,	1.41
505b	P. C.,	Westmoreland,	1.42
677	P. C.,	Indiana,	1.42
178	P. C.,	Washington,	1.45
177	P. C.,	Washington,	1.47
473a	P. C.,	Westmoreland,	1.47
473c	P. C.,	Westmoreland,	1.48
138	P. C.,	Washington,	1.50
134	P. C.,	Washington,	1.50
159	P. C.,	Greene,	1.52
143	P. C.,	Washington,	1.54
136	P. C.,	Washington,	1.55
181	P. C.,	Washington,	1.56
505c	P. C.,	Westmoreland,	1.56
495	P. C.,	Westmoreland,	1.58
6	P. C.,	Greene,	1.61
683	P. C.,	Indiana,	1.62
690d	P. C.,	Washington,	1.62
166	P. C.,	Washington,	1.62
135	P. C.,	Washington,	1.62
142	P. C.,	Washington,	1.64
489	P. C.,	Westmoreland,	1.66
505a	P. C.,	Westmoreland,	1.67
679	P. C.,	Indiana,	1.68
690c	P. C.,	Washington,	1.68

141	P. C.,	Washington,	1.69
137	P. C.,	Washington,	1.70
496	P. C.,	Fayette,	1.72
140	P. C.,	Washington,	1.74
482	P. C.,	Westmoreland,	1.74
497	P. C.,	Fayette,	1.76
501	P. C.,	Fayette,	1.79
479	P. C.,	Westmoreland,	1.81
684	P. C.,	Indiana,	1.81
480	P. C.,	Westmoreland,	1.83
499	P. C.,	Fayette,	1.83
440	P. C.,	Fayette,	1.88
475	P. C.,	Westmoreland,	1.90
477	P. C.,	Westmoreland,	1.92
436	P. C.,	Westmoreland,	1.93
498	P. C.,	Fayette,	1.94
685b	P. C.,	Indiana,	1.95
423a	P. C.,	Westmoreland,	1.95
30	P. C.,	Fayette,	1.98
685a	P. C.,	Indiana,	2.00
503	P. C.,	Westmoreland,	2.02
506	P. C.,	Westmoreland,	2.05
423b	P. C.,	Westmoreland,	2.07
471	P. C.,	Westmoreland,	2.07
481	P. C.,	Westmoreland,	2.08
638b	P. C.,	Westmoreland,	2.29
483	P. C.,	Westmoreland,	2.60
638a	P. C.,	Westmoreland,	2.60
484	P. C.,	Westmoreland,	2.76
443a	P. C.,	Somerset,	3.18
457	P. C.,	Somerset,	3.23
443b	P. C.,	Somerset,	3.26
459	P. C.,	Somerset,	3.27
458	P. C.,	Somerset,	3.28
460	P. C.,	Somerset,	3.35
349	P. C.,	Somerset,	3.58
1001c	P. C. (?),	Cumberland, Md.,	4.47
1001a	P. C. (?),	Cumberland, Md.,	4.75
1001b	P. C. (?),	Cumberland, Md.,	4.78

It is perfectly evident from the above figures that the *Carbon* ratio is lowest along the Monongahela river; increases eastward on approaching Chestnut Ridge; leaps from 2.29 to 2.60, on passing over one anticlinal to the isolated patches in the Ligonier Valley; leaps again from 2.76 to 3.18, on passing over two anticlinals to the isolated patch in the Salisbury basin; and again from 3.58 to 4.47 on crossing the Allegheny mountain eastward into the Cumberland basin in Maryland, or the great Morrison Cove anticlinal, 40 miles wide, into the Broad Top basin.

It has been impossible to show this satisfactorily by any comparison of the *full analyses* as they are recorded by the laboratory. Hence the value of Professor Frazer's method of comparison by ratios.

There is much to be said, which has never yet been said, respecting this curious and mysterious subject of the geographical gradual transition of bituminous into anthracite coal.

And first: A suggestion comes in place here, which should receive whatever consideration is due to it, however little; and no doubt the objections to it are very weighty, if not quite unanswerable.

There ought to be an increment of the Carbon ratio due to depth of coal beds beneath the surface.

But as the increment of temperature is only 1° F. for every fifty or sixty feet depth, and as the total thickness of our Coal Measures proper from the base of the conglomerate (Sharon block coal) up to the Washington Main coal is only about 1,600′ (sixteen hundred feet,*) then if the mean temperature at the present surface outcrop of the latter be taken at 50° F. that of the former at a point immediately under it should be only about 80° F.; and this agrees with the observed warmth of waters issuing from oil wells.

And even if we restore upon the Washington Main coal the Upper Barren Measures A and B, observed to overlie it in the central parts of the wide synclinal of Greene county, viz: 367′+715′=1082′, making the total height of rock strata remaining (in Greene county) over the Sharon coal about 2700′ (twenty-seven hundred feet) the temperature of the latter can only be placed as high as about 100° F., which would not justify us in assigning an appreciably higher carbon ratio to the Sharon at 2700′, than to the Washington Main at 1100′. For twenty degrees Farenheit could do little towards volatilizing the hydro-carbons.†

Consequently the observed ratios (as given above) at the present outcrops of the two beds are as follows:

$$\left.\begin{array}{ll}\text{Washington Main, ...} & 1.19 \\ \text{Sharon (block) . . . .} & 1.52\end{array}\right\}\text{Difference } 0.33$$

which difference may be due—1, to this very cause, viz., greater depth of covering, or—2, to difference of botany, or—3, to our having too few analyses for obtaining reliable ratios of the two beds, or—4, to other unknown or unsuggested causes.

Of course it is here supposed, to prevent complications, that the whole of the Coal Measures once overlaid the Sharon coal *at Sharon*, and have been removed by erosion. But it would be more satisfactory if we could reach the Sharon Coal (if it exists) beneath Greene county and get its ratio there in place.

The next thing to observe is the fact that we have no information respecting the amount of *still higher*, *once existing*, *but now eroded* measures in Greene county (and elsewhere); although for all we can tell, that amount may have been considerable. It is perfectly evident from the rounded hill tops in Greene county that the uppermost strata have entirely disappeared. In the deeper anthracite basins, the so-called Coal measures, *excluding* the Conglomerate, are 3000′ (three thousand feet) or more thick; and as the hill tops along the central lines of the synclinals are rounded, still higher measures once existed over them than any now observable west of Pottsville, and west of Wilkesbarre.

To this must be now added the further fact that Professors Fontaine and

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* See page MM 1, of this volume.

† Pressure and luting by clay strata are here left out of consideration.

White have recently proved, so far as botanical evidence goes, that the upper part of the Upper Barrens are of Permian age. Therefore we may take for granted that the central belts of the deeper anthracite basins are composed of Permian measures and greater still of a (present) thickness. Professor Cope has lately found zoological evidence of an area of Permian rocks overlying Coal measures on the borders of Indiana and Illinois; and many years ago Messrs. Meck and Worthen determined the Permian character of the upper Coal measures in Kansas.

A disposition indeed has been manifested by geologists to consider these areas of Permian as local deposits in isolated water areas. But there is just as good reason, to say the least of it, for considering them residual patches of a deposit once universal over the whole area of the Carboniferous, but now isolated from each other by the extensive areas of erosion.

If this view be taken, then, the next question arises: Did the Permian deposition obey the general law of all our non-coal bearing formations thinning from the Atlantic coast westward? If it did, we will have to imagine the top covering of the Coal Measures very thick in Eastern Pennsylvania (over the Anthracite), thinner in Western Pennsylvania (over the Bituminous) and thinnest in the far west.

In such case our coal beds will appear to have been subjected to more earth-heat in the east, and to less earth-heat in the west; and their carbon ratio (so far as *this* cause can be supposed to operate) will be presumably higher in the east and lower in the west; as it undoubtedly is.*

The second suggestion respecting the relationship of Bituminous to Anthracite coal comes from Dr. T. Sterry Hunt, who supposes that it depends on more or less *original oxidation* of the vegetable substance; and he refers to the fact mentioned by J. W. Dawson, Principal of McGill College, Montreal, that he found the bark of standing trees in the Coal measures of the eastern provinces of Canada turned to pure Anthracite, which must of course be due to oxidation.

But why should the coal beds of the Anthracite basins be more oxidized than those of the Bituminous fields? I suggest this answer:—The undisturbed western coal measures consist largely of clay strata; those of the eastern coal measures consist in a much larger proportion of sand and gravel strata. This would favor the superior oxidation of the latter.

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* As in the above paragraphs I wish merely to state the problem in a new aspect, it would be unwise to go into a discussion of the structural relationships of the Mesozoic (Permian, Trias, Jura or whatever it is) to our Coal Measures. The Mesozoic, dipping—with a few insignificant anticlinals and but few (as yet) recognized faults—all one way, northwestward, against the Palæozoic, seem to have an enormous thickness—at least 20,000 feet, and perhaps much more, for they have never been properly measured. In the Connecticut Valley, and in the Richmond, Releigh, Egypt belt, they dip the other way, southeastward. A central graud anticlinal uprise has undoubtedly produced both dips. If they are really 20,000 feet thick, then they must have formed (after upheaval) a range of mountains four or five miles high, of which the Philadelphia-Baltimore belt is the only relic. This at first view incredible erosion becomes easily credible when one glances at the Kishicoquilis or Nittany Valleys in Middle Pennsylvania, from over which 27,000 feet of *conformable* Carboniferous, Devonian and Silurian strata have been eroded, as I have shown in my preface to Report of Progress F, page xiii, et seq., 1878. There is no knowing how much of the lower part of the Mesozoic, if any, is Permian; nor when the uprise of the Appalacians took place; nor why the northwest dip is against the Silurian; nor whether the Permian, now confined to the belt of Middle New Jersey and Southeastern Pennsylvania, was laterally connected with the Permian over the top coals at Pottsville, Wilkesbarre, in Greene county, Indiana and Kansas. All these are side questions at present under discussion.

Secondly, the *undisturbed* clays of the west lute down and almost hermetically seal the coals of the underground; but the *disturbed* semi-metamorphised and cracked up clay slates of the east expose their coals, to the very bottom of the series, to percolation, evaporation, and oxidation. This is returning to the theory of the brothers Rogers.

Now if we combine the foregoing suggestions and consider how the bituminous *geographical conditions* differ from the anthracite *geographical conditions*, we find that they differ

1. In a heavier covering of Permian over the east, raising the earth-heat of the Anthracite beds;

2. In a greater constitutional looseness of the whole pile of deposits in the east, facilitating percolation and oxidation; and

3. In a universal fracturing of the whole pile at the east, facilitating the exit of the volatile hydrocarbons.

And if the first of these suggestions be applied to the anomaly that the Belgian disturbed fields are bituminous and not anthracite, while the undisturbed Arkansas field is anthracite and not bituminous, the anomaly disappears. The Belgian fields have not had covering enough to raise the ratio of earth heat; and the Arkansas field has been completely exposed in a region of hot springs so as to have had a high earth heat at the surface.

There still remains the factor of pressure; and it seems incredible that the Arkansas anthracite should have been made *not* under pressure.

There remains also the factor of plant species variation.

My object however is not to formulate any hypothesis, but to present the problem in a somewhat new light, for the consideration of the members of the Surveying Corps and others interested in its solution.

Philadelphia, May 14, 1879.

Note by A. S. McCreath.

In the foregoing discussion of fuel ratios, it has been assumed, evidently for the sake of simplifying the argument, that all the Volatile Matter is Volatile Hydro-carbon. In coking, part of the Sulphur is indeed volatilized; but this Volatile Sulphur should be subtracted from the "Volatile Hydro-carbon" percentage and added to that of the Fixed Carbon.

I have thought it worth while to calculate a few of the fuel-ratios on this basis to compare the results with those given above. In most cases the difference is not very appreciable, but in some cases it is sufficient to require the whole series to be recast.

Fuel-ratios.

Old.	*New.*	*Differences.*	*Sulp. in "Vol. Mat."*
.91	.96	.05	1.130
1.02	1.18	.16	3.044
1.17	1.27	.10	1.765
1.37	1.50	.13	.843
1.40	1.42	.02	.375
1.41	1.44	.03	.464
1.45	1.48	.03	.373
1.48	1.53	.05	.684
1.50	1.52	.02	.282
1.52	1.55	.03	.530

1.53	1.61	.08	1.000
1.58	1.66	.08	.952
1.66	1.69	.03	.435
1.98	2.00	.02	.272
2.44	2.54	.10	.780
2.70	2.92	.22	1.343
3.06	3.64	.58	2.481
3.12	3.16	.04	.199
3.40	3.47	.07	.573
3.77	3.79	.02	.100
3.88	3.90	.02	.086
4.13	4.19	.06	.211
4.24	4.53	.29	.908
4.51	4.89	.38	1.006
4.51	4.81	.30	.807

HARRISBURG, *May 23, 1879.*

CHAPTER II.

A. Clay Ironstone, or Carbonate Ore.

Analyses of Iron Ores.

§ 33. *Carbonate ores of the Upper Barren Measures, (partly Permian.)*

There is scarcely a farm in Greene and Washington counties on which nodules of carbonate of iron are not plowed up. The ore balls have been set free from the shales by the action of the air and frost; and there is hardly a stratum of shale or sandstone in the Barren Measures through which they are not disseminated; but no continuous beds are known to exist. (See K, p. 386.)

There is a local deposit of ore in the shales overlying the roof shales of the Upper Washington Limestone (No. VI of Stevenson's section to page 45, K) in Centre township, Greene county, near the head waters of Pursley Creek. (See K, p. 385.) The area is two miles long and the amount of ore large; the ore is full of phosphorus, but otherwise good. This horizon of ore is about eight hundred feet over the Pittsburgh Coal bed. It was carefully examined all over the two counties; but yielded no ore elsewhere.

Below Limestone No. V, (of Stevenson's section to page 45, K,) at many localities in Greene county, a good deal of ore occurs, (K. 385;) but the ore is rendered worthless by the large percentage of phosphorus.

Under the Washington Lower Limestone and on the Washington Coal bed in Fayette county, at A. Struble's, in German township, is a considerable deposit of lean ball ore. (KK., pp. 27, 245.)

Immediately above the Little Washington Coal bed in Greene county (five hundred and twenty feet above the Pittsburgh Coal bed) a little ore occurs in black shale, and a specimen was analysed. (K., p. 384.) On Smith's creek, near Waynesburg, a moderate amount of ore was found also immediately above this coal bed.

In the body of the Waynesburg Coal bed (three hundred and seventy feet above the Pittsburgh Coal) are five feet of shales holding ball ore loosely scattered. (KK, pp. 33, 228.)

Under the Waynesburg Coal bed in Greene county, the shales contain very moderate quantities of ball ore. (K, p. 384.) Some of it was once dug, at various points in Morgan township, for the old Clarksville furnace. This ore horizon seems persistent.

The following analyses will represent the character of the ores mentioned above:

Greene County.

	(*170*) *Hoge.*	(*167*) *Knight.*	(*169*) *Smith's.*	(*163*) *Smith's.*
Iron,	36.000	30.400	37.400	22.000
Sulphur,	.047	.281	.278	.356
Phosphorus,	.606	1.405	.285	.218
Insoluble residue,	5.520	12.110	9.950	14.350

(*170*) *J. Hoge's iron ore,* four miles from Rogersville, Centre township. *Ore about two hundred and fifty feet above the Washington coal bed.* See Report K, pages 152, 153. 385.

Crust hematitic; exceedingly hard and tough; color, generally bluish grey. (D. McCreath.)

(*167*) *Joshua Knight's iron ore,* near Rogersville, Centre township. *Ore two hundred and fifty feet above Washington coal bed.* See Report K, pp. 153, 385.

Crust hematitic; hard and compact; shows specks of pyrites; color, bluish grey. (D. McC.)

(*169*) *Smith's Creek iron ore,* near Waynesburg, Franklin township. *Ore three feet above Washington coal.* See K, page 384.

Compact; brittle; bluish grey. Fracture conchoidal, showing specks of pyrites. (D. McC.)

(*163*) *Smith's Creek iron ore,* near Waynesburg, Franklin township.

Hard, brittle, bluish grey; showing specks of pyrites. (D. McC.)

Greene County.	(168) *Smith's Creek.*
Protoxide of iron,	29.540
Sesquioxide of iron,	.714
Bisulphide of iron,	.375
Protoxide of manganese,	.325
Alumina,	1.685
Lime,	1.360
Magnesia,	.810
Sulphuric acid,	.040
Phosphoric acid,	.430
Carbonic acid,	19.895
Water,	.510
Carbonaceous matter,	19.870
Insoluble residue,	24.760
	100.314
Metallic iron,	23.650
Sulphur,	.216
Phosphorus,	.188

(*168*) *Smith's Creek iron ore*, two miles from Waynesburg, Franklin township. *Ore occurs in the black shale representing the Little Washington coal.* See K, page 384.

Comparatively soft; structure laminated; color, bluish black. The large percentage of carbonaceous matter in this ore is an interesting feature; but the amount of insoluble silicious matter detracts from its value.

Fayette County.	(557) *Struble.*	
Carbonate of iron,	10.564	=5.10 per cent. iron.
Carbonate of manganese,	.749	
Alumina,	2.578	
Carbonate of lime,	61.132	
Carbonate of magnesia,	1.459	
Sulphuric acid,	.867	=.347 per cent. sulphur.
Phosphoric acid,	.066	=.029 per cent. phosphorus.
Carbonaceous matter,	.370	
Insoluble residue,	21.405	
Water and loss,	.810	
	100.000	

(*557*) *A. Struble's ore*, three miles north of Masontown, German township. *Ore immediately above the Washington coal.* See KK, p. 27.

Hard and tough; irregularly seamed with calcite. Color, bluish grey and pearl grey. Properly speaking, this is simply a ferriferous limestone.

§ 34. *Carbonate ores of the Pittsburgh Coal horizon.*

Under the Pittsburgh coal bed (from four to six feet) occurs, in Southern Fayette county, an important deposit of ore formerly supposed to be confined to the Connellsville-Uniontown basin, but recently found along the Monongahela river in the trough next west, sinking below water level near Gray's distillery, above the mouth of Dunkard's creek. See K, pp. 304, 383.

In Washington and Allegheny counties no traces of this ore have been found. K, p. 384. But in Fayette county, on the contrary, it is a most important horizon of ore on which a number of furnaces have been and still are running with great success. Under the name of "The Pittsburgh Iron Ore Group," with its various beds of Blue Lump, Condemned Flag, Big Bottom, Red Flag, and Yellow Flag ores, at Oliphant's, Springfield, and Lemont furnaces; at Fairchance, Monroe, Frost's Station, New Geneva, Braddock's, on Scott's run, Cat's run, &c., &c., it is fully described in Report KK, on pages 111 to 118, 149, 170 to 181, 234 to 255, and 385, to which the reader is referred. See Index of Iron Ores, KK, p. 420.

The analyses given under this section speak in sufficiently strong terms of the excellent quality of the ores. They show them to be generally very rich in iron and comparatively free from phosphorus.

Fayette County.	*(469)* *Fuller.* [*Blue Lump.*]	*(35)* *Oliphant.* [*Blue Lump.*]	*(36)* *Oliphant.* [*Big Bottom.*]
Protoxide of iron,	46.671	49.500	44.742
Sesquioxide of iron,	8.285	.700	.818
Bisulphide of iron,	.034	.020	.272
Protoxide of manganese,	1.311	1.636	1.059
Oxide of cobalt,	trace.	trace.	trace.
Alumina,	1.606	1.153	2.795
Lime.	1.740	1.859	3.119
Magnesia,	1.001	2.018	3.870
Sulphuric acid,	.057	trace.	trace.
Phosphoric acid,	.161	.204	.096
Carbonic acid,	31.790	34.900	34.450
Water,	1.727	1.395	1.090
Carbonaceous matter,	1.040	.730	.640
Insoluble residue,	4.415	5.790	7.450
	99.838	99.905	100.401

Metallic iron,	42.116	89.000	35.500
Metallic manganese,	1.016	1.267	.820
Sulphur,	.041	.011	.145
Phosphorus,	.070	.089	.042

(*469*) *Dr. Fuller's Mines*, about three miles south-east of Uniontown, in South Union township. *Blue Lump ore.* See Report KK, p. 114.

Generally compact; minutely crystalline. Irregularly seamed with brown oxide of iron. Color, bluish grey.

(*35*) *Oliphant Furnace Mines*, in Georges township. *Blue Lump ore.* See Report L, p. 99; also KK, p. 114.

Exceedingly hard and compact; minutely crystalline; color, bluish grey; fracture, conchoidal.

(*36*) *Oliphant Furnace Mines*, in Georges township. *Big Bottom ore.* See Report L, p. 99; also KK, p. 114.

Hard and compact, with thin seams of brown oxide of iron. Fracture, conchoidal; color, bluish grey.

Fayette County.	(*37*) *Oliphant.* [*Condemned Flag.*]	(*38*) *Oliphant.* [*Red Flag.*]	(*39*) *Oliphant.* [*Yellow Flag.*]
Iron,	37.500	35.800	35.400
Sulphur,	.041	.047	.319
Phosphorus,	.505	.083	.069
Insoluble residue,	5.670	9.560	10.450

(*37*) *Oliphant Furnace mines*, in Georges township. *Condemned Flag ore.* See Report L., p. 100; also KK, p. 111.

Compact and fine grained; color blue; fracture sub-conchoidal.

(*38*) *Oliphant Furnace mines*, in Georges township. *Red Flag ore.* KK, p. 115.

Compact, fine grained, reddish grey.

(*39*) *Oliphant Furnace mines*, in Georges township. *Yellow Flag ore.* KK, p. 115.

Crust hematitic; structure, flaggy; color, yellowish brown; on fresh fracture, bluish grey.

Fayette County.	(732a)	(732b)	(732c)	(552)
		Lemont coal ores.		
	[*Upper Layer.*]	[*Middle Layer.*]	[*Lower Layer.*]	
Iron, ...	31.000	37.500	38.150	29.200
Manganese, . .	1.030	.691	.691	.612
Sulphur, .	.932	.512	.342	.415
Phosphorus, . . .	.151	.123	.121	.268
Lime, ...	4.680	3.530	3.860	3.380
Magnesia, . . .	5.405	3.459	2.828	3.012
Insoluble residue, .	8.855	4.735	3.360	19.240
Metallic iron in roasted ore, ...	47.880	56.020	57.220	

(732a) *Lemont Furnace mines*, three miles north-east of Uniontown. *Ore immediately under the Pittsburgh coal bed. Upper layer.* See Report KK, p. 116; also Report KKK, p. 228.

Comparatively soft and crumbling; structure, laminated; color, greyish black. Specimen shows numerous small rounded pebbles consisting of the carbonates of iron, lime, and magnesia. Has the general appearance of a dried mud.

(732b) *Lemont Furnace mines;* Pittsburgh coal ore. *Middle layer.*

Rather hard and tough; irregularly seamed with calc spar; contains small pits of white, pulverulent silicate of alumina. Fracture slightly conchoidal, inclining to rough; color, dark bluish grey.

(732c) *Lemont Furnace mines;* Pittsburgh coal ore. *Lower layer.*

Rather hard and tough, with irregular fracture and bluish black color. Irregularly seamed with carbonate of lime and white, pulverulent silicate of alumina.

(552) *Lemont Furnace mines*, three miles north-east of Uniontown. Pittsburgh coal ore. *Upper, middle, and lower layers, with a silicious layer, which is always rejected in mining.*

By an error in labeling, these samples were analyzed as one. The analysis is merely given to show the utterly worthless character of the silicious layer. Analyzed by D. McC. See report KK, p. 116; also Report KKK, p. 228.

Fayette County.

	(553) Lemont. [Calcined coal ore.]
Iron,	54.800
Sulphur,	1.650
Phosphorus,	.174
Insoluble residue,	7.920

(*553*) *Lemont Furnace mines*, three miles north-east of Uniontown. *Calcined Pittsburgh coal ore.* (Analyzed by D. McCreath.) See analyses Nos. (*732a*,) (*732b*,) (*732c*.)

The percentage of sulphur shown in the above analysis is much greater than was to be expected, judging from the raw ores. Duplicate determinations were made by myself, as follows: Sulphur, 1.652 per cent.; phorphorus, .171 per cent.

Fayette County.

	(700a)	(701a)	(702a)
	Hoggsett, Watt & Co.'s Mines.		
	[Upper layer.]	[Middle layer.]	[Lower layer.]
Iron,	3.661	2.809	20.856
Sulphur,	1.592	.970	.407
Phosphorus,	.128	.178	.360
Carbonate of lime,	80.714	80.893	36.893
Carbonate of magnesia,	2.421	2.171	4.578
Alumina,	.920	.802	1.920
Insoluble residue,	7.420	9.200	10.640

(*700a*) *Messrs. Hoggsett, Watt & Co.'s mines*, at Braddock's Station. *Ore under the Pittsburgh coal. Upper layer; first specimen.* See also analyses Nos. (700b,) (701b,) (702b.)

Exceedingly hard and brittle, with irregular fracture and bluish black color. Shows considerable iron pyrites.

(*701a*) *Hoggsett, Watt & Co.'s mines; middle layer; first specimen.*

Compact and brittle; fracture conchoidal; color bluish black.

(*702a*) *Hoggsett, Watt & Co.'s mines; lower layer; first specimen.*

Compact; tough; dark blue, spotted with pyrites.

Fayette County.	(700b)	(701b)	(702b)
	Hoggsett, Watt & Co.'s Mines.		
	[*Upper layer.*]	[*Middle layer.*]	[*Lower layer.*]
Iron,	29.000	33.900	28.800
Sulphur,	.603	.473	.492
Phosphorus,	.208	.112	.135
Carbonate of lime,	14.875	11.803	18.035
Carbonate of magnesia,	6.485	4.691	4.601
Insoluble residue,	9.540	5.540	10.030

(*700b*) *Hoggsett, Watt & Co.'s mines*, at Braddock's Station. *Ore under the Pittsburgh coal; upper layer; second specimen, obtained at one thousand one hundred feet from the outcrop.* See KKK, p. 229.

Exceedingly hard and tough, with irregular fracture and greyish black color. Spotted with pyrites; shows considerable calcareous matter.

(*701b*) *Hoggsett, Watt & Co.'s mines; middle layer; second specimen obtained at one thousand one hundred feet from the outcrop.*

Exceedingly hard and tough; irregularly seamed with white crystalline carbonate of lime. Fracture conchoidal; color greyish black and bluish black.

(*702b*) *Hoggsett, Watt & Co.'s mines*; *lower layer*; *second specimen obtained at one thousand one hundred feet from the outcrop.*

Hard and tough, with irregular fracture and greyish black and bluish black color.

Fayette County.	(558)	
	Crow.	
Carbonate of iron,	24.860	=12 per cent. iron.
Carbonate of manganese,	.599	
Alumina,	2.092	
Carbonate of lime,	43.250	
Carbonate of magnesia,	6.228	
Sulphur,	.199	=.199 per cent. sulphur.
Phosphorus,	.114	=.114 per cent. phosphorus.
Carbonaceous matter,	1.150	
Insoluble residue,	20.500	
Undetermined matter,	1.008	
	100.000	

(*558*) *Judge Crow's ore opening*, near New Geneva on

River bluff; *ore four feet below Pittsburgh coal. Outcrop specimen.* See KK, p. 112.

Exceedingly hard and tough; bluish grey. Shows considerable calcareous matter.

Fayette County.	*(193)* *Crow.*
Iron,	33.350
Sulphur,	.155
Phosphorus,	.072
Insoluble residue,	13.860

(*193*) *Judge Crow's ore opening*, near New Geneva on River bluff. *Ore four feet below Pittsburgh coal. Specimen from a trial pit, sunk at the end of a coal tunnel seven hundred feet long.* See KK, pp. 112, 113.

Exceedingly hard and tough; bluish grey.

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§ *35. Carbonate Ores over the Mahoning Sandstone.*

There are numerous ball-ore-bearing shales in the (Lower) Barren Measures, between the Pittsburgh coal bed and the Freeport Upper Coal.

In the country between the Chestnut Ridge and the Monongahela river, ores show themselves at many places in the three hundred foot interval between the Pittsburgh coal and the Green Crinoidal Limestone, but only in one place, (below New Geneva, one hundred and fifteen feet beneath the Pittsburgh bed,) as likely to be valuable. See KK, p. 119.

Over the Morgantown Sandstone, and one hundred and fifty-five feet beneath the Pittsburgh coal bed, a stratum of calcareous ore from one and a half to three feet thick, was once extensively stripped for the old Hermitage Furnace, in Ligonier township, Westmoreland county. (KKK, pp. 140, 141.)

Connected with the Elk Lick coal and limestone at Elk Lick Falls, Somerset county, is an excellent local deposit of carbonate ore, in three benches, twenty inches of ore in four feet of interval, more than two hundred feet below the Pittsburgh coal. (HHH, p. 70.)

In Greene county also there are some low grade ores about two hundred feet beneath the Pittsburgh coal.

A very fair ore occurs about three hundred and twenty-five feet beneath the Pittsburgh coal, below the mouth of Cheat river. (K, p. 384.) This is about the middle of the Barren Measures, near the Green Crinoidal Limestone.

Under the Green Crinoidal Limestone ball ore is abundant, in Hampton township, Allegheny county. (Q, p. 160.)

Between the Green Crinoidal Limestone and the Mahoning Sandstone are several horizons of ball ore in the country between Chestnut Ridge and the Monongahela river, one of which lying higher than the Mahoning Sandstone or Johnstown ore is—

The Snake-den Ore on Georges creek, a fair looking carbonate, eight to fourteen inches thick and once extensively mined for Springfield furnace. (See KK, pp. 119, 120.) It has been stripped along Cove run, N. Union township, Fayette county, for Lemont furnace.

About four hundred feet below the Pittsburg coal theoretically, or two hundred and twenty feet above the Freeport Upper coal actually, lies the Black Lick ore, (described in HHHH, pp. 99, 102 to 106, 114,) once mined for Black Lick and Buena Vista furnaces in eastern Indiana county. It lies just underneath the Black Fossil Limestone, which itself becomes a lean and poor iron ore along the eastern edge of the Ligonier valley, north from the Loyalhanna, and was mined for Laurel Run furnace, and old Washington furnace. (KKK, pp. 214, 215.)

This ore may be represented in Cambria county by the siliceous ore bed one hundred and fifty feet above the Johnstown ore bed (two hundred feet above the Freeport Upper coal, see HH, p. 112.)

In the Pine Creek Limestone, four hundred and fifty feet below the Pittsburgh coal, ore occurs in East Deer and Indiana townships, Allegheny county. (Q, pp. 149, 154.)

In the Brush Creek Limestone, five hundred and ten feet below the Pittsburgh coal, ore occurs on Davis run, Economy township, Beaver county, (Q, pp. 34, 183.) This may correspond to the Johnstown ore horizon of Cambria county.

The following analyses will represent the character of some of the ores mentioned above:

Westmoreland County.	(739) *Graham.*
Iron,	28.800
Sulphur,	.156
Phosphorus,	1.765
Insoluble residue,	6.400

(*739*) *R. M. C. Graham's ore opening*, near Oak Grove furnace, three miles north from Ligonier. *One hundred and fifty feet below Pittsburgh coal.*

Considerably oxidized throughout; carries considerable calcareous matter; breaks with irregular fracture, and has a bluish grey color on fresh surface.

Fayette County.	(547) *Georges Creek.*	(520) *New Geneva.*
Iron,	11.600	30.200
Sulphur,	.201	.001
Phosphorus,	.101	.192
Insoluble residue,	62.080	17.120

(*547*) *Ore opening on Georges Creek*, three miles east of New Geneva; near Crow's mill. "Snake-den Ore."

Very sandy; greenish grey, with specks of pyrites. (D. McC.)

(*520*) Ore opening near new Geneva, on river bluff, *one hundred and fifteen feet below the Pittsburgh coal.*

Hard, compact, bluish grey. (D. McC.)

Fayette County.	(548) *New Geneva.*	
Protoxide of iron,	4.628=	3.600 per cent. iron.
Protoxide of manganese,	.371=	.288 per cent. manganese.
Alumina,	3.660	
Lime,	37.829	
Magnesia,	1.365	
Sulphuric acid,	.292=	.117 per cent. sulphur.
Phosphoric acid,	.206=	.090 per cent. phosphorus.
Carbonic acid,	30.990	
Water,	1.620	
Insoluble residue,	19.295	
	100.256	

(*548*) *Near New Geneva*, on river bluff; *ninety feet below Pittsburgh coal.* See Report KK, pp. 118, 119.

Silicious; rather fine grained; pearl grey. (D. McC.)

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§ *36. Johnstown Ore Bed.*

The Johnstown ore lies in the lower rocks of the Barren Measures, and is an extensive ore horizon of Western Pennsylvania. It is minutely described in HH (pp. 118, 119, with analyses,) and its place among the members of the great Mahoning Sandstone group is indicated in Fig. 54, p. 111, where it is represented as two feet thick, as mined extensively by the Cambria Iron Company, in the hills around Johnstown, east of the Conemaugh river.

It overlies the Freeport Upper Coal about fifty-two feet, as measured by Mr. Fulton (HH, 112,) and is therefore to be placed between the lower and middle members of the Mahoning Sandstone.

The Lamoreaux ore on Black Creek, (HH, p. 163,) in the Armagh Valley, may be the same bed; but it was rather identified by Mr. Platt with the Ritter Furnace bed just overlying the Freeport Upper Coal (HH, 161, section p. 162.)

In Somerset County the Johnstown ore is recognized on Castleman's river, (HHH, pp. 185, 186,) resting on the upper of two members of the Mahoning Sandstone, but only in nodules. It was worked once for Ben's Creek furnace along Mill Creek (HHH, p. 216.) Scarcely a trace of it is to be found around Ursina.

In the Ligonier Valley the Johnstown ore may be recognized perhaps in a bastard limestone over the Mahoning Sandstone in Salt Lick township, Fayette County, (KKK, p. 116); as a lean black shale ore *in* the Mahoning Sandstone, in Fairfield township, Westmoreland county (KKK, p. 163); as a ferriferous shale, thirty-five feet above the Freeport Upper Coal, in St. Clair township (KKK, p. 175); and generally as a calcareous horizon *in* the Mahoning Sandstone along the east flank of Chestnut Ridge and *on top* of it west of Chestnut Ridge, (allowing for the absence or presence of one or other member of the Sandstone;) like the Stewart ore near Meadow run, the Springfield mines ore on the Youghiogheny; the Weaver ore north from Falls city; the rich, good ore on the Clay pike in Mount Pleasant township, Westmoreland county; or as a dark ferruginous shale along the base of Laurel Hill, like that once mined for Laurel Hill and Ross furnaces, always lean and unaccompanied by limestone. (KKK, p. 215.)

It was mined for Mount Pleasant Furnace on Jacob's creek, and also below the mouth of Indian Creek.

The Johnstown calcareous ore lies directly on the Mahoning Sandstone in the region south of the Youghiogheny river and west of Chestnut Ridge. It is the Fairchance ore. (KK, p. 149.) On Cove run it is called the "Limestone Ore," two feet thick; and it is two and a half feet thick at Beattie's in N. Union township. (KK, p. 120.) On Redstone it is in four layers in five feet of clay. It seems to be Hardman's four foot ore bed in Preston county, W. Virginia (See KK, p. 121); and the Haines' ore of Pride Vale furnace; and it seems to extend far south of the Baltimore and Ohio railroad. (See also KK, pp. 138; 165; 172; 186; 265; 318.)

In Indiana county, the Johnstown ore is recognized one hundred feet above the Freeport Upper coal, in Fry's Hill section on Rayne's run a few miles from Marion, Indiana county (See HHHH, p. 257); and perhaps in the form of a ferruginous limestone at Five Points, on Plum creek, Indiana county. See HHHH, p. 280.

A regular and presistent bed of carbonate ore exists on Mill creek, Cambria county, and worked extensively for Schoenberger's furnaces on Mill and Ben's creeks. It is doubtless the Johnstown ore bed. (HH, 132.)

Specimens representing the Johnstown ore have been analysed from Cambria, Fayette, Westmoreland and Indiana counties. The amount of iron varies from 11.10 to 35.93 per cent. The average character of the ore is shown by the following analyses:

Cambria County.

	I. Cambria Iron Co.'s mines.
Silica,	4.885
Alumina,	1.552
Carbonate of iron,	52.330
Sesquioxide of iron,	15.230
Carbonate of lime,	15.285
Carbonate of magnesia,	9.390
Phosphoric acid,	.530
Sulphur,	.850
Metallic iron,	35.93

I. Cambria Iron Co.'s mines, at Johnstown. Analysis made by Mr. T. T. Morrell, and published in Report HH, page 118.

	Calcined Ore.	
	Upper bench. II.	Lower bench. III.
Peroxide of iron,	77.64	45.68
Silica,	7.34	21.94
Alumina,	1.02	4.02
Sesquioxide of manganese,	1.39	.86
Lime,	10.10	19.94
Magnesia,	1.01	6.35
Phosphoric acid,	.99	.53
Sulphuric acid,	.52	.33
	100.01	99.83
Metallic iron,	54.350	32.110
Phosphorus,	.424	.232
Sulphur,	.210	.133

II. Cambria Iron Co's mines, at Johnstown. *Upper bench; calcined ore.* Analysis made by T. T. Morrell.

III. Cambria Iron Co.'s mines, at Johnstown. *Lower bench; calcined ore.* (T. T. Morrell.)

Cambria County.

	(79) Cambria Iron Co.
Iron,	24.150
Sulphur,	.057
Phosphorus,	.802
Carbonate of lime,	8.726
Carbonate of magnesia,	7.868
Insoluble residue,	20.090

(79) *Cambria Iron Co.'s ore opening*, on Mill creek, Yoder township. See Report HH, pp. 131, 132.

Compact; rather coarse grained: sandy, ; bluish grey. (D. McC.)

Fayette County.

	(554) *Lemont.*	(40) *Simmons.*
Iron,	18.000	11.100
Manganese,	.450	——
Sulphur,	.026	.313
Phosphorus,	.261	.018
Carbonate of lime	30.995	43.285
Carbonate of magnesia,	7.022	2.747
Insoluble residue,	18.190	26.090

(*554*) *Lemont Furnace mines*, three miles north-east from Uniontown. "*Limestone ore.*" See KK, p. 121.

Hard and tough, with conchoidal fracture and pearl grey color. (D. McCreath.)

(*40*) *Mr. Simmons' ore opening*, on Redstone creek, South Union township. "*Limestone ore*" *used at Oliphant furnace.* See report KK, p. 121.

Compact; bluish grey; shows considerable pyrites.

Westmoreland County.

	(544) *Stairs.*	(545) *Freeman.*
Iron,	32.200	27.600
Sulphur,	.040	.038
Phosphorus,	.123	.155
Insoluble residue,	24.169	23.160

(*544*) *Jacob F. Stairs' ore opening*, Mount Pleasant township. See KK, p. 121.

Hard, compact, rather coarse grained; pearl grey. (D. McC.)

(*545*) *Geo. Freeman's ore opening*, Mount Pleasant township.

Crust hematitic; hard, compact; reddish grey. (D. McC.)

Indiana County.

	(776) *Carpenter.*
Carbonate of iron,	22.992=11.10 per cent. metallic iron.
Carbonate of lime,	25.839
Carbonate of magnesia,	3.344
Alumina,	7.183
Sulphur,	.010
Phosphorus,	.201
Insoluble residue,	38.220

(776) *S. Carpenter's ore opening*, one and a half miles west from Five Points. See HHHH, page 282.

The specimen, having the general appearance of a conglomerate mass, is exceedingly sandy and brittle, with a rough, irregular fracture and greenish grey color. It emits a strong argillaceous odor when breathed upon.

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§ *37. Carbonate Ores of the Lower Productive Coal Measures.* (*Freeport, Kittanning and Clarion Groups.*)

Over the Freeport Upper coal, a calcareous ore occurs locally in Hampton township, Allegheny county. (Q, 159.)

The irregular bed of ore, mined at Springfield in Fayette county, comes directly under the Mahoning Sandstone. It thins away to nothing northward; and southward reappears on Decker's creek in West Virginia. (KK, pp. 121, 122.)

Over the Freeport Upper coal, ore in Ferruginous shale occurs at Hooversville and at Lohr's and elsewhere on Stony creek, Somerset county. See HHH, p. 121.

Ore overlying the Freeport Upper coal (?) was extensively worked for Ritter Furnace on Black Lick, and at Lamoreaux's, in Cambria county. (HH, pp. 161, 163.)

The Freeport Upper limestone has large quantities of ore associated with it, at Brady's Bend on the Allegheny river, where it has been extensively worked. (HHHH, p. 204; and HHHHH, 1879.)

On the lower waters of Yellow creek in Indiana county, D. Griffith's bed, two feet thick, in two layers three and a half feet apart, lies under one limestone and over another. See HHHH, p. 205.

Huge lumps of handsome ball ore are scattered through the Bolivar fire-clay, under the Freeport Upper Limestone, between Cucumber and Jonathan's run, Stewart township, Fayette county, KKK, p. 89. And again, ten feet from the bottom of the thirty foot plastic clay deposit over the Freeport Lower coal bed, on Tub Mill run, Fairfield township, Westmoreland county, is a persistent stratum of them. See KKK, p. 160, section Fig. 64, p. 158.

The Freeport Upper Limestone has often been mistaken for iron ore along Jacob's creek, in Westmoreland county; and in Tyrone township, of Fayette county, it actually has a top layer of pretty fair ore, sixteen to twenty inches thick; ten inches thick on Dunbar creek; a foot thick at Springfield furnace, changing to limestone. It is known as "Coal Bank" ore on Jacob's creek. See KK, p. 122.

This is the excellent ore of Pridevale and Decker's creek, and Booth's creek, in W. Virginia.

In the Freeport Upper Limestone, some layers are a calcareous iron ore in Big Beaver township, Beaver county. (Q, p. 224.)

Under the Freeport Upper Limestone, ore occurs on Pine creek, Hampton township, Allegheny county. (Q. p. 161.)

Between the Freeport Upper and Lower coals is a persistent bed of rich ore, at Pinkerton Point on Castleman's river, Somerset county; and the same (?) appears at Castleman station. (HHH, p. 185.)

Ball ore occurs over the Freeport Lower coal on Black creek, Cambria county, at Big Bend. (Moore's.) See HH, p. 161.

On the Freeport Lower Limestone ore occurs at various places, and ore balls everywhere in the Beaver river district. (Q, pp. 49, 93, 96, 138, 187; 219; 221; 241.)

Under the Johnstown Cement bed, ten feet thick, in the Conemaugh bluffs, above the mouth of Tom's run, Indiana county, a presistent bed of carbonate, eight inches thick, has been worked. See HHHH, pp. 178 and 179, Fig. 44.

The Johnstown Cement bed under the Freeport Lower Coal, is represented at Anderson's bridge, Forward township, Butler county. (Q, 111, 112.)

The Johnstown Cement bed ore is probably represented in Fayette county by "the Furnace ore" of Jacob's creek. See KK, 123.

Under the Darlington (Kittanning Upper) Coal bed ore balls are abundant in north Allegheny, south Butler, and north Beaver counties. (Q, 117; 184; 194; 200; 222; 245; 263.)

Shales carrying carbonate ore replace the Kittanning

Upper Limestone on Laurel run, Fayette county. See KKK, p. 109, 110.

Below the Kittanning (?) coal in Fayette county, Springfield township, nests of ore replace the clay. See KK, p. 140.

Above the Kittanning Lower Coal (C) ten feet on the Conemaugh at Lockport and Bolivar, occurs a six inch (local?) bed of Carbonate ore. See HHHH, p. 65, Fig. 5.

This horizon is represented on Schlimmer's run in Western Indiana county by fifty feet of shales through which ball ore is disseminated in lumps of all sizes, and a plate of the ore reported under the fire clay of the Kittanning Upper coal (D.) See HHHH, p. 267.

Over the Clarion Coal (B) on Simpson's creek, in Indiana county, ball and plate ore occur, but not workable. See HHHH, p. 191.

A persistent outcrop of carbonate ore over the Clarion Coal, but of unknown value, occurs along Fallen Timber run, Cambria county. (HH, p. 82.)

Between the Clarion and Brookville beds (A and B) occurs the persistent Carbonate ore bed of Hooversville, Somerset county, opened at Clark's, in two bands, two feet thick, and with only .3 phosphorus. See HHH, p. 120.

This is probably the same ore horizon as that at the Forks of Paint creek, Somerset county, where at least two feet of good carbonate plate and ball ore exists at water level. See HHH, p. 133, and Geol. of Penn'a, Vol. 2, p. 655. 1858.

Excellent carbonate ore in three layers occurs at Silver Diggings, in Well's creek, Somerset county, at some undetermined horizon (low?) in the Lower Productive Coal measures. (HHH, p. 18, plate 2.)

Below the Clarion coal, twenty feet, ball ore is very abundant throughout six feet of shale at Lloydsville, Cambria county. (HH, 87.)

Immense balls of carbonate ore, in shales, between the Clarion and Brookville coals, occur on Levi run, Cambria (county. HH, 91, 92.)

A lean silicious ore is found between the Clarion and

Brookville coals on Moore's hill, on Black creek, Cambria county. HH, p. 160.

Over the Brookville coal ball ore is abundant at New Brighton, Beaver county. Q, p. 250.

Lawrence County.

	(758) *Jones & Houk.*
Iron,	40.250
Manganese,	.533
Sulphur,	.079
Phosphorus,	.234
Lime,	3.980
Magnesia,	1.708
Insoluble residue,	2.810

(*758*) *Jones & Houk's ore opening*, four miles north-east from Chewton, Wayne township. *At the horizon of the Ferriferous Limestone.*

Coarse grained, globular; full of drussy cavities and small pits filled with white pulverulent silicate of alumina; color, generally brownish grey.

Butler County.

	(556) *Winfield Furnace.*	
Protoxide of iron,	34.200	=34.50 per cent. of iron.
Sesquioxide of iron,	11.285	
Alumina,	4.326	
Lime,	4.720	
Magnesia,	2.854	
Sulphuric acid,	.120	=.048 per cent. sulphur.
Phosphoric acid,	.849	=.371 per cent. phosphorus.
Carbonic acid,	28.670	
Water,	2.500	
Insoluble residue,	10.765	
	100.289	

(*556*) *Iron ore opening near Denny's mill*, one and a half miles west from Old Winfield furnace, Winfield township. *Ore 60′ to 70′ below the Freeport Upper coal.* See Report Q, p. 92.

Carbonate ore, considerably oxidized; reddish brown. (D. McCreath.)

Armstrong County.

	(966) Brown & Musgrove.	(965) Pine Creek.
Protoxide of iron,	41.400	46.285
Sesquioxide of iron,	2.000	1.428
Bisulphide of iron,	.041	.118
Protoxide of manganese,	1.896	1.655
Oxide of cobalt,	trace.	trace.
Alumina,	1.184	.823
Lime,	8.920	7.080
Magnesia,	1.801	1.484
Sulphuric acid,	trace.	trace.
Phosphoric acid,	.346	.600
Carbonic acid,	34.208	35.358
Insoluble residue,	6.430	3.150
Water and carbonaceous matter,	1.774	2.019
	100.000	100.000
Metallic iron,	33.620	37.050
Metallic manganese,	1.469	1.282
Sulphur,	.022	.063
Phosphorus,	.151	.262

(*966*) *Brown & Musgrove's ore opening* at Slabtown, on North Fork of Pine Creek, four miles southeast of Templeton. *Buhrstone iron ore.*

Somewhat oxidized; fine grained. Color, bluish grey to reddish brown; fracture, irregular.

(*965*) *Pine Creek Furnace ore opening*, six miles northeast of Kittanning. *Buhrstone iron ore.*

Somewhat oxidized; fine grained. Color, bluish grey to reddish brown; fracture, irregular, rough.

Indiana County.

	(777) Griffith.
Carbonate of iron,	59.278=28.60 per cent iron.
Carbonate of lime,	16.607
Carbonate of magnesia,	7.113
Alumina,	3.273
Sulphur,	.066
Phosphorus,	.051
Insoluble residue,	11.600

(*777*) *D. R. Griffith's ore opening* one and a half miles north northeast from Homer. *Iron ore underlying the Freeport Limestone.*

Compact, fine grained, brittle, bluish grey; with sub-conchoidal fracture.

Westmoreland County.

	(58) "*Furnace Ore.*"
Protoxide of iron,	51.271
Sesquioxide of iron,	.943
Bisulphide of iron,	.515
Protoxide of manganese,	2.352
Alumina,	2.050
Lime,	1.344
Magnesia,	.814
Sulphuric acid,	.007
Phosphoric acid,	.537
Carbonic acid,	33.980
Water,	.910
Carbonaceous matter,	.710
Insoluble residue,	5.120
	100.553
Metallic iron,	40.750
Metallic manganese,	1.822
Sulphur,	.278
Phosphorus,	.229

(*58*) "*Furnace Ore*" *on Jacob's creek*, Mount Pleasant township, two and a half miles south-east of Jacob's Creek station. See Report L, p. 105; also, Report KK, p. 123.

Compact, somewhat flaggy; irregularly seamed with white crystalline carbonate of lime; *exceedingly brittle;* bluish grey.

	(*49*) *Forge.*	(*50*) *Coal Bank.*	(*53*) *Bridge.*	(*54*) *Barren Run.*
Iron,	28.300	26.500	27.700	11.700
Sulphur,	.079	.090	.160	.075
Phosphorus,	.137	.046	.679	1.245
Carbonate of lime,	13.680	23.120	7.640	56.353
Carbonate of magnesia,	7.870	5.600	4.517	4.994
Insoluble residue,	13.885	13.810	25.240	10.920

(*49*) "*Forge Ore*" *on Jacob's creek*, two and a half miles south-east from Jacob's Creek station. See Report L, p. 106.

Compact, bluish grey, with conchoidal fracture.

(*50*) "*Coal Bank Ore*" *on Jacob's creek*, two and a half miles south-east of Jacob's Creek station, on the P. and C. R. R. See KK, p. 122.

Crust hematitic; fresh fracture bluish grey, showing considerable calcite.

(*53*) "*Bridge Ore*" *on Jacob's creek*, one and a half miles north-east from Jacob's Creek station.

Crust hematitic; bluish grey on fresh fracture; brittle; seamed with white crystalline carbonate of lime.

(*54*) "*Barren Run Ore*" *on Jacob's creek*, one mile south-east of Jacob's Creek station.

Crust hematitic; pearl grey on fresh fracture; very coarse grained.

	(737) *Washington Furnace.*
Iron,	32.500
Sulphur,	1.288
Phosphorus,	.152
Insoluble residue,	15.130

(*737*) *Iron ore opening on the Bedford pike*, near old Washington furnace, five miles east from Ligonier, Ligonier township. *About twenty-five feet above the Pottsville conglomerate.* See KKK, p. 217.

Crust hematitic, hard and tough; much spotted with pyrites; fracture, irregular; color, bluish black.

Fayette County.

	(741) *Fayette Furnace.*	(738) *Fayette Furnace.*
Iron,	33.900	38.100
Sulphur,	.333	.159
Phosphorus,	.302	.115
Insoluble residue,	18.690	9.250

(*741*) *Fayette Furnace property ore*, two miles east of Springfield, Springfield township. *Ore above the Kittanning Coal.* See Report KKK, page 216.

Hard and tough; minutely crystalline; fracture, irregular; color, light bluish grey.

(*738*) *Fayette Furnace property ore*, two miles east of Springfield, Springfield township. *Iron ore under the Kittanning Coal.* See Report KKK, page 217.

Exceeding hard and brittle; fracture, irregular; color, bluish grey.

Somerset County.

	(406) Clark.
Protoxide of iron,	44.357
Sesquioxide of iron,	2.857
Bisulphide of iron,	.247
Protoxide of manganese,	.873
Alumina,	3.220
Lime,	1.210
Magnesia,	1.690
Sulphuric acid,	.040
Phosphoric acid,	.338
Carbonic acid,	29.860
Water,	.990
Carbonaceous matter,	.930
Insoluble residue,	12.403
	99.015
Metallic iron,	36.500
Metallic manganese,	.677
Sulphur,	.148
Phosphorus,	.148

(*406*) *G. W. Clark's ore opening* at Hooversville. See Report HHH, page 120.

Carbonate ore; hard, compact, minutely crystalline, bluish grey. (D. McCreath.)

	(450) Well's Creek.
Iron,	40.700
Sulphur,	.027
Phosphorus,	.113
Insoluble residue,	10.940

(*450*) *Well's Creek ore*, ("Silver Diggings,") two miles above the mouth of Well's creek. See Report HHH, p. 18.

Crust hematitic; hard and tough; fracture, conchoidal; color, bluish grey. (D. McC.)

Cambria County.

	(81) Moore.	(420) Moore.	(82) Moore.	(417) Lamoreaux.	(80) Lamoreaux.
Iron,	23.600	14.200	13.300	23.900	24.400
Sulphur,	.035	.285	.231	.149	.036
Phosphorus,	.122	.084	.063	.199	.298
Carbonate of lime,	——	34.580	39.270	6.339	——
Carbonate of magnesia,	——	12.008	10.056	7.930	——
Insoluble residue,	37.380	21.305	18.700	30.770	34.850

(*81*) *Moore's ore opening*, on South Fork of Black Lick creek. *Ore about forty feet above Coal bed D'.* See Report HH, p. 161.

Hard, coarse, sandy, bluish grey. (D. McC.)

(*420*) *Moore's ore opening*, on South Fork of Black Lick creek. "*Ferriferous Limestone ore.*" See HH. p. 160.

Compact, sandy, brittle, bluish grey.

(*82*) *Moore's ore opening.* "*Ferriferous Limestone ore.*"

Hard, sandy, bluish grey, with conchoidal fracture. (D. McC.)

(*417*) *Lamoreaux's ore opening*, on North Fork of Black Lick creek. See Report HH, p. 163.

Hard, tough, sandy, minutely crystalline; greenish grey.

(*80*) *Lamoreaux's ore opening.*

Crust hematitic, hard, tough, silicious; bluish grey on fresh fracture. (D. McC.)

Huntingdon County.

	(*953*) *Robertsdale.*	(*954*) *Robertsdale.*
Iron,	28.775	28.075
Sulphur,	.037	.063
Phosphorus,	.541	.078
Insoluble residue,	30.430	30.710

(*953*) *Ore from old shaft* between drifts 2 and 4 at Robertsdale; Rockhill Iron and Coal Co.

Hard, compact, reddish grey. (S. S. H.)

(*954*) *Ore from same locality.* Hard, compact, dark grey. (S. S. H.)

Luzerne County.

	(*338*) *Plymouth.*
Iron,	37.400
Sulphur,	.082
Phosphorus,	.082
Carbon.	.770
Insoluble residue,	12.540

(*338*) *Iron ore below Coal Bed D*, found in shaft at Plymouth, Luzerne Co.

Carbonate ore; hard, brittle, bluish grey. (D. McC.)

§ 38. *Carbonate ores of the Pottsville Conglomerate, No. XII.*

These are best described in Prof. Stevenson's Report KK, under the head of the Mt. Savage Ore group, (See Index to KK, pp. 421, 422) because the beds have been extensively mined in southern Fayette county, under the names Stratford ore, (KK, pp. 110, 124, 196) Carr's ore, (p. 140) Jude ore, (p. 124) and Mahan ore (pp. 124, 160.)

In the upper part of the Conglomerate No. XII occur abundant deposits of ore balls and lens-shaped plates along Shade Creek near Old Shade furnace in Somerset County. (See HHH, p. 147.)

Ore of the same horizon occurs about one quarter of a mile east of Listonville in southern Somerset County. (See HHH, p. 271.)

In the Conglomerate along the Beaver waters ore is often found. (Q, pp. 225 and 69.)

In many other counties of Western Pennsylvania carbonate ball ore has been noticed at this horizon, at the base of the Coal Measures, but nowhere in quantity justifying mining operations.

Lawrence County.

	(759) Neshannock.	*(760) New Castle*
Iron,	37.250	35.200
Manganese,	.655	.807
Sulphur,	.154	.335
Phosphorus,	.145	.178
Lime,	3.020	4.120
Magnesia,	1.747	2.223
Insoluble residue,	9.790	11.190

(759) *Iron ore opening near Neshannock Falls*, Wilmington township. *From the horizon of the Mercer limestone.*

Crust hematitic; exceedingly hard and tough, with irregular fracture and reddish grey color.

(760) *Iron ore opening*, two miles north from New Castle, in Neshannock township. *From the horizon of the Mercer limestone.*

Exceedingly hard and tough, with irregular fracture and dark bluish grey color.

Somerset County.

	(416) *Liston Bros.*
Iron,	22.700
Sulphur,	.120
Phosphorus,	.098
Insoluble residue,	41.040

(*416*) *Liston Bros'. ore opening*, about one quarter of a mile east of Listonville, Addison township, Somerset county. See HHH, pp. 271, 272.

Hard, compact, bluish grey. (D. McC.)

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§ *39. Carbonate Ores of the Mauch Chunk Red Shale, No. XI.*

Everywhere throughout Pennsylvania, where the great Conglomerate exists, one or more plates of carbonate ore exist in the shales beneath it. Sometimes the shales are merely studded with balls of ore. In many places local lenticular deposits of solid greyish blue carbonate extend for hundreds of yards, or a mile or more, with a maximum thickness of three or four feet, as on the Tangascootac and Queen's run, in Clinton county. At Ralston, in Lycoming county, there are several beds which have been extensively stripped for long distances under the Conglomerate escarpment at the summit of the mountain walls of Lycoming creek. Around the Tioga mountain the bed is one foot thick. In the gaps of the Conemaugh, Loyalhanna, and Youghiogheny rivers in Westmoreland and Fayette counties, the ore appears and has been worked in certain places. It spreads in patches over the back of Laurel Hill in Somerset county, and is seen in many places along the front of the Allegheny mountain; and around Broad Top mountain in Huntingdon and Blair counties.

Sometimes the beds have been decomposed into brown hematite for a certain distance back from the outcrop. Bogs of loose limonite have formed on the terraces in front of the outcrop, some of them many acres in extent; and a few of them removed for use in furnaces.

The best description of this extensive deposit is to be found in Prof. Stevenson's Report KK, (see Index to KK,

p. 422,) where the ores are described under the names Big and Little Honeycomb; Kidney; Big Bottom of XI, and Red Belt of XI.

The analyses given under this section show the ores to be of excellent quality; generally very rich in iron and containing only a comparatively small amount of phosphorus.

Westmoreland County.

	(543) *Freeman.* [*Kidney ore.*]	(597) *Jacob's Creek.* [*Lower Big Bottom.*]	(598) *Freeman.* [*Red Belt ore.*]
Iron,	31.100	1.100	34.700
Sulphur,	.086	.035	.174
Phosphorus,	.103	240	.104
Carbonate of lime,	—	46.428	—
Carbonate of magnesia,	—	2.451	—
Alumina,	—	6.289	—
Insoluble residue,	25.960	39.275	13.750

(543) *Geo. Freeman's ore opening*, Jacob's creek, Mount Pleasant township. *Kidney ore.* See KK, p. 128.

Generally compact, with small lenticular masses of slate; pearl grey. (D. McCreath.)

(597) *Opening on Jacob's Creek*, Mt. Pleasant township. *Lower Big Bottom ore.*

Comparatively soft; argillaceous; dark grey.

(598) *John Freeman's ore opening*, Jacob's creek, Mt. Pleasant township. *Red Belt ore.*

Crust hematitic; hard and brittle, with conchoidal fracture; color generally reddish grey.

Specimen shows a small cell running through the mass, lined with pyrite partially changed into hydrous iron oxide.

Fayette County.

	(56) *Vernon Mines.* [*Pin Vein ore—Kidney (?).*]	(55) *Vernon Mines.* [*Lower Big Bottom.*]
Iron,	41.000	31.200
Sulphur,	.191	.253
Phosphorus,	.120	.129
Insoluble residue,	6.810	21.930

(56) *Vernon mines*, near old Mt. Vernon furnace, Bullskin township. *Pin Vein ore.* See KK, p. 128.

Compact, fine grained, brittle, bluish grey; shows small specks of pyrite.

(*55*) *Vernon mines*, near old Mt. Vernon furnace, Bullskin township. *Lower Big Bottom ore.* See KK, pp. 129, 131.

Structure somewhat flaggy; brittle; dark bluish grey.

	(*551*) *Lemont.* [*Big Honeycomb ore.*]	(*550*) *Lemont.* [*Lower Big Bottom.*]
Iron,	41.400	36.200
Sulphur,	.184	.107
Phosphorus,	.151	.154
Insoluble residne,	6.430	12.980

(*551*) *Lemont Furnace mines*, north-east from Uniontown, North Union township. *Big Honeycomb ore.* See KK, p. 127.

Cellular; exceedingly brittle; spotted with pyrites; generally bluish grey. (D. McCreath.)

(*550*) *Lemont Furnace mines*, north-east from Uniontown, North Union township. *Lower Big Bottom ore.* See KK, p. 131.

Brittle, rather coarse grained; bluish grey. (D. McC.)

	(*549*) *Lemont.* [*Kidney Ore.*]	
Protoxide of iron,	49.885	=38.800 per cent. iron.
Protoxide of manganese,	.799	=.619 per cent. manganese.
Alumina,	1.092	
Lime,	1.240	
Magnesia,	1.203	
Sulphuric acid,	1.020	=.408 per cent. sulphur.
Phosphoric acid,	.440	=.195 per cent. phosphorus.
Carbonic acid,	31.294	
Water,	1.575	
Carbonaceous matter,	.680	
Insoluble residue,	10.605	
	99.833	

(*549*) *Lemont Furnace Mines*, north-east of Uniontown, North Union township. *Kidney Ore.* (KK, page 129.)

Fine grained; hard and tough; fracture, conchoidal; color, generally bluish grey. (D. McCreath.)

	(730) Center Furnace. [Big Honeycomb.]	(740) Center Furnace. [Little Honeycomb.]	(731) Center Furnace. [Little Honeycomb?]
Iron,	42.300	42.500	42.500
Sulphur,	.227	.484	.153
Phosphorus,	.128	.160	.130
Insoluble residue,	9.640	5.190	7.110

(730) *Center Furnace mines*, Wharton township. *Big Honeycomb Ore.* See Report KKK, pages 218, 219, 220.

More or less oxidized throughout; color, light brown and bluish grey; fracture, irregular, rough. Shows numerous small drussy cavities.

(740) *Center Furnace mines*, Wharton township. *Little Honeycomb Ore.* See KKK, page 218.

Crust hematitic; spotted with pyrites; hard and tough. Fracture conchoidal; color, generally bluish grey on fresh surface.

(731) *Center Furnace mines*, Wharton township. *Little Honeycomb Ore?*

Crust hematitic; irregularly seamed with calcareous matter; brittle; bluish grey on fresh surface. Fracture, conchoidal.

	(57) Barchas.
Iron,	39.250
Sulphur,	087
Phosphorus,	.229
Insoluble residue,	9.880

(57) *D. Barchas' ore opening*, Henry Clay township.

Crust hematitic; fracture conchoidal, showing small crystals of calcite; color, bluish grey generally.

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§ 40. *Carbonate ores of the Siluro-Cambrian Formation, No. II.*

One theory of the origin of the limonites of our Limestone Valley derives them from intercalated beds of carbonate of iron and lime; and this view is supported by the frequent presence of rough carbonate of iron below or back of outcrop deposits of limonite in the beds of the Hamilton No. VIII, limiting the practical working of the limonite to a certain depth beyond which it does not exist.

Such carbonates have been found in the limestones of No. II on the surface of which such vast accumulations of limonite exist, as at Ironton, Trexlerville, Moselem, Pine Grove, Mt. Alto, Pennsylvania furnace, Springfield, Bloomfield, &c.

Northampton County.	*(995)* *Saucon Iron Co.*	
Protoxide of iron,	54.385	=43.050 per cent. iron.
Sesquioxide of iron,	1.071	
Protoxide of manganese,	3.254	=2.521 per cent. manganese.
Protoxide of cobalt,	.010	
Alumina,	1.457	
Lime,	.540	
Magnesia,	.540	
Sulphuric acid,	.112	=.045 per cent. sulphur.
Phosphoric acid,	.263	=.115 per cent. phosphorus.
Carbonic acid,	35.340	
Water (by difference),	.923	
Insoluble residue,	2.105	
	100.000	

(*995*) *Saucon Iron Co's Wharton mine*, two miles east of Hellertown, Northampton county.

Carbonate ore from shaft 126 feet deep. See analysis of limonite from this mine, § 13, No. 967.

Fine grained; hard and tough; fracture, conchoidal inclining to rough; color, steel grey on fresh surface.

B. Brown Hematite Ores.

§ 41. *Brown Hematite Ores of the Coal Measures.*

These occur along the outcrops of limestone beds, and sometimes replace the limestone in whole or in part.

The best known and most valuable of these deposits follow the outcrop of the Ferriferous Limestone through western Indiana, northern Armstrong, Butler, northern Beaver and Lawrence, Clarion and Jefferson counties; the limonite lying upon, or filling hollows in the limestone, sometimes to a thickness of ten or twelve feet.

Twenty years ago more than fifty charcoal furnaces were running upon this Burhstone ore, as it was called, in the region just mentioned; and there are not a few furnaces still in blast which use this ore as a mixture. It supplies many furnaces in South Eastern Ohio and once supplied nearly twenty furnaces in eastern Kentucky; although there are other limestone beds in the Lower Productive Coal Measures which carry a similar ore.

On the geological colored county maps of Western Pennsylvania a blue line marks the outcrop of the Ferriferous limestone and therefore that of the Buhrstone ore.

Sufficiently detailed descriptions of the ore may be found in Report Q (Beaver, Butler and Allegheny) pp. 60, 92, 140, 256; in Report HHHH (Indiana) p. 268; and in Reports QQ, HHHHH, and V, (Lawrence, Armstrong and north Butler counties) not yet published. But much may be learned of them from the Geology of Pennsylvania, Vol. II, 1858.

Lawrence County.

	(753) Rose Point.	*(752) Rose Point.*
Sesquioxide of iron,	79.000	76.428
Bisulphide of iron,	.056	.041
Sesquioxide of manganese,	.517	1.034
Alumina,	2.980	1.331
Lime,	.480	.710
Magnesia,	.396	.564
Sulphuric acid,	trace.	trace.
Phosphoric acid,	.572	.831
Carbonic acid,	none.	none.
Water,	13.566	13.000
Insoluble residue,	2.708	5.995
	100.275	99.934
Metallic iron,	55.326	53.519
Metallic manganese,	.360	.720
Sulphur,	.030	.022
Phosphorus,	.230	.363

(753) *Ferriferous Limestone ore*, near Rose Point, eight miles east from New Castle, Slippery Rock township. *Bomb Shell ore*, used at Hope furnace.

Hard, brittle bomb shell ore; the walls of the bombs being lined with fibrous, botryoidal, dark brown iron oxide.

(*752*) *Ferriferous Limestone ore*, near Rose Point, eight miles east from New Castle, Slippery Rock township. Ore used at Hope furnace.

Generally compact and brittle, with dark brown color; structure laminated; fracture irregular. Surface of specimen coated with light brown, botryoidal iron oxide.

	(*750*) *Houk & Granniss.*	(*751*) *Houk & Granniss.*	(*754*) *Houk & Granniss.*	(*756*) *Houk & Granniss.*
Sesquioxide of iron,	76.500	83.142	85.571	71.000
Bisulphide of iron,	.123	.197	.041	.060
Sesquioxide of manganese,	.950	.673	.692	1.240
Alumina,	.914	.732	1.775	1.321
Lime,	2.160	.510	.380	6.070
Magnesia,	.940	.360	.432	.979
Sulphuric acid,	trace.	.007	trace.	.007
Phosphoric acid,	.936	.346	.600	.625
Carbonic acid,	1.697	none.	none.	4.770
Water,	13.234	12.736	8.536	11.010
Insoluble residue,	2.385	1.568	2.256	3.273
	99.839	100.271	100.283	100.356
Metallic iron,	53.607	58.292	59.919	49.728
Metallic manganese,	.663	.469	.482	.864
Sulphur,	.066	.108	.022	.035
Phosphorus,	.409	.151	.262	.273

(*750*) *Houk & Granniss' mines*, four miles north-east of Chewton, Wayne township. *Ferriferous Limestone ore.*

Brittle; full of seams of ochreous iron ore; color, dark brown and yellowish brown; fracture irregular, rough.

(*751*) *Houk & Granniss' mines*, four miles north-east of Chewton, Wayne township. *Ferriferous Limestone ore.*

Specimen curiously honeycombed; the cells partially filled with ochreous iron oxide; generally hard and brittle, with irregular fracture, *showing kernels of pyrite.*

(*754*) *Houk & Granniss' mines*, four miles north-east of Chewton, Wayne township. *Ferriferous Limestone ore; "Keel Ore."*

The specimen consists of hard and tough deep red ore, with thin (surface) layer of brown oxide; generally very compact and earthy looking; fracture irregular.

(*756*) *Houk & Granniss' mines*, four miles north-east of Chewton, Wayne township. *Ferriferous Limestone ore.*

Exceedingly hard and tough, with reddish brown color, and somewhat conchoidal fracture; irregularly seamed with brown oxide of iron.

	(755) *Ziegler.*	(757) *Ziegler.*
Sesquioxide of iron,	49.571	69.714
Bisulphide of iron,	.054	.038
Sesquioxide of manganese,	.845	1.304
Alumina,	1.720	1.410
Lime,	19.950	5.500
Magnesia,	.540	.945
Sulphuric acid,	.007	.007
Phosphoric acid,	.199	.238
Carbonic acid,	15.370	4.100
Water,	6.060	12.720
Insoluble residue,	5.715	4.300
	100.031	100.276
Metallic iron,	34.729	48.818
Metallic manganese,	.576	.908
Sulphur,	.032	.021
Phosphorus,	.087	.104

(*755*) *Mr. Ziegler's mines*, four miles north-east of Chewton, Wayne township. *Ferriferous Limestone ore.*

Hard and tough, reddish brown ore with conchoidal fracture.

(*757*) *Mr. Ziegler's mines*, four miles north-east of Chewton, Wayne township. *Ferriferous Limestone ore.*

Specimen irregularly seamed with brown oxide of iron, is exceedingly hard and tough with reddish brown color and conchoidal fracture.

Cambria County.

	(426) *Shoemaker.*
Iron,	40.000
Sulphur,	.046
Phosphorus,	.154
Insoluble residue,	27.600

(*426*) *S. A. Shoemaker's ore*, near Carrolltown.

Bombshell ore; arenaceous, carrying considerable clay in bombs. Dark brown.

Sullivan County.

	(405a.) North Mountain.	(405b.) North Mountain.
Sesquioxide of iron,	35.714	37.714
Sesquioxide of manganese,	.632	.238
Alumina,	5.564	6.797
Lime,	3.750	4.830
Magnesia,	.548	.522
Sulphuric acid,	.062	.075
Phosphoric acid,	3.062	3.339
Water,	5.374	2.428
Insoluble residue,	44.660	43.485
	99.366	99.428
Metallic iron,	25.000	26.400
Metallic manganese,	.440	.166
Sulphur,	.025	.030
Phosphorous,	1.340	1.458

(*405a*) *North Mountain iron ore* from First Bituminous Coal Basin. *Surface ore.*

(*405b*) *North Mountain iron ore*; "*Vein ore.*"

These specimens were forwarded to the Laboratory by Col. R. B. Ricketts, and were analysed at the request of Mr. Franklin Platt, Assistant Geologist.

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§ *42. Brown Hematite Ores of the Mauch Chunk Red Shale, No. XI.*

These ores are merely the decomposed outcrops of beds of carbonate ore underlying the Conglomerate.

Only one specimen has thus far been analysed.

Huntingdon County.

	(949) Diggin.
Iron,	25.240
Sulphur,	.029
Phosphorus,	.100
Insoluble residue,	48.240

(*949*) *Jos. Diggin's ore opening,* one and three quarter miles east of Broad Top City.

Hard, botryoidal; yellowish brown to dark brown. (S. S. Hartranft.)

§ 43. *Brown Hematite Ores of the Marcellus Formation, No. VIII.*

A continuous outcrop of more or less ferriferous calcareous clay bed runs through the middle counties of Pennsylvania, carrying on Yellow Creek, in Blair County, on Aughwick Creek, in Huntingdon County, and on the affluents of the Juniata river in Juniata and Perry counties, large deposits of brown hematite, the full width of the bed, which sometimes amount even to twenty or twenty-five feet. Slopes are sunk on the bed to depths of one or two hundred feet in the ore, when nuts and masses of rough carbonate replace the limonite, and finally further down the whole beds turns to a dark pyritous clay. For descriptions see Report of Progress F.

Blair County.

	(816a.)	(816b.)
	McLanahan, Stone & Bayley.	
Iron,	38.300	40.500
Manganese,	1.395	—
Sulphur,	.682	.024
Phosphorus,	.054	.094
Insoluble residue,	16.330	24.060

(*816a*) *Ore opening at point of hill near station at McKee's Gap.* 30 ft. of cover over this specimen ; so-called Blackband ore. From McLanahan, Stone & Bayley, Hollidaysburg.

Dark brownish black, brittle ore, carrying considerable carbonaceous matter.

(*816b*) *Ore from same locality. Very near the surface;* found among the black slates.

Cellular, brittle, dark brown. Carries considerable corbonaceous matter ; but not so much as No. (816a.)

Huntingdon County.

	(530) *Fleck.*	
Sesquioxide of iron,	71.142 =	49.800 per cent. iron.
Sesquioxide of manganese,	.195 =	.136 per cent. manganese.
Alumina,	1.965	
Lime,	none.	
Magnesia,	.198	

	(530) Fleck.	
Sulphuric acid,	.182 =	.073 per cent. sulphur.
Phosphoric acid,	.343 =	.150 per cent. phosphorus.
Carbonaceous matter,	.390	
Water,	10.395	
Insoluble residue,	13.435	
Undetermined,	1.755	
	100.000	

(*530*) *Isaac Fleck's ore opening* at Saltillo, Cromwell township. Specimen from most northern of open cuts. (Bank No. 3.) See F, page 236.

Cellular, brittle; seamed with ochreous iron ore. Color, various shades of brown and reddish brown. (D. McCreath.)

	(529) Fleck.	(531) Fleck.	(463) Saltillo.
Iron,	46.500	51.700	49.500
Sulphur,	trace.	.062	.072
Phosphorus,	.133	.058	.207
Insoluble residue,	17.120	9.320	12.900

(*529*) *Isaac Fleck's ore opening*, at Saltillo. *Bank No. 2.* Brittle, cellular; light brown. (D. McC.)

(*531*) *Isaac Fleck's ore opening*, at Saltillo. *Bank No. 1.* Cellular, brittle; full of seams of ochreous iron ore. Color, various shades of brown and red. (D. McC.)

(*463*) *Iron Ore opening near Saltillo*, on the north-west slope of Jack's Mountain.

Botryoidal, cellular; bright brown.

	(568) McCarthy.
Protoxide of iron,	25.714
Sesquioxide of iron,	27.000
Bisulphide of iron,	.429
Sesquioxide of manganese,	.289
Sesquioxide of cobalt,	.580
Alumina,	2.002
Lime,	1.143
Magnesia,	.832
Sulphuric acid,	.502
Phosphoric acid,	.137
Carbonic acid,	15.938
Carbonaceous matter,	2.681
Water,	6.460
Insoluble residue,	16.211
	99.918

Metallic iron,	39.100
Metallic manganese,	.201
Sulphur,	.430
Phosphorus,	.060

(*563*) *McCarthy's ore bank*, near Saltillo. Marcellus iron ore. See F, p. 237.

Altered carbonate ore; generally compact with laminated structure. Color various shades of brown.

	(*92*) *Shade Gap.*	(*96*) *Peters.*	(*523*) *Goosehorn.*
Iron,	53.550	28.400	51.100
Manganese,	.165	—	—
Sulphur,	.082	trace.	.031
Phosphorus,	.145	.234	.268
Insoluble residue,	7.910	46.090	7.120

(*92*) *Iron ore opening*, one mile south-west from Shade Gap. Marcellus iron ore.

Cellular, brittle, dark brown.

(*96*) *John Peters ore opening*, two miles north-east from Pott's Gap, Shade Valley.

Compact, argillaceous, brittle; structure slaty; color reddish brown.

(*523*) *Robert Goosehorn's ore opening*, in Shade Valley, six miles north-east of Shade Gap.

Cellular, with cells filled with a yellow clay; color generally dark brown. (D. McCreath.)

	(*942*) *Robinson.*	
Sesquioxide of iron,	73.964 =	51.775 per cent iron.
Sesquioxide of manganese,	.689 =	.432 per cent. manganese.
Alumina,	1.511	
Lime,	.700	
Magnesia,	.106	
Sulphuric acid,	.227 =	.090 per cent. sulphur.
Phosphoric acid,	.385 =	.168 per cent. phosphorus.
Water,	12.400	
Insoluble residue,	10.270	
	100.252	

(*942*) *Henry Robinson's ore opening*, Shade Valley, two and a half miles from Shade Gap.

Generally hard and compact; structure, somewhat laminated; fracture, conchoidal; color, dark brown. (S. S. Hartranft.)

Juniata County.

	(602) Dougherty.
Sesquioxide of iron	84.643
Sesquioxide of manganese,	.081
Alumina,	.950
Lime,	.370
Magnesia,	.230
Sulphuric acid,	.175
Phosphoric acid,	.847
Water,	10.520
Insoluble residue,	2.255
	100.071
Metallic iron,	59.250
Metallic manganese,	.056
Sulphur,	.070
Phosphorus,	.370

(602) *Ore opening on William Dougherty's property*, three miles south-west of McCoytown, and one mile south-west of Reed's Gap, Tuscarora Valley.

Limonite, cellular, stalactitic, dark brown.

§ 44. *Brown Hematite Ores of the Oriskany and Lower Helderberg Formations, No. VII and No. VI.*

Accumulations of limonite, quite local and usually insignificant, but sometimes, as at Blair's and Baker's mines in Blair county, of vast width and depth, occur along the many outcrops of the Oriskany sandstone and Lewistown limestone in Middle Pennsylvania. For a description of some of these, see Report F, 1878, and Report T, 1879.

Huntingdon County.

	(931) Miller.
Iron,	17.900
Manganese,	4.135
Sulphur,	.035
Phosphorus,	.983
Insolnble residue,	39.450

(931) *A. B. Miller's farm*, Warrior Ridge, Barre township. Oriskany ore. Formation No. VII.

The ore is cellular, the cells being partially filled with a silicious clay; with dark brown color. It emits a strong argillaceous odor when breathed upon.

Blair County.

	(713) Baker.	(728) Baker.	(729) Baker.	(714) Baker.
Sesquioxide of iron,	83.071	83.000	68.286	67.214
Sesquioxide of manganese,	.350	.312	1.405	.985
Sesquioxide of cobalt,	trace.	trace.	.116	.102
Alumina,	2.124	1.980	3.534	4.440
Lime,	.215	.210	.220	.290
Magnesia,	.312	.302	.456	.479
Sulphuric acid,	.115	.127	.257	.282
Phosphoric acid,	.455	.673	.600	.506
Water,	11.772	12.314	11.950	9.660
Insoluble residue,	1.675	1.430	13.630	16.120
	100.089	100.348	100.454	100.078
Metallic iron,	58.150	58.100	47.800	47.050
Metallic manganese,	.244	.217	.978	.685
Sulphur,	.046	.051	.103	.113
Phosphorus,	.199	.294	.262	.221

(*713*) *Baker's ore bank*, at Blair Furnace, near Altoona. *Pipe ore.* Formation No. VI.

Brittle, dark brown pipe ore; somewhat coated with a yellow clay; pipes very distinct.

(*728*) *Baker's ore bank*, at Blair Furnace, near Altoona. *Pipe ore.*

Brittle, dark brown pipe ore; pipes somewhat obliterated.

(*729*) *Baker's ore bank*, at Blair Furnace, near Altoona. Limonite, cellular, brittle, dark brown.

(*714*) *Baker's ore bank*, at Blair Furnace, near Altoona. *Bomb shell ore.*

Hard, tough, arenaceous; dark brown and liver brown. The walls of the bombs are coated with a sandy clay of a pinkish grey color.

	Huntingdon County. (564) *Goosehorn.*	*Fulton County.* (524) *Dougherty.*
Iron,	56.000	41.500
Sulphur,	.015	traces.
Phosphorus,	.734	1.281
Insoluble residue,	3.880	31.150

(*564*) *Brown hematite ore on Mr. Goosehorn's property*, Shade Valley, seven miles north-east of Shade Gap. Ore found on surface, thrown from the No. VI Limestone Shales underlying the Oriskany Sandstone.

Compact; also cellular, the cells partially filled with a yellow clay. Color, generally dark brown.

(*524*) *Brown hematite ore on Mr. John Dougherty's property*, one half mile south-west of Fort Littleton. From a deposit on the Lower Helderberg Limestone, No. VI.

Hard, compact, carrying considerable quartz; reddish brown. (D. McC.)

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§ *45. Brown Hematite Ores of the Medina Formation, No. IV.*

Some of the Sandstones of the Medina are highly ferruginous, and blocks coated with a crust of limonite sometimes line the crest of the mountains of IV. Local deposits of a coarse limonite are sometimes found along the outcrop, but are never of much value.

West of Orbisonia, in Huntingdon county, a large deposite of limonite fills a cross fissure in the top of the Black Log mountain. See F, p. 257.

Huntingdon County.

	(*94*) *Black Log Mt.*	(*93*) *Ramsey.*	(*97*) *Stambach.*
Iron, ...	35.500	40.700	44.700
Manganese, . .	3.566	2.269	—
Sulphur, ...	None.	None.	.031
Phosphorus, ...	.478	.709	.197
Insoluble residue, ...	29.575	18.100	18.820

(*94*) *Iron ore found scattered upon the terrace of the north-west side of Black Log Mountain*, one mile south-west from Beaver Gap and seven miles from Fort Littleton. See F, p. 239.

Compact, brittle, sandy; dark brown and reddish brown.

(*93*) *Same ore, from the surface on Alexander Ramsey's property*, four miles north-east from Fort Littleton. See F, p. 139.

Hard, arenaceous, somewhat cellular; color, various shades of light and dark brown.

(*97*) *Wm. Stambach's ore opening*, five miles north-east from Fort Littleton, on the north-west side of Black Log Mountain. See F, p. 128.

Cellular; the cells for the most part filled with yellow clay; brittle, and of a light brown color. (D. McCreath.)

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§ 46. *Brown Hematite Ores of the Trenton, Chazy and Calciferous (Siluro-Cambrian,) Formation, No. II.*

These are the great deposits of iron ore of Pennsylvania, furnishing about half of their stock to the anthracite furnaces on the Lehigh, Schuylkill and Susquehanna rivers, and the whole of their stock to the old furnaces of the Kishicoquilis, Nittany and Canoe Valleys, and Morrison's Cove, in Middle Pennsylvania, as well as to furnaces in Mountain Creek Valley in Cumberland county, and Path Valley and the Conecocheague region of Franklin county.

They are scattered over the surface of the southern or limestone half of the Cumberland Valley, from the Lehigh river to Maryland, and south-ward through Virginia and East Tennessee to Alabama.

But they are distinguishable into ores at the top, ores in the middle, and ores at the bottom of the great limestone formation No. II. Those at the top form a belt along the middle of the valley where the Trenton limestone underlies the Utica or Hudson river slates. Those in the middle are connected with various horizons of ferruginous limestones in the Chazy and Calciferous. Those at the bottom, along the north or west foot of the South Mountain-Blue Ridge range, are geologically connected with the Potsdam Sandstone, or the slates which intervene between it and the base of the Calciferous.

Blair County.	(*565*) *Henrietta.*	(*566*) *Falkner.*	(*567*) *Hoover.*
Sesquioxide of iron, ...	60.000	63.571	69.428
Sesquioxide of manganese, ...	3.517	.933	.270
Alumina, ...	2.321	3.796	1.891

	(565) *Henrietta.*	(566) *Falkner.*	(567) *Hoover.*
Lime,	.270	.390	.270
Magnesia,	.398	.302	.619
Sulphuric acid,	.162	.091	.092
Phosphoric acid,	.822	2.153	1.021
Water,	11.138	12.620	12.364
Insoluble residue,	20.590	15 930	13.660
	99.218	99.786	99.615
Metallic iron,	42.000	44.500	48.600
Metallic manganese,	2 449	.650	.191
Sulphur,	.065	.036	.037
Phosphorus,	.359	.940	.446

(565) *Henrietta mines*, four miles south-east from Martinsburg. Mine No. 1; the large open cut. *Sample taken from washed ore pile. Ore from top of Formation No. II in Utica Slate.*

Nearly all fine ore; sandy, brittle, dark brown.

(566) *Falkner ore shaft*, south of Henrietta mine, in Leathercracker Cove. *Lump ore taken from pile. Top of Formation No. II.*

Compact, botryoidal, with velvety surface. Light brown and reddish brown.

(567) *Hoover bank*, one mile south of Henrietta main mine. Hoover open cut. *Top of Formation No. II.*

Compact, with laminated structure; ,also cellular, with considerable yellow and white clay in cells. Color, dark brown and reddish brown.

	(788) *Robeson.*	(789) *Clark.*	(603) *Etna.*	(466) *Short Mountain.*
Sesquioxide of iron,	79.714	80.428	78.428	78.428
Sesquioxide of manganese,	.061	.184	.102	.356
Sesquioxide of cobalt,	none.	none.	trace.	trace.
Alumina,	1.320	1.636	2.204	1.886
Lime,	.260	.460	.050	.030
Magnesia,	.392	.598	.511	.097
Sulphuric acid,	.030	.050	.025	.060
Phosphoric acid,	.224	.286	.174	.396
Water,	11.050	11.700	11.958	11.248
Insoluble residue,	7.560	5.165	5.700	7.410
	100.611	100.507	99.152	99.911

Metallic iron, ...	55.800	56.300	54.900	54.900
Metallic manganese, . . .	.043	.128	.072	.248
Sulphur, ...	.012	.020	.010	.024
Phosphorus, ...	.098	.125	.076	.173

(*788*) *Robeson farm ore bank*, two miles south south-west from Birmingham station. *Outcrop ore.*

Cellular, brittle; dark brown and yellowish brown. Some masses of quartz throughout specimens.

(*789*) *Clark farm ore bank*, near Etna furnace.

Cellular, brittle, dark brown.

(*603*) *Ore bank near Etna furnace*, Catherine township, Canoe Valley.

Stalactitic, botryoidal; somewhat coated with a yellowish clay; color, generally dark brown.

(*466*) *Short Mountain mines*, Catherine township, one and a half miles north-west from Franklin Forge. Etna Iron Works; Isett & Brothers.

Compact; also cellular, botryoidal, mammillary, with radiated fibrous brown oxide. Generally hard and tough, with light and dark brown color.

	(*640*) *Brower.*	(*644*) *Patterson.*	(*639*) *Red Bank.*	(*583*) *Dean.*
Sesquioxide of iron,	62.714	70.143	72.857	75.571
Sesquioxide of manganese,	345	.123	.173	.081
Sesquioxide of cobalt., . .	trace.	trace.	trace.	——
Alumina, ...	2.655	2.069	3.239	3.426
Lime, ...	.350	.020	.320	.680
Magnesia, ...	.292	.158	.338	.673
Sulphuric acid, ...	trace.	trace.	trace.	trace.
Phosphoric acid, ...	.311	.238	.504	.513
Water, ...	10.113	10.213	11.391	12.595
Insoluble residue, ...	23.450	17.240	11.325	7.010
	100.230	100.204	100.147	100.549
Metallic iron, ...	43.900	49.100	51.000	52.900
Metallic manganese, . . .	.240	.085	.120	.057
Sulphur, ...	trace.	trace.	trace.	trace.
Phosphorus, ...	.136	.104	.220	.224

(*640*) *Brower mine*, two and a half miles north-west of Williamsburg.

Compact, fine grained, jaspery, brittle; reddish brown and liver brown.

(*644*) *Patterson mine*, one mile south from Williamsburg.

Compact, brittle, arenaceous, with masses of quartz throughout the specimen. Color of ore, dark brown.

(*639*) *Red Bank mine*, two miles south from Williamsburg.

Generally cellular, with cells partially filled with a reddish brown ochreous earth. Comparatively soft; reddish brown, showing spangles of quartz.

(*583*) *Dean's mine*, two miles south-east of Williamsburg, Woodberry township.

Cellular, with cells filled with a yellow clay; generally dark brown. (D. McCreath.)

	(*468*) *Springfield.* [*Bank No. 3.*]	(*467*) *Springfield.* [*Bank No. 2.*]	(*526*) *Springfield.* [*Bank No. 2.*]	(*525*) *Springfield.* [*Bank No. 1.*]
Sesquioxide of iron,	78.143	84.428	73.714	52.428
Bisulphide of iron,	.024	.004		
Sesquioxide of manganese,	.103	.368	.610	1.344
Sesquioxide of cobalt,	trace.	trace.	trace.	——
Alumina,	2.146	2.617	1.979	2.042
Lime,	.030	.070	trace.	trace.
Magnesia,	.493	.227	.309	.129
Sulphuric acid,	.147	.237	.072	.075
Phosphoric acid,	.137	.123	.137	.080
Water,	11.886	8.672	10.510	9.375
Insoluble residue,	6.845	3.460	12.260	34.700
	99.954	100.206	99.591	100.173
Metallic iron,	54.710	59.100	51.600	36.700
Metallic manganese,	.072	.256	.425	.936
Sulphur,	.072	.096	.029	.030
Phosphorus,	.060	.054	060	.035

(*468*) *Springfield Mines*, one mile south of Springfield. *Bank No. 3*, two thirds of a mile west of Bank No. 2. *Lump and Wash ore.*

Nodular, cellular, with cells partially filled with a yellow clay. *Shows small kernels of pyrite, without crystalline form; also rhombic dodecahedron crystals of hydrous iron oxide.* Color of ore generally dark brown.

(*467*) *Springfield mines; Bank No. 2, Lykens mine*, one half mile south of Bank No. 1. *Bombshell ore.*

Bombshell ore, the bombs partially filled with clay, and lined with fibrous, botryoidal iron oxide. Exceedingly hard and tough; dark brown and reddish brown.

(*526*) *Springfield mines; Bank No. 2. Ore as taken from washer*, and used by Cambria Iron Company.

Specimen consists of small masses of brown hematite iron ore with admixture of bombshell ore. (D. McCreath.)

(*525*) *Springfield mines; Bank No. 1*, generally known as Davis' bank. At north end of line of mines. *Wash ore.*

Lump and fine ore; structure of lumps somewhat laminated. Fine ore carries considerable quartz. (D. McCreath.)

	(*643*) *McPheese.*	(*604*) *Rebecca.*	(*606*) *Thompson.*	(*607*) *Red Ore.*
Sesquioxide of iron, . .	74.143	65.713	78.000	77.143
Sesquioxide of manganese,	.265	.551	.195	.093
Sesquioxide of cobalt, . .	——	——	trace	——
Alumina, ...	3.019	3.908	2.348	2.438
Lime, ...	.150	.240	.220	.130
Magnesia, ...	.255	.200	.396	.464
Sulphuric acid, .	trace	.115	.102	.041
Phosphoric acid, . .	.238	.219	.462	.194
Water, ...	10.865	11.876	11.880	10.164
Insoluble residue, .	11.360	17.560	6.805	9.260
	100.295	100.382	100.408	99.927
Metallic iron, ...	51.900	46.000	54.600	54.000
Metallic manganese, . . .	.181	.384	.136	.035
Sulphur, ...	trace	.046	.041	.017
Phosphorus, ...	.104	.096	.202	.085

(*643*) *McPheese bank*, one and a half miles south of Springfield.

Brittle, argillaceous; somewhat cellular; dark brown and reddish brown.

(*604*) *Rebecca mine*, four miles north-east of Henrietta P. O.

Brittle, arenaceous; cellular, with cells lined with goethite; considerable adhering white clay. Color of ore generally light brown.

(*606*) *Thompson mine*, two miles west from Fredericksburg.

Cellular, nodular, brittle; dark brown.

(*607*) *Red Ore bank*, one third mile from Millerstown.

Ore for the most part coated with a reddish brown clay;

exceedingly hard and tough. On fresh fracture the color is dark brown.

	(612) Soister.	(963) Sarah.	(973) Sarah.
Sesquioxide of iron,	76.214	59.428	69.857
Sesquioxide of manganese,	.011	1.758	.509
Alumina,	2.491	3.024	3.176
Lime,	.020	.080	.130
Magnesia,	.386	.331	trace
Sulphuric acid,	.020	.062	.138
Phosphoric acid,	.259	.128	.057
Water,	12.486	8.795	10.280
Insoluble residue,	7.470	25.855	16.350
	99.357	99.461	100.497
Metallic iron,	53.350	41.600	48.900
Metallic manganese,	.007	1.224	.353
Sulphur,	.008	.025	.055
Phosphorus,	.113	.056	.025

(*612*) *Soister mine*, three and a half miles north from Woodberry, near county line. Abandoned mines.

Exceedingly hard and tough; generally very compact; carries considerable quartz. Color, various shades of dark brown, reddish brown and vermilion.

(*963*) *Sarah Furnace ore bank*, (Springfield mines,) about two miles south of Springfield.

Hard and tough, with considerable quartz; color, dark brown and brownish black; fracture irregular, rough.

(*973*) *Sarah Furnace ore bank*, about two miles south of Springfield. So-called "burnt ore."

Somewhat cellular; with considerable quartz; dark brown to reddish brown. (S. S. Hartranft.)

	(608) Bloomfield. [Lump ore.]	(609) Bloomfield. [Wash ore.]
Sesquioxide of iron,	72.143	51.571
Sesquioxide of manganese,	1.273	.548
Sesquioxide of cobalt,	.011	trace.
Alumina,	2.457	3.996
Lime,	.170	.075
Magnesia,	.457	.209
Sulphuric acid,	.135	.057
Phosphoric acid,	.103	.185
Water,	11.276	9.811
Insoluble residue,	11.970	32.830
	99.995	99.282

Metallic iron,	50.050	36.100
Metallic manganese,	.886	.382
Sulphur,	.054	.023
Phosphorus,	.045	.081

(*608*) *Bloomfield mines*, about three miles south from Roaring springs. *Lump ore.*

Generally compact; also cellular and bombshell, the walls of the bomb lined with fibrous, botryoidal iron ore. Color, light and dark brown. Considerable adhering yellowish white clay.

(*609*) *Bloomfield mines*, about three miles south from Roaring Springs. *Wash ore.*

Specimens consist of a mixture of small masses of brown hematite iron ore, with a considerable amount of argillaceous iron ore, ferruginous clay and quartz pebbles.

	(*708*) *Bloomfield.* [*Bombshell ore.*]	
Sesquioxide of iron,	75.071	= 52.550 per cent. iron.
Binoxide of manganese,	3.760	= 3.004 per cent. manganese.
Protoxide of manganese,	.779	
Sesquioxide of cobalt,	.030	
Alumina,	2.678	
Lime,	.240	
Magnesia,	.235	
Sulphuric acid,	.182	= .073 per cent. sulphur.
Phosphoric acid,	.071	= .031 per cent. phosphorus.
Water,	13.330	
Insoluble residue,	3.948	
	100.324	

(*708*) *Bloomfield mines*, about three miles south from Roaring Springs. *Bombshell ore.*

Bombshell ore, the walls of the shell lined with nodular lumps consisting mainly of oxide of manganese. The ore is generally fibrous and brittle; also partially foliated, with iridescent surface.

	(*709a*) *Bloomfield.* [*Manganese Ore.*]	(*709b*) *Bloomfield.* [*Manganese Ore.*]
Iron,	22.700	40.250
Manganese,	37.611	11.870
Sulphur,	.018	.015
Phosphorus,	.043	.033

	(709a) Bloomfield. [Manganese Ore.]	(709b) Bloomfield. [Manganese Ore.]
Alumina,	1.144	1.950
Lime,	.470	.157
Magnesia,	.271	.216
Silica,	2.850	11.360

(*709a*) *Bloomfield mines*, about three miles south of Roaring Springs. *Manganese ore.*

Hard and tough; minutely crystalline; steel grey.

(*709 b*) *Bloomfield mines. Manganese ore.*

Analysed for Pennsylvania Steel Company in 1874, and published by permission.

Analyses of Bloomfield Wash Ore made for Pennsylvania Steel Company; and published by permission.

Date of Analysis.	Per cent. Iron.	Per cent. Phosphorus.
July, 1873,	32.25	.053
March, 1874,	39.06	.041
April, 1874,	33.50	.039
April, 1874,	35.00	.059
May, 1874,	36.60	.053
Average,	35.28	.049

Bedford County.

	(613) Baker.	(605) R. Hoover.
Sesquioxide of iron,	56.214	80.000
Sesquioxide of manganese,	.073	.207
Sesquioxide of cobalt,	none.	trace.
Alumina,	4.855	3.069
Lime,	.015	.310
Magnesia,	.335	.562
Sulphuric acid,	.012	.082
Phosphorio acid,	.451	.201
Water,	10.390	12.106
Insoluble residue,	27.960	3.970
	100.305	100.507
Metallio iron,	39.350	56.000
Metallio manganese,	.050	.144
Sulphur,	.005	.033
Phosphorus,	.197	.088

(*613*) *Baker's mine*, one mile south from Bloomfield furnace. Cambria Iron Company.

Brittle, sandy, argillaceous; generally compact; dark brown and liver brown.

(*605*) *R. Hoover's mine*, one mile north from Woodberry. *Surface pipe ore.*

Stalactitic, brittle, dark brown. Considerable yellow clay in cells.

Franklin County.

	(*1007*) *Douglas.*	(*465*) *English.*	(*521*) *Pond.*	(*452*) *Wolf.*
Sesquioxide of iron, . .	62.428	56.286	43.142	81.857
Sesquioxide of manganese,	.237	1.839	.310	.233
Sequioxide of cobalt, . . .	trace.	——	——	——
Alumina, ...	1.500	4.316	1.398	.623
Lime, ...	.110	.030	——	.050
Magnesia, ...	.395	.612	.216	.050
Sulphuric acid, ...	.087	.052	.052	.105
Phosphoric acid, ...	.602	1.268	.180	2.710
Water, ...	9.392	10.892	7.595	11.490
Insoluble residue, ...	25.570	23.960	46.300	2.155
	100.321	99.255	99.193	99.273
Metallic iron, ...	43.700	39.400	30.200	57.300
Metallic manganese, . .	.165	1.280	.216	.150
Sulphur, ...	.035	.021	.021	.042
Phosphorus, ...	.263	.554	.079	1.185

(*1007*) *Wyeth Douglas ore bank*, near Mt. Airy, one mile north-east of Quincy.

Generally compact, but with numerous small drussy cavities lined with quartz crystals; somewhat jaspery; color, yellowish brown.

(*465*) *English ore bank*, two miles south-east from Greenwood.

Cellular, nodular, dark brown.

(*521*) *Pond ore bank*, two miles south-east of Greenwood, on Greenwood and Funkstown road. "*Poor specimen of ore.*" See Report CC, p. 250. (D. McC.)

(*452*) *S. Wolf's ore bank*, about one mile north-west from Greenwood. "*Float ore.*" See Report, CC, p. 247.

Hard and compact; various shades of brown and reddish brown. (D. McC.)

	(186) Good.	(432) Good.
Sesquioxide of iron,	76.571	77.571
Sesquioxide of manganese,	.392	.103
Sesquioxide of cobalt,	——	——
Alumina,	5.010	.942
Lime,	.200	.160
Magnesia,	.281	.076
Sulphuric acid,	.185	.040
Phosphoric acid,	.409	.185
Water,	10.980	10.874
Insoluble residue,	6.100	9.775
	100.128	99.726
Metallic iron,	53.600	54.300
Metallic manganese,	.273	.072
Sulphur,	.074	.016
Phosphorus,	.179	.081

(*186*) *Michael Good's ore bank*, one and a half miles northwest from Fayetteville. *From ore bank back of mill.* See CC, p. 247.

Somewhat cellular, botryoidal; dark brown and reddish brown. (D. McC.)

(*432*) *Michael Good's ore bank*, one and a half miles northwest from Fayetteville.

Cellular, botryoidal; brittle; light and dark brown.

Cumberland County.

	(458) Thomas Iron Co.	(413) Mt. Holly.	(433) Mt. Holly.
Sesquioxide of iron,	44.142	46.214	58.000
Sesquioxide of manganese,	.578	1.944	.342
Alumina,	6.523	2.654	2.405
Lime,	trace.	.260	.170
Magnesia,	1.239	.540	.415
Sulphuric acid,	.070	.222	.010
Phosphoric acid,	5.915	3.472	5.795
Water,	12.430	9.840	12.788
Insoluble residue,	28.575	34.840	19.670
	99.472	99.986	99.625
Metallic iron,	30.900	32.350	40.600
Metallic manganese,	.403	1.354	.238
Sulphur,	.028	.088	.016
Phosphorus,	2.583	1.516	2.530

(*453*) *Thomas Iron Co.'s ore bank*, (now the property of the South Mountain Iron Co.,) one and a quarter miles from Pine Grove, on Bendersville road. "*Poor specimen of ore.*"

Argillaceous, brittle; light brown and dark brown. (D. McC.)

(*413*) *Mt. Holly ore bank No. 2*, one mile north-east of Papertown. "*Not a good specimen of the ore.*" See Report CC, p. 241.

Compact, arenaceous; structure somewhat laminated; surface velvety. (D. McC.)

(*433*) *Mt. Holly ore bank No. 1*, one mile north-east of Papertown. "*Not a good specimen of the ore.*"

Argillaceous, brittle; light and dark brown.

Lancaster County.

	(*642*) *Chestnut Hill.*	(*651*) *Chestnut Hill.*	(*652*) *Chestnut Hill.*	(*641*) *Chestnut Hill.*	(*797*) *Chestnut Hill.*
Sesquioxide of iron,	64.571	78.571	78.857	76.428	76.714
Sesquioxide of manganese, .	1.450	.657	1.302	1.456	.723
Sesquioxide of cobalt, ...	.185	.130	.047	.066	.045
Alumina, ...	2.633	2.367	2.112	1.260	2.791
Lime, ...	.054	.170	.210	.230	.030
Magnesia, ...	.047	.187	.335	.147	.198
Sulphuric acid, . .	008.	trace.	.095	.008	.027
Phosphoricacid, .	1.026	.847	.581	.602	1.475
Water, . .	10.970	12.468	12,075	12.733	13.472
Insoluble residue, .	19.015	4.770	4.765	7.290	4.385
	99.959	100.167	100.379	100.220	99.860
Metallic iron, . . .	45.200	55.000	55.200	53.500	53.700
Metallic manganese, ...	1.010	.457	.908	1.015	.504
Sulphur, ...	.003	trace.	.038	.003	.011
Phosphorus, . . .	.448	.370	.254	.263	.644

(*642*) *Chestnut Hill ore mines*, about three miles north-east from Columbia. Mined by Chickies Iron Company, in the bank of Edward B. Grubb's heirs. From eastern series of mines; *one third lump, two thirds fine ore.*

Generally compact and fine grained; but with numerous cavities filled with ochreous iron ore. Bombshell ore lined with fibrous, botryoidal brown oxide of iron. Fine ore carries considerable quartz.

(*651*) *Chestnut Hill ore mines;* mined by Chickies Iron Company in the bank of Edward B. Grubb's heirs. *All lump ore.*

Stalactitic; bombshell ore, with fibrous, botryoidal brown oxide of iron. Specimens show some specks of quartz. Color, generally dark brown.

(*652*) *Chestnut Hill ore mines; Clement B. Grubb's bank. All lump ore.*

A mixture of bombshell ore, with walls of shell lined with fibrous iron oxide with velvety surface; and cellular, dull earthy looking ore. Portions of the ore have a distinctly laminated structure. Generally coated with a yellowish white clay.

(*641*) *Chestnut Hill ore mines; Chestnut Hill Iron Co.'s bank;* C. J. Nourse, Supt. *One fourth fine ore; three fourths lump ore.*

Nodular; stalactitic; bombshell; with considerable fibrous brown oxide of iron. Color, generally dark brown. Some masses of quartz throughout specimens.

(*797*) *Chestnut Hill ore mines; float ore* from Chestnut Hill Iron Co.'s bank.

Fibrous, brittle; dark brown.

Berks County.	(*983*) *Fleetwood.*	(*992*) *Lewis.*	(*993*) *Kline.*	(*984*) *C. Miller.*
Sesquioxide of iron,	67.857	62.857	65.000	75.857
Sesquioxide of manganese,	.155	.557	.288	.950
Sesquioxide of cobalt,	trace	.060	.040	trace
Alumina,	3.685	3.450	3.881	1.906
Lime,	.020	.150	.170	.110
Magnesia,	.237	.432	.421	.230
Sulphuric acid,	.037	.052	.070	.155
Phosphoric acid,	.527	1.266	.339	.087
Water,	12.504	12.098	11.280	12.366
Insoluble residue,	15.185	19.270	18.610	7.850
	100.207	100.192	100.099	99.511
Metallic iron,	47.500	44.000	45.500	53.100
Metallic manganese,	.108	.388	.201	.662
Sulphur,	.015	.021	.028	.062
Phosphorus,	.230	.553	.148	.038

(*983*) *Fleetwood Iron Co.'s mine*, one mile north-west of Mertztown, at station 2312. *Lump and wash ore.*

Generally compact and fine grained; also cellular; dark brown.

(*992*) *Samuel Lewis' mine*, one and a half miles north-west from Mertztown, at station 2321. *Lump and wash ore.*

Compact; also cellular; full of seams of ochreous iron ore; dark brown to yellowish brown. Wash ore carries considerable quartz.

(*993*) *D. K. Kline's mine*, two and a half miles from Mertztown; Kline's Corners. *Lump and wash ore.* Leased by Temple Iron Co.

Compact; also cellular, with cells for the most part filled with ochreous iron ore. Color, dark brown and yellowish brown.

(*984*) *Charles Miller's mine*, three miles north-west of Mertztown, near station 2472. *Lump and wash ore.*

Cellular; full of seams of ochreous iron ore, with spangles of quartz. Generally dark brown.

	(*982*) *Trexler.*	(*986*) *Merkel.*	(*988*) *J. Ziegler.*	(*987*) *D. Ziegler.*
Sesquioxide of iron,	74.571	67.428	64.000	52.214
Sesquioxide of manganese,	.496	.320	3.414	.185
Sesquioxide of cobalt,	.020	.020	.040	.010
Alumina,	2.714	3.333	2.039	3.337
Lime,	.020	.290	.120	.250
Magnesia,	.201	.360	.245	.302
Sulphuric acid,	.012	.085	.032	.085
Phosphoric acid,	.405	.259	.691	.629
Water,	12.934	11.698	12.308	10.888
Insoluble residue,	8.460	16.580	17.490	32.380
	99.833	100.573	100.379	100.380
Metallic iron,	52.200	47.200	44.800	36.550
Metallic manganese,	.346	.223	2.377	.129
Sulphur,	.005	.034	.013	.034
Phosphorus,	.177	.113	.302	.275

(*982*) *E. H. Trexler's mine*, one mile north-east of Mertztown. *Lump and wash ore.*

Generally compact and fined grained, with admixture of fibrous iron ore. Color, dark brown to brownish black.

(*986*) *Mrs. John Merkel's mine*, at Farmington, two miles north of Mertztown. *Lump and wash ore.*

Cellular, with cells filled with clay; shows some masses of quartz. Color of ore light and dark brown.

(*988*) *Jonathan Ziegler's mine*, at Farmington, two miles north of Mertztown. *Lump and wash ore.*

Cellular, brittle, dark brown.

(*987*) *David Ziegler's mine*, near Farmington, three miles north north-east of Mertztown. *Lump and wash ore.* Leased by Temple Iron Co.

General appearance very sandy; cellular; also compact and fine grained. Carries considerable quartz. Color of ore dark brown and reddish brown.

	(*990*) *Wm. Miller.*	(*985*) *Smyers.*	(*989*) *Heffner.*	(*991*) *Clymer Iron Co.*
Sesquioxide of iron,	63.857	46.857	51.643	57.571
Sesquioxide of manganese,	.505	2.183	3.320	2.441
Sesquioxide of cobalt,	trace	.060	.050	.050
Alumina,	3.468	4.291	4.740	3.150
Lime,	.080	.150	.230	.060
Magnesia,	.331	.604	.518	.479
Sulphuric acid,	.020	.057	.065	.065
Phosphoric acid,	.355	1.172	.827	1.034
Water,	11.442	11.162	11.690	11.822
Insoluble residue,	20.100	32.710	26.910	23.590
	100.158	99.246	99.993	100.262
Metallic iron,	44.700	32.800	36.150	40.300
Metallic manganese,	.353	1.520	2.312	1.700
Sulphur,	.008	.023	.026	.026
Phosphorus,	.155	.512	.361	.453

(*990*) *Wm. Miller's mine*, three miles north of Topton. *Lump and wash ore.*

Arenaceous, brittle, dark brown.

(*985*) *D. H. Smyers' Heirs mine*, one mile south from Bauers, near station 2709. *Lump and wash ore.*

General appearance very sandy, with dark brown to yellowish brown color. Carries a small admixture of manganiferous ore.

(*989*) *Charles Heffner's mine*, one half mile south from Lyons. *Lump and wash ore.* Leased by Temple Iron Co.

Sandy; full of seams of ochreous iron ore; compact; also cellular, with cells filled with clay. Color of ore various shades of light and dark brown.

(*991*) *Clymer Iron Co.'s Udree mine*, two miles northwest of Pricetown. *Lump and wash ore.*

Generally very compact and fine grained, with conchoidal fracture and dark brown color.

Lehigh County.

	(*61*) *Ritter.*	(*62*) *Ritter.*	(*63*) *Brown.*	(*391*) *Brown.*	(*369*) *Ironton.*
Iron, ...	39.300	47.700	50.000	47.000	26.400
Manganese, . . .	.065	2.968	.208	.641	17.648
Sulphur, ...	.008	.049	.080	.053	.010
Phosphorus,	1.269	.328	.086	.061	.095
Insoluble residue, .	28.195	12.595	12.520	15.770	21.860

(*61*) *J. Ritter's mine*, at Ironton; leased by the Crane Iron Co.

Limonite forming vein in Utica shale and damourite clay. Compact, flaggy; with more or less adhering clay.

(*62*) *J. Ritter's mine*, at Ironton. *Lump and wash ore* from bottom of mine. See Report DD, p. 44.

Compact, botryoidal; considerable adhering clay and some quartz in wash ore.

(*63*) *P. Brown's mine*, at Ironton. *Lump ore.*

Compact, rather fine grained; dark brown.

(*391*) *P. Brown's mine*, at Ironton. *Lump and wash ore.*

Compact, arenaceous; dark brown. (D. McCreath.)

(*369*) *Ironton Railroad Co.'s mine*, at Ironton. *Lump and wash ore.*

Compact, botryoidal; also stalactitic; general structure somewhat flaggy. Some of the ore carries considerable binoxide of manganese.

(*301*)
Ironton R. R. Co.

Binoxide of manganese, .	77.960	=52.631 per cent. manganese.
Protoxide of manganese, .	4.320	
Sesquioxide of iron, .	3.660	= 2.562 per cent. iron.
Alumina, ...	.711	
Oxide of cobalt, ...	.390	
Oxide of nickel, ...	trace.	
Oxide of copper, ...	trace.	
Baryta, ...	.152	
Lime, ...	.770	
Magnesia, ...	.236	

	(301) Ironton R. R. Co.	
Soda,	.368	
Potash,	3.042	
Sulphuric acid,	trace.	
Phosphoric acid,	.149	= .063 per cent. phosphorus.
Water,	3.980	
Silicic acid,	4.845	
	100.583	

(*301*) *Ironton Railroad Co.'s mine*, at Ironton. *Manganese Wash ore.*

Stalactitic, botryoidal, reniform; partially compact and cellular, with cells more or less filled with iron oxide.

	(195) Heninger.	(196) Boyer.	(64) Sieger.	(190) Levan.
Iron,	41.200	51.300	40.600	40.000
Manganese,	.028	.064	.554	.115
Sulphur,	.191	.106	.027	.140
Phosphorus,	.056	.192	.393	.099
Insoluble residue,	25.945	9.145	25.460	26.860

(*195*) *John Heninger's mine*, near Siegersville, four and a half miles west of Catasauqua. *Wash ore.* See DD, p. 39.

Compact, arenaceous; carries considerable adhering clay; color, various shades of brown and vermilion.

(*196*) *Hiram Boyer's mine*, near Siegersville, four and a half miles west of Catasauqua. *Wash ore.* Leased by Lehigh Valley Iron Co.

Cellular, stalactitic; argillaceous. (D. McCreath.)

(*64*) *Samuel Sieger's mine*, at Siegersville, four and a half miles west of Catasauqua. *Lump and Wash ore.* Leased by Bethlehem Iron Co.

Arenaceous, cellular; cells much filled with clay. Some of the ore is compact and fine grained, with flaggy structure. Wash ore carries considerable quartz.

(*190*) *Daniel Levan's mine*, near Siegersville, four and a half miles west of Catasauqua. *Wash ore.*

Arenaceous, cellular; cells carrying considerable clay.

	(194) Guth.	(340) Weaver.	(74) Kline.	(367) Sheiver.	(352) Ruch & Bros.
Iron,	41.000	44.200	43.900	46.000	46.300
Manganese,	.036	.036	.165	.050	.201
Sulphur,	.098	.043	.038	.073	.033
Phosphorus,	.240	.760	.164	.210	.264
Insoluble residue,	26.735	20.315	21.860	17.870	17.500

(*194*) *Calvin Guth's mine*, near Guthville, four miles west of Catasauqua. Leased by Bethlehem Iron Co.

Arenaceous, cellular; some of the pieces fine grained and flaggy. Color, various shades of brown and vermilion.

(*340*) *Benjamin Weaver's mine*, near Guth's Station, four and a half miles west of Catasauqua. *Lump and wash ore.*

Compact, brittle, dark brown. Fine ore carries considerable quartz.

(*74*) *James Kline's mine*, at Orefield, five miles west of Catasauqua. *Lump and wash ore.* Leased by Thomas Iron Co.

Compact, flaggy, arenaceous; considerable yellow, white and pink tinted clay.

(*367*) *Sheiver's mine*, one and a half miles west of Catasauqua. *Lump and wash ore.*

Compact, arenaceous; also cellular. Dark brown, reddish brown.

(*352*) *Ruch & Bros.' mine*, at Ruchsville, three miles north-west of Catasauqua. *Lump and wash ore.*

Cellular, botryoidal, with considerable clay. Wash ore carries a good deal of quartz.

	(*189*) *Biery.*	(*357*) *Glick.*	(*368*) *Kehm.*	(*355*) *Roth.*
Iron, ...	32.500	49.500	49.200	53.000
Manganese, ...	.338	.194	.317	.216
Sulphur, ...	.038	.019	.005	.024
Phosphorus, ...	.168	.102	.180	.096
Insoluble residue, ...	42.370	13.410	14.005	7.290

(*189*) *Jonas Biery's mine*, about four miles north-west of Allentown.

Exceedingly sandy; somewhat cellular; with considerable free quartz and clay.

(*357*) *Charles Glick's mine*, three and a half miles north-west of Emaus. *Lump ore.* Leased by Allentown Iron Co.

Compact; also cellular, with considerable adhering clay; color, dark brown.

(*368*) *Solomon Kehm's mine*, two and a half miles north-west of Emaus. *Lump ore.*

Hard, compact, and tough; carries some particles of quartz and considerable adhering clay.

(355) *John Roth's mine*, three miles north of Emaus. *Lump ore.*

Exceedingly compact and fined grained; dark brown.

	(366) Jobst.	(363) Schwartz.	(365) Daney.
Iron,	46.300	34.000	45.200
Manganese,	.475	.115	2.132
Sulphur,	.018	.020	.026
Phosphorus,	.160	.676	.657
Insoluble residue,	15.290	37.695	12.780

(366) *H. & F. Jobst's* mine, two and a half miles west of Emans. *Wash ore.*

Rather compact; shelly; with a large amount of clay. (D. McCreath.)

(363) *Schwartz's mine*, one half mile south of Emaus. *Lump ore.*

Very hard and tough, arenaceous, dark brown.

(365) *Elias Daney's mine*, one mile south of Emaus. *Lump ore.* Leased by Coleraine Iron Co.

Brittle, shelly, botryoidal, dark brown. (D. McCreath.) A sample of titaniferous iron ore found in the top clay when working this mine, gave the following analysis: Fe. 38.16; Mn. .35; S. none; P. trace; CaO. .52; MgO. 3.87; Al_2O_3 2.79; TiO_2 32.18 per cent.

	(356) Keck & Ritter.	(361) Trexler & Kline.	(362) H. Kline.	(358) J. Kline.
Iron,	39.250	36.500	30.100	47.200
Manganese,	5.512	1.325	.489	2.709
Sulphur,	.029	.107	.062	.039
Phosphorus,	.149	.547	.299	.075
Insoluble residue,	21.880	31.215	43.035	14.980

(356) *Keck & Ritter's mine*, two miles east of Emaus. *Lump ore.* Leased by Emaus Iron Co.

Compact, sandy, nodular, with specks of quartz.

(361) *Trexler & Kline's mine*, three quarters of a mile east of Emaus. *Lump ore.*

Compact, arenaceous, dark brown. (D. McCreath.)

(362) *Henry Kline's mine*, three quarters of a mile east of Emaus. *Lump ore.*

Sandy, shelly, dark brown; ore carries considerable quartz. (D. McCreath.)

(*358*) *Jesse Kline's mine*, one half mile east of Emaus. *Lump ore.*

Compact; also cellular and bombshell; considerable clay.

	(*364*) *Seam.*	
Sesquioxide of iron,	69.714 =	48.80 per cent. iron.
Sesquioxide of manganese,	1.292 =	.900 per cent. manganese.
Alumina,	2.388	
Lime,	.300	
Magnesia,	.317	
Sulphuric acid,	.035 =	.014 per cent. sulphur.
Phosphoric acid,	.448 =	.196 per cent. phosphorus.
Water,	11.340	
Insoluble residue,	13.915	
	99.749	

(*364*) *Conrad Seam's mine*, one and a half miles east of Emaus. *Lump and wash ore.*

Hard, tough, shelly, botryoidal; reddish brown. Ore carries considerable adhering clay. (D. McCreath.)

	(*968*) *Schneider.*	(*969*) *Kurtz.*	(*970*) *M. Mory.*	(*981*) *G. & W. Mory.*
Sesquioxide of iron,	64.428	75.714	68.785	47.000
Sesquioxide of manganese,	.982	.228	.207	.889
Sesquioxide of cobalt,	.040	.010	.020	.080
Alumina,	2.108	1.421	2.974	3.696
Lime,	.170	.160	.120	.100
Magnesia,	.288	.288	.288	.418
Sulphuric acid,	.032	.447	.612	.062
Phosphoric acid,	1.104	1.175	.941	.584
Water,	11.374	12.724	12.866	8.622
Insoluble residue,	19.760	7.790	13.310	38.940
	100.286	99 957	100.123	100.391
Metallic iron,	45.100	53.000	48.150	32.900
Metallic manganese,	.684	.159	.144	.619
Sulphur,	.013	.179*	.245‡	.025
Phosphorus,	.482	.513†	.411	.255

(*968*) *David Schneider's mine*, three miles from Friedensville, and seven miles south-west from Hellertown. *Lump and wash ore.* Leased by Saucon Iron Co.

Generally compact and fine grained; with considerable

* Duplicate sulphur determination gave .179.

† Duplicate phosphorus determination gave .514.

‡ Duplicate sulphur determination gave .246.

bomb shell ore, the walls of the bombs being lined with dark brown fibrous iron oxide.

(969) *Widow Kurtz's mine*, near Friedensville, and four miles south-west from Hellertown. *Pipe ore.* Leased by Saucon Iron Co.

Cellular, pipe ore, generally of a dark brown color.

(970) *Morgan Mory's mine*, near Friedensville, and four miles south-west of Hellertown. *Lump and wash ore.* Leased by Saucon Iron Co.

Brittle, cellular; the cells for the most part filled with ochreous iron ore. Color, light and dark brown.

(981) *G. & W. Mory's mine*, near Friedensville, and four miles south-west from Hellertown. *Lump and wash ore.* Leased by Saucon Iron Co.

Cellular, brittle, with considerable ferruginous clay and free quartz. Color of ore, dark brown to yellowish brown.

Northampton County.	*(980) Saucon Iron Co.*	*(967) Saucon Iron Co.*
Sesquioxide of iron,	49.928	63.714
Sesquioxide of manganese,	7.358	.455
Sesquioxide of cobalt,	.140	.040
Alumina,	3.053	1.090
Lime,	.110	.180
Magnesia,	.418	.324
Sulphuric acid,	.042	.027
Phosphoric acid,	1.169	.836
Water,	11.384	11.980
Insoluble residue,	26.700	21.940
	100.302	100.586
Metallic iron,	34.950	44.600
Metallic manganese,	5.123	.317
Sulphur,	.017	.011
Phosphorus,	.509	.365

(980) *Wharton mine of Saucon Iron Co.*, two miles east from Hellertown. *Specimens from higher level, about eighty feet deep. Lump and wash ore.*

Compact, brittle, sandy; dark brown to reddish brown.

(967) *Wharton mine of Saucon Iron Co.*, two miles east from Hellertown. *From deep shaft 126 feet under ground. Lump and wash ore.*

Hard, tough, fine grained; color, liver brown.

§ 47. *Brown Hematite Ores of York County.*

The Brown hematite deposits of York county are discussed by Prof. Frazer in Reports of Progress C and CC.

These ores are of obscure origin, and of more than one age. Some of them occur at the contact of the slates and limestones as in the Great Valley, above described. Others are the decomposed outcrops of ferriferous beds in the Azoic rocks.

For this reason their analyses are here collected into a separate section under a different heading from that of the limonites of Formation II.

York County.	*(455) McCormick.*	*(110) Bender.*
Sesquioxide of iron,	71.714	45.428
Sesquioxide of manganese,	.288	.298
Alumina,	4.089	8.676
Lime,	.250	.290
Magnesia,	.216	.987
Sulphuric acid,	.077	.128
Phosphoric acid,	3.007	.476
Water,	14.700	10.230
Insoluble residue,	5.685	33.330
	100.026	99.843
Metallic iron,	50.200	31.800
Metallic manganese,	.201	.208
Sulphur,	.031	.051
Phosphorus,	1.313	.208

(*455*) *McCormick & Co.'s ore bank*, one and a half miles south-west from Dillsburg. See Report CC, p. 228.

Compact, brittle, argillaceous; reddish brown. (D. McC.)

(*110*) *Christian Bender's ore bank*, one and a half miles south-west from Dillsburg. "*Poor specimen of the ore.*" See CC, p. 227.

Exceedingly sandy and brittle; structure flaggy; color light brown. (D. McC.)

	(112) Mickley.	*(360) Mickley.*	*(387) Tronc.*	*(449) Rudesill.*
Sesquioxide of iron,	74.285	62.428	68.143	64.714
Sesquioxide of manganese,	3.900	.992	.183	.155
Alumina,	1.632	2.024	1.698	1.607
Lime,	.340	.020	.180	.250
Magnesia,	.190	.237	.212	.317
Sulphuric acid,	.211	.100	.025	.067
Phosphoric acid,	.948	.698	1.679	1.559

	(112) *Mickley.*	(360) *Mickley.*	(387) *Trone.*	(449) *Rudesill.*
Water, . . . } Carbonaceous matter, }	12.140	11.826	9.986 / .530	12.045
Insoluble residue, .	5.740	21.795	17.620	19.410
	99.386	100.120	100.256	100.124
Metallic iron, . . .	52.000	43.700	47.700	45.300
Metallic manganese,	2.716	.690	.128	.108
Sulphur,	.084	.040	.010	.027
Phosphorus, ...	.414	.305	.733	.681

(*112*) *Mickley's ore bank*, one mile north-east of Smith's station, Hanover Junction railroad. *Limonite from large shaft south-west of bank.* Denny & Hess, lessees.

Cellular, the walls of the cells being for the most part lined with goethite. Carries a small quantity of adhering yellow clay. (D. McC.) See Report C, p. 37.

(*360*) *Mickley's ore bank*, one mile north-east of Smith's station, Hanover Junction railroad.

Cellular, arenaceous; small quantity of adhering yellow clay. Color, various shades of brown.

(*387*) *Trone's ore bank*, one eighth of a mile west by north of Smith's station, Hanover Junction railroad. See Report C, p. 36.

Very compact, fine grained, arenaceous, with some free quartz. Fracture, conchoidal; color, dark brown.

(*449*) *Rudesill's ore bank*, three quarters of a mile north from Smith's station. *From blocks in bottom of bank.* See Report C, p. 36.

Hard, compact, reddish brown. Carries considerable quartz. (D. McC.)

	(111) *Bauman.*	(353) *Bauman.*	(385) *Stoner.*	(429) *Bollinger.*	(354) *Forney.*
Sesquioxide of iron, .	65.000	60.857	36.428	56.143	38.571
Sesquioxide of manganese, ...	1.712	2.638	.051	.201	3.165
Alumina, .	2.355	1.912	1.908	2.321	1.499
Lime, ...	.390	.160	.040	.140	.040
Magnesia, . .	.356	.407	.313	.324	.263
Sulphuric acid, . . .	.105	.057	.077	.073	.075
Phosphoric acid, . . .	3.295	2.691	1.014	.616	1.571
Water, .	11.790	11.560	6.218	6.286	8.210
Insoluble residue, . .	14.880	19.115	53.790	34.330	46.155
	99.883	99.397	99.839	100.434	99.549

Metallic iron, ...	45.500	42.600	25.500	39.300	27.000
Manganese, ...	1.192	1.837	.036	.139	2.204
Sulphur, ...	.042	.023	.031	.027	.030
Phosphorus, . . .	1.439	1.175	.443	.269	.686

(*111*) *Henry L. Bauman's ore bank*, one half mile east of York Road Station, Hanover Junction Railroad. *Sprenkel's opening.* See Report C, p. 39.

Arenaceous, seamed with quartz, dark brown. (D. McC.)

(*353*) *Henry L. Bauman's ore bank*, one eighth mile east of York Road Station, Hanover Junction Railroad. *Kraber & Ness' opening.* See Report C, p. 40.

Arenaceous, brittle; seamed with quartz; ore carries considerable argillaceous slaty gangue. Color, generally dark brown.

(*385*) *Stoner's ore opening*, one fourth mile east of York Road Station, Hanover Junction Railroad. Thomas Iron Co., lessees. *Ore from abandoned shaft.*

Brittle, exceedingly sandy, carrying more or less decomposed argillaceons slaty gangue.

(*429*) *Bollinger's bank*, at Kaufman's siding, one fourth mile east from York Road Station, Hanover Junction Railroad. See Report C, p. 38.

Compact, brittle; carries a large amount of adhering yellow and white clay. Color, various shades of red and brown.

(*354*) *A. M. Forney's bank*, half a mile from Hanover.

Arenaceous, compact, brittle, carrying a large admixture of quartz and clay.

C. RED HEMATITE (SPECULAR) ORES.

§ *48. Red Hematite and Specular Iron Ores of York and Adams Counties.*

Red hematite ore is rare in Pennsylvania. The "Red oxide" of Haldeman's bank, about four miles north of Hanover, is described by Prof. Frazer in his Report on York county, C, p. 60;—that of the Mount Holly banks in Cumberland county, on page 241 CC. Other instances occur elsewhere along the Azoic belts of South-Eastern Pennsylvania. Some specimens have been found in the Coal

Measures, but are extraordinary in character. In Ohio, beds of Red hematite have been found interstratified with Coal Measures.

The Specular ores of York county are described on pages 53, 57, 64, 70, 133 and 137 C; and as coating Mesozoic rocks, in page 328 CC.

York County.	(*490*) *Cookson.*	(*492*) *McIlwee.*	(*438*) *Mine bank.*	(*185*) *Mine bank.*
Protoxide of iron,	7.457	3.021	2.121	——
Sesquioxide of iron,	45.142	91.214	88.357	82.607
Sesquioxide of manganese,	.668	trace.	016	.041
Oxide of copper,	none.	trace.	none.	.222
Alumina,	2.066	1.819	3.424	4.843
Lime,	18.290	.270	1.290	.760
Magnesia,	.198	.187	.479	.918
Sulphuric acid,	.002	.132	.010	.150
Phosphoric acid,	.027	.160	.291	traces.
Carbonic acid,	none.	none.	none.	.123
Water,	1.230	1.770	.551	1.277
Insoluble residue,	25.280	1.910	3.373	9.530
	100.360	100.583	99.913	100.471
Metallic iron,	37.400	66.200	63.500	57.825
Metallic manganese,	.465	trace	.011	.029
Sulphur,	.001	.053	.004	.060
Phosphorus,	.012	.070	.127	trace.

(*490*) *Franklin Cookson's ore opening*, eight miles east from Dillsburg. See Report C C, page 237.

Hematite, impregnated with magnetite; micaceous, sandy, brittle. (D. McC.)

(*492*) *McIlwee's ore opening*, four miles south-east from Dillsburg. D. Altland, lessee.

Hematite, impregnated with magnetite; foliated, micaceous, somewhat cellular; color, generally iron black. (D. McC.)

(*438*) *Mine ore bank*, two and a half miles south-west from Wellsville. *McCormick & Co., lessees.* See Report CC, page 236.

Red hematite, with foliated, micaceous hematite; unctuous; reddish brown and iron black. Slightly impregnated with magnetite.

(*185*) *Mine ore bank*, two and a half miles south-west from Wellsville. *McCormick & Co., lessees.*

Hematite, with small scales of malachite ; foliated, micaceous, with thin seams of unctuous red hematite. Color, generally iron black. (D. McC.)

	(*491*) *Smith.*	
Protoxide of iron, ...	1.285	= 40.500 per cent. iron.
Sesquioxide of iron, . . .	56.428	
Sesquioxide of manganese,	.206	= .144 per cent. manganese.
Oxide of copper, . . .	.868	
Alumina, ...	10.416	
Lime, ...	8.260	
Magnesia, ...	.990	
Sulphuric acid, ...	.050	= .020 per cent. sulphur.
Phosphoric acid, ...	.297	= .130 per cent. phosphorus.
Carbonic acid, ...	.483	
Water, . . .	1.802	
Silicic acid, . . .	17.560	
Alkalies, (undetermined,)	1.355	
	100.000	

(*491*) *Jacob T. Smith's ore opening*, three miles south of Wellsville. *From shaft in woods.* See Report C C, p. 238.

Hematite, impregnated with magnetite, and carrying more or less malachite ; foliated, micaceous. Ore has a silicious gangue of a greenish color. (D. McC.)

	(*184*) *Bentz.*	
Protoxide of iron, ...	11.700	=63.700 per cent. iron.
Sesquioxide of iron, . . .	78.000	
Protoxide of manganese,	.667	=.367 per cent. manganese.
Alumina, ...	5.420	
Lime, ...	.280	
Magnesia, ...	.169	
Sulphuric acid, ...	.077	=.031 per cent. sulphur.
Phosphoric acid, ...	.100	=.044 per cent. phosphorus.
Water, ...	.250	
Insoluble residue, ...	3.120	
	99.783	

(*184*) *Joseph Bentz's ore opening*, two miles south-west of Wellsville. See Report CC, p. 234.

Hematite, strongly impregnated with magnetite ; foliated, micaceous, iron black. (D. McC.)

	(388) Sprenkel.
Protoxide of iron,	3.985
Sesquioxide of iron,	46.000
Bisulphide of iron,	.046
Sesquioxide of manganese,	trace.
Alumina,	2.528
Lime,	15.250
Magnesia,	1.333
Sulphuric acid,	trace.
Phosphoric acid,	.154
Carbonic acid,	14.170
Water,	.330
Insoluble residue,	16.310
	100.106
Metallic iron,	35.300
Metallic manganese,	trace.
Sulphur,	.025
Phosphorus,	.068

(388) *Sprenkel's ore opening*, one half mile west of Mengis Mill Station, north of Hanover and York Short Line railroad.

Hematite ore, with crust of bluish grey limestone, exceedingly hard and tough; slightly impregnated with magnetite. Color, generally reddish grey.

Adams County.	(435) Cole.	
Protoxide of iron,	.321	} = 50.900 per cent. iron.
Sesquioxide of iron,	72.357	
Sesquioxide of manganese,	.031	= .022 per cent. manganese.
Alumina,	.999	
Lime,	.240	
Magnesia,	.133	
Sulphuric acid,	.017	= .007 per cent. sulphur.
Phosphoric acid,	.007	= .003 per cent. phosphorus.
Water,	.224	
Silicic acid, ($Si O_2$,)	25.660	
	99.989	

(435) *George Cole's ore opening*, one and a half miles from Newmans, on the Cole's Valley road. See Report CC, p. 249.

Specular iron ore; foliated, brittle; iron black, with gangue of quartz.

D. MAGNETIC ORES.

§ 49. *Magnetic Iron Ores.*

The Magnetic ores of Pennsylvania occur along the South Mountain belt, and throughout the Azoic slates and gneissoid rocks between it and the Maryland, Delaware and New Jersey State lines.

They are as yet best described on pages 9 to 35, 48, 53, 64, 69, 71, 82, 108 to 133 of Report C, and on pages 221, 232, 237, 238, 326 CC.

Adams County.	(*15*) *Minter.*	(*16*) *Minter.*
Protoxide of iron,	12.214	15.429
Sesquioxide of iron,	53.376	48.565
Bisulphide of iron,	.050	.009
Protoxide of manganese,	.896	.617
Alumina,	4.424	3.486
Lime,	1.868	4.746
Magnesia,	4.198	6.866
Potash and soda,	.953	1.143
Carbonic acid,	none.	1.375
Phosphoric acid,	.128	.160
Water,	5.000	1.888
Silicic acid, ($Si\ O_2$,)	17.024	15.466
	100.131	99.750
Metallic iron,	46.900	46.000
Metallic manganese,	.523	.478
Sulphur,	.027	.005
Phosphorus,	.056	.070

(*15*) *Minter ore bank*, about one and a half miles north north-west of McKnightstown. *Upper level of bank.*

Magnetite; lump and fine ore; rather soft, with somewhat slaty structure and dark green color. (S. A. Ford.)

(*16*) *Minter ore bank*; *Lower level of bank.* See Report CC, pp. 251, 252, 253.

Magnetite; lump and fine ore; somewhat oxidized; color, generally dark blue. (S. A. Ford.)

NOTE.—Mr. Ford reported a small quantity of arsenic in this ore; but the amount was considered too inappreciable to be determined.

York County.

	(395a) McClure.
Protoxide of iron,	13.821
Sesquioxide of iron,	47.859
Bisulphide of iron,	1.605
Protoxide of manganese,	.036
Oxide of copper,	trace.
Oxide of cobalt,	.040
Alumina,	3.775
Lime,	5.604
Magnesia,	4.129
Sulphuric acid,	1.105
Phosphoric acid,	.107
Carbonic acid,	none.
Water,	1.140
Silicic acid,	20.330
	99.551
Metallic iron,	45.000
Metallic manganese,	.028
Sulphur,	1.297
Phosphorus,	.047

(*395a*) *McClure's mine*, two miles east of Dillsburg. *Sample taken thirty feet from outcrop. King & Jauss, lessees.* See Report CC, p. 212.

Magnetite; more or less oxidized; minutely crystalline. Shows considerable pyrites. Color, sea-green and iron black.

	(395b) McClure.
Iron,	43.000
Sulphur,	1.230
Phosphorus,	.028
Silicic acid,	17.780

(*395b*) *McClure's mine*, two miles east of Dillsburg. *Sample taken one hundred and ten feet from outcrop.*

Ore has the same general appearance as first sample—but shows considerable calcareous matter.

	(430) McIlwee.
Protoxide of iron,	27.964
Sesquioxide of iron,	66.780
Bisulphide of iron,	.009
Protoxide of manganese,	.280
Alumina,	2.642
Lime,	.410

	(430) McIlwee.
Magnesia,	.259
Sulphuric acid,	.020
Phosphoric acid,	.029
Titanic acid,	.330
Water,	.371
Silicic acid,	1.700
	100.794
Metallic iron,	68.500
Metallic manganese,	.217
Sulphur,	.013
Phosphorus,	.013

(*430*) *McIlwee's ore opening*, four miles south-east of Dillsburg. *D. Altland, lessee.*

Magnetite; strongly crystalline, cellular; iron black.

	(454) Price & Hancock.	(183) Comfort.	(109) March.
Protoxide of iron,	15.364	8.485	20.442
Sesquioxide of iron,	72.214	38.357	68.142
Protoxide of manganese,	.296	trace.	.278
Alumina,	4.752	3.005	3.515
Lime,	.460	2.620	1.570
Magnesia,	1.448	.627	.277
Sulphuric acid,	.047	.112	.225
Phosphoric acid,	.113	.240	.448
Water,	1.485	2.515	—
Insoluble residue,	3.840	43.490	5.310
	100.019	99.451	100.207
Metallic iron,	62.500	33.450	63.600
Metallic manganese,	.230	trace.	.216
Sulphur,	.019	.045	.090
Phosphorus,	.050	.105	.096

(*454*) *Price & Hancock's ore opening*, one and a half miles east from Dillsburg.

Magnetite, somewhat oxidized; hard and compact; color, generally black and reddish brown. (D. McC.)

(*183*) *Henry Comfort's ore opening*, two miles west of Wellsville. See Report CC, page 233.

Magnetite, much oxidized; hard, compact, sandy, greyish black. (D. McC.)

(*109*) *S. March's ore opening*, one and three quarter miles south-east of Wellsville. *Float ore from shaft.*

Magnetite, somewhat oxidized; compact, also cellular; brownish black. (D. McC.)

Lancaster County.	*(798)* *Chestnut Hill.*	*(800)* *Brenneman.*
Protoxide of iron,	15.171	19.285
Sesquioxide of iron,	39.181	62.857
Bisulphide of iron,	.050	——
Sesquioxide of manganese,	.102	.232
Alumina,	1.490	3.232
Lime,	.040	1.010
Magnesia,	.396	1.396
Sulphuric acid,	——	.007
Phosphoric acid,	.039	.082
Water,	.350	1.896
Insoluble residue,	43.350	10.670
	100.169	100.667
Metallic iron,	39.250	59.000
Metallic manganese,	.079	.180
Sulphur,	.027	.003
Phosphorus,	.017	.036
Magnetic oxide,	48.880	62.140
Ferric oxide,	5.460	20.000

(798) *Chestnut Hill ore bank*, three miles north north-east from Columbia. *Soft ore in place south-east of rock shaft.*

Magnetite; coarse grained, crumbling; greyish black.

(800) *Iron ore opening near J. Brenneman's house*, five miles north-west from Marietta.

Magnetite; coarse grained, cellular; brownish black.

Lancaster County.	*(799)* *Chestnut Hill.*	
Protoxide of iron,	5.528	= 65.600 per cent. iron.
Sesquioxide of iron,	87.571	
Sesquioxide of maganese,	.155	= .108 per cent. manganese.
Alumina,	3.217	
Lime,	.050	
Magnesia,	.252	
Sulphuric acid,	.007	= .003 per cent. sulphur.
Phosphoric acid,	.109	= .048 per cent. phosphorus.
Water,	.950	
Insoluble residue,	2.260	
	100.099	

(799) *Chestnut Hill ore bank*, three miles north north-east

from Columbia. *Micaceous, slightly magnetic, ore from dividing ridge.*

Micaceous ore; compact, more or less impregnated with magnetite; reddish brown.

Berks County.	*(994)* *Clymer Iron Co.*	*(1008)* *Beitler.*
Metallic iron,	42.700	63.750
Metallic manganese,	7.997	.936
Sulphur,	.020	.224
Phosphorus,	.135	.040
Alumina,	3.411	3.750
Lime,	.040	.090
Magnesia,	1.502	.400
Titanic acid,	——	3.930
Insoluble residue,	14.305	1.010

(*994*) *Clymer Iron Co.s ore*, on Cornman's farm, two and a half miles north-east of Pricetown.

Ore for the most part in powder; soft, dull black to brownish black. Shows numerous small scales of mica. Iron for the most part as magnetic oxide.

(*1008*) *Beitler's mine*, Rockland township. Berks County Mining Co.

Rather coarse grained; hard and tough, with some pyrites throughout the mass. Color generally iron black; luster bright.

E. Fossil Ores.

§ *50. Fossil Ores of the Chemung Formation, No. VIII.*

These have been long known as the Mansfield ores of Tioga county, reported on first in 1841 by J. P. Lesley (published in 1858, Geology of Pennsylvania, Vol. 1, page 311,) and then in greater detail in 1875 by Mr. Sherwood (published in 1878, Report of Progress G, pages 33 to 37; 41, 42; 67.)

The series consists of three beds—1. Upper, or *Spirifer* bed; 2. Middle, or *Fish* bed; and 3. Lower ore bed.

The Upper, or *Spirifer* bed is full of shells, but contains no fish remains. It lies about 200 feet below the base of the Catskill red rocks of Formation No. IX. Near Mansfield it is from two to three feet thick; on Lamb's creek from one to three feet thick. (G, 60, 61.)

The Middle, or *Fish* bed, is oolitic, and very similar to the Clinton Fossil ores of Middle Pennsylvania; yields remains of *fish*, (*Diplodus; Heliodus;*) and is ground for paint. It lies 200 (?) feet beneath the Upper ore bed at Wilcox's on Mann's creek, (G. 61,) and is opened in many places, as at Roseville (four feet thick;) Whipple's Hill; Bixby's Hill; on Elk run, at Covington; Oak hill; Clark's hill; Austenville (where it thickens to 6 and 7 feet;) Columbiana, &c., (G, 66.)

The Third or Lower ore bed on Tioga river, back of Shaw's, is described on page 61 G, as from 100 to 200 feet beneath the Middle bed. It contains small flattened pebbles of quartz.

At Canton Corners, Bradford county, two beds, separated by 8 feet of shale, yield 5 feet of ore, under a roof of shaly Chemung limestone, 10 feet thick, full of fossils, (G, 41.)

Mr. Sherwood discovered one of the Mansfield ore beds on a sharp anticlinal in Lycoming county, in front of the Alleghany mountain; and traces of this deposit have been seen elsewhere in Middle Pennsylvania, as in Huntingdon county, see Report F, page 235, where they have been referred to the Larry's creek ore; and since they lie 13 feet beneath the bottom of the *Transition* layers of IX and VIII, they may represent under a very much changed aspect the Upper Mansfield ore bed.

Tioga County.	*(203)* *Waddle's brook.*	
Sesquioxide of iron,	26.714	=18.70 per cent. iron.
Sesquioxide of manganese,	.247	
Alumina,	4.464	
Lime,	12.678	
Magnesia,	.944	
Sulphuric acid,	.152	=.061 per cent. sulphur.
Phosphoric acid,	.622	=.272 per cent. phosphorus.
Carbonic acid,	9.390	
Water,	1.960	
Insoluble residue,	42.565	
	99.736	

(*203*) *Fragments of iron ore in bed of Waddle's Brook*, Clymer township. See Report G, pp. 86, 87.

Fossil ore; hard, sandy; with specks of carbonate of lime and considerable adhering clay. (D. McCreath.)

Bradford County.	(*200*) *Roseville.*
Iron,	41.900
Sulphur,	.035
Phosphorus,	.389
Insoluble residue,	28.950

(*200*) *The Second Ore Bed*, at Roseville, Rutland township, eight miles east of Mansfield. See G, page 64.

Compact, granular; comparatively soft; reddish grey.

Tioga County.	(*319*) *Shaw.*	(*198*) *Upper ore bed.*	(*318*) *Wilson.*	(*335*) *Lower ore bed.*	(*317*) *Middle ore bed.*
Iron,	42.800	38.900	32.400	43.100	35.300
Sulphur,	.018	.063	.065	.018	.026
Phosphorus,	.903	.603	.585	.657	.215
Lime,	——	13.100	9.170	1.800	4.740
Magnesia,	——	2.140	2.918	.922	——
Insoluble residue,	21.670	11.565	23.890	20.910	28.845

(*319*) *Upper or Mansfield Ore Bed*, on Andrew Shaw's farm, two miles north-east of Mansfield, Richmond township. Upper vein, three feet thick. See G, p. 61.

Compact, coarse grained, reddish brown.

(*198*) *Upper or Mansfield Ore Bed*, about three miles west of Mansfield. See G, p. 60.

Compact, deep red; shows considerable calcareous matter.

(*318*) *Upper or Mansfield Ore Bed*, on lands of G. R. Wilson, three miles north-west of Mansfield, Lamb's Creek, Richmond township. Eighteen inches thick. See G, p. 60.

Compact, coarse grained; reddish brown.

(*335*) *Lower or Third Ore Bed*, one mile north-west of Mansfield. Outcrop in the bed of the Tioga river. See G, p. 61.

Hard and compact; *with small flattened quartz pebbles.* Color, generally reddish brown. (D. McCreath.)

(*317*) *Middle or Second Ore Bed*, one and a half miles south of Mansfield; on Bixby's Hill.

Fine grained, reddish brown. (D. McCreath.)

Tioga County.	*(199) Wilson.*
Sesquioxide of iron, . . .	. 44.571=31.20 per cent. iron.
Sesquioxide of manganese,	. trace.
Alumina, ...	8.295
Lime, ...	5.250
Magnesia, ...	1.448
Sulphuricacid, ...	.125=.050 per cent. sulphur.
Phosphoric acid, ...	3 854=1.683 per cent. phosphorus.
Water, ...	5.166
Insoluble residue, ...	30.550
	99.259

(*199*) *Middle or Second Ore Bed*, on lands of G. R. Wilson, one mile north of Mansfield, Richmond township. Bed sixteen inches thick. See G, p. 61.

Compact; oolitic; argillaceous; reddish brown.

Tioga County.	*(201) Second ore bed.*	*(320) Second ore bed.*
Iron, ...	31.800	24.000
Sulphur, ...	.034	.017
Phosphorus, ...	.253	.213
Insoluble residue, ...	35.120	51.390

(*201*) *Middle or Second Ore Bed*, in Charlestown township, three fourths mile west of the house of J. Rouse. See G, p. 58.

Compact, coarse grained (oolitic); with seams of shaly ore running through the mass. Color, reddish brown.

(*320*) *Middle or Second Ore Bed*, exposed on a small stream half a mile east of Covington. Eight inches thick. See G, p. 63.

Hard, sandy, oolitic, reddish brown. (D. McC.)

Tioga County.	*(324) Hermon and Meetem.*	*(323) Hermon and Meetem.*	*(322) Hermon and Meetem.*	*(321) Hermon and Meetem.*
Iron, ...	39.300	31.300	37.000	28.900
Sulphur, ...	.027	.018	trace.	.015
Phosphorus, ...	.184	.229	.241	.298
Insoluble residue, . .	34.400	44.420	36.370	44.980

Ore openings on the lands of Mr. Hermon and Mr. Meetem, one mile south-east of Ogden's Corners, Union township. See G, pp 33, 34.

(*324*) *Ore from the top band;* four feet thick.

Compact, fine grained; dark reddish brown.

(*323*) *Ore from the second band*; one foot five inches thick.

Compact, fine grained; reddish brown.

(*322*) *Ore from the third band;* eight inches thick.

Compact, fine grained; reddish brown and reddish grey.

(*321*) *Ore from the bottom band;* one foot thick.

Compact, sandy; reddish brown. (D. McCreath.)

Tioga County.	(*325*) *Roaring Branch.*	(*202*) *Pratt.*
Iron,	28.850	18.500
Sulphur,	.018	.033
Phosphorus,	.233	.191
Insoluble residue,	50.470	62.360

(*325*) *Iron ore exposure* north of Roaring Branch P. O., Union township; about one foot thick.. See G, p. 34.

Fine grained, sandy; reddish brown.

(*202*) *Same ore bed*, one third of a mile east of J. Pratt's, near the main road; eight inches thick. See G, p. 34.

Compact, fine grained; exceedingly sandy; showing small scales of mica. Reddish brown.

Bradford County.	(*333*) *Second ore bed.*	(*205*) *Second ore bed.*
Iron,	33.600	32.400
Sulphur,	.018	.130
Phosphorus,	.179	.288
Insoluble residue,	40.690	40.130

(*333*) *Middle or second ore bed*, at Austinville, Columbia township. See G, pp. 65, 66.

Fine grained, sandy, reddish brown.

(*205*) *Middle or second ore bed*, half a mile south-west of Columbia Cross Roads.

Compact, sandy, reddish brown, with specks of quartz. (D. McCreath.)

Bradford County.	(*332*) *East Troy.*	(*329*) *Barnes.*	(*327*) *E. Sellard.*	(*204*) *I. Sellard.*	(*328*) *I. Sellard.*
Iron,	24.700	28.400	28.500	32.200	14.600
Sulphur,	.016	.014	.039	.059	——
Phosphorus,	.248	.258	.294	.311	——
Insoluble residue,	52.440	45.310	45.110	40.640	65.520

(*332*) *Ore exposure* in Troy township, in the main road below East Troy. See G, p. 36.

Fine grained, reddish brown, with spangles of quartz. (D. McCreath.)

(*329*) *Ore exposure* in Canton township, in the main road south-east of Canton, near the house of B. D. Barnes, and west of Mud Lake. (G, p. 36.)

Hard, sandy, greyish brown. (D. McCreath.)

(*327*) *Ore exposure* in Canton township, two miles south of Canton, on the land of Enoch Sellard.

Fine grained, sandy, reddish brown.

(*204*) *Ore exposure* in Canton township, on land of Ichabod Sellard, about two miles south of Canton, on the west side of the creek.

Brittle, fine grained, sandy, reddish brown. (D. McCreath.)

(*328*) *Ore exposure* in Canton township, on land of Ichabod Sellard, on the east side of hill. (G, p. 35.)

Hard, very sandy, reddish brown. (D. McCreath.)

Bradford County.	(*331*) *LeRoy.*	(*330*) *Wilcox.*
Iron,	20.700	29.500
Sulphur,	trace.	trace.
Phosphorus,	.185	.204
Lime,	8.710	—
Magnesia,	1.300	—
Insoluble residue,	46.655	49.270

(*331*) *Ore exposure at LeRoy Village*, in Gulf Brook, LeRoy township. See G, p. 36.

Compact, sandy, reddish brown; showing considerable calcareous matter. (D. McC.)

(*330*) *Ore exposure in LeRoy township*, about one and a half miles west of LeRoy, in the main road near the house of J. Wilcox.

Compact, fined grained, reddish brown.

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§ *51. Fossil Ores of the Clinton Formation, No. V.*

A detailed description of these beds will be found in Report of Progress F, on the Juniata District.

1. The Sand Vein ore bed, the uppermost of the group, overlying the Sand Rock or upper member of the Ore

Sandstone. It is a hard, lean calcareous ore below the drainage level; but soft, and comparatively rich, from drainage level up to outcrop. Sometimes it is represented by loose sand. Fossil impressions are numerous. (See F preface, pp. xxxv to xxxviii.)

2. The Danville ore group of three or four beds underlying the Ore Sandstone, and about twenty-five or thirty feet beneath the Sand Vein ore. These beds are very variable; calcareous; fossiliferous; and from four to eight inches thick. Sometimes they lie near enough together to allow forty inches of ore to be taken out of a drift. They are softened into rich ore at the surface of the ground and for one, two or three hundred feet down to drainage level. (F preface, xxxix to xl.)

3. The Block ore lies one hundred and fifty feet beneath the Danville ore group and is called also the Iron Sandstone. It separates the Clinton Upper from the Clinton Lower shales. (F, xli.)

4. The Boyer Block ore lies two hundred and fifty to three feet beneath the Iron Sandstone, and is six feet thick in Mahontongo Gap.

5. The Bird-Eye Fossil ore bed occurs one hundred to one hundred and fifty feet above the base of the Clinton formation No. V, in the Clinton Lower shales, and varies from six to fourteen inches. (F, xlv.)

6. The Shot Block ore bed lies still lower, and if it be the same with R. H. Powell's ore bed south-west of Huntingdon, it lies close upon the Medina Sandstone and sometimes attains a thickness of more than twenty feet, of which from two to six feet is soft ore. This may be the Dye-stone ore of the Southern States. (F, xlvii.)

Blair County.	*(710) Baker.*	*(711) Baker.*	*(647) Frankstown.*
Sesquioxide of iron,	69.285	29.071	59.857
Sesquioxide of manganese,	.130	.278	.403
Alumina,	9.164	2.342	2.748
Lime,	.190	32.340	12.110
Magnesia,	.601	1.852	4.195
Sulphuric acid,	.075	.072	.087
Phosphoric acid,	.451	.767	.588
Carbonic acid,	none.	26.360	14.075

Blair County.	(*710*) *Baker.*	(*711*) *Baker.*	(*647*) *Frankstown.*
Water,	8.374	1.660	1.305
Insoluble residue,	12.015	5.520	4.800
	100.285	100.262	100.168
Metallic iron,	48.500	20.350	41.900
Metallic manganese,	.090	.194	.280
Sulphur,	.030	.029	.035
Phosphorus,	.197	.335	.257

(*710*) *Baker's ore bank*, at foot of Brush mountain, near Altoona. *Soft fossil ore.*

Generally compact and rather fine grained; full of fossil casts partially filled with specular iron oxide. Fracture, even. Color, yellowish brown.

(*711*) *Baker's ore bank*, at foot of Brush mountain, near Altoona. *Hard fossil ore.*

Compact, fossiliferous, brittle, reddish grey.

(*647*) *Frankstown slope mine*, Frankstown.

Exceedingly hard and tough; fossiliferous; deep red. A second specimen of this ore was examined which gave: Iron 40.40 per cent; Insoluble residue 5.86 per cent.

Blair County.	(*646a*) *Hollidaysburg.*	(*646b*) *Hollidaysburg.*
Sesquioxide of iron,	30.857	19.285
Sesquioxide of manganese,	.053	.046
Alumina,	2.850	1.828
Lime,	31.530	38.160
Magnesia,	.865	.846
Sulphuric acid,	.060	.085
Phosphoric acid,	1.092	.417
Carbonic acid,	23.778	30.205
Water,	1.885	1.015
Insoluble residue,	7.090	8.315
	100.0[illegible]0	100.202
Metallic iron,	21.600	13.500
Metallic manganese,	.035	.032
Sulphur,	.024	.034
Phosphorus,	.477	.182

(*646a*) *Hollidaysburg Double fossil ore; upper layer.*

Compact, fossiliferous, showing considerable calcareous matter; reddish brown.

(*646b*) *Hollidaysburg Double fossil ore; lower layer.*

Compact, fossiliferous, reddish grey and reddish brown.

Blair County.	*(645) Hollidaysburg and Gap Iron Co*	*(712) Hollidaysburg and Gap Iron Co.*	*(962) Sarah furnace.*
Sesquioxide of iron, .	74.285	67.285	69.357
Sesquioxide of manganese, ...	.072	.278	.014
Alumina, ...	7.392	7.044	6.285
Lime, ...	.960	.550	.910
Magnesia, ...	.552	.569	.551
Sulphuric acid, . . .	.077	.082	.008
Phosphoric acid, . .	.758	.398	.768
Carbonic acid, ...	traces.	traces.	none.
Water, ...	4.962	6.190	5.167
Insoluble residue, . .	11.115	17.855	17.230
	100.173	100.251	100.290
Metallic iron, ...	52.000	47.100	48.550
Metallic manganese, .	.050	.194	.010
Sulphur, ...	.031	.033	.003
Phosphorus, ...	.331*	.174†	.327

(*645*) *Hollidaysburg and Gap Iron Company's Mine,* McKee's Gap. *Lump ore.*

Compact and tough; full of seams of ochreous iron ore and spangles of specular iron oxide. Color, generally reddish brown.

(*712*) *Hollidaysburg and Gap Iron Company's Mine,* McKee's Gap. *Second sample; consisting of two thirds lump ore and one third fine ore.*

Lump ore has the general appearance of first specimen. Fine ore is for the most part a yellowish ochreous mud, rather lean in iron.

(*962*) *Sarah Furnace ore bank,* on Dunning's Mountain, near Sarah Furnace.

Dark reddish brown, brittle; full of fossil pits for the most part filled with specular iron ore. Emits a strong argillaceous odor when breathed upon.

Huntingdon County.	*(930) Little furnace.*	*(929) Monroe furnace.*	*(944) Manor Hill.*	*(943) Manor Hill.*
Iron, ...	46.500	34.800	25.075	11.825
Sulphur, ...	.025	.038	.012	.019
Phosphorus, ...	.475	.132	.223	.255
Carbonate of lime, ...	17.550	none.	54.359	71.518
Carbonate of magnesia, . .	1.551	none.	1.112	2.792
Insoluble residue, ...	6.880	40.680	5.235	5.800

* A duplicate test for phosphorus gave .329 per cent.

† A duplicate test for phosphorus gave .171 per cent.

(*930*) *Iron ore opening, one mile north-west of McAleavy's Fort.* From old workings of Little Furnace.

Compact; showing considerable calcareous matter; fracture, irregular; color, reddish grey and reddish brown.

(*929*) *Iron ore opening, three miles west of McAleavy's Fort.* Surface specimen from old workings of Monroe furnace.

Sandy, coarse grained; dark brown and yellowish brown. Fracture rough, irregular.

(*944*) *Iron ore opening, two miles north-west of Manor Hill.* Hard fossil ore; surface specimen.

Hard, showing considerable calcareous matter, with some adhering clay. Reddish brown. (S. S. Hartranft.)

(*943*) *Iron ore opening, four miles from Manor Hill*, Barre township; Tussey mountain ore range. Hard fossil ore fourteen inches thick, dipping 33° south-east.

Hard, compact, reddish brown. (S. S. Hartranft.)

Huntingdon County.

	(*787*) *Barr.*	
Sesquioxide of iron,	71.500=	50.050 per cent. iron.
Sesquioxide of manganese,	.643=	.448 per cent. manganese.
Alumina,	5.825	
Lime,	1.715	
Magnesia,	1.248	
Sulphuric acid,	.069=	.028 per cent. sulphur.
Phosphoric acid,	1.285=	.561 per cent. phosphorus.
Water,	4.979	
Insoluble residue,	12.385	
	99.649	

(*787*) *Iron ore opening, four miles from Greenwood furnace.* Fossil ore from outcrop in ridge back of J. Barr's. Dip S. E.

Brittle, fossiliferous, reddish brown. Emits a strong argillaceous odor when breathed upon. (S. S. Hartranft.)

Fulton County.

	(*124*) *Kerlin.*
Iron,	55.000
Sulphur,	.005
Phosphorus,	.252
Insoluble residue,	9.630

(*124*) *Peter Kerlin's ore opening*, one mile north-east of Fort Littleton, south-west end of Shade Mountain.

Block ore, compact, oolitic; color, iron rust.

Juniata County.	(*101*) *Bilger.*	(*927*) *Echman.*	(*389*) *Boyer.*	(*95*) *Creaghton.*
Iron, ...	55.750	57.217	29.200	29.500
Sulphur, ...	.025	.020	.048	trace.
Phosphorus, . . .	.120	.122	.537	.111
Insoluble residue,	10.700	9.660	46.550	49.840

(*101*) *Tobias Bilger's ore opening*, three and a half miles east of McAllisterville.

Coarse grained; reddish brown. (D. McCreath.)

(*927*) *Michael Echman's ore opening*, three and a half miles east of McAllisterville.

Comparatively soft, reddish brown; with some specks of micaceous iron ore. (S. S. Hartranft.)

(*389*) *William Boyer's ore opening*, on south side of Shade Mountain. *From bottom bench of ore.*

Block ore; fine grained, reddish brown. (D. McCreath.)

(*95*) *W. W. Creaghton's ore opening*, near McCoytown.

Coarse grained, sandy, with quartz spangles. (D. McCreath.)

Juniata County.	(*22*) *H. Aughey.*	(*928*) *S. Aughey.*	(*13*) *Hirsh.*	(*17*) *Robinson.*
Iron, ...	44.600	41.273	46.000	31.150
Sulphur, ...	.012	.020	.009	.009
Phosphorus, ...	.496	.348	.299	1.643
Insoluble residue, ...	18.080	25.775	24.220	37.110

(*22*) *Henry Aughey's ore opening*, four miles north-west of Mifflintown, and three miles west of the Juniata River. Hirsh & Hiestand, lessees.

Block ore; compact, rather coarse grained, reddish brown.

(*928*) *Samuel Aughey's ore opening*, two miles south-west of the Juniata River. Specimen analysed consisted of one half "Jack" and one half ore; this being about the proportions in which they occur in the bed.

Comparatively soft, reddish brown; with numerous small pebbles and some micaceous iron ore. (S. S. Hartranft.)

(*13*) *Hirsh & Hiestand ore opening*, south side of Lost Creek ridge. "*Sand rock ore.*"

Very hard and compact, with slaty structure and dark brown color.

(*17*) *John Robinson's ore opening*, on Lost Creek ridge, Licking Creek Valley. "*Shot Block ore.*"

Hard and compact with numerous pebbles of impure phosphate of lime. See analysis of pebbles in Chapter VII.

Juniata County.

	(*19*) *Graham.*	(*20*) *Graham.*	(*21*) *Graham.*	(*24*) *Juniata river.*	(*25*) *Penni-becker.*
Iron, ...	47.900	51.900	24.800	50.000	45.100
Sulphur, ...	.008	.005	.005	.010	.005
Phosphorus, ...	.279	.215	.562	.338	.168
Insoluble residue, .	17.760	14.030	43.610	14.330	25.310

(*19*) *Graham ore bank* (No. 1), four miles north-east of Mifflintown, east of Juniata river. (Toll & Williams.) Vein twenty inches thick with five inches "Jack." *Specimen analysed consisted of three fourths ore and one fourth "Jack."*

Block ore; compact, light brown, with some intermingled slate.

(*20*) *Graham ore bank* (Nos. 2 and 3), four miles north-east of Mifflintown and one mile east of Juniata river. *Vein two feet thick. Ore specimen analysed, eighteen inches thick.* Leased by Glamorgan Iron Company.

Block ore; coarse grained, light brown and reddish brown; with numerous specks of quartz and specular iron ore.

(*21*) *Graham ore bank* (Nos. 2 and 3) "*Jack*" *from the vein.*

Compact, slaty; iron rust and various shades of brown.

(*24*) *Iron ore opening six and a half miles west from Juniata river*, Licking Creek valley.

Compact, with considerable altered fossil ore. Color, dark brown and liver brown.

(*25*) *S. S. Pennibecker's ore opening*, five miles west from Mifflintown; south side of Lost Creek ridge. *This ore is the sand rock ore found along this range and shows the general character west of Licking Creek Gap.*

Hard, coarse grained, sandy, dark brown.

Juniata County.	*(941)* *William Nankwell.*	*(29)* *William Nankwell.*	*(14)* *William Nankwell.*	*(23)* *William Nankwell.*	*(18)* *Richard Nankwell.*
Iron, ...	29.775	42.100	16.500	32.100	45.450
Sulphur, . .	.112	trace.	.249	.010	trace.
Phosphorus, . .	.351	.338	.122	.257	.246
Carbonate of lime, .	38.375	——	12.172	34.250	——
Carbonate of magnesia,	.892	——	2.662	3.465	——
Insoluble residue,	9.340	23.050	49.748	11.360	21.600

(*941*) *Wm. Nankwell's ore opening*, five miles north from Mifflintown, on South slope of Lost Creek ridge. *Hard fossil ore from "Sand Vein" ore bed.*

Hard, tough, reddish brown. Sparkles with calcareous matter. (S. S. Hartranft.)

(*29*) *Wm. Nankwell's ore opening*, three and a half miles west of the Juniata river.

Block ore ; compact, coarse grained, reddish brown.

(*14*) *Wm. Nankwell's ore opening*, on A. Guss' property, three miles from Juniata river, Licking Creek Valley. Vein ten inches thick.

Hard, sandy, calcareous, chocolate brown.

(*23*) *Wm. Nankwell's ore opening*, on A. Guss' property, three miles from Juniata river, Licking Creek Valley. Vein fourteen inches thick.

Hard, compact, reddish brown.

(*18*) *Richard Nankwell's ore opening*, Licking Creek Valley.

Compact, brownish black and reddish brown.

Juniata County.	*(26)* *J. Suloff.*	*(27)* *J. Suloff.*	*(390)* *H. Suloff.*	*(28)* *H. Suloff.*
Iron, ...	50.000	53.100	49.700	30.800
Sulphur, ...	.005	.008	.038	.062
Phosphorus, ...	.451	.152	.590	.457
Insoluble residue, . . .	15.880	12.600	15.800	36.240

(*26*) *Jacob Suloff's ore opening*, four and a half miles north-east of Mifflintown ; north dip of Blue Ridge, near where the ridge ends. Toll and Williams, lessees.

Comparatively soft and fine grained ; color, iron rust.

(*27*) *Iron ore opening on north dip of Blue Ridge*, near Jacob Suloff's opening. This outcrop is towards the Juniata River.

Block ore ; compact, reddish brown.

(*390*) *Henry Suloff's ore opening*, in synclinal at south base of Shade Mountain, four and a half miles north-east of Mifflintown.

Hard, rather fine grained, reddish brown. (D. McC.)

(*28*) *Henry Suloff's ore opening; shale overlying fossil ore.* Mined with the vein.

Structure slaty; fracture irregular; color, various shades of red and brown.

Mifflin County.	(*721*) *Mann.*	(*722*) *Mann.*	(*98*) *Oswell's Gap.*	(*222*) *Gibbony.*
Iron, .	26.100	46.900	42.700	32.700
Sulphur, ...	.051	.005	trace.	.031
Phosphorus, ...	.544	.310	.138	.415
Carbonate of lime,	47.018	——	——	——
Carbonate of magnesia,	2.240	——	——	——
Insoluble residue, . .	9.610	22.880	28.680	32.560

(*721*) *Iron ore opening on property of J. H. Mann*, Logan Gap. *Hard fossil ore from Danville ore bed.* See report F, p. 17.

Hard, compact, coarse grained; reddish brown and reddish grey.

(*722*) *Iron ore opening on property of J. H. Mann*, Logan Gap. *Fossil ore from "Sand Vein" ore bed.* See F, p. 18.

Generally compact, and rather earthy; sparkles with scales of specular iron oxide. Color, pink and reddish brown.

(*98*) *Iron ore opening at Oswell's Gap*, Shade Mountain. *"Sand Vein" ore bed.*

Compact, with spangles of quartz and specular iron ore. Color, light brown. (D. McCreath.)

(*222*) *Henry Gibbony's ore opening*, east of Mowry's Gap, ten miles east of Lewistown. See F, p. 44.

Altered fossil ore; brittle, argillaceous, reddish brown. (D. McC.)

Snyder County.	(*103*) *Conrad.*	(*104*) *Conrad.*	(*99*) *Conrad.*	(*126*) *Conrad.*
Iron, . .	52.300	52.900	50.300	29.400
Sulphur, . .	trace.	.011	.006	.056
Phosphorus, . . .	.378	.514	.488*	.726
Insoluble residue,	10.550	9.070	14.270	32.660

* My test for phosphorus in this specimen gave .485 per cent.

(*103*) *Dr. J. D. Conrad's ore opening*, one and one fourth miles south-west of Beavertown. "*Sand Vein*" *ore bed*; twenty-four inches thick, with six inches of "Jack" in the middle. *Top bench of the vein.*

Compact, coarse grained; showing spangles of quartz. Color, iron rust. (D. McCreath.)

(*104*) *Dr. J. D. Conrad's ore opening; upper part of lower bench.*

Compact, coarse grained; with spangles of quartz. (D. McC.)

(*99*) *Dr. J. D. Conrad's ore opening; lower part of vein.*

Compact, coarse grained; with spangles of quartz. (D. McC.)

(*126*) *Dr. J. D. Conrad's ore opening; "Jack" of the vein.*

Specimen carries considerable intermingled slate; is very compact, and of a dark brown and iron rust color.

Snyder County.	*(610)* *Conrad.*	
Sesquioxide of iron,	77.714=	54.400 per cent. iron.
Sesquioxide of manganese,	.325=	.226 per cent. manganese.
Alumina,	5.654	
Lime,	.740	
Magnesia,	.410	
Sulphuric acid,	.065=	.026 per cent. sulphur.
Phosphoric acid,	.771=	.337 per cent. phosphorus.
Water,	5.822	
Insoluble residue,	8.315	
	99.816	

(*610*) *Dr. J. D. Conrad's ore opening*, one mile south-west of Beavertown, on the property of J. F. Middlesworth. "*Sand Vein*" *ore bed;* twenty-six inches thick, with six inches of "Jack" in the middle. *This specimen from the bottom bench of vein.* See F, p. 37.

Compact, rather coarse grained; reddish brown and iron rust.

Snyder County.	*(125)* *Bloomsburg Iron Co.*	*(127)* *Earnest.*	*(100)* *Earnest.*
Iron,	43.100	52.600	49.900
Sulphur,	.010	.023	.006
Phosphorus,	.243	.521	.196
Insoluble residue,	21.800	11.560	15.100

(*125*) *Bloomsburg Iron Company's ore opening*, one mile south-west of Beavertown, on the property of J. F. Middlesworth. "*Sand Vein*" *ore bed.* See F, page 37.

Compact, coarse grained, reddish brown.

(*127*) *John Earnest's ore opening*, three fourths of a mile south-west of Beavertown. "*Sand Vein*" *ore bed.* Vein twenty-four inches thick, with six inches "Jack." (Bloomsburg Iron Company.)

Compact, coarse grained, reddish brown.

(*100*) *John Earnest's ore opening; "Jack" of the vein.* See F, p. 35.

Block fossil ore, showing spangles of quartz and specular iron ore. Color, iron rust. (D. McC.)

Snyder County.	(*925*) *Bloomsburg.*	(*102*) *Bloomsburg.*	(*725*) *Swengle.*
Iron,	52.100	42.750	48.800
Sulphur,	.032	.021	.028
Phosphorus,	.396	.113	.326
Insoluble residue,	12.960	27.430	15.230

(*925*) *Bloomsburg Iron Co.'s ore opening*, on property of Jacob Gross, south-east of Adamsburg. "*Sand vein*" *ore bed.*

Soft, reddish brown, spotted with quartz. (S. S. Hartranft.)

(*102*) *Bloomsburg Iron Co.'s ore opening*, on property of Jacob Gross, one mile south-west of Adamsburg.

Ore comparatively soft, with considerable specular iron oxide. Reddish brown. (D. McC.)

(*725*) *Swengle & Dunning ore opening*, on the property of Reuben Dreese, one mile south-west of Adamsburg. "*Sand vein*" *ore bed.*

Rather friable, argillaceous, reddish brown. Shows numerous small spangles of quartz.

Snyder County.	(*724*) *Cruikshank.*	(*926*) *"Block ore."*	(*128*) *Bickle.*
Iron,	45.125	32.455	50.500
Sulphur,	.015	.094	.024
Phosphorus,	.407	1.975	.257
Carbonate of lime,	10.928	——	——
Carbonate of magnesia,	2.497	——	——
Insoluble residue,	12.855	29.635	15.220

(*724*) *Cruikshank & Brother's ore opening*, on the property of Emanuel Duck, two miles from Smithgrove. *"Bird Eye" fossil ore.*

Compact, coarse grained, brittle; fracture irregular; color reddish brown.

(*926*) *Ore opening two miles south-east of Smithgrove*, on road leading to Freeburg. *"Block ore."*

Hard, reddish brown, with shot-like pebbles of impure phosphate of lime. Spotted with quartz. (S. S. Hartranft.)

(*128*) *Andrew Bickle's ore opening*, two miles north of Freeburg, and two and a half miles south-east of Smithgrove. *"Bird Eye" fossil ore.*

Coarse grained, brittle, reddish brown.

Union County.	*(723)* *Union Furnace Co.*
Iron,	33.800
Sulphur,	.004
Phosphorus,	.358
Carbonate of lime,	39.142
Carbonate of magnesia,	2.497
Insoluble residue,	3.851

(*723*) *Union Furnace Co.'s mines*, at Winfield. *Hard fossil ore; Danville ore bed.*

Exceedingly hard and tough, carrying small lenticular masses of slate. Color, reddish brown and reddish grey.

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52. *Iron and Phosphorus in Certain Ores.*

The accompanying table E shows the percentage of iron and phosphorus in certain ores; and the percentage of phosphorus which would be contained in one hundred parts of iron produced from them.

In this table only those ores are included which—from their contents of iron and phosphorus—might be used to advantage in the production of Bessemer pig iron.

TABLE E.

NAME OF ORE.	County.	Character of ore.	Per cent. iron.	Per cent. phosphorus.	Phosphorus in 100 parts iron.
Big Bottom ore, Oliphant's furnace, . .	Fayette, . .	Carbonate,	35.500	.042	.118
Springfield mines, bank No. 1, ...	Blair, ...	Limonite, .	36.700	.035	.095
Springfield mines, bank No. 2. *Bombshell ore*, ...	Blair, ...	Limonite, .	59.100	.054	.091
Springfield mines, bank No. 2. *Wash ore*, ...	Blair, ...	Limonite, .	51.600	.060	.116
Springfield mines, bank No. 3, ...	Blair, ...	Limonite, .	54.710	.060	.109
Bloomfield *bombshell ore*, ...	Blair, ...	Limonite, .	52.550	.031	.059
Bloomfield *lump ore*, ...	Blair, ...	Limonite, .	50.050	.045	.089
Sarah furnace ore, ...	Blair, ...	Limonite, .	41.600	.056	.134
Sarah furnace, "burnt ore,"	Blair, ...	Limonite, .	48.900	.025	.051
McLanahan, Stone & Bayley's ore, .	Blair, ...	Limonite, .	38.300	.054	.140
Fleck ore, No. 1, ...	Huntingdon,	Limonite, .	51.700	.058	.112
Minter ore, upper level, ...	York, ...	Magnetite, .	46.900	.056	.117
McClure's ore, ...	York, ...	Magnetite, .	45.000	.047	.104
McClure's ore, ...	York, ...	Magnetite, .	43.000	.028	.065
McIlwee's ore, ...	York, ...	Magnetite, .	68.500	.013	.019
Price & Hancock's ore, ...	York, ...	Magnetite, .	62.500	.050	.080
Joseph Bentz' ore, ...	York, ...	Hematite, .	63.700	.044	.069
Mine bank, ...	York, ...	Hematite, .	57.825	trace.	trace.
E. L. Cookson's ore, ...	York, ...	Hematite, .	37.400	.012	.032
McIlwee's ore, ...	York, ...	Hematite, .	66.200	.070	.105
George Coles' ore, ...	Adams, . . .	Hematite, .	50.900	.003	.005
Near J. Brenneman's house, ...	Lancaster, . .	Magnetite, .	59.000	.036	.061
Chestnut Hill mine, soft ore in place S. E. of Rock shaft, ...	Lancaster, . .	Magnetite, .	39.250	.017	.043
Chestnut Hill mine, dividing ridge, top bench, ...	Lancaster, . .	Hematite, .	65.600	.048	.073
John Henninger's ore, ...	Lehigh, . .	Limonite, .	41.200	.056	.135
Brown's mine, *	Lehigh,	Limonite, .	47.000	.061	.129
Beitler's mine, ...	Berks, ...	Magnetite, .	63.750	.040	.062
Charles Miller's mine, ...	Berks, ...	Limonite, .	53.100	.038	.071

Analyses made in 1874 and 1875, and published in report M.

NAME OF ORE.	County.	Character of ore.	Per cent. iron.	Per cent. phosphorus.	Phosphorus in 100 parts iron.
Rockhill Iron and Coal Co.'s ore, Sandy Ridge, ...	Huntingdon,	Limonite, .	51.700	.068	.131
Rockhill Iron and Coal Co.'s ore, Orbison slope, Sandy Ridge, ...	Huntingdon,	Carbonate,	33.700	.045	.133
James Rhodes' ore opening, ...	Juniata, . . .	Limonite, .	29.500	.039	.132
Logan's shaft, (Mumper ore,) (Dillsburg,)	York, . . .	Magnetite, .	45.880	.023	.050
Fuller's mine, (Dillsburg,)	York, . . .	Magnetite, .	44.900	.023	.051
Alexander Underwood, (Dillsburg,) . .	York, . . .	Magnetite, .	42.750	.011	.025
Alexander Underwood, (Dillsburg,) . .	York, . . .	Magnetite, .	47.314	.018	.038
D. V. Ahl's ore, ...	Adams, . . .	Magnetite, .	50.000	.060	.120
Cornwall ore; surface ore at Robesonia,	Lebanon,	Magnetite, .	52.580	trace.	trace.
Frank S. Lichtenwalner, ...	Lehigh, . .	Limonite, .	48.250	.025	.051
Thomas Breinig's mine, ...	Lehigh, . .	Limonite, .	58.500	.043	.073
Gachenbach's mine, ...	Lehigh, . .	Limonite, .	51.700	.066	.127

CHAPTER III.

§ 53. *Analyses of Irons, Cinders, &c.*

Most of the analyses (1 to 42) given under this section were made in connection with certain experiments to test the value of natural gas in iron working. The subject has been fully discussed by Mr. John B. Pearse, in his Appendix D to Report L, 1875, to which the reader is referred.

Coal.	*No 1.*
Water @ 225°,	.920
Volatile matter,	36.800
Fixed carbon,	49.912
Sulphur,	1.672
Ash,	10.696
	100.000

Coke, per cent. 62.28; color of ash, cream.

No. 1. *Freeport Upper Coal, used in puddling furnaces.*

Cold Fix.	*No. 2.*
Metallic iron,	63.250
Sulphur,	.056
Phosphorus,	.072
Insoluble matter,	5.940

No. 2. *Lake Superior iron ore, used as "cold fix."*

Roll Scale.	*No. 3a.*	*No. 3b.*	*No. 4.*
Protoxide of iron,	61.842	59.597	64.285
Sesquioxide of iron,	17.000	16.383	11.428
Sulphur,	.380	.366	.311
Phosphorus,	.748	.720	.723
Silica,	13.990	13.482	18.180
Iron as protoxide,	48.100	46.354	50.000
Iron as sesquioxide,	11.900	11.468	8.000
Total iron,	60.000	57.822	58.000
Water,	—	3.630	—

No. 3*a*. *Roll scale* used in *coal charges.*

No. 3*b*. *Roll scale* used in *coal charges*; *wet.*

No. 4. *Roll scale* used in *gas charges.*

Tap Cinder.

	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
Protoxide of iron, . .	42.235	72.000	56.571	56.571	56.571	56.571
Sesquioxide of iron, .	33.785	17.571	10.857	8.786	7.429	7.713
Sulphur,	.151	.209	.291	.401	.376	.308
Phosphorus, . .	.419	.276	1.088	.888	.963	.968
Silica, ...	17.650	5.970	23.940	26.890	27.130	27.030
Iron as protoxide, .	32.850	56.000	44.000	44.000	44.000	44.000
Iron as sesquioxide, .	23.650	12.300	7.600	6.150	5.200	5.400
Total iron, ...	56.500	68.300	51.600	50.150	49.200	49.400

No. 5. *Cinder* tapped from No. 21 furnace *before first coal charge.*

No. 6. *Tap Cinder* charged with *first coal charge* in No. 21 furnace.

No. 7. *Cinder* tapped from and after *first coal charge* in No. 21 furnace.

No. 8. *Cinder* tapped out of furnace No. 22, *before first gas charge.*

No. 9. *Tap Cinder* charged into *first gas charge*, No. 22 furnace.

No. 10. *Tap Cinder* charged into *second gas charge*, No. 22 furnace.

Pig Iron.

	No .11.	No. 12.	No. 13.	No. 14.
Carbon, graphitic, . .	2.770	2.860	2.880	3.050
Carbon, combined, . . .	1.495	1.380	1.425	1.293
Silicium, . . .	1.421	1.409	1.566	1.713
Sulphur, . . .	.180	.198	.198	.143
Phosphorus,	.545	.546	.548	{ .486 .488 }
Manganese, . .	.324	.289	.331	.245
Calcium, . .	.147	.141	.139	.149
Magnesium, ...	trace.	trace.	trace.	trace.
Iron, ...	93.085	93.050	93.100	92.650
	99.967	99.873	100.187	99.731

No. 11. *Isabella grey forge pig iron* from which the *first coal charge* was boiled.

No. 12. *Isabella grey forge pig iron* from which the *second coal charge* was boiled.

No. 13. *Isabella grey forge pig iron* from which the *first gas charge* was boiled.

No. 14. *Isabella grey forge pig iron* from which the *second gas charge* was boiled.

	Muck-Bars. *No. 15.* *Ends.*	*No. 16.* *Centers.*	*No. 17.* *Ends.*	*No. 18.* *Centers.*
Carbon,	.060	.064	.054	.058
Silicium,	.246	.272	.259	.235
Sulphur,	.055	.055	.067	.065
Phosphorus,	.198	.216* / .212	.205 / .202	.173* / .171
Manganese,	.039	.036	.023	.021
Cinder,	.060	.016	.076	.014
Oxide of iron,	1.510	1.385	——	.950
Metallic iron,	98.223	98.281	99.320	98.735
	100.391	100.321	100.001	100.249
Total iron,	99.280	99.250	99.320	99.400

No. 15. *Muck-bar;* sample from the *ends* of muck-bars of *first coal charge.*

No. 16. *Muck-bar;* sample from the *centers* of muck-bars of *first coal charge.*

No. 17. *Muck-bar;* sample from the *ends* of muck-bars of *second coal charge.*

No. 18. *Muck-bar;* sample from the *centers* of muck-bars of *second coal charge.*

	No. 19. *Ends.*	*No. 20.* *Centers.*	*No. 21.* *Centers.*	*No. 22.* *Centers.*	*No. 23.* *Near ends.*
Carbon,	.052	.055	.049	.048	.055
Silicium,	.260	.309	.269	.273	.283
Sulphur,	.065	.095 / .092*	.086	.087	.067
Phosphorus,	.194	.235 / .229*	.321 / .312*	.349* / .346	.194
Manganese,	.030	.031	.029	.029	.029
Cinder,	.058	.098	.036	.006	.050
Oxide of iron,	——	1.280	1.480	1.210	——
Metallic iron,	99.260	98.314	98.114	98.253	99.300
	99.919	100.408	100.384	100.252	99.978
Total iron,	99.260	99.210	99.150	99.100	99.300

No. 19. *Muck-bar; special sample* from the *ends* of a muck bar of *second coal charge.*

No. 20. *Muck-bar; special sample* from the *center* of this one bar, *second coal charge.*

No. 21. *Muck-bar*; sample from the *centers* of bars of *first gas charge.*

Determinations marked with an * were made by David McCreath.

No. 22. *Muck-bar;* sample from the *centers* of bars of *second gas charge.*

No. 23. *Muck-bar;* sample from *near the ends of a special muck-bar* from which the trial bar No. 15 was made.

Finished Bars.

	No. 24. Ends.	No. 25. Centers.	No 26. Ends.	No. 27. Centers.
Carbon,	.053	.050	.050	.052
Silicium,	.248	.336	.280*	.329
Sulphur,	.043	.053	.029*	.071
Phosphorus,	.204	.234	.214*	{ .216 .214 }
Manganese,	.032	.029*	.025	.029*
Cinder,	.054	.040	.067	.014
Oxide of iron,	1.173	1.073	1.043	.820
Metallic iron,	98.180	98.539	98.300	98.606
	99.987	100.354	100.008	100.137
Total iron,	99.000	99,290*	99.030*	99.180*

No. 24. *Bar iron;* rolled from *ends* of muck-bars of *first coal charge*, corresponding to muck-bar analysis No. 15.

No. 25. *Bar iron;* rolled from *centers* of muck-bars of *first coal charge*, corresponding to muck-bar analysis No. 16.

No. 26. *Bar iron;* rolled from *ends* of muck-bars of *second coal charge*, corresponding to muck-bar analysis No. 17.

No. 27. *Bar iron;* rolled from *centers* of muck-bars of *second coal charge*, corresponding to muck-bar analysis No. 18.

	No. 28. Ends.	No. 29. Centers.	No. 30. Ends.	No. 31. Centers.	No. 32. ?
Carbon,	.045	.054	.049	.055	.053
Silicium,	.248*	.348	.249	.270	.260
Sulphur,	.045*	.083	.042	.066	.064
Phosphorus,	.298*	{ .342* .342 }	.313	{ .302* .300 }	.186
Manganese,	.029	.015	.025	.029*	.029
Cinder,	.042	.018	.012	.020	.020
Oxide of iron,	.766	.600	1.053	.813	.821
Metallic iron,	98.615	98.680	98.300	98.681	98.785
	100.088	100.140	100.043	100.234	100.218
Total iron,	99.150*	99.100*	99.050	99.250*	99.360

Determinations marked with an * were made by David McCreath.

No. 28. *Bar iron;* rolled from *ends* of muck-bars of *first gas charge.*

No. 29. *Bar iron;* rolled from *centers* of muck bars of *first gas charge*, corresponding to muck-bar analysis No. 21.

No. 30. *Bar iron;* rolled from *ends* of muck-bars of *second gas charge.*

No. 31. *Bar iron;* rolled from *centers* of muck-bars of *second gas charge*, corresponding to muck-bar analysis No. 22.

No. 32. *Bar iron;* rolled in regular routine.

Deposited Carbon.	*No. 33.*
Water @ 225°,	.023
Volatile matter,	.133
Fixed carbon,	92.134
Sulphur,	.102
Ash,	7.608
	100.000

No. 33. *Carbon deposited by Natural gas*, in flues of a furnace at places where a slight inward leakage of air produces an incomplete combustion.

Natural Gas.	*No. 34.*
Carbonic acid,	.66
Carbonic oxide,	trace.
Illuminating hydrocarbons.	——
Hydrogen,	13.50
Marsh gas,	80.11
Ethyl-hydride,	5.72
	99.99
Specific gravity	.5119

No. 34. *Natural gas from Harvey Well*, Butler county, Pennsylvania, used in the iron works of Spang, Chalfant & Co. Analysed by Prof. S. P. Sadtler. See Report L, Appendix B, p. 146, &c.

Pig iron.	*No. 35.*	*No. 36.*
Carbon, graphitic,	3.860	2.890
Carbon, combined,	.341	1.135
Silicium,	3.008	.766
Sulphur,	.050	.098
Phosphorus,	.592	.353
Manganese,	.511	.209
Iron, &c., (by deduction,)	91.638	94.549
	100.000	100.000

No. 35. *Isabella grey forge iron,* used in puddling furnaces.

No. 36. *Scrap iron;* old car wheels, &c., used in puddling furnace.

Tap Cinder.	*No. 37.*	*No. 38.*
Silica,	24.640	21.040
Protoxide of iron,	57.471	62.100
Sesquioxide of iron,	5.857	6.143
Protoxide of manganese,	2.072	1.662
Alumina,	.942	2.608
Lime,	2.363	1.786
Magnesia,	.367	.230
Sulphur,	.289	.249
Phosphoric acid,	3.685	3.609
Undetermined,	2.314	.573
	100.000	100.000

No. 37. *Tap cinder* from *gas heat.*

No. 38. *Tap cinder* from *coal heat.*

Muck-bar.	*No. 39.*	*No. 40.*
Carbon, graphitic,	.004	.005
Carbon, combined,	.102	.126
Silicium,	.289	.212
Sulphur,	.011	.008
Phosphorus,	.312	.136
Manganese,	.051	.072
Iron, &c. (by deduction),	99.231	99.441
	100.000	100.000

No. 39. *Muck-bar; gas heat.*

No. 40. *Muck-bar; coal heat.*

*Standard English and American Irons.**

	No. 41.	*No. 42.*
Carbon,	.045	.037
Silicium,	.148	.158
Sulphur,	.002	.003
Phosphorus,	.248	.197
Manganese,	.020	.019
Copper,	.056	.011
Cobalt,	.051	.049
Nickel,	.027	.021
Slag and oxide of iron,	2.164	2.191
Metallic iron,	97.239	97.314
	100.000	100.000
Total iron,	98.753	98.847

*These irons were analysed for the purpose of comparing them with those made by the use of natural gas; but the analyses were not finished in time to be inserted in Mr. Pearse's Report.

No. 41. *Sir Wm. G. Armstrong's "Ridsdale" iron.* Coil-bar for gun tube; best iron, four times worked.

No. 42. "*Ulster iron.*" Coil bar for gun tube; extra best iron, four times worked.

Pig Irons.

	No. 43.	No. 44.	No. 45.	No. 46.
Silicium,	4.233	1.664	.289	2.729
Sulphur,	.037	.005	.008	.164
Phosphorus,	.151	.288	.253	.286
Manganese,	3.314	.173	.309	.036

No. 43. *Blair Iron and Coal Co.' iron*, No. 1 furnace; No. 1 iron, made from one sixth Spanish ore; one sixth Franklinite and two thirds hematite.

No. 44. *Mt. Etna Furnace iron;* No. 1 iron, made from Short mountain ore.

No. 45. *Mt. Etna Furnace iron;* mottled iron, made from Short Mountain ore.

No. 46. *Williamsburg Furnace iron;* No. 3 iron, made from one half Frankstown fossil ore and one half Springfield ore.

	No. 47.	No. 48.	No. 49.
Silicium,	1.814	1.252	.513
Sulphur,	.057	.037	.160
Phosphorus,	.164	.145	.157
Manganese,	.303	.461	.317

No. 47. *Springfield furnace iron;* No. 1 iron.

No. 48. *Springfield furnace iron;* No. 2 iron; gun metal.

No. 49. *Springfield furnace iron;* No. 3 forge iron.

	No. 50.	No. 51.	No. 52.	No. 53.
Silicium,	4.937	1.704	3.184	2.713
Sulphur,	.037	.034	.082	.123
Phosphorus,	.184	.234	.195	.192
Manganese,	2.133	.072	.144	.864

No. 50. *Frankstown Furnace iron;* No. 1 iron.

No. 51. *Sarah Furnace iron;* No. 3 iron.

No. 52. *Rodman Furnace iron;* No. 2 iron.

No. 53. *Rodman Furnace iron;* No. 3 iron.

	No. 54.	No. 55.	No. 56.
Silicium,	2.636	3.882	3.033
Sulphur,	.139	.093	.161
Phosphorus,	.982	.966	.936
Manganese,	.641	.951	.807
Iron,	91.250	90.100	91 100

No. 54. *Lemont Furnace iron;* made from one fourth coal ore, three fourths hematite ore.

No. 55. *Lemont Furnace iron;* mill iron made from one half coal ore, one half hematite ore.

No. 56. *Lemont Furnace iron;* made from seven fourteenths coal ore, five fourteenths mountain ore, two fourteenths mill cinder.

	No. 57	No. 58.	No. 59.	No. 60.
Carbon, graphitic,	3.040	2.330	2.745	2.970
Carbon, combined,	.100	.110	.560	.110
Silicium,	3.362	3.551	1.373	3.114
Sulphur,	.216	.256	.125	.101
Phosphorus,	.608	.996	1.229	.999
Manganese,	1.195	.432	1.160	1.037
Copper,	.014	.018	.011	.130
Cobalt,	.051	.036	.124	.081
Iron, &c., (by difference,)	91.414	92.271	92.673	91.458
	100.000	100.000	100.000	100.000

No. 57. *Oliphant Furnace iron; mill iron* made from Blue Lump ore and Pittsburgh Big Bottom ore.

No. 58. *Oliphant Furnace iron; foundry iron.*

No. 59. *Dunbar Furnace iron; mill iron.*

No. 60. *Dunbar Furnace iron; foundry iron.*

	No. 61.	No. 62.	No. 63.
Carbon, graphitic,	2.870	2.720	3.080
Carbon, combined,	.130	.214	.125
Silicium,	2.971	3.048	2.531
Sulphur,	.093	.106	.180
Phosphorus,	.908	.948	.477
Manganese,	1.037	1.037	.231
Copper,	.022	.161	.033
Cobalt,	.074	.072	.037
Iron, &c.,	91.895	91.694	93.306
	100.000	100.000	100.000

No. 61. *Lemont Furnace iron*; *Foundry iron*, made from nine fourteenths coal ore two fourteenths honeycomb ore, three fourteenths mill cinder.

No. 62. *Lemont Furnace iron; foundry iron*, from same mixture of ores.

No. 63. *Lemont Furnace iron; mill iron*, made from one third coal ore, one third honey-comb ore, one third mill cinder.

Blast Furnace Slags.

	No. 64.	*No. 65.*	*No. 66.*
Silica,	57.700	58.300	53.360
Alumina,	7.940	7.150	5.599
Protoxide of iron,	1.674	2.466	12.672
Protoxide of manganese,	1.061	1.300	1.208
Lime,	23.400	22.800	19.020
Magnesia,	7.484	8.104	7.477
Sulphur,	.110	.125	.100
	99.369	100.245	99.436

No. 64. *Springfield Furnace, slag from No. 1 iron.*
Porous, greenish grey.
No. 65. *Springfield Furnace, slag from No. 2 iron.*
Brittle, vitreous ; grass green. (S. S. Hartranft.)
No. 66. *Springfield Furnace, slag from No. 3 forge iron.*
Brittle, vitreous ; bottle green. (S. S. Hartranft.)

The following analyses of Bessemer pig iron and steel are here in place.

They were made for the Pennsylvania Steel Company and are published by permission.

Bessemer pig iron.	*No 67. Atkins.*	*No. 68. Crane.*
Carbon, graphitic,	1.500	3.760
Carbon, combined,	1.512	.658
Silicium,	3.241	1.017
Sulphur,	.176	.021
Phosphorus,	.028	.106
Manganese,	.726	.756
Copper,	.416	none.
Aluminium,	.245	.021
Calcium,	.014	trace.
Magnesium,	.009	trace.
Iron, &c.,	92.133	93.661
	100.000	100.000

No. 67. Atkins Bros.' Bessemer pig iron, Pottsville. No. 3 iron. 1872.

No. 68. Crane Iron Co.'s Bessemer iron, Catasauqua. No. 1 iron. 1872.

Bessemer steel.	*No. 69.*	*No. 70.*
Carbon,	.502	.396
Silicium,	.033	.080
Sulphur,	.066	.065
Phosphorus,	.111	.033
Manganese,	.756	.720
Copper,	.018	.328
Iron,	98.514	98.378
	100.000	100.000

Nos. 69 and 70. Bessemer steel made by Pennsylvania Steel Company in 1872.

Open Hearth steel.	*No.71.*
Carbon,	.364
Silicium,	.012
Sulphur,	.029
Phosphorus,	.063
Manganese,	.302
Copper,	none.
Iron,	99.275
	100.045

No. 71. *Nashua Iron & Steel Co.'s open-hearth steel.* Nashua, New Hampshire. 1879.

CHAPTER IV.

ANALYSES OF CLAYS AND FIRE-BRICKS.

§ 54. *Champlain Formation, Drift Clay.*

The valleys of the Ohio and the two Beavers are filled with a Glacial Drift, similar in many respects to that which spreads in an unbroken sheet over Northern Ohio and north-western Pennsylvania.

Along the Ohio and Big Beaver rivers are some very handsome terraces. These are fully described in Report Q, pp. 10, 11, 12, 13.

On one of these (the fourth terrace) occurs an important deposit of clay which has been extensively mined for use in the Terra-cotta works of Messrs. Elverson & Sherwood, at New Brighton.

This deposit was evidently accumulated in still water and probably marks the upper limit to which the valleys of the Beaver and Ohio were filled with silt during the Champlain period. See Q, p. 13.

The following analyses will represent the character of the clay :—

Beaver County.

	(577) *Mendenhall & Chamberlin.*	(576) *Elverson & Sherwood.*
Silica,	46.160	67.780
Alumina,	26.976	16.290
Sesquioxide of iron,	7.214	4.570
Titanic acid,	.740	.780
Lime,	2.210	.600
Magnesia,	1.520	.727
Alkalies,	3.246	2.001
Water,	11.220	6.340
	99.286	99.088

(*577*) *Mendenhall & Chamberlin's clay*, near New Brighton, Pulaski township. Taken from the surface of the Fourth Terrace, (counting upward from the bed of the Ohio river.) (D. McC.)

(*576*) *Elverson & Sherwood's clay*, at New Brighton. Fourth Terrace Clay. Used in the manufacture of plant pots. Analysed by D. McCreath.

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§ *55. Freeport Upper Coal Underclay.*

Under the Freeport Upper Coal occurs an important deposit of excellent fire-clay, which has been extensively mined at many localities for the manufacture of fire bricks. It is well known as the Bolivar fire-clay. The typical locality is at Bolivar, at the east end of the Conemaugh gap, through Chestnut Ridge, where it occurs from three to twelve feet thick, immediately below the place of the Freeport Upper limestone. See KKK, p. 34.

In Wharton township, Fayette county, it is exposed in the road near Wharton furnace, where it is ten feet thick, light blue, and contains many nodules of clay iron-stone. This is its character throughout the township.

In Stewart township, Fayette county, it seems to be persistent, and is eight feet thick along the river hills, where it contains huge balls of iron ore.

On Indian creek, in Springfield township, it is but four feet thick.

In Westmoreland county it is two feet thick on Laurel run, Ligonier township. North from the Loyalhanna, on the west side of the valley, it is persistent from the southern boundary of Fairfield township to the Conemaugh river. (KKK, p. 34.)

In Indiana county it has been mined at many localities. It varies in thickness from three to eight feet, and is generally of good quality, being quite free from impurities. See Report HHHH, p. 89.

In Big Beaver township, Beaver county, the Freeport fireclay is extensively mined and manufactured into fire brick. It varies from two to ten feet in thickness, at times being replaced by limestone and iron ore.

The average character of the clay will be shown by the following analyses:

Indiana County.

	(811) E. Robinson.
Silica,	59.830
Alumina,	24.580
Protoxide of iron,	1.655
Titanic acid,	1.170
Lime,	.280
Magnesia,	.872
Alkalies,	3.114
Water,	7.830
	99.331

(*811*) *E. Robinson's clay*, opposite Bolivar. Under the Freeport Upper Coal bed. Used at the Bolivar Fire Clay Works. See HHHH, pages 88, 89, 90.

Plastic clay; soft, crumbling; dark grey.

Westmoreland County.

	(957) Kier Bros.	(956a) Kier Bros.	(956b) Kier Bros.	(956c) Kier Bros.	(956d) Kier Bros.
Silica,	51.920	47.250	40.720	60.520	55.330
Alumina,	31.640	34.350	37.280	24.970	27.841
Protoxide of iron,	1.134	.693	2.448	1.650	2.916
Titanic acid,	1.160	1.990	2.280	1.220	1.140
Lime,	.030	.580	.520	.910	.580
Magnesia,	.443	.090	.002	trace.	.756
Carbonic acid,	none.	.455	.408	.725	.455
Alkalies,	.402	.261	.570	.218	3.916
Water,	13.490	13.695	15.002	9.395	7.495
	100.219	99.364	99.230	99.608	100.429

(*957*) *Kier Bros.' clay*, at Salina, Bell township. Specimen selected by Mr. Wm. G. Platt, in 1878.

Hard and brittle; color, dark pearl grey; fracture irregular.

(*956a*) *Kier Bros.' clay*, at Salina. *Top stratum.*

Hard and brittle; dark pearl grey color and irregular fracture. (S. S. Hartranft.)

(*956b*) *Kier Bros.' clay*, at Salina. *Middle stratum.*

Hard and brittle; dark pearl grey color and very irregular fracture. (S. S. Hartranft.)

(*956c*) *Kier Bros.' clay*, at Salina. *Bottom stratum.*

Hard and brittle; color dark pearl grey; fracture conchoidal. (S. S. Hartranft.)

(*956d*) *Kier Bros.' clay*, at Salina. *Plastic clay.*

Dark pearl grey; comparatively soft; fracture irregular. (S. S. H.)

These last four specimens were sent to the Laboratory of the Survey in 1876, by the Messrs. Kier Bros.

Westmoreland County.	(*743*) *Hall.*	(*59*) *"Furnace."*	(*60*) *"Forge."*
Silica,	55.680	56.780	65.370
Alumina,	29.180	26.890	24.870
Protoxide of iron,	.837	.322	.756
Titanic acid,	1.490	not determined.	
Lime,	.130	.369	.168
Magnesia,	.180	.987	.234
Alkalies,	.245	3.920	.010
Water,	12.490	8.380	8.790
	100.232	100.548	100.378

(*743*) *Robert Hall's clay*, near Laughlinstown, four miles east from Ligonier, Ligonier township. Bolivar fire-clay below Freeport Upper coal bed. See Report KKK, page 249.

Color, generally pearl grey; irregularly seamed with thin bands of bluish black clay; brittle, with irregular fracture.

(*59*) "*Furnace clay*" on Jacob's Creek, two miles south-east of Jacob's Creek station. See L., p. 112.

Comparatively soft and brittle; somewhat sandy; color, pearl grey and greenish grey.

(*60*) "*Forge clay*" on Jacob's Creek, two and a half miles south-east of Jacob's Creek station. See L., p. 112.

Hard, compact; bluish grey, with conchoidal fracture.

Fayette County.	(*744*) *Potter.*
Silica,	52.230
Alumina,	31.310
Protoxide of iron,	1.008
Titanic acid,	1.680
Lime,	.130
Magnesia,	.165
Alkalies,	.720
Water,	13.190
	100.433

(*744*) *George Potter's clay*, on Meadow Run, south of Ohiopyle falls. Bolivar fire clay under the Freeport Upper Coal bed. See KKK, p. 249.

Brittle, pearl grey, with conchoidal fracture.

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§ *56. Kittanning Lower Coal Underclay.*

Immediately underlying the Kittanning coal in every portion of Beaver county, is found a large bed of fire-clay. This clay has been extensively mined and has given rise to an important industry in the making of fire-bricks, furnace linings, &c. The bricks do not withstand the highest degree of heat, but they are especially desired for those portions of the stack where there is considerable friction. See Report Q, p. 59.

This bed of clay is seldom less than ten feet thick, and in some cases as much as fifteen. Usually not more than six or seven feet of it is used, as the bottom becomes too silicious.

It is the same clay which is so extensively worked along the Ohio river, in Columbiana county, Ohio. (Q, p. 59.)

In Springhill township, Fayette county, at about fifteen to twenty feet below the Kittanning coal there is a remarkably fine fire-clay, compact, and from four to six feet thick, which has been opened at several places along the face of the ridge. It is drab to dove-colored, and always *compact.* It has been used in the manufacture of fire-brick. For the most part it is free from iron, but occasionally a nest of ore is found, which, for a short distance wholly displaces the clay. See Report KK, page 140.

In Westmoreland county there is usually a bed of *plastic* clay, five to seven feet thick, underlying the Kittanning Lower Coal bed. See KKK, page 40.

The following are some analyses of the Kittanning Underclay:

Beaver County.	(*568*) *Elverson & Sherwood.*	(*569*) *Elverson & Sherwood.*	(*570*) *Elverson & Sherwood.*	(*575*) *Elverson & Sherwood.*
Silica,	61.970	61.750	62.890	62.260
Alumina,	22.940	23.660	21.490	23.890
Protoxide of iron,	1.818	1.930	1.818	1.408
Titanic acid,	1.975	1.780	1.825	1.780
Lime,	.440	.455	.380	.470
Magnesia,	.522	.353	.569	.309
Alkalies,	1.750	2.418	2.525	1.977
Water, hygroscopic,	1.480	.680	1.160	7.640
Water, combined,	7.370	7.200	7.580	
	100.265	100.226	100.237	99.734
Sand,	34.250	——	35.510	——
Silica in sand,	34.180	——	35.100	——

(*568*) *Elverson & Sherwood's clay: Grade No. 1.* Terra-cotta works, near New Brighton, Pulaski township. See Report Q, p. 195.

Specimen consisted of a moderately soft rounded ball of a pearl grey color, with a somewhat gritty feel, but apparently in the main free from impurity. (Duplicate test for Titanic acid=1.920 per cent.)

(*569*) *Elverson & Sherwood's clay: Grade No. 2.*

Specimen has the same general appearance as No. 1. (Analysed by David McCreath.)

(*570*) *Elverson & Sherwood's clay: Grade No. 3.*

Specimen similar to the last. (Duplicate analysis for Titanic acid=1.810 per cent.)

(*575*) *Elverson & Sherwood's mines*, near New Brighton, Pulaski township. *Raw clay.*

Analysed by D. McCreath.

Beaver County.	(*578*) *Mendenhall.*	(*574*) *Coale.*	(*573*) *Couch.*	(*572*) *Severn.*	(*571*) *S. Barnes.*
Silica,	66.610	56.670	57.670	60.190	61.980
Alumina,	18.390	26.560	27.520	24.230	23.880
Protoxide of iron,	1.964	2.106	1.494	2.097	1.395
Titanic acid,	2.810	1.790	2.540	2.345	1.830
Lime,	.490	.260	.380	.850	.040
Magnesia,	.547	.277	.122	.036	.281
Alkalies,	1.079	3.790	.619	1.669	1.217
Water, hygroscopic,	7.495	8.360	9.680	9.015	1.460
Water, combined,					7.820
	99.385	99.813	100.025	100.432	99.903

(*578*) *Mendenhall & Chamberlin's mines*, near New Brighton, Pulaski township. Analysed by David McCreath.

(*574*) *Mr. Coale's clay*, near New Brighton, Pulaski township. See Q, p. 196. (D. McCreath.)

(*573*) *Mr. Couch's clay*, (drift,) near New Brighton, Pulaski township. See Q, p. 196. (D. McCreath.)

(*572*) *Mr. Severn's clay mines*, near Vanporte, on the Ohio river, New Brighton township.

Clay very brittle and moderately soft, breaking up readily in the hand; it has a pearl grey color and somewhat unctuous appearance. (D. McCreath.)

(*571*) *S. Barnes & Co.'s clay*, at fire-brick works, near Bridgewater, one mile north from Rochester, Rochester township. (Analysed by D. McCreath.)

Clay contains a little manganese. (Duplicate analysis for alumina=23.76 per cent. A. S. McC.)

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§ 57. *Fire-clays over the Conglomerate, No. XII.*

Within a hundred feet of the top of the Conglomerate No. XII are several important and persistent fire-clay deposits.

At Johnstown, in Cambria county, a valuable bed of fire-clay underlies Coal bed B. See Report HH, p. 148; and analysis.

In Indiana county it is five feet thick on the Conemaugh river, but apparently impure. It is nowhere developed in the Ligonier valley. (HHHH, p. 67.)

In Beaver county a large bed of fire-clay, seven to ten feet thick, the lower part of which is non-plastic, underlies the Clarion Coal along the Big Beaver river. (Q, p. 63.)

The fire-clay deposit under Bed A is one of the most persistent and widely distributed members of the Lower Productive group, and is everywhere in the Bituminous regions an unfailing accompaniment of Bed A, though often too impure to be utilized for fire-bricks.

It is from this bed that the well-known fire-brick works at Sandy Ridge, Blue Ball, Woodland and Hope Station, in Clearfield county; Benezette, in Elk county; Brookville, in Jefferson county, and Queen's Run and Farrandsville, in Clinton county, derive their supply of fire-clay. It is this bed which is so extensively worked by Mr. A. J. Hawes at Johnstown, Cambria county. It is here over four feet thick, yielding two distinct qualities of clay, but is without persistent partings of slate. (HH, p. 146.) This clay is fully described in Reports of Progress H, HH, HHH and and HHHH, to which the reader is referred.

Somerset County.	*(1005)* *Savage Fire Brick Works.*
Silica,	47.080
Alumina,	35.523
Protoxide of iron,	1.170
Titanic acid,	2.260
Lime,	.230
Magnesia,	.126
Alkalies,	.692
Water,	13.480
	100.561

(*1005*) *Savage Fire Brick Works' clay*, Keystone Junction, Somerset county.

Pearl grey and bluish grey; brittle, with irregular fracture. (S. S. Hartranft.)

Indiana County.	*(809)* *Meldren.*	*(808)* *Meldren.*	*(810)* *Robinson.*
Silica,	68.490	64.830	50.840
Alumina,	18.460	23.950	30.745
Protoxide of iron,	1.566	.900	3.213
Titanic acid,	2.150	.880	1.260
Lime,	.230	.110	.160
Magnesia,	.551	.187	.288
Alkalies,	2.755	.296	.541
Water,	6.310	9.390	13.050
	100.512	100.543	100.097

(*809*) *E. J. Meldren's clay*, one half mile east from Bell's Mills. *Plastic clay;* lower bench of deposit at Black Lick Manufacturing Company's Works. See HHHH, p. 193.

Comparatively soft and brittle; somewhat micaceous; greyish black and pearl grey.

(*808*) *E. J. Meldren's clay*, one half mile east from Bell's Mills. *Hard clay* on top of Pottsville Conglomerate. Used in the Black Lick Manufacturing Company's Works. See HHHH, p. 193.

Hard, brittle, dark grey.

(*810*) *E. Robinson's clay*, opposite Bolivar. *Hard clay* used in the Bolivar Clay Works. Clay underlies coal bed "A."

Compact, brittle, bluish black.

Clearfield County.	(*591*) *Bilger.*	(*592*) *Bigler.*	(*593*) *Graham.*
Silica,	43.920	44.050	57.030
Alumina,	38.195	37.510	29.100
Protoxide of iron,	.810	.819	1.107
Titanic acid,	2.610	1.840	1.210
Lime,	.220	.490	.190
Magnesia,	.054	.181	.136
Alkalies,	.285	.065	.087
Water, &c.,	14.200	15.210	11.310
	100.294	100.165	100.170

(*591*) *Bilger clay*, one mile from Curwensville.

Compact, pearl grey ; conchoidal fracture.

(*592*) *Ex-Gov. Bigler's clay*, about one mile south-west of Clearfield.

Compact, brittle ; brownish black. Carries considerable carbonaceous matter.

(*593*) *Hon. Jas. B. Graham's clay*, about five miles from Clearfield.

Compact, brittle, dark grey ; conchoidal fracture.

These three specimens of clay were forwarded to the Laboratory of the Survey by the late Dr. Robt. Wilson, Clearfield.

Clinton County.	(*107*) *Queen's Run.*	(*108*) *Queen's Run.*	(*1015*) *Queen's Run.*	(*106*) *Farrandsville.*	(*105*) *Farrandsville.*
Silica,	42.440	63.180	43.830	42.180	63.880
Alumina,	36.685	23.700	38.750	38.960	24.140
Protoxide of iron,	2.128	1.200	1.116	.760	1.600
Titanic acid,	4.000	1.460	1.430	3.360	——
Lime,	.200	.170	.010	.510	.200
Magnesia,	.276	.470	.392	.180	.684
Sulphuric acid,	.820	.190	——	.010	.158
Alkalies,	.718	2.520	1.341	1.000	2.952
Water,	13.370	6.870	13.620	13.790	6.770
	100.637	99.760	100.489	100.750	100.384

(*107*) *Queen's Run lower fire-clay, Mine No. 1*, three and a half miles from Lock Haven, on Queen's Run. *Hard clay. Under Coal bed "A."*

Hard and exceedingly brittle; pearl grey. (D. McCreath.)

(*108*) *Queen's Run lower fire-clay, Mine No. 2*, three and a half miles from Lock Haven, on Queen's Run. *Soft clay. Under Coal bed "A."*

Comparatively soft and brittle; various shades of light blue and bluish grey. (D. McCreath.)

(*1015*) *Queen's Run fire-clay*, three and a half miles from Lock Haven.

Analysed by John M. Stinson, under my direction.

(*106*) *Farrandsville Fire-brick Work's clay*, on Lick Run, one mile from Farrandsville. *Hard clay. Under Coal bed "A."*

Hard, brittle; pearl grey. (D. McCreath.)

(*105*) *Farrandsville Fire-brick Work's clay*, on Lick Run, one mile from Farrandsville. *Soft clay. Under Coal bed "B."*

Comparatively soft; compact; pearl grey. (D. McC.)

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§ 58. *Miscellaneous Clays.*

The following are the analyses of some clays which have not been classified geologically:

	Maryland. (*996a*) *Mt. Savage.*	*N. Jersey.* (*996b*) *Woodbridge.*	*N. Jersey.* (*996c*) *Woodbridge.*
Silica,	44.395	43.690	42.080
Alumina,	38.558	38.300	38.826
Protoxide of iron,	1.080	.900	1.485
Titanic acid,	1.530	1.000	1.640
Lime,	trace.	.480	.520
Magnesia,	.108	.310	.277
Alkalies,	.247	.447	.287
Water,	14.575	15.120	15.120
	100.493	100.247	100 235

(*996a*) *Mount Savage fire-clay*, Union Mining Company, Mt. Savage, Maryland.

Pearl grey to bluish grey; fracture, uneven, somewhat conchoidal. (S. S. H.)

(*996b*) *Woodbridge fire-clay*, New Jersey. Used by Hyzer & Lewellen in their fire-brick works at Philadelphia. (S. S. H.)

(*996c*) *Woodbridge fire-clay*, New Jersey. Used by Hall & Sons in their works at Perth Amboy, N. J. (S. S. H.)

Fayette County.	(*1016*) *Soisson & Glover.*	(*1017*) *Wilgus.*
Silica,	56.885	57.430
Alumina,	28.250	26.050
Protoxide of iron,	.810	1.629
Titanic acid,	1.500	1.330
Lime,	.290	.580
Magnesia,	.136	.980
Alkalies,	.538	4.537
Water,	12.290	7.890
	100 699	100.426

(*1016*) *Soisson & Glover's fire-clay mine*, on the western slope of Chestnut ridge, Fayette county.

(*1017*) *J. S. Wilgus' clay*, near Layton station, Fayette county.

The above analyses were made by J. M. Stinson, under my direction.

	Greene Co. (*197*) *Dunlap.*	*Somerset Co.* (*451*) *Lohr.*	*Huntingdon Co.* (*347*) *Oriskany.*	(*346*) *Oriskany.*	*Warren Co.* (*958*) *Lottsville.*
Silica,	64.600	45.730	73.900	77.640	65.120
Alumina,	17.842	29.693	13.070	12.005	15.939
Protoxide of iron,	4.885	6.857	6.100	4.285	5.464
Titanic acid,	——	——	not determined.		.750
Lime,	.040	.440	.060	.140	1.550
Magnesia,	1.336	1.005	.526	.486	1.848
Alkalies,	3.059	3.415	.909	1.678	3.580
Carbonic acid,	——	——	——	——	2.810
Water,	7.410	12.860	5.435	3.923	3.160
	99.172	100.000	100 000	100.157	100.251

(*197*) *Dunlap farm clay*, near Greensboro', Monongahela township, Greene county.

Soft, pearl grey, with scales of mica. (D. McC.)

(*451*) *Jonathan Lohr's clay*, between Hooversville and Stoystown, Somerset county. See HHH, page 123.

Soft, unctuous; straw yellow color. (D. McC.)

(*347*) *Oriskany sandstone clay*, near Lewistown, on the turnpike road near the toll gate; Huntingdon county. *Upper stratum.*

(*346*) *Oriskany sandstone clay*, near Lewistown. *Lower stratum.*

(*958*) *Lottsville clay*, from a deposit said to be four hundred feet thick, in the valley of the Little Brokenstraw creek, Warren county. See Report III.

Lehigh and Northampton Counties.	(*1010a*) *Schneider.*	(*1010b*) *Saucon Iron Co.*
Silica,	53.170	49.130
Alumina, (by deduction,)	23.431	33.873
Protoxide of iron,	5.400	3.040
Titanic acid,	1.250	.190
Lime,	.130	.120
Magnesia,	3.376	.987
Soda,	1.228	.526
Potash,	7.155	.634
Water,	4.860	11.500
	100.000	100.000

(*1010a*) *Clay found inside of an ore-bomb* from David Schneider's mine, Lehigh county.

(*1010b*) *Clay from ore of Saucon Iron Co.'s Wharton mine*, at eighty feet below the surface; Northampton county.

The above analyses were made by J. M. Stinson, under my direction.

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§ 59. *Fire-bricks.*

The physical connection of the standing up power of fire-bricks, with the chemical composition and manufacture of the brick, are discussed in a special report (given below) by Mr. Franklin Platt, on the basis of a series of tests made in an experimental shaft furnace at Harrisburg.

The following analyses of bricks were made to illustrate this Report; and they are therefore given here without comment:

	Clearfield. (997c) *Clearfield.*	*Clinton.* (997b) *Queen's Run.*	*Fayette.* (1004a) *Maxwell.*	*Somerset.* (1005b) *Savage.*
Silica, ...	52.870	52.480	78.080	58.970
Alumina, ...	40.280	40.650	17.890	32.969
Sesquioxide of iron,	1.320	1.990	.970	1.970
Titanic acid, ...	2.440	1.670	.810	1.620
Lime, ...	1.410	.260	.560	.120
Magnesia, ...	.396	.299	.350	.503
Alkalies, ...	.980	2.790	2.115	1.277
	99.696	100.139	100.775	100.429

(*997c*) *Clearfield fire-brick*, Clearfield county.

(*997b*) *Queen's Run fire-brick*, Clinton county.

(*1004a*) *Maxwell, Bradley & Co. fire-brick*, Diamond Fire-brick Works, Layton station, Pittsburgh and Connellsville R. R., Fayette county.

(*1005b*) *Savage Fire-brick Works*, Keystone Junction, Somerset county.

The above analyses were made by S. S. Hartranft.

	Maryland. (1004b) *Mt. Savage.*	*N. Jersey.* (998a) *Hall & Sons.*	*N. Jersey.* (1013) *Hyzer & Lewellen.*	*Fayette Co., Pa.* (1014) *Soisson & Glover.*
Silica, ...	59.980	71.550	58.750	65.240
Alumina, ...	36.009	25.090	36.790	28 875
Sesquioxide of iron,	1.911	1.280	1.390	2.710
Titanic acid, ...	1.700	1.050	1.750	1.670
Lime, ...	.100	.650	.110	.090
Magnesia, ...	trace.	.364	.301	.338
Alkalies, ...	1.175	.384	.913	1.312
	100.875	100.368	100.004	100.235

(*1004b*) *Mount Savage fire-brick*, Union Mining Co., Mt. Savage, Maryland. (S. S. H.)

(*998a*) *Hall & Son's No. 1 fire-brick*, Perth Amboy, N. J. (S. S. H.)

(*1013*) *Hyzer & Lewellen's fire-brick*, made from Woodbridge clay, at their works in Philadelphia.

(*1014*) *Soisson & Glover's fire-brick*, Connellsville.

Scotch Fire-Bricks.

	(997a) Heathery Knowe.	(998b) Gartcosh.	(1004c) Allen & Mann.	(998c) Brown & Son.
Silica,	59.080	58.830	57.780	58.010
Alumina,	34.170	33.413	34.829	34.856
Sesquioxide of iron,	2.440	5.280	3.910	3.424
Titanic acid,	.930	1.300	1.400	1.660
Lime,	.600	.230	.520	.920
Magnesia,	.709	.472	.742	.446
Alkalies,	2.355	.757	.680	.300
	100.284	100.282	99.861	99.616

(*997a*) *Heathery Knowe fire-brick*, near Glasgow, Scotland.

(*998b*) *Gartcosh fire-brick*, Scotland.

(*1004c*) *Allen & Mann's fire-brick*, Govan, near Glasgow, Scotland.

(*998c*) *R. Brown & Son's fire-brick*, Paisley, Scotland.

The above analyses were made by S. S. Hartranft.

FIRE BRICK TESTS.

Special Report by FRANKLIN PLATT. 1876.

Some of the fireclays of Clearfield and Jefferson counties are described and compared on pp. 118–131, Report H of the Second Geological Survey on the Clearfield and Jefferson district. The clays of Cambria County have been described in the Report HH on Cambria and Somerset counties. It having been determined upon that the Second Geological Survey would institute some tests of the standing up power of some of the best known firebricks, under instructions from Prof. Lesley, Mr. Chas. A. Young, Aid, was requested to observe carefully and note the behavior of the different bricks in the test furnace. Mr. Young's description of the behavior of the bricks is embodied in the chapter below, much of it in his own language.

The place selected for the test was the trial furnace of the Harrisburg Fire Brick Company, at Harrisburg, the company having kindly placed their furnace at the service of the Survey. To Mr. John B. Keefer, Superintendent, and to the foreman of the works also, the Survey is much indebted for skillful and cordial assistance in the experiment.

The test furnace.

The bricks were tested in a small shaft furnace, supplied with a blast through an eight inch pipe, furnished by a fan of thirty inches diameter, making fifty revolutions per minute.

The furnace was large enough to test two bricks at a time, the subjects resting directly on the fuel, anthracite coal.

Method of testing.

The bricks were kept in the furnace for one hour and three quarters, at the end of which time the furnace began to cool. They were observed several times during the progress of the test to ascertain any alteration in condition; but owing to the glare and intense heat of the furnace, little could be seen. Steel placed in the furnace, securely wrapped in clay to prevent the absorption of carbon, melted in forty-five minutes from the time of turning on the blast. The steel was of the kind used for carpenter's chisels. There was no pyrometer attached to the trial furnace, and the exact temperature could not be ascertained, but the bricks were always submitted to a temperature *considerably higher than the melting point of steel.*

Before being subjected to the test, the bricks were heated on the tile covering of the furnace.

After coming from the furnace they were placed in the ash pit of the boiler.

The bricks tested.

In securing bricks for testing, care was taken to see that the manufacturers of nearly all of the best known and esteemed bricks were afforded an opportunity to forward specimens for examination. Some of the companies availed themselves of the opportunity, and the test included representative bricks from many of the great fireclay deposits of the State of Pennsylvania, and several from other States.

The bricks tested were twenty-one in all, coming from the following works:

1 brick, Hyzer & Lewellen, Philadelphia.
1 " Harrisburg Fire Brick Company.
2 " Queen's Run, Clinton county; 1 brick, made of hard clay, and 1 of half soft and half hard clay.
2 " Clearfield, Clearfield county.
1 " "Savage brick," Keystone Junction, Somerset county, Pa.
2 " Layton Station, P. & Conn. R. R., Maxwell, Bradley & Co.
1 " S. W. Penn. R. R., Soisson & Glover, "S. W. Brick."

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5 " Union Mining Co., Mt. Savage, Maryland. 1 ordinary brick, and 4 steel bricks—"a. c. r. ss."

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2 " A. Hall & Sons, Perth Amboy, N. Jersey.

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4 " Scotch Bricks—Gartcosh.
R. Brown & Sons, Paisley.
Govan.
Heatheryknowe.

Gartcosh and Brown & Sons, Paisley.

The first bricks tested were two Scotch bricks, viz: the *Gartcosh* and the *R. Brown and Sons, Paisley.*

The lower edges of the Gartcosh brick, those on the side exposed to the blast and resting on the fuel, were rounded in places.

The edges and corners of the Brown & Sons' brick stood well, but the bottom gave slightly in three or four places.

Govan and Heatheryknowe.

Two other Scotch bricks, the *Govan* and *Heatheryknowe*, looked so broken at the end of one hour and a half that they were withdrawn at that time. They had melted badly, the slag of the two forming so close an union that the bricks could not be separated. At least one half of the bricks had melted; portions of the melted matter being found in the ash pit.

The upper surface and edges of both bricks stood moderately well, but the Heatheryknowe exhibited a wide gaping crack extending through the entire thickness of the brick.

Clearfield.

Two *Clearfield* bricks had their edges slightly rounded; but preserved their bottom intact.

Queen's Run.

Two *Queen's Run* bricks, one of them made of hard clay and one of half hard and half soft clay, presented so bad an appearance in the furnace in one hour and thirty-five minutes that they were taken out. The result showed that the appearance of the brick in the furnace was too deceitful to have any reliance placed upon it. The brick of hard clay had run on bottom and lower edges.

The brick containing one half soft clay lost one of its corners by cracking, and also showed cracks through its its mass. The lower edges had given away badly.

Perth Amboy, A. Hall & Sons.

Two of A. Hall & Son's *Perth Amboy* bricks were tested full time.

Their lower edges showed a slight rounding, though it was scarcely perceptible. The bottom glazed, but did not melt. There were a few surface cracks visible.

Mount Savage, Union Mining Company.

Five kinds of brick were sent by the Union Mining Company of *Mount Savage, Maryland;* the ordinary firebrick and bricks of four different kinds for steel furnace use.

The quantity of silica was the point of difference in these bricks.

One of the "steel bricks," a, and the ordinary firebrick were tested together.

The lower edges of the latter rounded, and showed by lumps that fusion had taken place at a few points on the edges.

The top edges of the "steel brick" a, rounded, and the bottom and lower edges gave badly.

"Steel bricks," c and r, suffered on the bottom and lower edges, the latter turning badly.

"Steel brick" ss suffered worst, the bottom and lower edges giving away.

Harrisburg Firebrick Works.

A No. 1 brick from the *Harrisburg* Firebrick Works showed bottom edges slightly rounded, but suffered no further.

Keystone, Somerset County.

A brick of the brand "Savage," made at *Keystone Junction, Somerset county, Pennsylvania,* had scarcely a sign of rounding on the bottom edges; but one corner gave evidences of having been softened by the heat.

Philadelphia Works. Hyzer & Lewellen.

A brick made of New Jersey clay by Messrs. Hyzer & Lewellen of *Philadelphia* stood the test best of all. It came from the furnace glazed, but with corners and edges sharp, and bottom intact.

South-west Penn. R. R. Soisson & Glover.

The "S. W." brick made by Messrs. Soisson & Glover, *three miles north of Connellsville, Fayette county, Pennsylvania,* on the line of the South-west Pennsylvania railroad, gave a little at one corner. This brick is made from clay from the deposits on the west flank of Chestnut Ridge, and behaved the best of all the bricks made from native clays entirely.

Layton Station, Fayette County.

The Diamond firebrick made at *Layton Station, Fayette county, Pennsylvania*, by Messrs. Maxwell, Bradley & Co., from clay lying on the Mahoning Sandstone, was tested in the ordinary way. The brick is made for use in Steel Works. Sand is mixed with the clay.

The brick in each case cracked entirely through: but remained angular and sharp on corners and edges.

The surface which rested on the coal, and was exposed to the blast, remained intact and hard.

Second Testing.

All the bricks which had stood up well under the first tests were subjected to an extraordinary trial; fresh specimens, of course, being used.

The bricks were allowed to remain in the furnace for an hour. Fresh coal was then put on so that the brick lay in the midst of a mass of ignited fuel.

The blast was kept up for an hour after the second coaling.

A *Queen's Run* brick had one end melted.

A *Clearfield* brick had one end melted.

The *Gartcosh* brick melted badly, and was taken from the furnace in pieces, some few of which only retained their identity, the rest looking like furnace slag.

The *R. Brown & Sons, Paisley*, brick melted badly and cracked, breaking into two pieces. Although the upper third of the brick preserved its form, some of its mass had melted and run out, as it was light and porous.

The *S. W. brick* and the *Mount Savage* brick were tested together. Both gave at one end; but the Mount Savage brick also melted along one side.

The *Harrisburg* brick and the *Mount Savage* brick were tested together. The lower half melted in each case, and the brick broke. The fusion however did not extend into the untouched portion of the brick as in the case of the Paisley brick.

A *Harrisburg* brick of the brand "P. W.," made from selected Pennsylvania and New Jersey clays, and a "*S.*

W." *brick* were tested together. A corner and an edge gave way in each case; but both bricks behaved very well in all other respects.

One of *Hall's Perth Amboy* bricks and one of the bricks made by Messrs. *Hyzer & Lewellen* of *Philadelphia*, were tried together.

They held better than any other bricks subjected to this test. One of the lower short edges melted in each case, but not to any great extent, the fused portion not extending more than three quarters of an inch into the brick.

Of the two the Philadelphia made brick held the better. This brick maintained a strictly first class character through all the tests, and stood No. 1.

Such is the brief record of the actual behavior of the different bricks in the trial furnace as noted by Mr. Young.

It is obvious that such record is only one part of the material needed for a discussion of the relationship between various differences in chemical composition or methods of manufacture, and proportionate increase or decrease of standing up power.

For such discussion then are required full details upon at least three points, viz:

1. Complete analyses of the clay and bricks.

2. Method of manufacture of the brick, whether the clay is perfectly or imperfectly ground up and mixed, how well burned, &c.

3. Standing up power tests.

It was soon apparent that to make the examination properly would require the testing of many more specimens of clay and bricks, and that such a mass of complete chemical analyses could not be made by the Laboratory of the Survey except by postponing other work which called for immediate attention.

Under such circumstances it was resolved to leave the work as it stood, without completing it any further at that time.

The Survey Laboratory (A. S. McCreath, Chemist) has now analysed all of the bricks tested, and they are included in this report in the pages just preceding. These analyses were specially made to illustrate these tests.

Moreover, in the course of the ordinary Survey Reports upon counties, numerous analyses of fireclays had already been made at the Laboratory, taking in nearly all the fireclay deposits from which these tested Pennsylvania firebricks were made. Some of these analyses were made several years ago and were published in Report M, and are now reproduced below for convenience of reference in connection with the analyses of the firebricks made from the same clays, and the result of the tests of their standing up power.

The Queen's Run fireclays have been analysed at Harrisburg, by A. S. McCreath, and showed

	Hard clay.	*Soft clay.*
Silica,	42.440	63.180
Alumina,	36.685	23.700
Protoxide of iron,	2.128	1.200
Titanic acid,	4:000	1.460
Lime,	.200	.170
Magnesia,	.276	.470
Alkalies,	.718	2.520
Sulphuric acid,	.820	.190
Water,	13.370	6.870
	100.637	99.760

The Harrisburg Fire Brick Works use the Blue Ball fireclay, from Clearfield county, mixed with other clays.

*The Blue Ball fireclay shows on analysis: (S. A. Ford.)

	Upper layer.	*Middle.*	*Bottom.*
Silica,	42.700	43.350	44.550
Alumina,	37.600	37.550	39.000
Protoxide of iron,	2.385	2.145	1.440
Titanic acid,	2.500	2.825	1.700
Lime,	.112	.084	.028
Magnesia,	.270	.234	.072
Alkalies,	.730	.235	.530
Water and organic matter,	13.840	14.170	13.660
	100.137	100.593	100.980

†The Clearfield fire bricks used in the tests are from clay which analysed as follows: (S. A. Ford.)

* Report H, Second Geological Survey of Pennsylvania, p. 121.

† Report H, Second Geological Survey of Pennsylvania, p. 123.

Silica,	45.450
Alumina,	36.125
Protoxide of iron,	2.275
Lime,	.168
Magnesia,	.342
Alkalies,	1.290
Water and organic matter,	13.730
	99.380

The Woodbridge, N. J., fire-clays are given below, the analyses being taken from Prof. Cook's State Geological Report of New Jersey.* These analyses are of especial interest, since the Perth Amboy brick of A. Hall and the firebrick of Hyzer & Lewellen, made from New Jersey clay also, were of the highest rank in standing up power.

Woodbridge Fire-clays.

	1	2	3	4	5
Alumina,	40.14	37.94	36.49	37.92	35.95
Silicic acid, (combined,)	42.88	44.26	42.82	42.40	38.18
Water,	13.59	14.10	12.42	14.60	12.38
Quartz sand,	.50	1.10	5.80	1.41	10.50
Ferric oxide,	.51	.96	.78	1.05	.96
Magnesia,	——	.11	.11	——	traces.
Lime,	.10	——	——	——	——
Potash,	.41	.15	.45	.35	.37
Soda,	.08	——	——	.37	——
Titanic acid,	1.42	1.30	1.12	1.41	1.61
	99.63	99.92	99.99	99.51	99.95

1. Loughridge & Powers' fire-clay, Woodbridge.
2. Hampton Cutter & Son's fire-clay, Woodbridge.
3. A. Hall & Son's fire-clay, Woodbridge.
4. Wm. H. P. Benton's fire-clay, Wooodbridge.
5. Crossman Clay & Manufacturing Co.'s fire-clay, north shore of Raritan river.

It is to be regretted that it should have been necessary to make this examination simply a fragment of a full inquiry into the subject; yet fragmentary though it be it is a step in the right course of investigation, and its facts remain and become of value as soon as the subject is again

*See Report on Clays, 1878, Geological Survey of New Jersey, for very complete details of New Jersey clays.

pursued. And imperfect as the facts may be, it will be found that an examination of the analysis of the clay, the resultant brick therefrom, and the behavior of that brick in the test furnace, will be of some interest and value to all persons interested in firebrick tests.

CHAPTER V.

Analyses of Zinc and Lead Ores.

§ 60. *Zinc and Lead Ores.*

In the interior valleys of Pennsylvania considerable quantities of zinc and lead ore have been found in the Siluro-Cambrian limestones. The principal localities are near Bethlehem in Northampton county, Landisville in Lancaster county, and Sinking Valley in Blair county.

Isolated masses of galena occur in crevices in these limestone formations throughout the entire range of the great valley, from Newburgh on the Hudson, to Chattanooga in Tennessee.

The ores of Sinking Valley will be fully described by Mr. Franklin Platt, in his forthcoming report on Blair county; and those of Lancaster county are best described in Prof. Frazer's report CCC.

Blair County.

	(1002) *Borie & Fteck.*	*(999)* *Keystone.*
Sulphide of lead,	7.10	18.37
Sulphide of zinc,	62.24	76.98
Carbonate of zinc,	6.66	none.
Sulphate of baryta,	12.98	none.
Oxide of iron and alumina,	2.98	1.90
Carbonate of lime,	1.70	.05
Carbonate of magnesia,	1.85	.17
Water,	2.57	.27
Silica,	2.13	1.67
	100.21	99.41
Metallic lead,	6.15	15.91
Metallic zinc,	45.21	51.63

(*1002*) *Between Borie & Fleck's farms*, about six miles south-west of Birmingham, Blair county.

Specimen consisted of a rather compact and fine-grained ore, being a mixture of galena, zinc blende and smithsonite; the latter for the most part granular, showing separation in laminae. A previous analysis of this specimen gave —metallic lead, 6.22; metallic zinc, 45.36—the latter determination being made by David McCreath; the others by myself.

(*999*) *Keystone Zinc Co.'s mines*, near Birmingham, Sinking Valley, Blair county.

The specimen (boulder) of an exceedingly compact and fine grained structure, consists of a mixture of galena and zinc blende.

Blair County.

	(*817b*) *Borie.*	(*792*) *Fleck.*	(*793*) *Fleck.*	(*794*) *McMullin.*	(*817a*) *McMullin.*
Metallic lead, . .	5.99	14.48	11.95	.34	.39
Metallic zinc, . .	36.12	9.31	28.16	41.17	42.87

(*817b*) *Deep shaft on Borie property*, about six miles south-west from Birmingham, Sinking Valley, Blair county.

(*792*) *Fleck's farm*, about six miles south-west from Birmingham, Sinking Valley, Blair county.

(*793*) *Fleck's farm; specimen from vein.*

(*794*) *McMullin's farm*, three and a half miles south-west from Birmingham station. *From shaft.*

(*817a*) *McMullin's farm*, near Sinking Valley P. O.

Blair County.

	(*790*) *Dickson.*	(*817c*) *Sinking Valley.*	(*796*) *Tatham.*	(*795*) *Snyder.*
Metallic lead, .	5.86	.24	13.96	25.80
Metallic zinc, .	30.40	18 22	37.01	32.97

(*790*) *Dickson farm*, one mile south-west from Birmingham, Sinking Valley, Blair county.

(*817c*) *Two and a half miles from Sinking Valley P. O.*, Blair county.

(*796*) *Tatham's shaft*, Sinking Valley, Blair county.

(*795*) *S. Snyder's farm*, three miles west from Woodberry, Bedford county. *Surface ore.*

	Fayette County. (*801a*)	(*801b*)	(*801c*)	(*801d*)	(*801e*)
	Victor Hollow.				
Metallic lead, .	.129	.129	.200	.321	.307
Metallic zinc., . .	.016	.064	.024	.842	3.370

Specimens of sandstone (Pocono) more or less impregnated with galena and zinc blende; from Victor Hollow, a tributary of Georges Creek, in Georges township, Fayette county.

See Prof. Stevenson's Report KKK, p. 240.

CHAPTER VI.

ANALYSES OF LIMESTONES.

Limestones of the Coal Measures.

The number of limestones in the Coal Measures is very great; for almost every coal bed is connected with a limestone bed. There is some obscure law in obedience to which deposits took place in the following order: first, limestone or calcareous shale; then, more or less immediately above it, fire-clay or argillaceous shale; and then coal. This order is sometimes broken by the interposition of some non-calcareous stratum between the limestone and fire-clay; and occasionally by the actual superposition of coal on limestone; but so usual is the arrangement that the carboniferous limestones have received names from the coal beds overlying them.

The exceptions are: 1. The limestones of the Upper Barren Measures; 2. The Great Limestone of the Upper Productive; 3. The Crinoidal Green Limestone, in the middle of the Barren Measures; 4. The Fossiliferous Black Limestone, lower in the same; 5. The Johnstown Cement bed; and 6. The Ferriferous Limestone, both of them in the Lower Productive Coal Measures.

The Mercer Limestones, in the Conglomerate No. XII, are named after the Mercer Coals, but overlie them; although the intervals are very small, and an overlying coal is sometimes added to the group.

The limestones of the Mauch Chunk Red Shale Formation, No. XI, (the Mountain Limestone of Southern Pennsylvania, Virginia and Kentucky, and the equivalents of the lower limestones of the Mississippi river) lie beneath the Conglomerate Series, and are really the lowest recognized Carboniferous limestones.

The following list will be serviceable. It commences with the highest known Carboniferous (Permian) limestone in Greene county and descends to the lowest, the limestone of XI, and includes the principal limestones of the series:

Greene County Group.

	Thickness in feet.
Limestone No. XIV,	8′
" No. XIII,	4′
" No. XII,	10′
" No. XI,	2′ 6″
" No. X,	2′ 6″
" No. IX*b*,	3′
" No. IX*a*,	15′
" No. VIII,	5′
" No. VII,	2′ 6″

Washington County Group.

Washington Upper Limestone No. VI,	30′
Limestone No. V,	5′
Washington Middle Limestone No. IV,	15′
Limestone No. III,	8′
Washington Lower Limestone No. II,	20′
Limestone No. I*b*,	20′
Limestone No. I*a*,	8′
Thickness of rocks 1000′; *of limestone,*	158′

Upper Productive Coal Measures.

WaynesburgLimestone,		5′
Uniontown or Great Limestone,	top member,	18′
	Shale 60′,	
	lower member,	55′
Sewickley Limestone,		18′
Redstone Limestone,		10′
Thickness of rocks, 460′; *of limestone,*		106′

Lower Barren Measures.

Pittsburgh Lower Limestone,		12′
Elk Lick Limestone,	Somerset county,	5′
Berlin Limestone,	Somerset county,	8′
Coleman Limestone,	Somerset county,	3′
Philson Limestone,	Somerset county,	1′ 6″

Lower Productive Coal Measures.

Freeport Upper Limestone.		
Freeport Lower Limestone.		
Kittanning Upper Limestone, or Johnstown Cement Bed.		
Ferriferous Limestone, maximum, ...		20′
Mountain Limestone.	Mercer Upper Limestone, . .	very thin.
	Mercer Lower Limestone, ...	very thin.
	Sharon Limestone.	

No thickness can be assigned to this last group, because of their wide extent and extreme variability. The thicknesses of the Upper Barren Measure Limestones are also greater to the west than to the east.

These strata are of every kind; silicious, argillaceous, ferruginous, ferriferous, fossiliferous, non-fossiliferous, black, green, grey, blue, and white, as the examples analysed will affirm; and some of them are as magnesian as the Magnesian Limestones of No. II; and carbonate of magnesia is found in *all* of them.

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§ *61. Washington Upper Limestone.*

The Washington Upper Limestone occurs in the Upper Barren Measures sometimes thirty feet thick. It is usually divided into several layers. The upper part is quite slaty and is blue on the freshly exposed surface; the middle layers are dark, almost black, and frequently mottled with drab. They are exceedingly brittle and yield a limestone of good quality. The lower part is ordinarily of a light flesh color, and in point of purity is scarcely inferior to the middle portions. (K, p. 46.)

Its thickness varies from six to thirty feet, being greatest in the central portions of Washington county.

In Greene county it has been everywhere identified except in the Fish Creek region. The thickness is from four to eight feet. Only one specimen of it has thus far been analysed.

Washington County.	(*129*) *Washington.*
Carbonate of lime,	72.866
Carbonate of magnesia,	3.813
Oxide of iron and alumina,	2.929
Sulphur,	.155
Phosphorus,	.061
Insoluble residue,	17.380

(*129*) *Washington Upper limestone*, from opening one mile east of Washington, at tunnel on Hempfield railroad extension, Washington county. *From the middle of the bed.* See Report K, pp. 46, 388.

Hard, compact; bluish grey, with conchoidal fracture. (D. McC.)

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§ *62. Uniontown or Great Limestone.*

This limestone bed lies in the Upper Productive Coal Measures between the Uniontown and Sewickley coal beds.

On the Monongahela river it occurs in two divisions, separated by sandstone or shale; the top member being about fifteen feet thick, and the lower member fifty-five feet thick.

The *upper* division lies directly under the Uniontown coal, and is readily distinguished by its bright buff color. It exists at many localities in Greene and Washington counties, but has not been identified in Allegheny county.

The *lower* division is found along the Monongahela river wherever its horizon is exposed, except in north-eastern Allegheny county. (K, p. 64.) The character of the rock is variable, the lower portion being more or less *magnesian.* This part is employed for the manufacture of *cement* at many places, and is available throughout eastern Washington county.

It is the more persistent part of the mass, and has been identified in Allegheny county, on the Pittsburgh and Steubenville pike. Near Pittsburgh it seems to be altogether wanting.

In Ohio, north from the Central Ohio railroad, the lower division varies in thickness from 0′ to 75′, and rests directly on the Sewickley coal.

In West Virginia it thins out quite rapidly, and on the Parkersburg branch of the Baltimore and Ohio railroad it is represented by only some thin argillaceous limestones, while at twenty miles further south no trace of it exists. (K, p. 65.)

In the Salisbury basin in Somerset county the Uniontown limestone is worked at numerous places. It lies one hundred and sixty feet above the Pittsburgh coal, and is so regular that it may be found wherever its horizon is exposed.

In the Saltzburg basin in Indiana county this limestone is exposed on Elder's Ridge, where it exists as several layers separated by variable intervals of shale, the whole deposit being over twenty-five feet thick. (HHHH, p. 271.)

The following analyses will represent the average character of the limestone:

Washington County.

	(*132*) *Upper layer.*	(*130*) *Middle layer.*	(*131*) *Bottom layer.*	(*133*) *Shaner.*
Carbonate of lime, ...	68.837	48.823	47.080	47.750
Carbonate of magnesia, .	14.649	20.621	28.528	30.943
Carbonate of iron, . . .	3.306 (iron and alumina)	3.625	7.511 (iron and alumina)	5.608 (iron and alumina)
Alumina, ...		3.523		
Sulphur, ...	.097	.203	.069	.126
Phosphorus, ...	.049	.051	.127	.015
Insoluble residue, . . .	13.300	22.520	15.750	14.920

(*132*) *Great Limestone, lower division, upper layer*, one mile north of Cannonsburg. See Report K, pp. 64, 388.

Very hard and compact; conglomerate like, bluish grey. (D. McC.)

(*130*) *Great Limestone, lower division, middle layer*, one mile north of Cannonsburg.

Compact; structure, somewhat slaty; color, bluish grey. (D. McC.

(*131*) *Great Limestone, lower division, bottom layer*, one mile north of Cannonsburg.

Hard, compact, unctuous; pearl grey. (D. McC.)

(*133*) *Great Limestone*, eight miles from Washington, Somerset township, on property of Dr. Shaner.

Hard, brittle, unctuous, pearl grey. (D. McC.)

Somerset County.

	(448) *Keystone.*	(540) *Saylor Hill.*
Carbonate of lime,	72.623	85.732
Carbonate of magnesia,	12.614	5.098
Carbonate of iron,	2.239	2.871
Alumina,	.972	
Sulphur,	.159	.104
Phosphorus,	.005	.037
Insoluble residue,	9.180	6.220

(*448*) *Keystone Coal and Manufacturing Co.'s quarry*, two and a half miles south-west of Meyersdale. See HHH, p. 93.

Hard, compact, bluish grey. (D. McC.)

(*540*) *Saylor Hill quarry*, three quarters of a mile west from Meyersdale. See HHH, pp. 92, 94.

Compact, fine grained, brittle, bluish grey. (D. McC.)

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§ *63. Sewickley Limestone.*

This is the Fishpot Limestone of Prof. Stevenson's Reports K and KK, underlying the Sewickley coal at an interval of about fifteen feet. It varies considerably in thickness, reaching its maximum on Redstone creek, Fayette county, where it is thirty feet thick and of excellent quality.

At the southern end of the Blairsville basin this limestone is thin and of inferior quality; but northwards it grows thicker and improves in quality, so that in North Union township, Fayette county it is quarried for use as a flux.

In Dunbar township it is irregular; and northward from the Youghiogheny river its occurrence is uncertain, the rock being present at some localities and absent at others in the immediate vicinity. (KK, p. 45.)

In the Greensburg basin in Hempfield township it is probably represented by the limestone seen on the railroad, at sixty feet above the Pittsburgh coal bed, with a thickness of twenty feet.

At New Geneva it is ten feet thick; on the Redstone

Creek thirty feet, and of such excellent quality that it is the chief source of lime for all purposes. (KK, p. 46.)

In South Huntingdon township, Westmoreland county, it is fully twenty feet thick, and of great purity.

In the Blairsville basin, in Indiana county, it caps the Coleman Knob overlooking the valley of Black Lick. It yields an abundant supply of excellent limestone. (HHHH, p. 159.)

In the Salisbury basin in Somerset county it has been mined five feet thick, and divided into two layers, the upper one being fossiliferous.

The average character of the Sewickley limestone is shown by the following analyses :

Fayette County.

	(41) *Oliphant.*
Carbonate of lime,	80.647
Carbonate of magnesia,	2.217
Carbonate of iron,	1.657
Bisulphide of iron,	1.125
Alumina,	.543
Sulphuric acid,	.052
Phosphoric acid,	.066
Water,	1.010
Carbonaceous matter,	1.250
Insoluble residue,	10.770
	99.337

(*41*) *Oliphant Furnace quarry*, Georges township, Fayette county.

Compact, minutely crystalline; spotted with pyrites; dark blue.

Somerset County.

	(538) *Hayes.*	(539) *Saylor Hill.*
Carbonate of lime,	74.803	69.160
Carbonate of magnesia,	6.734	15.535
Carbonate of iron,	5.282	3.935
Alumina,	1.548	1.366
Sulphur,	.052	.046
Phosphorus,	.070	.017
Insoluble residue,	11.510	9.730

(*538*) *J. M. Hayes' quarry*, one mile north of Salisbury. See Report HHH, p. 92.

Hard, brittle; bluish grey. (D. McC.)

(*539*) *Saylor Hill quarry*, three fourths of a mile west from Meyersdale.

Compact, brittle; yellowish grey. (D. McC.)

Indiana County.

	(*772*) *R. Smith.*
Carbonate of lime,	79.821
Carbonate of magnesia,	3.601
Oxide of iron and alumina,	3.020
Sulphur,	.117
Phosphorus,	.018
Insoluble residue,	12.160

(*772*) *Robert Smith's quarry*, at Smith's Station, two miles north north-east from Blairsville. See Report HHHH, p. 159.

Compact, brittle; sparkling with calcite; bluish grey, with irregular fracture. More or less stained with iron oxide.

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§ *64. Redstone Limestone.*

This limestone, when present, directly underlies the Redstone coal bed. Its occurrence is very irregular, and its character very variable.

It is rarely present in the Salisbury basin, but is persistent in the Blairsville trough.

On Redstone creek and thence northward to the Youghiogheny river, it is thick and is quarried for use as a flux at the furnaces. Northward from the Youghiogheny it becomes irregular and impure.

In East Huntingdon township, Westmoreland county, it is very ferruginous.

In the Greensburg trough this limestone is not present. See Report KK, p. 48.

It is extensively quarried in the south end of the Salisbury basin in Somerset county, where it is fully ten feet thick. See HHH, p. 62.

The following analyses will show the character of the limestone at two localities:

	Fayette County. (594) Lemont furnace.	Somerset County. (464) Beechy.
Carbonate of lime,	66.471	86.625
Carbonate of magnesia,	17.711	6.152
Carbonate of iron,	5.178	1.825
Alumina,	.812	
Sulphur,	.080	.093
Phosphorus,	.048	.023
Insoluble residue,	9.460	4.040

(594) Lemont Furnace quarry, three miles north-east from Uniontown, Fayette county.

Hard and brittle; sparkles with calcite; pearl grey, with conchoidal fracture.

(464) Manasses J. Beechy's quarry, two and one half miles south-west of Salisbury, Somerset county.

Minutely crystalline; pearl grey, with conchoidal fracture.

§ 65. *Pittsburgh Limestone.*

This limestone underlies the Pittsburgh coal at an interval of about twenty feet. It has a wide range throughout south-western Pennsylvania, and extends eastward across the Allegheny Mountain into the Cumberland basin of Maryland, showing also in the Salisbury basin in Somerset county.

The following are two analyses of this limestone:

Indiana County.

	(764) A. H. Fulton.
Carbonate of lime,	82.768
Carbonate of magnesia,	2.875
Oxide of iron and alumina,	2.830
Sulphur,	.156
Phosphorus,	.011
Insoluble residue,	10.327

(764) A. H. Fulton's quarry, at West Lebanon.

Generally compact and brittle, with irregular fracture and bluish grey color. Seamed with bluish black limestone.

Fayette County.

	(595) *Lemont furnace.*
Carbonate of lime,	87.868
Carbonate of magnesia,	1.733
Carbonate of iron,	1.914
Alumina,	.135
Sulphur,	.106
Phosphorus,	.050
Insoluble residue,	7.360

(*595*) *Lemont Furnace quarry*, three miles north-east of Uniontown.

Comparatively soft and brittle, with very irregular fracture and bluish grey color.

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§ *66. Little Pittsburgh Limestone.*

This limestone lies in the Lower Barren Measures almost immediately underneath the *Little Pittsburgh* coal bed and seems to have a range co-extensive with the coal. It is usually not of much economic importance; but in the Salisbury basin of Somerset county it is a persistent limestone averaging four to five feet in thickness.

The following analysis shows its character in that locality:

Somerset County.

	(462) *Flickinger.*
Carbonate of lime,	64.706
Carbonate of magnesia,	2.156
Carbonate of iron,	4.274
Alumina,	1.700
Sulphur,	2.431
Phosphorus,	.751
Carbonaceous matter,	2.602
Insoluble residue,	20.660

(*462*) *S. S. Flickenger's limestone quarry*, two and a half miles north of Salisbury. Fifty feet below Pittsburgh Coal bed. See HHH, pp. 74, 75.

Compact; exceedingly brittle; structure somewhat slaty; color, dark bluish grey. Carries considerable coaly matter and a large amount of iron pyrites.

§ 67. *Elk Lick Limestone.*

In the Salisbury basin in Somerset county, the Elk Lick Limestone is opened and worked at several localities. It averages fully six feet in thickness and is of good quality. It is usually separated into two layers, the lower one being quite argillaceous. See HHH, p. 72.

Limestone is found underlying the Elk Lick Coal in various places in Westmoreland, Fayette, Indiana, Allegheny, Butler and Beaver counties. See Report KK, pp. 304, 349; HHHH, p. 32, &c.; Q, pp. 164, 168:

Somerset County.

	(380) P. C. C. & I. Co.	(537) Yoder.	(427) Berkey.
Carbonate of lime,	90.803	55.589	89.522
Carbonate of magnesia,	2.738	14.224	5.327
Carbonate of iron,	1.986	6.835	1.812
Alumina,		2.886	.224
Sulphur,	.084	.185	.245
Phosphorus,	.048	.032	.016
Insoluble residue,	3.740	19.800	2.500

(*380*) *Pittsburgh Coal, Coke & Iron Co.'s quarry*, three quarters of a mile north of Ursina. See Report HHH, p. 259.

Exceedingly compact and fine-grained; bluish grey, with conchoidal fracture. (D. McC.)

(*537*) *Elias Yoder's quarry*, one mile west from Meyersdale.

Hard, compact; bluish grey. (D. McC.)

(*427*) *Peter G. Berkey's quarry*, near Jenner Cross Roads.

Compact; bluish grey, with conchoidal fracture. (D. McC.)

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§ 68. *Freeport Upper Limestone.*

This limestone lies at an interval of a few feet below the Freeport Upper Coal, in the Lower Productive Measures.

In the Ligonier basin in Indiana county, it is a persistent stratum averaging fully six feet in thickness and yielding an abundant supply of excellent lime. (HHHH, p. 72.)

On Loyalhanna creek in Westmoreland county, it is five feet thick; and on the Conemaugh it averages from three to five feet.

Throughout the whole of the Wilmore sub-basin in Cambria county, it is present at an interval of about twenty feet below the Freeport Upper Coal.

The average character of the limestone is shown by the following analyses:

Indiana County.

	(761) *Brown.*	*(773)* *Groft.*	*(771)* *Hazlett.*	*(774)* *Griffith.*	*(769)* *Livengood.*
Carbonate of lime, . . .	84.125	84.407	89.821	72.264	54.768
Carbonate of magnesia,	5.198	2.800	1.801	6.493	8.627
Oxide of iron and alumina,	3.220	2.120	1.700	4.190	6.930
Sulphur, ...	.073	.188	.133	.068	.112
Phosphorus, ...	.014	.018	.027	.029	.017
Insoluble residue, . . .	6.021	9.150	5.430	14.980	27.230

(*761*) *Rev. S. Brown's quarry*, one and a half miles south west from Five Points.

Compact, brittle; sparkles with calcite; bluish grey, with sub-conchoidal fracture.

(*773*) *Groft Brothers' quarry*, one mile east of Chambersville. See Report HHHH, p. 254.

Compact, brittle; dark bluish grey, with irregular fracture.

(*771*) *S. C. Hazlett's quarry*, two miles south of Jacksonsville.

Compact, brittle; bluish grey, with sub-conchoidal fracture.

(*774*) *D. R. Griffith's quarry*, one and a half miles north north-east from Homer.

Compact, brittle; dark bluish grey, with irregular fracture. Emits a strong argillaceous odor when breathed upon.

(*769*) *G. Livengood's quarry*, three miles east south-east from Blairsville. (HHHH, p. 179.)

Compact, brittle; bluish grey, with irregular fracture; sparkles with calcite. Specimen, more or less stained with iron oxide, emits a strong argillaceous odor when breathed upon.

Westmoreland County.

	(763) *Wining & Cuisan.*	(948) *Kier Bros.*
Carbonate of lime,	91.982	94.643
Carbonate of magnesia,	1.664	1.144
Oxide of iron and alumina,	1.520	2.720
Sulphur,	.091	.028
Phosphorus,	.012	.015
Insoluble residue,	4.015	.990

(*763*) *Wining & Cuisan's quarry*, one half mile north-west from Kelly's Station. (HHHH, pp. 245, 246.)

Compact, brittle; pearl grey, with conchoidal fracture. Sparkles with calcite.

(*948*) *Kier Brothers' quarry*, at Salina.

Fine grained, brittle; reddish grey, with conchoidal fracture.

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§ *69. Freeport Lower Limestone.*

The Freeport Lower Limestone has been recognized under the Freeport Lower Coal in a great many places between the Allegheny mountain and the Allegheny river, as will be seen by reference to the Reports of Progress.

But in the reports H and HH, it is spoken of as the "ferriferous limestone." In other reports care has been taken to avoid this name so that the bed may not be confounded with the Ferriferous Limestone underlying the Kittanning Coal group. See HH, p. 52.

Indiana County.

	(766) *Palmer*	(762) *Brown.*
Carbonate of lime,	88.232	82.321
Carbonate of magnesia,	1.371	8.021
Oxide of iron and alumina,	1.960	2.630
Sulphur,	.048	.102
Phosphorus,	.017	.017
Insoluble residue,	8.210	5.502

(*766*) *S. Palmer's quarry*, three quarters of a mile west north-west of Decher's Point. See Report HHHH, p. 228.

Irregularly seamed with white crystalline carbonate of lime; exceedingly brittle, with rough irregular fracture and bluish grey color.

(*762*) *P. Brown's quarry*, four and one half miles east north-east from Blairsville, on Cambria and Indiana pike.

Compact, brittle; bluish grey, with irregular fracture.

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§ *70. Johnstown Cement Bed.*

The Johnstown Cement bed is remarkable for preserving this special character—as a cement bed—in many of its exposures. It is carefully described in Report HH, pp. 152, 153, in connection with Hawes' cement works near Johnstown, Cambria county.

It has been recently discovered in its proper place, under the Kittanning Upper or Darlington coal bed, by Mr. Wm. G. Platt in the very perfect section at Putneyville on the Mahoning Creek in Armstrong county, and will be fully described in his report H^5.

Indiana County.

	(*768*) *Gorman.*	(*775*) *Gorman.*	(*767*) *Tyhawk.*
Carbonate of lime,	36.214	58.750	78.768
Carbonate of magnesia,	16.883	16.005	2.421
Oxide of iron and alumina,	——	7.380	3.540
Carbonate of iron,	8.078	——	——
Alumina,	4.360	——	——
Sulphur,	.056	.041	.097
Phosphorus,	.056	.085	.018
Insoluble residue,	32.790	15.060	13.790

(*768*) *A. Gorman's quarry*, two miles south-west from Smithport. *Upper portion of deposit.* See HHHH, p. 221.

Hard and tough, with rough irregular fracture and pearl grey color. Emits a strong argillaceous odor when breathed upon.

(*775*) *A. Gorman's quarry*, two miles south-west from Smithport. *Lower portion of deposit.*

Hard and tough, with irregular fracture and bluish grey color. Emits a strong argillaceous odor when breathed upon.

(*767*) *Tyhawk's quarry*, one mile east from Black Lick station. *From main bench of deposit.* See HHHH, p. 190.

Compact; bluish grey, with irregular fracture.

Cambria County.	(370) *Hawes.*
Carbonate of lime,	34.301
Carbonate of magnesia,	21.650
Carbonate of iron,	8.700
Alumina,	3.390
Bisulphide of iron,	1.268
Phosphorus,	.049
Insoluble residue,	27.873

(*370*) *A. J. Hawes' quarry*, at Johnstown. See HH, p. 153.

Hard and brittle; bluish grey; shows considerable pyrites, and emits a strong argillaceous odor when breathed upon.

Somerset County.	(393) *Zimmerman.*	(394) *Reitz.*	(418) *Wilt.*	(407) *Pile.*
Carbonate of lime,	63.969	86.778	88.139	79.478
Carbonate of magnesia,	4.244	2.908	1.854	10.222
Carbonate of iron, / Alumina,	4.393	2.972	1.798 / .340	3.693
Sulphur,	.385	.166	.357	.168
Phosphorus,	.142	.137	.023	.034
Insoluble residue,	24.780	6.040	5.640	4.970

(*393*) *Zimmerman's quarry*, three and a half miles southeast of Somerset. See HHH, p. 155.

Compact, sandy; bluish grey. (D. McC.)

(*394*) *Reitz's quarry*, one and a quarter miles south southeast of Friedensburg.

Hard, compact; bluish grey. (D. McC.)

(*418*) *Wilt's quarry*, near Stoystown. See HHH, p. 128.

Compact, fine grained; bluish grey. (D. McC.)

(*407*) *J. J. Pile's quarry*, near Sipesville, on Quemahoning creek. See HHH, p. 232.

Compact, brittle; bluish grey. (D. McC.)

Somerset County.	(419a) *Beam.*	(419b) *Beam.*	(419c) *Beam.*
Carbonate of lime,	92.298	54.321	69.264
Carbonate of magnesia,	1.483	23.088	13.773
Carbonate of iron,	1.167	8.492	4.739
Alumina,	.359	1.626	.403
Carbonate of manganese,	trace.	trace.	trace.
Sulphur,	.097	.127	.106
Phosphorus,	.018	.051	.047
Carbonaceous matter,	.550	.980	.590
Insoluble residue,	3.950	12.020	10.760

(*419a*) *J. W. Beam's quarry*, at Jenner Cross Roads. *Upper bench of quarry.* See Report HHH, p. 231.

Compact, brittle; fine grained, bluish grey.

(*419b*) *J. W. Beam's quarry*; *middle bench of quarry.* Hard, brittle; bluish grey. (D. McC.)

(*419c*) *J. W. Beam's quarry*; *lower bench of quarry.* Compact, brittle; bluish grey.

Somerset County.

	(*83*) *Rodgers.*	(*424*) *Trevorrow.*	(*84*) *Weaver.*
Carbonate of lime,	52.940	90.544	50.160
Carbonate of magnesia,	16.060	2.134	18.494
Carbonate of iron,	5.800	1.503	11.600
Alumina,	4.440	.261	
Sulphur,	.088	.464	.153
Phosphorus,	.058	.013	.120
Insoluble residue,	17.770	3.850	13.360

(*83*) *D. Rodgers' quarry*, on Huskin's Run, Shade township. See HHH, p. 146.

Hard, rather sandy, bluish grey. (D. McC.)

(*424*) *Trevorrow's quarry*, near Davidsville.

Very brittle; fine-grained; bluish grey, with conchoidal fracture.

(*84*) *J. Weaver's quarry*, about three quarters of a mile west of Scalp Level. See HHH, p. 134.

Compact, bluish grey; much coated with iron oxide. (D. McC.)

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§ *71. Ferriferous Limestone.*

The Ferriferous Limestone has been assumed as the base of the Kittanning Coal group over a region limited by a north-east south-west line through the middle of Indiana county. To the south-east of this line no exposures of the bed have ever been seen; it seems therefore not to have been deposited in Westmoreland, Cambria and Somerset counties. In North Butler it is often absent.

North and west of this line it extends from McKean county to Beaver county. Along its final outcrop towards the north-west, through Jefferson, Clarion, Butler, and Lawrence counties, it is not only very thick and divided into two parts—the upper grey and the lower blue—but carries those important deposits of brown hematite ore (Buhrstone) described in § 41, pp. 188, 189.

It is fully described in Reports Q, p. 60, and V, pp. 141, 142, 145.

Its average character is shown by the following analyses:

Beaver County.	(596) *Severn.*	(599) *Powers.*	(600) *Powers.*	(555) *Tygart.*
Carbonate of lime,	93.482	88.464	91.607	91.089
Carbonate of magnesia,	1.544	1.445	1.566	1.587
Oxide of iron and alumina,	1.823	2.324	1.291	1.589
Sulphur,	.030	.097	.290	.047
Phosphorus,	.047	.029	.030	.040
Insoluble residue,	2.770	7.030	4.780	4.800
	99.696	99.389	99.564	99.152

(*596*) *Severn's quarry*, half a mile below Vanport, New Brighton township. *Upper bench.* See Report Q, p. 255.

Exceedingly brittle, with irregular fracture; color, generally reddish grey.

(*599*) *Powers' quarry*, near Vanport, on the Ohio river. *Top stratum.* See Report Q, p. 255.

Compact; very brittle; fracture irregular; color, dull grey and reddish grey.

(*600*) *Powers' quarry; middle stratum.*

Compact and tough; sparkling with calcite; spotted with pyrites. Color, pearl grey and reddish grey.

(*555*) *Tygart's quarry*, half a mile below Vanport. *Lower stratum.* See Q, p. 61.

Hard and brittle; fracture irregular, sparkling with calcite; color, bluish grey and reddish grey. (Analysed by David McCreath.)

Lawrence County.	(747) *Shinn.*	(748) *McCord.*	(745) *Green.*	(746). *Moffit.*
Carbonate of lime,	94.214	95.768	93.340	94.785
Carbonate of magnesia,	1.732	1.097	1.460	1.369
Oxide of iron and alumina,	.805	.632	1.563	1.187
Sulphur,	.165	.088	.123	.123
Phosphorus,	.020	.017	.047	.032
Insoluble residue,	2.790	1.970	3.070	2.080
	99.726	99.572	99.603	99.576

(*747*) *J. K. Shinn & Bros.' quarry*, near Wampum, Big Beaver township.

Compact; brittle; sparkling with calcite; bluish grey.

(*748*) *McCord's quarry*, three miles north-west from Mt. Jackson, North Beaver township.

Compact; brittle; sparkling with calcite; pearl grey, with irregular fracture.

(*745*) *Green, Marquis & Johnson's quarries*, near New Castle.

Compact; brittle; sparkling with calcite; bluish grey, with irregular fracture.

(*746*) *Moffit's quarry*, two miles north from Croton.

Compact; brittle; sparkling with calcite; bluish grey and pearl grey, with irregular fracture.

	Armstrong County. (*947*) *Pine Creek.*	*Indiana County.* (*765*) *Simpson.*
Carbonate of lime,	96.785	92.857
Carbonate of magnesia,	1.278	1.589
Oxide of iron and alumina,	1.000	2.030
Sulphur,	.060	.187
Phosphorus,	.029	.035
Insoluble residue,	.370	2.090
	99.522	98.788

(*947*) *Pine Creek Furnace quarry*, six miles north-east of Kittanning, Armstrong county.

Compact; bluish grey, with irregular fracture.

(*765*) *Isaac Simpson's quarry*, half a mile south-west from Richmond, Indiana county. See HHHH, p. 264.

Hard and tough; fossiliferous; fracture irregular; color, dark bluish grey.

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§ 72. *Limestone of the Mauch Chunk Red Shale, No. XI.*

This is the Mountain Limestone of southern Pennsylvania, Virginia and Kentucky.

In Pennsylvania it is exposed not only around Broad Top in Blair and Huntingdon counties (where the specimen analysed below was obtained) but along the face of the Allegheny Mountain, under the Pottsville Conglomerate, at

Queen's Run in Clinton county, and in Somerset county, as well as in the gaps near Johnstown, Blairsville, Confluence and Connellsville.

It appears in the Boyd's well at Pittsburgh (see Report L, p. 222;)—on Mahoning creek in Armstrong county; and on Mahoning river in Mercer county; but the exact equivalency of the limestone at the two last mentioned localities is still an open question, there being apparently two distinct horizons of limestone under the Conglomerate.

Huntingdon County.	(562) *Whitney.*
Carbonate of lime,	92.323
Carbonate of magnesia,	1.089
Carbonate of iron,	.683
Alumina,	.180
Sulphur,	.034
Phosphorus,	.014
Insoluble residue,	4.640

(562) *John Whitney's quarry*, half a mile south of Todd P. O., Todd township. See Report F, pp. 199, 200.

Coarse grained; rather tough; bluish grey.

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§ 73. *Chemung Limestone, Formation No. VIII.*

This is the limestone of Formation No. VIII. The analyses below are of specimens collected in Tioga, Bradford and Sullivan counties. See Reports G and GG.

	Tioga County. (336) *Wilson.*	*Bradford County.* (334) *Kline.*
Lime,	28.872	41.048
Magnesia,	1.117	1.135
Sesquioxide of iron,	2.142	4.428
Alumina,	2.269	2.613
Sulphuric acid,	.087	.167
Phosphoric acid,	.729	.279
Carbonic acid,	23.227	33.240
Insoluble residue,	41.700	18.010
	100.143	100.920

(336) *G. R. Wilson's limestone*, one and a half miles north of Mansfield, Tioga county. See Report G, p. 62.

Specimen for the most part composed of *comminuted sea shells* cemented together with shale. Color, reddish grey. (D. McC.)

(*334*) *W. B. Kline's limestone*, about one mile east of Burlington, Bradford county. "*Burlington Limestone.*" See G, p. 38.

A compact mass of small fossil shells cemented together with fossil ore. (D. McC.)

Sullivan County.

	(*923*) *Lucke.*	(*924*) *Lucke.*
Carbonate of lime,	80.393	69.000
Carbonate of magnesia,	5.653	5.387
Carbonate of manganese,	3.116	1.689
Oxide of iron and alumina,	5.196	5.870
Sulphur,	.240	.092
Phosphorus,	.133	.144
Insoluble residue,	5.240	17.850
	99.971	100.032

(*923*) *Lucke's quarry*, near Millview, Sullivan county. *Upper bench of quarry.*

Irregularly seamed with calcite; generally coarse grained and fossiliferous; dark bluish grey color, with irregular fracture. Specimen shows reddish yellow and rose tinted carbonate of manganese. (S. S. H.)

(*924*) *Lucke's quarry; lower bench of quarry.*

Specimen has the same general appearance as that from the upper bench. (S. S. H.)

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§*74*. *Lewistown Limestone, Lower Helderberg Formation, No. VI.*

The outcrop of this, the Lower Helderberg formation (No. VI,) the recognized top of the Silurian system, makes an important element in the topography of the Appalachian belt of the United States, from Lake Erie to the Gulf of Mexico.

The whole mass of the Lower Helderberg is 900 feet thick in Blair county (see Sanders' measurements in Report F, pp. 262, 264);—895 feet by Chance's measurement in Clinton county (F, pp. 265, 269);—and 1182 feet by Ashburner's measurements in Huntingdon county, where the Water Lime and Onondaga formations are included in the count. (F, pp. 240, 241.)

The Lewistown Limestone proper measures 162 feet in Huntingdon county (F, 241,) and 185 feet at Lewistown in Juniata county. (F, 49.) These thicknesses are maintained throughout the mountain belt of middle Pennsylvania west of the Susquehanna river. But between the Susquehanna river and the Delaware river, along the south-easternmost outcrop of the formation, back of the Kittatinny, Blue or North mountain, through Dauphin, Schuylkill, Lehigh, and Northampton counties, the limestone is absent or scarcely visible; so that the deposit was limited to an area north and west of this line.

Very exact descriptions of this formation, with measurements of its individual beds, are given in Report F.

Blair County.

	(802a) Baker. [Upper.]	(802b) Baker. [Middle.]	(802c) Baker. [Lower.]
Carbonate of lime,	95.664	95.089	95.571
Carbonate of magnesia,	1.547	1.581	1.521
Oxide of iron and alumina,	.842	.644	.570
Sulphur,	.103	.029	.027
Phosphorus,	.015	.020	.009
Insoluble residue,	2.500	3.000	3.020
	100.671	100.363	100.718

(802a) *Baker's quarry,* near Altoona. *Upper layer.*

Coarse grained; fossiliferous; light bluish grey, with conchoidal fracture. Carries considerable white crystalline carbonate of lime. (S. S. Hartranft.)

(802b) *Baker's quarry,* near Altoona. *Middle layer.*

Fine grained; sparkling with calcite; dark grey, with irregular fracture. (S. S. H.)

(802c) *Baker's quarry,* near Altoona. *Lower layer.*

Rather fine grained; sparkling with calcite; color, grey; fracture, even. (S. S. H.)

Blair County.

	(648) *Creswell.*	(649) *Manning.*	(650) *Loop.*
Carbonate of lime,	95.251	96.164	84.782.
Carbonate of magnesia,	2.265	1.589	3.859
Carbonate of iron,	.745	.615	.534
Alumina,	.054	.035	.043
Sulphur,	.053	.070	.053
Phosphorus,	.003	.005	.004
Insoluble residue,	1.800	1.615	10.850
	100.171	100.093	100.125

(*648*) *Creswell's quarry,* near Hollidaysburg.

Exceedingly hard and tough; seamed with calcite; generally dark grey.

(*649*) *Manning & Lewis' quarry* at Hollidaysburg.

Compact and brittle; seamed with calcite; pearl grey and bluish grey.

(*650*) *Loop's quarry* at Hollidaysburg.

Hard and tough; mottled with calcite; shows small particles of quartz. Generally dark grey.

Blair County.

	(961) *Sarah Furnace.*
Carbonate of lime,	96.142
Carbonate of magnesia,	1.604
Oxide of iron and alumina,	.440
Sulphur,	.053
Phosphorus,	.005
Insoluble residue,	1.688
	99.932

(*961*) *Sarah Furnace quarry.*

Fine grained; dark bluish grey, with somewhat laminated structure.

Huntingdon County.

	(560) *Hudson.*	(527) *Hudson.*	(528) *Hudson.*
Carbonate of lime,	90.904	94.035	91.125
Carbonate of magnesia,	2.162	1.965	1.572
Carbonate of iron,	1.642	.697	1.139
Alumina,	.123		
Sulphur,	.081	.056	.030
Phosphorus,	.010	.012	.014
Insoluble residue,	5.700	2.330	5.040

(*560*) *Hudson's quarry* at Three Springs. *Specimen from seventy feet above bottom of formation.* See Report F, p. 244.

Fine grained; bluish grey, with conchoidal fracture.

(*527*) *Hudson's quarry* at Three Springs. *Specimen from sixty feet above bottom of formation.*

Fine grained; compact; bluish grey. (D. McCreath.)

(*528*) *Hudson's quarry* at Three Springs. *Specimen from fifty feet above bottom of formation.*

Irregularly seamed with white crystalline carbonate of lime; compact; bluish grey. (D. McC.)

Huntingdon County.

	(*532*) *McCarthy.*	(*534*) *McCarthy.*
Carbonate of lime,	89.292	47.300
Carbonate of magnesia,	2.557	2.011
Carbonate of iron, Alumina,	1.783	1.667
Sulphur,	.059	.146
Phosphorus,	.027	.027
Insoluble residue,	5.300	49.030

(*532*) *C. R. McCarthy's quarry*, near Saltillo. *Specimen taken one hundred and twenty-five feet from bottom of formation.*

Irregularly seamed with calcite; minutely crystalline; bluish grey. (D. McC.)

(*534*) *C. R. McCarthy's quarry*, near Saltillo. *Specimen taken as a representative of some of the flinty beds which exist in the series.* See Report F, p. 244.

Compact; silicious; bluish grey. (D. McC.)

Water-lime Cement Beds.

Huntingdon County.

	(*536*) *Saltillo.*	(*561*) *Saltillo.*	(*535*) *Saltillo.*
Lime,	39.537	47.080	14.120
Magnesia,	8.821	4.598	9.571
Protoxide of iron,	.638	.576	3.342
Alumina,	1.260	.550	14.066
Carbonic acid,	41.528	42.090	24.592
Water,	——	.020	1.005
Silica,	8.150	5.320	33.220

(*536*) *Massive bluish grey limestone from Saltillo;* taken at three hundred and seventy-five feet above bottom of formation. See Report F, pp. 241, 245, 246.

(*561*) *Dark blue limestone from Saltillo;* one hundred and ninety feet above bottom of formation.

(*535*) *Massive bluish grey limestone from Saltillo;* one hundred and sixty feet above bottom of formation.

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§ *75. Siluro-Cambrian Limestones, Formation No. II.*

The great limestone valleys of the Appalachian mountain belt are floored by the outcrops of the Trenton, Chazy and Calciferous formations, the northern outcrops of which extend from Albany to Buffalo, and are continued westward through Upper Canada to the Straits of Mackinaw, and stretch thence southward along the west shore of Lake Michigan.

The Great Valley extends from Canada through western New England and eastern and southern New York, northern New Jersey to the Delaware river at Easton; thence through Northampton, Lehigh, Berks, Lebanon, Dauphin, Cumberland and Franklin counties to Maryland; thence across the Potomac and through Virginia by Martinsburg, Staunton, Christiansburg and Wythe to the Tennessee line; thence by Knoxville and Chattanooga into Alabama.

This valley bears many names, but is generally known in Pennsylvania as the Great, Lebanon, or Cumberland Valley, and in Virginia as the Shenandoah Valley. Its limestones have been thrown by Safford into his Knox group in east Tennessee.

Back of the Great Valley, anticlinals bring up part or all of the mass in long valleys, sometimes narrow, sometimes broad, like McConnellsville Cove, Kishicoquillis Valley, Nittany, Brush and Sugar Valleys, Sinking Spring and Canoe Valleys, Morrison's Cove and Milliken's Cove in Pennsylvania, and many others in Virginia. The outcrops in southern Virginia, east Tennessee and Alabama are repeated not by anticlinals but by faults, producing other limestone or "Rich" valleys.

At only one place in the interior valleys of Pennsylvania is the base of the formation exposed, viz: at Birmingham on the Little Juniata river, in Blair county. Here the whole thickness of No. II has been carefully measured and seems to amount to six thousand six hundred feet (6600′, F. 265.) This will be described in Report of Progress T, Blair county, 1879.

The mass throughout the Great Valley—where its top (Trenton) is seen going under the slates of III (Utica, or Hudson River) and its bottom is seen resting on the sandstone of No. I (Potsdam) all along the north or west flank of the South Mountain-Blue Ridge range,—is so contorted and plicated as to defy accurate measurement. It seems however to range between 2000 and 3000 feet.

An attempt was made to measure it along the Susquehanna river at Harrisburg; but some doubt is entertained respecting the structure here, there being to all appearance a fault against the south edge of the slates of III, and an overturned collapsed anticlinal to the south of the fault. From a point 1000 feet south of the place of the supposed anticlinal (650 yards below the west end of the Cumberland Valley railroad bridge at Harrisburg,) to the southern (top) limit of the limestones (top of Trenton) going down under the slates of III on Yellow Breeches creek (one mile south of Harrisburg) there is great regularity of (southern) dip, (24°,) and an observed thickness of 1980′ feet; but how much more is underground cannot be observed.

North of the supposed overturn the southward dip of the strata is regular, (25° to 30°,) and the beds are exposed for a thickness of 600 feet, in quarries and railway cuttings. Here the analytical investigation, described further on, was undertaken.

Contorted exposures of the limestones of No. II, occur in the quarries and railway cuttings along the Lehigh river above Allentown; and others between Bethlehem and Easton.

Very long and fine exposures occur along the Upper Juniata and Little Juniata rivers; and isolated exposures are frequent in all the valleys mentioned above.

The upper part of the whole mass corresponding to the Trenton is of pretty pure limestone without magnesia. The Chazy and Calciferous portions are highly magnesian; but as the investigation to be described further on plainly shows, magnesian not as a whole but in alternate strata.

The following analyses have been made of specimens sent in by the assistant geologists of the survey, and most of them are supposed to represent Calciferous strata:

Blair County.

	(786) *Mt. Etna.*	(807) *Spring-field.*	(964a) *Rod-man.*	(964b) *Rod-man.*	(964c) *Rod-man.*
Carbonate of lime, . .	94.980	78.196	78.176	91.892	54.571
Carbonate of magnesia,	3.866	17.510	10.746	2.875	44.180
Oxide of iron and alumina, . .	.264	1.126	1.850	.640	.234
Sulphur, . .	.053	.085	.149	.097	.002
Phosphorus, ...	.011	.015	.029	.022	.003
Insoluble residue, . . .	.910	3.210	8.570	4.380	1.330

(786) *Mt. Etna Furnace quarry,* Catherine township.

Irregularly seamed with calcite; dark bluish grey, with conchoidal fracture. (S. S. Hartranft.)

(807) *Springfield Furnace quarry.*

Irregularly seamed with thin veins of white crystalline carbonate of lime; generally very hard and tough; dark blue.

(964a) *Rodman Furnace quarry, No.*

Fine grained; seamed with calcite; brittle; bluish grey.

(964b) *Rodman Furnace quarry, No. 2.*

Coarse grained; sparkling with calcite; bluish grey, with rough irregular fracture.

(964c) *Rodman Furnace quarry,* on railroad south of Roaring Springs, near Rodman furnace.

Fine grained; very hard; pearl grey.

Blair County.

	(1011a) *Tyrone.*	(1011b) *Tyrone.*
Carbonate of lime, ...	90.389	92.115
Carbonate of magnesia, ...	2.245	4.234
Carbonate of iron, ... Alumina, ...	1.682	.189
Insoluble residue, ...	5.880	3.620

(*1011a*) *Limestone quarry*, near Tyrone.

Hard and compact; mottled with calcite; light bluish grey. (J. Hartshorne.)

(*1011b*) *Limestone quarry*, near Tyrone.

Irregularly seamed and mottled with calcite; hard and compact; dark grey, with conchoidal fracture. (J. Hartshorne.)

Blair County.

	(*85*) *Borie.*	(*86*) *Keystone.*
Carbonate of lime,	48.030	53.870
Carbonate magnesia,	37.670	41.320
Oxide of iron and alumina,	2.850	1.190
Sulphur,	.463	.045
Phosphorus,	.042	.013
Insoluble residue,	10.380	2.910

(*85*) *Borie property limestone*, about six miles south-west of Birmingham. *Wall rock at deep shaft.*

Hard, compact; minutely crystalline; bluish grey. (D. McC.)

(*86*) *Keystone Zinc Co.'s limestone*, near Birmingham.

Conglomerate-like; irregularly seamed with white crystalline carbonate of lime; color, various shades of grey and bluish grey. (D. McC.)

Centre County.

	(*1012a*) *Shortlidge.* [*Upper.*]	(*1012b*) *Shortlidge.* [*Middle.*]	(*1012c*) *Shortlidge.* [*Lower.*]
Carbonate of lime,	97.890	98.322	97.532
Carbonate of magnesia,	1.285	1.170	1.210
Carbonate of iron, Alumina,	.203	.320	.377
Insoluble residue,	.540	.390	.815

(*1012a*) *Shortlidge's quarry*, near Bellefonte. *Upper bed.* Hard and compact; seamed with calcite; pearl grey, with conchoidal fracture. (J. Hartshorne.)

(*1012b*) *Shortlidge's quarry; middle bed.*

Very hard and compact; fine grained; seamed with calcite; pearl grey, with conchoidal fracture. (J. Hartshorne.)

(*1012c*) *Shortlidge's quarry; lower bed.*

Hard and compact; mottled with calcite; pearl grey, with conchoidal fracture. (J. Hartshorne.)

Mifflin County.

	(784) D. Campbell.	(783) A. Campbell.	(781) A. Campbell.	(782) Greenwood.
Carbonate of lime,	97.651	81.178	70.214	54.285
Carbonate of magnesia.	1.131	13.398	24.415	36.109
Oxide of iron and alumina,	.426	1.253	1.360	1.422
Sulphur,	.034	.054	.034	.151
Phosphorus,	.039	.025	.016	.011
Insoluble residue,	.760	4.530	4.050	8.010

(*784*) *Douglas Campbell's quarry*, two miles from Belleville. *Fossiliferous limestone from top of II.*

Specimen sparkles with calcite; slightly coated with iron oxide; light bluish grey, with rough fracture. (S. S. H.)

(*783*) *Andrew Campbell's quarry. "Probably top of calciferous."*

Mottled black and grey limestone with drussy cavities. (S. S. H.)

(*781*) *Andrew Campbell's quarry. "Bottom of Chazy."*

Light bluish grey limestone; rather hard and tough.

(*782*) *Greenwood ore bank limestone*, one mile from Belleville. *"Magnesian limestone."*

Hard and tough; sparkles with calcite; dark bluish grey.

York County.	(386) Sprenkel.	(431) Sprenkel.
Lime,	36.816	38.500
Magnesia,	5.019	.814
Protoxide of iron,	2.443	2.228
Sesquioxide of iron,	.896	5.524
Bisulphide of iron,	.065	.041
Protoxide of manganese,	.321	trace.
Alumina,	1.138	1.930
Sulphuric acid,	trace.	trace.
Phosphoric acid,	.132	.050
Carbonic acid,	35.550	31.632
Water,	.350	1.055
Insoluble residue,	16.650	18.210
	99.380	99.984

(*386*) *Sprenkel's limestone*, one half mile west of Mengis Mill Station, Hanover and York Short Line railroad. See Report C, p. 57.

Generally very hard and compact; structure somewhat laminated; irregularly seamed with crystalline carbonate of lime of a delicate pink color. Color, greenish grey and pink.

(*431*) *Sprenkel's limestone*, one half mile west of Mengis Mill Station. *From along side of ore in main shaft.*

More or less impregnated with magnetic oxide of iron; minutely crystalline; generally bluish grey.

Lancaster County.

	(*779*) *Haldeman.*	(*778a*) *Haldeman.*	(*778b*) *Haldeman.*	(*778c*) *Haldeman.*
Carbonate of lime,	54.750	55.104	53.517	50.339
Carbonate of magnesia,	44.204	43.602	43.522	41.143
Oxide of iron and alumina,	.517	.304	.869	.731
Sulphur,	.011	.023	.021	.030
Phosphorus,	.010	.016	.014	.029
Insoluble residue,	.436	.847	1.926	7.699

(*779*) *Haldeman's quarries*, at Chickies. *South quarry; best blue limestone.*

Fine grained and very hard; brittle; light bluish grey color, with irregular fracture.

(*778a*) *Haldeman's quarries*, at Chickies. *North quarry;* middle of quarry; *best specimen.*

Rather coarse grained; hard and brittle; fracture, irregular; color, light grey and brownish grey.

(*778b*) *Haldeman's quarries*, at Chickies. *North quarry;* middle of quarry; *worst specimen.*

Rather coarse grained; hard and tough; fracture, irregular; color, dark bluish grey.

(*778c*) *Haldeman's quarries*, at Chickies. *North quarry; sandy layer at extreme north end of quarry.*

Specimen, having the general appearance of a soft sand rock, is coarse grained and crumbling, with brownish grey color.

Lehigh County.

	(*65*) *Kohler.*	(*66*) *Wenner.*	(*67*) *Wenner.*
Carbonate of lime,	49.316	51.558	86.036
Carbonate of magnesia,	40.463	35.216	4.594
Carbonate of iron,	1.035	1.450	.538
Bisulphide of iron,	.030	.611	.268
Alumina,	.070	.140	.065
Phosphorus,	.006	.018	.016
Carbonaceous matter,	.250	.210	.420
Insoluble residue,	8.980	10.750	8.400

(*65*) *Mary Kohler's quarry*, three fourths of a mile west of Whitehall station, Lehigh Valley railroad. See DD, p. 15.

Brecciated limestone; various shades of blue and grey.

(*66*) *Ephraim Wenner's quarry*, at the Jordan Bridge of the Catasauqua and Fogelsville railroad, four and a half miles north-west of Allentown. Leased by the Crane Iron Co. "*Hard limestone.*"

Fine grained; hard and brittle; spotted with pyrites; bluish grey.

(*67*) *Ephraim Wenner's quarry.* "*Soft limestone.*"

Comparatively soft; fine grained; dark blue, with laminated structure.

Lehigh County.	(*68*) *Guth.*	(*69*) *Thomas Iron Co.*	(*392*) *Ironton R. R. Co.*
Carbonate of lime,	70.750	56.220	83.632
Carbonate of magnesia,	15.256	31.201	5.462
Carbonate of iron,	1.398	1.305	1.188
Bisulphide of iron,	.105	.320	.238
Alumina,	.860	.300	——
Phosphorus,	.019	.005	.026
Carbonaceous matter,	.120	.120	.835
Insoluble residue,	11.070	10.980	7.850

(*68*) *Edward Guth's quarry*, at Guth's station, four and a half miles west of Catasauqua.

Fine grained; dark blue, with slaty structure.

(*69*) *Thomas Iron Company's quarry*, at Guth's station.

Fine grained, bluish grey; with some quartz.

(*392*) *Ironton Railroad Company's quarry*, one mile south-east of Ironton.

Hard and compact; bluish grey. (D. McC.)

Dauphin County.	(*780a*) *Rutherford.* [*East quarry.*]	(*780b*) *Rutherford.* [*West quarry.*]
Carbonate of lime,	86.125	90.625
Carbonate of magnesia,	8.861	6.167
Oxide of iron and alumina,	.363	.600
Sulphur,	.136	.080
Phosphorus,	.038	.022
Insoluble residue,	4.300	2.508

(*780a*) *Rutherford's quarries*, four miles east south-east of Harrisburg. "*East quarry.*"

Dark bluish grey limestone.

(*780b*) *Rutherford's quarries*, four miles east south-east of Harrisburg. "*West quarry.*"

Dauphin County.	(*1018a*) *Couffer.*	(*1018b*) *Frantz.*	(*1018c*) *Cumbler.*	(*1018d*) *Strickler.*
Carbonate of lime, ...	65.750	79.500	92.000	69.250
Carbonate of magnesia, . .	28.430	11.730	4.540	26.635
Phosphorus, ...	.005	trace.	trace.	trace.
Insoluble residue, ...	4.250	7.450	2.550	2.750

(*1018a*) *Couffer's quarry;* about four miles below Harrisburg, on Harrisburg and Lancaster pike.

(*1018b*) *Frantz's quarry;* same general locality.

(*1018c*) *Cumbler's quarry;* same general locality.

(*1018d*) *Strickler's quarry;* same general locality.

The above analyses were made for the Penn'a. Steel Co. in 1872–73, and are published here by permission.

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§ 76. *Notes on a series of Analyses of the Dolomitic limestone rocks of Cumberland county, Pa., made by Messrs. Hartshorne and Hartranft in the Laboratory of the Second Geological Survey of Pennsylvania. By J. P. Lesley.*

We have long known that the older limestone formations were highly magnesian.

We have long known also that beds of comparatively pure limestone intervened between beds highly magnesian. For a good many years past the superintendents of Iron Furnaces have been careful to select special beds in their quarries from which to procure their flux stone; and have been guided to the selection, in part by their general experience, and still more, latterly, by chemists employed by the Iron Companies.

A large body of analytical data might be collected from the records kept in the offices of Iron Companies; and I en-

(*Continued on page 343.*)

Analyses of TOP specimens of beds opposite Harrisburg.

Cumberland County. Bed (top of cut.)	*I.*		*II.*		*IIIa.*	*IIIb.*	*IV.*	
	Duplicate analyses.		*Duplicate analyses.*				*Duplicate analyses.*	
Carbonate of lime,	57.087	57.156	56.241	56.201	91.961	66.546	97.051	97.239
Carbonate of magnesia,	38.314	38.204	39.735	39.816	4.045	4.098	1.882	1.780
Carbonate of iron,	.653	.641	.334	.330	.580	1.885	.058	.062
Alumina,	none.	none.	none.	none.	.010	1.850	none.	none.
Sulphur,	.076	.069	.033	.040	.101	.345	.060	.066
Phosphorus,	.007	.006	.003	.004	.005	.018	.004	.008
Carbonaceous matter,	.130	.121	.074	.080	.066	.764	.132	.140
Insoluble residue,	4.040	3.990	3.860	3.680	4.100	25.260	1.380	1.410
	100.307	100.187	100.280	100.151	100.898	100.766	100.567	100.705
	The stone in these beds is of precisely the same physical character, but the bed plate between them is distinctly visible.				No bed plate.			

Bed I. Light bluish grey; slightly seamed with calcite; compact; moderately hard; slightly conchoidal fracture. Darker than specimen at R. R. level, and contains more calcite.

Bed II. Light grey; spotted with calcite; slight conchoidal fracture; moderately hard and brittle; slightly crystalline. Has less calcite than specimen at R. R. level.

Bed III*a*. Very dark grey; spotted with calcite in small spots; rather soft; fracture conchoidal; structure slightly crystalline.

Bed III*b*. Very dark grey; rather hard; conchoidal fracture; laminated structure.

Bed IV. Medium shade of grey; compact; very hard and brittle; conchoidal fracture; very slightly veined with calcite. Darker than specimen at R. R. level, contains more calcite and is not quite so hard.

Analyses of BOTTOM specimens of beds opposite Harrisburg.

Cumberland County.

Bed (at R. R. level.)	*I.*		*II.*		*IIIa.*	*IIIb.*	*IV.*	
	Duplicate analyses.		*Duplicate analyses.*				*Duplicate analyses.*	
Carbonate of lime,	58.314	58.360	55.634	55.552	89.889	67.242	93.944	93.896
Carbonate of magnesia,	36.915	36.670	38.322	38.675	3.553	3.205	1.845	1.791
Carbonate of iron,	.725	.723	.638	.642	.334	1.450	.406	.414
Alumina,	none.	none.	none.	none.	.030	1.350	none.	none.
Sulphur,	.048	.050	.044	.050	.045	.158	.070	.075
Phosphorus,	.006	.008	.003	.005	none.	trace.	.006	.008
Carbonaceous matter,	.094	.090	.012	.020	.090	.858	.166	.178
Insoluble residue,	4.600	4.580	5.260	5.300	5.710	26.600	3.820	3.810
	100.702	100.481	99.913	100.244	99.651	100.863	100.257	100.172

Bed I. Light bluish grey; compact; moderately hard; slightly seamed with calcite; slightly conchoidal fracture.

Bed II. Light grey; spotted with calcite; slight conchoidal fracture; moderately hard and brittle; slightly crystalline.

Bed III*a*. Very dark grey; spotted with calcite in small spots; rather soft; fracture conchoidal; structure slightly crystalline.

Bed III*b*. Very dark grey; rather hard; conchoidal fracture; laminated structure.

Bed IV. Medium shade of grey; compact; very hard and brittle; conchoidal fracture; very slightly veined with calcite.

Bed, (top of cut.)	*V.*		*VI.*	*VII.*	*VIII.*	*IX.*	*X.*	*XI.*	*XII.*
	Duplicate analyses.								
Carbonate of lime, . . .	97.248	97.266	97.551	87.389	87.603	67.582	90.300	96.694	75.893
Carbonate of magnesia,	.718	.724	1.300	3.674	7.535	27.057	8.165	1.338	19.922
Carbonate of iron, . .	.203	.198	.145	.145	.348	.537	.421	.131	.740
Alumina, ...	.030	.035	none.	none.	none.	.020	.110	none.	.390
Sulphur,	.077	.081	.103	.108	.105	.024	.149	.031	.057
Phosphorus,	none.	none.	trace.	trace.	.008	trace.	none.	none.	trace.
Carbonaceous matter, .	.060	.050	.300	.220	.147	.150	.076	.140	.120
Insoluble residue, .	2.110	2.100	1.070	9.060	3.950	5.420	1.660	2.200	2.500
	100.446	100.454	100.469	100.596	100.696	100.790	100.881	100.531	99.622

(V.–VII.) The stone in these beds is of precisely the same physical character, but the bed plate between them is distinctly visible.

(X.–XII.) The stone in these beds is of precisely the same physical character, but the bed plate between them is distinctly visible.

Bed V. Dark bluish grey; very slightly spotted with calcite; moderately hard; conchoidal fracture; slightly crystalline structure. Contains flint in lenticular masses. Specimens analysed were free from flint.

Bed VI. Dark mottled grey; moderately hard; slightly conchoidal fracture; slightly laminated structure; sparingly seamed with calcite.

Bed VII. Medium shade of grey; irregular fracture; moderately hard; slightly crystalline. There are no veins of calcite in this part of the bed.

Bed VIII. Light mottled grey; hard; compact; irregular fracture; shows very few seams of calcite.

Bed IX. Light grey; moderately hard; compact; very irregular fracture; has thick veins of calcite.

Bed X. Dark grey; hard; compact; slightly conchoidal fracture; crystalline structure; sparsely spotted with calcite. Rather darker and harder than specimen at R. R. level.

Bed XI. Grey, finely mottled; very hard, compact and heavy; slightly crystalline structure; irregular fracture.

Bed XII. Grey; mottled; seamed with calcite; moderately hard; irregular fracture. Lighter in color than specimen at R. R. level.

Bed (at R. R. level.)	V.		VI.	VII.	VIII.	IX.	X.	XI.	XII.
	Duplicate analyses.								
Carbonate of lime, . . .	96.373	96.373	95.462	87.121	82.335	68.350	90.659	97.605	66.028
Carbonate of magnesia, . .	1.429	1.414	1.429	3.561	14.500	24.817	8.127	1.845	32.425
Carbonate of iron, . . .	.058	.044	.914	.203	.319	.566	.102	.044	.015
Alumina, ...	.002	.003	.130	.020	.180	.030	.080	.020	.050
Sulphur, . . .	.050	.060	.032	.058	.076	.028	.589	.042	.034
Phosphorus,	trace.	trace.	trace.	none.	.008	trace.	.006	.014	.006
Carbonaceous matter, . .	.128	.125	.090	.250	.152	.150	.098	.124	.128
Insoluble residue, . .	1.860	1.870	1.540	9.680	3.150	5.470	1.870	1.050	1.550
	99.900	99.889	99.597	100.893	100.720	99.411	100.531	100.744	100.236

Bed V. Dark bluish grey; very slightly spotted with calcite; moderately hard; conchoidal fracture; slightly crystalline structure. Contains flint in lenticular masses. Specimens analysed were free from flint.

Bed VI. Dark mottled grey; moderately hard; slightly conchoidal fracture; slightly laminated; very sparingly seamed with calcite.

Bed VII. Medium shade of grey; irregular fracture; slightly laminated structure; moderately hard; slightly crystalline. Very few and fine veins of calcite run through this part of the bed.

Bed VIII. Light mottled grey; hard; compact; irregular fracture; slightly laminated; somewhat seamed with calcite.

Bed IX. Light grey; moderately hard; compact; irregular fracture; strongly seamed with calcite in narrow veins.

Bed X. Dark grey; hard; compact; slightly conchoidal fracture; crystalline structure. Sparsely spotted with calcite.

Bed XI. Grey; finely mottled; very hard, compact and heavy; slightly crystalline structure; irregular fracture. Spotted with calcite.

Bed XII. Grey; mottled; seamed with calcite; moderately hard; irregular fracture; inclining to laminated structure.

Bed (top of cut.)	*XIII.*	*XIV.*	*XV.*	*XVI.*	*XVII.* (*Duplicate analyses.*)		*XVIII.*	*XIX.*	*XX*
Carbonate of lime,	97.283	83.888	97.534	97.123	60.063	60.251	93.479	62.349	98.747
Carbonate of magnesia,	1.828	11.915	.786	1.966	33.438	33.400	4.271	34.526	.756
Carbonate of iron,	.147	.247	.290	.073	1.044	.841	.421	.392	.145
Alumina,	.020	.010	.020	none.	.010	.050	.060	.260	.010
Sulphur,	.066	.053	.035	.079	.108	.108	.084	.076	.042
Phosphorus,	none.	none.	none.	none.	none.	none.	none.	trace.	trace.
Carbonaceous matter,	trace.	.130	.136	——	.144	.144	.028	.020	.010
Insoluble residue,	1.390	3.450	1.790	1.250	5.890	5.930	2.040	2.900	.540
	100.734	99.693	100.591	100.491	100.697	100.724	100.383	100.523	100.250

(XIII.–XVI.) The stone in these beds is of precisely the same physical character, but the bed plate between them is distinctly visible.

Bed XIII. Light grey; hard and brittle; moderately compact; conchoidal fracture; crystalline structure. More crystalline in structure and conchoidal in fracture than specimen at R. R. level.

Bed XIV. Pinkish grey; hard; brittle; compact; irregular fracture; slightly crystalline structure; sparsely seamed with calcite. More crystalline, lighter in color, and more indefinite in tinge than specimen at R. R. level.

Bed XV. Light grey, brown tinge; moderately hard; irregular fracture; slightly spotted with calcite.

Bed XVI. Dark grey; soft; irregular fracture; fine grained.

Bed XVII. Light grey; very hard; compact; irregular fracture; seamed with calcite. Contains more calcite than specimen at R. R. level.

Bed XVIII. Grey; moderately hard; compact; irregular fracture. More laminated than specimen at R. R. level.

Bed XIX. Light bluish grey; hard; compact; irregular fracture. Is harder and contains more calcite than specimen at R. R. level.

Bed XX. Dark grey; soft; irregular fracture; slightly laminated. Darker, harder, and more laminated than specimen at R. R. level.

Bed (at R. R. level.)	*XIII.*	*XIV.*	*XV.*	*XVI.*	*XVII.*	*XVIII.*	*XIX.*	*XX.*
Carbonate of lime,	96.801	95.783	92.354	97.801	97.730	97.033	65.314	96.444
Carbonate of magnesia,	2.291	2.359	4.362	1.261	1.141	1.240	30.830	2.948
Carbonate of iron,	.073	.073	.058	.029	.450	.203	.682	.123
Alumina,	none.	none.	none.	.030	.070	nono.	.040	.005
Sulphur,	.027	.018	.040	.095	.088	.076	.025	.106
Phosphorus,	.015	.008	.003	trace.	.003	.011	.006	.006
Carbonaceous matter,	.050	.208	.138	.076	.040	.040	.020	.036
Insoluble residue,	1.250	1.850	3.410	1.070	1.130	1.350	3.510	.750
	100.507	100.299	100.365	100.362	100.652	99.953	100.427	100.418

Bed XIII. Light grey color; hard and brittle; moderately compact; conchoidal fracture; in parts laminated.

Bed XIV. Pinkish grey; hard; brittle; compact; irregular fracture; slightly crystalline structure; sparsely seamed with calcite.

Bed XV. Light grey; moderately hard; irregular fracture; seamed with calcite.

Bed XVI. Dark grey; soft; fine grained; irregular fracture.

Bed XVII. Light grey; very hard; compact; irregular fracture; seamed with calcite.

Bed XVIII. Grey; moderately hard; compact; irregular fracture; slightly laminated.

Bed XIX. Light bluish grey; hard; compact; irregular fracture; very slightly seamed with calcite.

Bed XX. Dark grey; soft; irregular fracture; slightly laminated.

Bed (top of cut.)	*XXI.*	*XXII.*	*XXIII.*	*XXIV.*	*XXV.*	*XXVI.*	*XXVII.*	*XXVIII.*
Carbonate of lime,	71.501	97.355	64.282	93.086	68.886	71.047	75.726	94.158
Carbonate of magnesia,	24.305	1.580	28.577	1.935	23.572	6.260	18.114	1.966
Carbonate of iron,	.421	.116	.580	.218	.363	.505	.580	.406
Alumina,	.130	none.	.200	.170	none.	none.	.130	none.
Sulphur,	.098	.060	.022	.025	.047	.047	.049	.222
Phosphorus,	.010	none.	trace.	none.	trace	trace.	none.	none.
Carbonaceous matter,	.126	.128	.040	.076	.540	.040	.120	—
Insoluble residue,	4.230	1.270	6.470	4.850	6.260	22.900	5.600	3.980
	100.821	100.509	100.171	100.360	100.668	100.799	100.319	100.732

Bed XXI. Grey; hard; compact; irregular fracture; crystalline. Has less calcite than specimen at R. R. level.

Bed XXII. Grey; soft; irregular fracture; seamed with calcite. Darker than specimen at R. R. level.

Bed XXIII. Light grey; hard; compact; irregular fracture. More calcite in wider seams than specimen at R. R. level.

Bed XXIV. Very dark grey; moderately hard; irregular fracture. Contains no flint, and is seamed with calcite.

Bed XXV. Light grey; hard; irregular fracture; seamed with calcite. Darker and harder than specimen at R. R. level.

Bed XXVI. Grey; moderately hard; compact; irregular fracture.

Bed XXVII. Grey; hard; irregular fracture; partially crystalline. Harder than specimen at R. R. level, and seamed with quartz.

Bed XXVIII. Dark grey; moderately hard; compact; irregular fracture: crystalline. Darker and more compact than specimen at R. R. level.

Bed (at R. R. level.)	*XXI.*	*XXII.*	*XXIII.*	*XXIV.*	*XXV.*	*XXVI.*	*XXVII.*	*XXVIII.*
Carbonate of lime,	76.262	93.729	65.332	94.887	68.868	89.979	63.314	81.031
Carbonate of magnesia,	18.514	3.772	30.822	1.565	23.754	6.789	28.524	6.744
Carbonate of iron,	.131	.087	.392	.174	.460	.189	1.189	.290
Alumina,	.010	.020	.150	.060	none.	none.	.600	.300
Sulphur,	.016	.095	.089	.065	.069	.017	.176	.095
Phosphorus,	trace.	trace.	trace.	trace.	trace.	trace.	none.	none.
Carbonaceous matter,	.010	.016	.160	.060	.130	.030	.590	.123
Insoluble residue,	5.300	1.880	3.400	3.940	7.430	3.390	6.250	11.980
	100.243	99.599	100.345	100.701	100.711	100.394	100.643	100.563

Bed XXI. Grey; very hard; compact; crystalline; seamed with very fine veins of calcite.

Bed XXII. Grey; soft, irregular fracture; seamed with calcite.

Bed XXIII. Light grey; hard; compact; irregular fracture; many seams of calcite.

Bed XXIV. Very dark grey; moderately hard; irregular fracture; contains flint in small masses.

Bed XXV. Light grey; hard; irregular fracture; seamed with calcite.

Bed XXVI. Grey; moderately hard; compact; irregular fracture.

Bed XXVII. Grey; hard; irregular fracture; partially crystalline; slightly seamed with calcite and quartz.

Bed XXVIII. Dark grey; moderately hard; compact; irregular fracture; crystalline; very slightly seamed with calcite.

Bed (top of cut.)	*XXIX.*	*XXX.*	*XXXI.*	*XXXII.*	*XXXIII.*	*XXXIV.*	*XXXV.*	*XXXVI.*
Carbonato of lime,	62.420	97.873	64.135	97.551	71.940	96.319	67.011	79.925
Carbonate of magnesia,	31.374	1.512	24.993	1.043	15.543	1.225	25.643	16.949
Carbonate of iron,	.508	.145	.798	.160	—	.218	.406	—
Oxide of iron,	—	—	—	—		—	—	
Alumina,	.360	.020	.120	none.	1.970	none.	.340	.270
Sulphur,	.045	.086	.177	.062	none.	.079	.438	none.
Phosphorus,	.010	.010	none.	none.	none.	none.	none.	none.
Carbonaceous matter,	.450	.200	.194	.112	—	.124	.158	—
Insoluble residue,	5.400	.920	10.290	1.840	10.430	1.490	5.900	4.180
	100.567	100 766	100.707	100.768	99.883	99.455	99.896	101.324

Bed XXIX. Light grey; very hard; irregular fracture; crystalline; seamed with calcite and quartz. Darker than specimen at R. R. level.

Bed XXX. Very dark grey; soft; compact; irregular fracture; not laminated.

Bed XXXI. Grey; hard; compact; irregular fracture; seamed with calcite.

Bed XXXII. Dark grey; moderately hard; compact; seamed with calcite.

Bed XXXIII. No description given of specimen.

Bed XXXIV. Dark grey; hard; compact; irregular fracture.

Bed XXXV. Dark grey; very hard; compact; crystalline; irregular fracture.

Bed XXXVI. Dark grey; soft; compact; irregular fracture, slightly conchoidal.

Bed (at R. R. level.)	XXIX.	XXX.	XXXI.	XXXII.	XXXIII.	XXXIV.	XXXV.	XXXVI.
Carbonate of lime,	65.010	98.890	60.974	96.694	73.333	97.605	75.155	82.926
Carbonate of magnesia,	29.091	1.074	27.745	1.663	12.406	1.550	18.764	13.472
Carbonate of iron,	.696	.058	.219	.363	—	.110	.885	—
Oxide of iron,	—	—	—	—		—	—	
Alumina,	.040	none.	.450	.010	1.710	.203	.260	.680
Sulphur,	.081	.128	.150	.080	—	.048	.133	none.
Phosphorus,	none.	.010	none.	none.	—	.005	none.	none.
Carbonaceous matter,	.200	.018	.268	.082	—	.100	.266	—
Insoluble residue,	5.430	.550	10.870	1.700	12.440	1.130	4.720	2.730
	100.548	100.728	100.676	100.592	99.889	100.751	100.183	99.808

Bed XXIX. Light grey; very hard; irregular fracture; crystalline; slightly spotted with calcite.

Bed XXX. Very dark grey; soft; compact; irregular fracture; slightly laminated.

Bed XXXI. Grey; hard; compact; irregular fracture; seamed with calcite.

Bed XXXII. Dark grey; moderately hard; compact; irregular fracture.

Bed XXXIII. No description of specimen given.

Bed XXXIV. Dark grey; hard; compact; irregular fracture.

Bed XXXV. Dark grey; very hard; compact; crystalline; irregular fracture.

Bed XXXVI. Dark grey; soft; compact; irregular fracture; slightly conchoidal.

Bed (top of cut.)	*XXXVII.*	*XXXVIII.*	*XXXIX.*	*XL.*	*XLI.*	*XLII.*	*XLIII.*	*XLIV.*
Carbonate of lime,	88.996	82.905	93.748	56.259	95.783	57.223	90.997	65.546
Carbonate of magnesia,	5.829	13.330	1.575	37.248	2.170	34.789	1.278	28.204
Carbonate of iron,	—	.435	.145	.682	.464	1.994	.319	1.523
Oxide of iron,	.850	—	—	—	—	—	—	—
Alumina,		.040	none.	.170	.010	.214	.130	.100
Sulphur,	none.	.103	.028	.075	.107	.133	.055	.154
Phosphorus,	—	trace.	none.	none.	.015	.017	.004	.013
Carbonaceous matter,	—	.158	.042	.034	.096	.072	.166	.022
Insoluble residue,	3.600	2.790	.330	6.070	1.860	6.490	7.890	4.840
	99.275	99.761	100.866	100.538	100.505	100.832	100.839	100.401

Bed XXXVII. Dark grey; soft; compact; irregular fracture; slightly conchoidal.

Bed XXXVIII. Grey; hard; irregular fracture. No calcite visible.

Bed XXXIX. Dark grey; moderately hard; conchoidal fracture; spotted with calcite.

Bed XL. Light grey; very hard; compact; irregular fracture; seamed with calcite. Contains more calcite than specimen at R. R. level.

Bed XLI. Very dark mottled grey; moderately hard; irregular fracture.

Bed XLII. Light grey; very hard; compact; irregular fracture. Contains more quartz and calcite than specimen at R. R. level.

Bed XLIII. Light grey; moderately hard; compact; conchoidal fracture. Harder than specimen at R. R. level, and lighter in color.

Bed XLIV. Grey; moderately hard; irregular fracture; slightly seamed with calcite.

Bed (at R. R. level.)	*XXXVII.*	*XXXVIII.*	*XXXIX.*	*XL.*	*XLI.*	*XLII.*	*XLIII.*	*XLIV.*
Carbonate of lime,	90.997	79.691	89.657	51.528	96.944	55.580	97.819	73.626
Carbonate of magnesia,	5.450	16.919	8.231	33.574	1.656	34.965	1.338	22.543
Carbonate of iron,	—	.580	.479	.725	.479	2.422	.218	.617
Oxide of iron,	.580	—	—	—	—	—	—	—
Alumina,		.040	.070	.210	.020	.350	.020	.022
Sulphur,	—	.141	.051	.072	.071	.115	.059	.092
Phosphorus,	—	none.	none.	none.	.018	none.	.003	.006
Carbonaceous matter,	—	.086	.054	.032	.060	.288	trace.	.174
Insoluble residue,	3.600	2.940	1.620	4.680	1.370	6.890	1.330	3.420
	100.627	100.397	100.162	100.821	100.618	100.610	100.787	100.500

Bed XXXVII. Dark grey ; soft ; compact ; irregular fracture, slightly conchoidal.

Bed XXXVIII. Grey ; hard ; irregular fracture ; spotted with calcite.

Bed XXXIX. Dark grey ; hard ; compact ; irregular fracture.

Bed XL. Light grey ; very hard ; compact ; irregular fracture ; slightly seamed with calcite.

Bed XLI. Very dark grey ; moderately hard ; irregular fracture.

Bed XLII. Light grey ; very hard ; compact ; irregular fracture ; contains quartz in seams.

Bed XLIII. Light grey ; moderately hard ; compact ; conchoidal fracture.

Bed XLIV. Grey ; moderately hard ; irregular fracture ; slightly seamed with calcite.

Bed (top of cut.)	*XLV.*	*XLVI.*	*XLVII.*	*XLVIII.*	*XLIX.*	*L.*	*LI.*	*LII.*
Carbonate of lime,	—	90.586	68.225	95.283	66.220	62.038	95.747	68.886
Carbonate of magnesia,	—	7.583	27.110	2.230	26.860	31.669	2.905	23.708
Carbonate of iron,	—	.479	1.537	.290	1.552	—	—	—
Oxide of iron,	—	—	—	—	—	1.770	.100	.710
Alumina,	—	.210	.110	.010	.280			
Sulphur,	—	.006	.186	.307	.102	—	—	—
Phosphorus,	—	.061	none.	.006	.013	—	—	—
Carbonaceous matter,	—	trace	.010	.212	.050	—	—	—
Insoluble residue,	—	1.800	3.570	2.220	5.747	5.110	1.710	7.170
		100.725	100.748	100.558	100.824	100.587	100.462	100.474

The stone in these beds is of precisely the same physical character, but the bed plate between them is distinctly visible.

Bed XLV. No specimen taken from this bed at top of cut.

Bed XLVI. Grey; moderately hard; compact; conchoidal fracture. Rather darker than specimen at R. R. level.

Bed XLVII. Light grey; very hard; compact; rather brittle; irregular fracture, slightly conchoidal; seamed with a few fine veins of calcite. Rather more calcite than specimen at R. R. level.

Bed XLVIII. Grey; very hard; compact; irregular fracture; slightly conchoidal.

Bed XLIX. Light grey; very hard and tough; compact; irregular fracture; seamed with calcite in veins from ¼ in. thick to mere threads.

Bed L. Light grey; hard; compact; irregular fracture; no calcite.

Bed LI. Very dark grey; hard; compact; semi-conchoidal fracture.

Bed LII. Light grey; very hard; compact; irregular fracture. Rather more calcite than in specimen at R R. level.

Bed (at R. R. level.)	*XLV.*	*XLVI.*	*XLVII.*	*XLVIII.*	*XLIX.*	*L.*	*LI.*	*LII.*
Carbonate of lime,	96.176	97.194	63.403	94.274	57.774	60.403	92.908	61.385
Carbonate of magnesia,	2.019	1.656	29.484	1.852	33.240	32.054	3.228	31.888
Carbonate of iron,	.058	.040	1.310	.334	1.438	—	—	—
Oxide of iron,	—	—	—	—	—			
Alumina,	.030	.479	.040	.110	.180	1.630	.310	1.250
Sulphur,	.035	.071	.096	.096	.075	—	—	—
Phosphorus,	trace.	.004	.011	trace.	trace.	—	—	—
Carbonaceous matter,	trace,	.126	.064	.104	.050	—	—	—
Insoluble residue,	2.440	.670	6.380	3.510	8.017	5.350	2.980	5.330
	100.758	100.240	100.788	100.280	100.774	99.437	99.426	99.853

The stone in these beds is of precisely the same physical character, but the bed plate between them is distinctly visible.

Bed XLV. Dark grey ; moderately hard ; slightly conchoidal fracture ; spotted with calcite. *Only one specimen of this bed taken. The exposure was very small.*

Bed XLVI. Grey ; moderately hard ; compact ; conchoidal fracture.

Bed XLVII. Light grey ; very hard ; compact ; rather brittle ; irregular fracture, slightly conchoidal ; seamed with a few fine veins of calcite.

Bed XLVIII. Grey ; very hard ; compact ; irregular fracture, slightly conchoidal.

Bed XLIX. Light grey ; very hard and tough ; compact ; irregular fracture ; seamed with calcite in veins from $\frac{1}{4}$ in. thick to mere threads.

Bed L. Light grey ; hard ; irregular fracture ; seamed with calcite.

Bed LI. Very dark grey ; hard ; compact ; slightly conchoidal fracture.

Bed LII. Light grey ; very hard ; compact ; seamed with calcite.

Bed (top of cut.)	*LIII.*	*LIV.*	*LV.*	*LVI.*	*LVII.*	*LVIII.*	*LIX.*	*LX.*
Carbonate of lime,	88.679	97.891	79.495	66.082	90.979	60.081	99.302	76.334
Carbonate of magnesia,	6.955	1.157	13.411	23.217	2.344	29.883	1.300	19.883
Oxide of iron and alumina,	.560	.370	1.050	1.400	.340	1.570	.110	.640
Insoluble residue,	3.410	.670	6.900	9.680	6.820	8.580	.250	2.410

(LIII., LIV., LV.) The stone in these beds is of precisely the same physical character, but the bed plate between them is distinctly visible.

Bed LIII. Dark grey; moderately hard; irregular fracture, slightly conchoidal; no calcite.

Bed LIV. Dark grey; moderately hard; compact; irregular fracture; seamed with calcite.

Bed LV. Dark grey; hard; irregular fracture; no calcite.

Bed LVI. Dark grey; hard; compact; irregular fracture; slightly seamed with calcite.

Bed LVII. Very dark grey; hard; compact; irregular fracture; seamed with calcite and contains quartz in small pockets.

Bed LVIII. Grey; hard; compact; irregular fracture; much less calcite than in specimen at R. R. level, and in finer veins.

Bed LIX. Grey; soft; irregular fracture; compact.

Bed LX. Light grey; hard; irregular fracture; spotted with calcite. Lighter shade of grey than specimen at R. R. level.

Bed (at R. R. level.)	*LIII.*	*LIV.*	*LV.*	*LVI.*	*LVII.*	*LVIII.*	*LIX.*	*LX.*
Carbonate of lime,	84.103	98.194	79.763	66.946	91.604	64.752	97.060	75.137
Carbonate of magnesia,	10.009	1.331	10.781	24.213	2.412	27.375	1.785	20.938
Oxide of iron and alumina,	1.040	.220	.890	1.500	.570	1.570	.110	.220
Insoluble residue,	4.710	1.160	8.590	7.360	5.870	7.220	1.060	3.080

Bed LIII. Dark grey; moderately hard; irregular fracture, slightly conchoidal; seamed with calcite.

Bed LIV. Dark grey; moderately hard; compact; irregular fracture.

Bed LV. Dark grey; hard; irregular fracture; slightly laminated structure; seamed with calcite and quartzite.

Bed LVI. Dark grey; hard; compact; irregular fracture; slightly seamed with fine veins of calcite.

Bed LVII. Very dark grey; hard; irregular fracture.

Bed LVIII. Grey; hard; compact; irregular fracture; seamed with calcite in large veins.

Bed LIX. Grey; soft; irregular fracture; compact.

Bed LX. Light grey; hard; irregular fracture; spotted with calcite.

Bed (at top of cut.)	*LXI.*	*LXII.*	*LXIII.*	*LXIV.*	*LXV.*	*LXVI.*	*LXVII.*	*LXVIII.*
Carbonate of lime,	95.123	61.706	72.922	87.693	70.047	79.066	61.778	95.980
Carbonate of magnesia,	1.807	28.404	23.035	10.025	21.531	13.645	32.062	2.268
Oxide of iron and alumina,	.090	1.040	.010	.790	.830	1.300	1.040	.640
Insoluble residue,	2.140	8.220	4.910	2.290	7.810	5.850	5.890	1.930

Bed LXI. Grey; moderately hard; irregular fracture; compact; seamed with fine veins of calcite and quartzite.

Bed LXII. Medium shade of grey; very hard; irregular fracture; seamed with calcite in large veins.

Bed LXIII. Grey; soft; compact; irregular fracture.

Bed LXIV. Grey; soft; compact; irregular fracture.

Bed LXV. Dark grey; moderately hard; compact; irregular fracture; no calcite.

Bed LXVI. Dark grey; hard; irregular fracture.

Bed LXVII. Light grey; irregular fracture; seamed with calcite in small veins.

Bed LXVIII. Medium shade of grey; moderately soft; irregular fracture; slightly laminated; compact.

Bed (at R. R. level.)	*LXI.*	*LXII.*	*LXIII.*	*LXIV.*	*LXV.*	*LXVI.*	*LXVII.*	*LXVIII.*
Carbonate of lime,	89.300	49.847	71.047	80.727	67.743	75.119	61.028	85.093
Carbonate of magnesia,	1.542	31.940	23.799	14.175	20.900	19.172	33.650	10.419
Oxide of iron and alumina,	.090	2.200	.130	1.560	1.100	.630	1.290	1.020
Insoluble residue,	8.860	16.900	5.990	2.500	10.180	5.370	4.650	3.230

Bed LXI. Grey; moderately hard; irregular fracture; compact.

Bed LXII. Medium shade of grey; very hard; irregular fracture; seamed with calcite in large veins.

Bed LXIII. Grey; compact; soft; irregular fracture.

Bed LXIV. Grey; soft; compact; irregular fracture.

Bed LXV. Dark grey; moderately hard; compact; irregular fracture; slightly spotted with calcite.

Bed LXVI. Dark grey; hard; irregular fracture.

Bed LXVII. Moderate shade of grey; soft; irregular fracture; seamed with very fine veins of calcite.

Bed LXVIII. Medium shade of grey; moderately soft; irregular fracture; slightly laminated; compact.

Bed (top of cut.)	*LXIX.*	*LXX.*	*LXXI.*	*LXXII.*	*LXXIII.*	*LXXIV.*	*LXXV.*	*LXXVI.*
Carbonate of lime,	58.527	97.355	53.348	97.337	96.605	96.837	92.139	62.992
Carbonate of magnesia,	27.443	1.353	35.381	1.573	1.565	1.164	3.153	26.725
Oxide of iron and alumina,	2.090	.190	1.790	.240	.360	.250	.590	1.430
Insoluble residue,	11.900	.940	10.010	1.180	2.540	2.150	5.080	9.810

Bed LXIX. Dark grey ; hard ; irregular fracture ; seamed with calcite and quartzite.

Bed LXX. Dark grey ; moderately soft ; irregular fracture, slightly conchoidal.

Bed LXXI. Dark grey ; hard ; irregular fracture ; spotted and seamed with calcite in fine veins.

Bed LXXII. Dark grey ; hard ; irregular fracture.

Bed LXXIII. Dark grey ; moderately hard ; irregular and slightly conchoidal fracture.

Bed LXXIV. Grey ; soft ; irregular and slightly conchoidal fracture.

Bed LXXV. Dark grey ; moderately soft ; irregular fracture, slightly conchoidal.

Bed LXXVI. Dark grey ; very hard ; irregular fracture ; seamed with quartzite and calcite.

Bed (at R. R. level.)	*LXIX.*	*LXX.*	*LXXI.*	*LXXII.*	*LXXIII.*	*LXXIV.*	*LXXV.*	*LXXVI.*
Carbonate of lime, ...	51.687	98.248	55.634	98.105	93.854	95.569	91.300	64.993
Carbonate of magnesia, ...	32.722	1.512	33.672	1.391	8.644	1.474	2.827	23.587
Oxide of iron and alumina, ...	2.250	.280	.830	.230	.420	.330	.340	1.570
Insoluble residue, ...	12.930	.800	10.280	.780	2.750	2.800	5.370	10.600

Bed LXIX. Dark grey ; hard ; irregular fracture ; seamed with calcite and quartzite.

Bed LXX. Dark grey ; moderately soft ; irregular and slightly conchoidal fracture.

Bed LXXI. Dark grey ; hard ; irregular fracture ; spotted and seamed with calcite in fine veins.

Bed LXXII. Dark grey ; hard ; irregular fracture.

Bed LXXIII. Dark grey ; moderately hard ; irregular fracture, slightly conchoidal.

Bed LXXIV. Grey ; soft ; irregular fracture, slightly conchoidal.

Bed LXXV. Dark grey ; moderately soft ; irregular fracture, slightly conchoidal.

Bed LXXVI. Dark grey ; very hard ; irregular fracture ; seamed with quartzite and calcite.

Bed (top of cut.)	*LXXVII.*	*LXXVIII.*	*LXXIX.*	*LXXX.*	*LXXXI.*	*LXXXII.*	*LXXXIII.*	*LXXXIV.*
Carbonate of lime,	97.909	56.045	85.210	95.905	56.670	86.889	90.979	75.619
Carbonate of magnesia,	1.792	31.525	8.710	1.958	23.953	8.543	7.628	16.292
Oxide of iron and alumina,	.390	2.250	.870	.210	1.840	.330	.540	1.980
Insoluble residue,	.960	10.760	5.530	2.560	18.420	4.000	1.860	5.550

$\underbrace{\text{LXXIX. LXXX.}}$ The stone in these beds is of precisely the same physical character, but the bed plate between them is distinctly visible.

Bed LXXVII. Dark grey; very hard; irregular fracture; seamed with calcite and quartzite.

Bed LXXVIII. Grey; very hard; irregular fracture; seamed with calcite and quartzite.

Bed LXXIX. Very dark grey; hard; conchoidal and slightly irregular fracture.

Bed LXXX. Very dark grey; hard; conchoidal and slightly irregular fracture; slightly striated structure; seamed with calcite and quartzite.

Bed LXXXI. Light grey; very hard; irregular fracture; seamed with calcite.

Bed LXXXII. Grey; hard; compact; irregular fracture; slightly conchoidal.

Bed LXXXIII. Grey; hard; compact; irregular fracture.

Bed LXXXIV. Grey; very hard; irregular fracture.

Bed (at R. R. level.)	*LXXVII.*	*LXXVIII.*	*LXXIX.*	*LXXX.*	*LXXXI.*	*LXXXII.*	*LXXXIII.*	*LXXXIV.*
Carbonate of lime, ...	85.532	56.722	86.675	79.762	54.884	84.709	90.747	66.791
Carbonate of magnesia, ...	9.790	31.916	7.097	9.934	35.706	10.847	8.014	27.201
Oxide of iron and alumina, ...	.970	2.030	1.020	1.240	1.740	.680	.530	1.820
Insoluble residue, ...	4.470	8.520	4.970	9.360	7.740	4.100	1.750	4.360

Bed LXXVII. Dark grey; very hard; irregular fracture; seamed with calcite and quartzite.

Bed LXXVIII. Grey; very hard; irregular fracture; seamed with calcite and quartzite.

Bed LXXIX. Very dark grey; hard; conchoidal fracture, slightly irregular.

Bed LXXX. Very dark grey; hard; conchoidal and slightly irregular fracture; slightly striated structure.

Bed LXXXI. Light grey; very hard; irregular fracture; seamed with calcite.

Bed LXXXII. Grey; hard; compact; irregular fracture, slightly conchoidal.

Bed LXXXIII. Grey; hard; compact; irregular fracture.

Bed LXXXIV. Grey; very hard; irregular fracture.

Bed (top of cut.)	*LXXXV.*	*LXXXVI.*	*LXXXVII.*	*LXXXVIII.*	*LXXXIX.*	*XC.*	*XCI.*	*XCII.*
Carbonate of lime,	93.676	98.912	54.134	98.409	61.599	97.569	74.119	97.676
Carbonate of magnesia,	4.120	1.134	28.123	1.081	31.843	1.497	23.134	1.886
Oxide of iron and alumina,	.430	.390	3.020	.300	1.610	.460	1.490	.240
Insoluble residue,	2.100	.620	15.870	.660	5.930	.890	3.040	.650

Bed LXXXV. Light brownish grey; rather soft; irregular fracture.

Bed LXXXVI. Dark grey; soft; compact; irregular fracture.

Bed LXXXVII. Grey; hard; compact; irregular fracture; slightly seamed with calcite.

Bed LXXXVIII. Brownish grey; soft; irregular fracture.

Bed LXXXIX. Light brownish grey; hard; compact; irregular fracture; slightly seamed with calcite.

Bed XC. Light grey (drab); soft; irregular fracture, slightly conchoidal.

Bed XCI. Light grey; hard; irregular fracture; slightly crystalline.

Bed XCII. Dark grey; rather soft; irregular fracture, slightly conchoidal.

Bed (at R. R. level.)	*LXXXV.*	*LXXXVI.*	*LXXXVII.*	*LXXXVIII.*	*LXXXIX.*	*XC.*	*XCI.*	*XCII.*
Carbonate of lime,	96.979	95.372	52.025	96.265	59.420	97.605	68.243	98.176
Carbonate of magnesia,	.945	1.339	33.657	1.867	33.680	1.762	27.942	1.342
Oxide of iron and alumina,	.370	.580	2.630	.500	1.520	.320	1.180	.180
Insoluble residue,	8.640	3.820	12.500	2.200	6.120	.860	3.980	1.196

Bed LXXXV. Grey; rather soft; irregular fracture; slightly seamed with calcite.

Bed LXXXVI. Dark grey; soft; compact; irregular fracture.

Bed LXXXVII. Grey; hard; compact; irregular fracture; slightly seamed with calcite.

Bed LXXXVIII. Brownish grey; soft; irregular fracture.

Bed LXXXIX. Light brownish grey; hard; compact; irregular fracture; slightly seamed with calcite.

Bed XC. Light grey (drab); soft; irregular fracture, slightly conchoidal.

Bed XCI. Light grey; hard; irregular fracture; slightly crystalline.

Bed XCII. Dark grey; rather soft; irregular fracture, slightly conchoidal.

Bed (top of cut.)	*XCIII.*	*XCIV.*	*XCV.*	*XCVI.*	*XCVII.*	*XCVIII.*	*XCIV.*	*C.*
Carbonate of lime,	59.197	85.482	55.196	95.428	77.571	60.018	95.964	62.543
Carbonate of magnesia,	35.075	1.415	30.641	2.241	16.406	32.828	3.164	29.423
Oxide of iron and alumina,	1.120	.520	1.010	.370	.800	.800	.340	.860
Insoluble residue,	5.050	12.580	12.890	1.830	4.810	6.660	.880	7.100

Bed XCIII. Seamed with calcite; is hard and compact, with pearl grey color and irregular fracture.

Bed XCIV. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed XCV. Seamed with calcite; is hard and compact, with bluish grey color and uneven fracture.

Bed XCVI. Soft and compact, with dark grey color and conchoidal fracture.

Bed XCVII. Hard and compact, with dark bluish grey color and conchoidal fracture.

Bed XCVIII. Seamed with calcite; is hard and compact, with light grey color and uneven fracture.

Bed XCIX. Soft and compact, with very dark bluish grey color and conchoidal fracture.

Bed C. Seamed with calcite; is hard and compact, with a very light grey color and conchoidal fracture.

Bed (at R. R. level.)	*XCIII.*	*XCIV.*	*XCV.*	*XCVI.*	*XCVII.*	*XCVIII.*	*XCIX.*	*C.*
Carbonate of lime,	58.643	96.714	54.821	95.839	75.232	62.036	96.303	62.178
Carbonate of magnesia,	34.107	1.392	31.049	2.747	17.330	29.423	1.922	29.521
Oxide of iron and alumina,	1.100	.450	1.040	.190	.630	1.090	.350	.560
Insoluble residue,	5.580	1.770	13.050	1.330	6.690	7.790	1.100	8.300

Bed XCIII. Seamed with calcite ; is hard and compact, with pearl grey color and rough fracture.

Bed XCIV. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed XCV. Seamed with calcite ; is hard and compact, with bluish grey color and conchoidal fracture.

Bed XCVI. Soft and compact, with dark grey color and sub-conchoidal fracture.

Bed XCVII. Hard and compact, with very dark grey color and conchoidal fracture.

Bed XCVIII. Seamed with calcite ; is hard and compact, with light grey color and uneven fracture.

Bed XCIX. Soft and compact, with a very dark bluish grey color and conchoidal fracture.

Bed C. Seamed with calcite ; is hard and compact, with light grey color and conchoidal fracture.

Bed (top of cut.)	*CI.*	*CII.*	*CIII.*	*CIV.*	*CV.*	*CVI.*	*CVII.*	*CVIII.*
Carbonate of lime,	98.821	60.428	93.071	79.464	96.857	63.285	98.982	65.018
Carbonate of magnesia,	.756	34.220	4.791	14.741	1.611	31.647	.520	29.574
Oxide of iron and alumina,	.150	.650	.460	.760	.450	.970	.260	.750
Insoluble residue,	.320	4.780	1.410	4.330	1.150	4.150	.420	5.020

Bed CI. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CII. Seamed with calcite; is hard and compact, with pearl grey color and conchoidal fracture.

Bed CIII. Soft and compact, with dark bluish grey color and sub-conchoidal fracture.

Bed CIV. Seamed with calcite, is hard and compact, with bluish grey color and uneven fracture.

Bed CV. Seamed with calcite; is soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CVI. Seamed with calcite; is hard and compact, with pearl grey color and conchoidal fracture.

Bed CVII. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CVIII. Seamed with calcite; is hard and compact, with pearl grey color and sub-conchoidal fracture.

Bed (at R. R. level.)	*CI.*	*CII.*	*CIII.*	*CIV.*	*CV.*	*CVI.*	*CVII.*	*CVIII.*
Carbonate of lime,	98.178	64.393	94.678	80.214	98.196	63.446	98.157	64.982
Carbonate of magnesia,	1.210	30.452	4.608	13.205	1.158	31.551	1.611	29.120
Oxide of iron and alumina,	.090	.790	.280	.620	.340	1.200	.200	.910
Insoluble residue,	.630	4.260	1.020	5.560	.630	3.840	.330	5.120

Bed CI. Soft and compact, with dark bluish grey color and sub-conchoidal fracture.

Bed CII. Seamed with calcite; is hard and compact, with pearl grey color and conchoidal fracture.

Bed CIII. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CIV. Seamed with calcite; is hard and compact, with bluish grey color and sub-conchoidal fracture.

Bed CV. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CVI. Seamed with calcite; is hard and compact, with pearl grey color and conchoidal fracture.

Bed CVII. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CVIII. Seamed with calcite; is hard and compact with light pearl grey color and sub-conchoidal fracture.

Bed (top of cut.)	*CIX.*	*CX.*	*CXI.*	*CXII.*	*CXIII.*	*CXIV.*	*CXV.*
Carbonate of lime,	86.928	64.285	88.375	54.446	76.214	55.446	97.732
Carbonate of magnesia,	4.343	22.316	8.324	36.210	3.662	33.714	.908
Oxide of iron and alumina,	.350	1.300	.270	1.630	1.520	1.320	.300
Insoluble residue,	7.700	11.610	2.640	7.740	18.240	9.730	1.370

Bed CIX. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CX. Hard and compact, with dark bluish grey color and conchoidal fracture.

Bed CXI. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CXII. Seamed with calcite; is hard and compact; bluish grey color and sub-conchoidal fracture.

Bed CXIII. Soft and compact, with dark bluish grey color and sub-conchoidal fracture.

Bed CXIV. Hard and compact, with dark bluish grey color and conchoidal fracture.

Bed CXV. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed (at R. R. level.)	*CIX.*	*CX.*	*CXI.*	*CXII.*	*CXIII.*	*CXIV.*	*CXV.*
Carbonate of lime,	94.803	78.089	94.482	54.428	98.053	64.625	95.121
Carbonate of magnesia,	2.474	16.493	2.686	35.204	.893	26.191	1.952
Oxide of iron and alumina,	.400	.730	.350	2.050	.150	1.020	.900
Insoluble residue,	1.820	9.110	1.900	8.440	1.050	8.530	1.670

Bed CIX. Seamed with calcite; is soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CX. Hard and compact, with dark bluish grey color and conchoidal fracture.

Bed CXI. Soft and compact, with dark bluish grey color and conchoidal fracture.

Bed CXII. Seamed with calcite; is hard and compact, with dark bluish grey color and sub-conchoidal fracture.

Bed CXIII. Seamed with calcite; is soft and compact, with dark bluish grey color and sub-conchoidal fracture.

Bed CXIV. Seamed with calcite; is hard and compact, with pearl grey color and conchoidal fracture.

Bed CXV. Soft and compact, with dark bluish grey color and conchoidal fracture.

Analyses of CALCITE *contained in limestones.*

	Bed IX. (Top of cut.)	Bed IX. (At R. R. level.)	Bed XXIII. (At R. R. level.)
Carbonate of lime,	88.614	88.746	87.675
Carbonate of magnesia,	.904	.843	1.807
Carbonate of iron,	.145	trace.	.247
Alumina,	trace.	trace.	.010
Sulphur,	.035	.026	.011
Phosphorus,	.039	.020	trace.
Insoluble residue,	9.900	10.380	10.380
	99.637	100.015	100.171

Bed IX, (top of cut.) *Calcite* contained in limestone in veins about an inch wide. Pure white; crystalline structure; hard and tough. Contains quartz in crystalline masses.

Bed IX, (at R. R. level.) *Calcite* contained in limestone in veins about an inch wide. Pure white; crystalline structure, showing small plates when broken; hard and tough. Contains quartz in crystalline masses.

Bed XXIII, (at R. R. level.) *Calcite* contained in limestone in veins varying from two inches thick to mere threads. Contains quartz in crystalline masses.

Analyses of FLINT *contained in limestones.*

Specimens from Bed V.	(Top of cut.)	(At R. R. level.)
Carbonate of lime,	9.337	6.483
Carbonate of magnesia,	.302	.779
Carbonate of iron,	.798	.348
Alumina,	.190	.650
Sulphur,	.053	.046
Phosphorus,	.006	trace.
Carbonaceous matter,	none.	.386
Silica,	89.890	90.800
	100.576	99.492

Bed V, (top of cut.) *Flint* contained in the limestone in lenticular masses. Blue black; very hard and brittle; massive structure; irregular fracture; somewhat disintegrated; more profusely spotted than specimen at R. R. level.

Bed V, (at R. R. level.) *Flint* contained in the limestone in lenticular masses. Blue black; very hard and brittle; massive structure; irregular fracture; spotted with fine white spots.

tertain hopes that this paper will induce those personally engaged in the Iron manufacture in Pennsylvania, and perhaps elsewhere, to forward their analyses of flux stones to Mr. McCreath, the Chemist of the Survey at Harrisburg, for collation, comparison and, if desired, publication.

In spite however of the abundance of such materials for a right knowledge of the constitution of our limestone formations, and in spite of the no doubt entirely reliable accuracy of the individual analyses, although made by so many different chemists, in different laboratories, and probably by somewhat different methods, there has been until now no extensive and serial research into the subject such as we desire.

All the quarries opened for furnace use are comparatively small, exposing but a limited number of beds,—are scattered about the formation according to the accidents of local exposures, or the convenience of land owners and quarrymen,—their places in the vertical geological series of strata unknown and in fact disregarded,—and no regular series of analyses made of them even as they lie in any one quarry.*

Consequently, no approach to general averages of the different chemical constituents of our magnesian limestone beds as a mass, or formation, or whole series of strata, has ever been made. No idea of how the magnesian and non-magnesian layers are arranged has been got. No law of regular or irregular inter-stratification has appeared. It has not been possible to say whether the several magnesian layers resemble each other; whether the several purer limestone layers are alike, or not; nor, to what degree the two series represent two kinds of physical action intermittent in the ancient seas.

Yet, until this was learned we could not take the first step towards a rational geological explanation of our larger limestone formations.

At a meeting of the American Philosophical Society, December 20, 1877, I described the progress of an elaborate

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*Doubtless exceptions to this part of the above statement may be made. See for example Report F, p. 260.

investigation which I had instituted for the purpose of determining whether or not any fixed or rational order of deposition could be observed in our Siluro-Cambrian Magnesian Limestone Formation No. II.

I selected a fine exposure, made by the Walton quarry and rock-cut of the Northern Central Railroad, on the west bank of the Susquehanna river opposite Harrisburg; where a consecutive series of the beds, all conformable, and all dipping regularly about 30° to the southward, afforded a good opportunity for collecting two sets of specimens for analysis, one at the bottom and the other at the top of the cut. Great care was taken to survey the cut, mark the beds (from 1 to 115) and range the specimens in two parallel series; so that any lack of homogenousness in any bed might be detected by analyses of two specimens, taken from places in the edge of the bed 5 to 30 feet apart, according to the depth of the cut; and sometimes by the selection of a third and intermediate specimen; many of the analyses of individual specimens being also repeated.

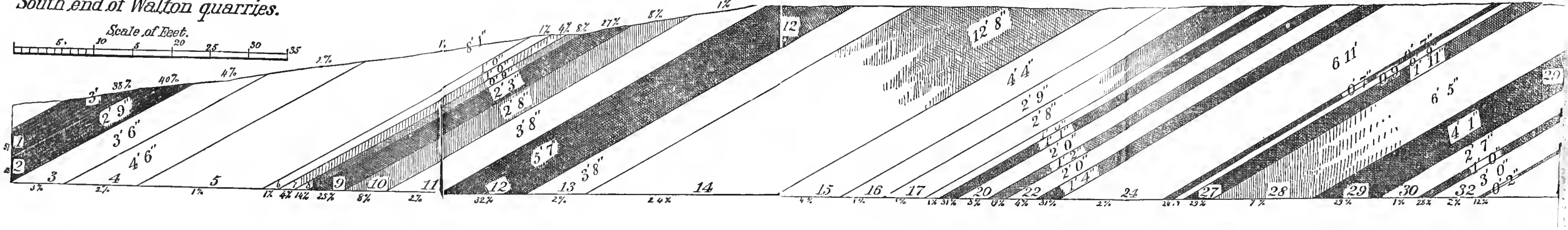
The investigation was continued throughout the winter of 1877–8 by Mr. Joseph Hartshorne, and completed during the summer of 1878 by Mr. S. S. Hartranft; and I now find myself able to bring some of the results to the notice of chemists and geologists in the form of tables:—(1) of analyses, and (2) of averages.

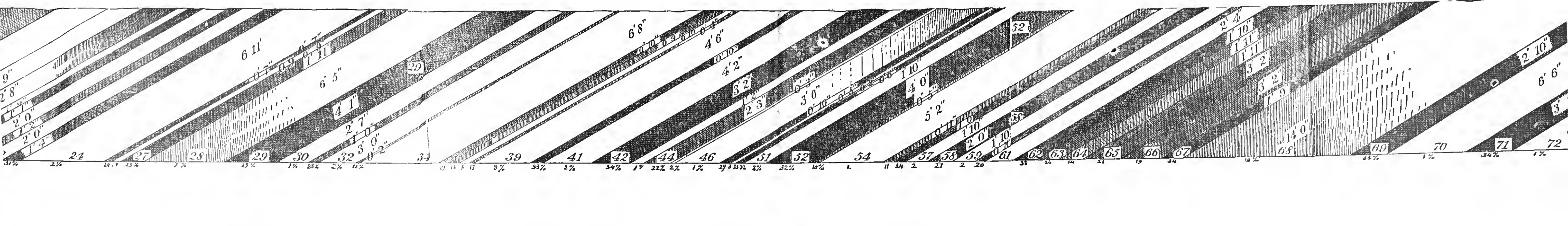
The analyses, as reported to me, have been given in full on the preceding pages.

In the following table (Table 1) the relative proportions of Carbonate of lime, Carbonate of magnesia, and Insoluble residue, are given, *and to the second decimal only.*

Attention is drawn to abnormal beds or analyses by enclosing certain percentages in brackets. The greatest pains were taken to prevent mistakes as to the *locus* of each specimen; yet, some of these extraordinary percentages *may* be significant of such mistakes. Most of them are probably indicative of actual variations of composition in the beds.

South end of Walton quarries.

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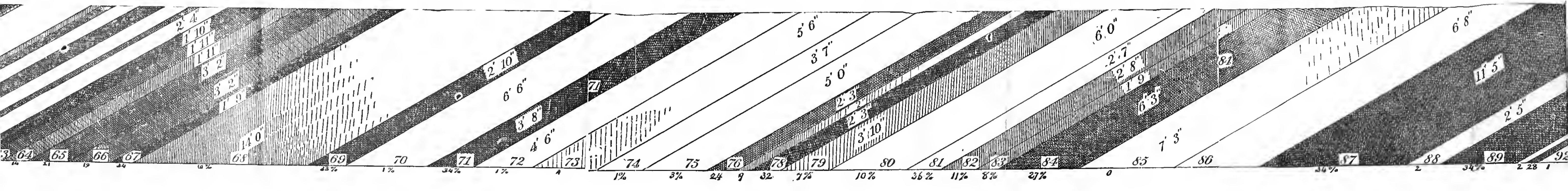
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5' 6"
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6' 0"
2' 7"
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11' 5"
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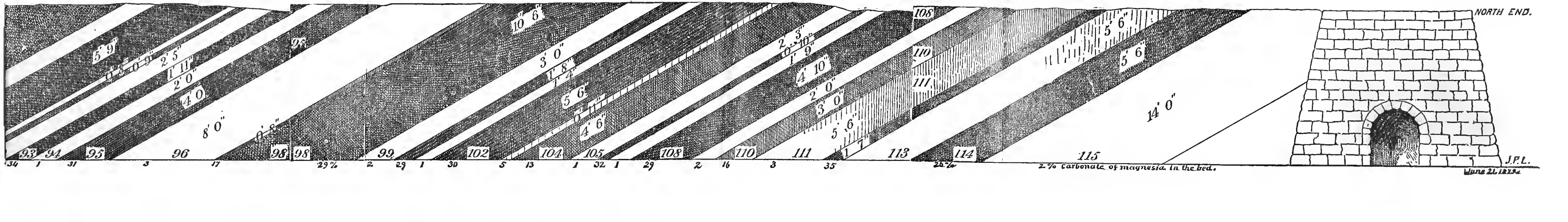

NORTH END.
J.P.L.
2% carbonate of magnesia in the bed.
June 21, 1849.

TABLE I.

Bed.	Lime Carb. Grade.	Lime Carb. Top.	Magnesia Carb. Grade.	Magnesia Carb. Top.	Insol. Matter. Grade.	Insol. Matter. Top.
1	58.35	57.10	36.80	38 25	4.60	4.00
2	55.60	56.20	38.50	39.75	5.30	3.80
(a) 3a	89.90	92.00	3.60	4.00	5.70	4.10
4	93.90	97.05	1.80	1.85	3.80	1.40
(b) 5	96.40	97.20	1.40	0.70	1.90	2.10
6	95.50	97.60	1.40	1.30	1.50	1.10
7	87.10	87.40	3.60	3.70	9.70	9.10
(c) 8	82.30	87.45	14.50	7.50	3.10	3.90
(e) (d) 9	68.30	67.60	24.80	27.00	5.50	5.40
10	90.70	90.40	8.05	8.15	1.90	1.70
11	97.60	96.70	1.80	1.30	1.00	2.20
12	66.00	75.80	32.40	19.85	1.60	2.50
13	96.80	97.20	2.30	1.85	1.20	1.40
14	95.85	83.70	2.40	11.85	1.80	3.40
15	92.75	97.30	4.45	1.00	3.40	1.80
16	97.80	97.10	1.30	2.00	1.10	1.20
(f) 17	96.60	[60.20]	1.10	[33.40]	1.10	[5.90]
18	97.00	93.50	1.20	4.30	1.40	2.00
19	65.30	62.30	30.80	34.50	3.50	3.00
20	96.40	98.70	2.90	0.80	0.70	0.50
21	76.30	71 75	18.50	24.30	5.30	4.20
22	93.7	97.4	3.8	1.6	1.9	1.3
(g) 23	65.3	64.3	30.8	28.6	3.4	6.5
24	94.8	93.1	1.6	1.9	3.9	4.8
25	68.9	68.9	23.8	23.6	7.4	6.3
(h) 26	90.0	[70.85]	6.8	6.3	3.4	[22.95]
(i) 27	63.3	75.7	28.60	18.1	6.2	5.6
(j) 28	81.25	94.15	6.65	2.15	12.0	4.0
29	65.0	62.4	29.1	31.4	5.4	5.4
30	98.9	97.9	1.1	1.30	0.5	0.9
31	61.0	64.30	27.7	25.20	10.9	10.3
32	96.7	97.6	1.7	1.0	1.7	1.8
33	73.3	71.9	12.4	15.5	12,4	10.4
34	97.6	96.3	1.5	1.2	1.1	1.5
35	75.20	67.25	18.90	25.65	4.7	5.9
36	82.9	79.9	13.5	16.9	2.7	4.2
37	91.0	89.0	5.4	5.8	3.6	3.6
38	79.7	82.9	16.9	12.3	2.9	2.8
39	89.7	98.7	8.2	1.6	1.6	0.3
40	61.5	56.3	33.6	37.2	4.7	6.1
41	96.9	95.8	1.7	2.2	1.4	1.9
42	55.6	57.15	35.0	34.95	6.9	6.5
(k) 43	97.8	[91.0]	1.3	[1.3]	1.3	[7.9]
(l) 44	73.6	65.5	22.5	28.2	3.4	4.8
(m) 45	96.2	[96.2]	2.0	[2.0]	2.4	[2.4]
46	97.2	90.6	1.7	7.6	0.7	1.8
47	63.4	68.2	29.5	27.1	6.4	3.6
48	94.3	95.3	1.9	2.2	3.5	2.2
(n) 49	57.8	66.2	33.2	26.9	8.0	5.7
50	60.4	62.0	32.1	31.7	5.3	5.1

	51	92.9	95.7	3.2	2.9	3.0	1.7
	52	61.4	68.9	31.9	23.7	5.3	7.2
	53	81.1	88.7	10.0	7.0	4.7	3.4
	54	98.2	97.9	1.3	1.2	1.2	0.7
	55	79.8	79.5	10.8	13.4	8.6	6.9
	56	66.9	66.0	24.2	23.2	7.4	9.7
	57	91.6	91.0	2.4	2.3	5.9	6.8
	58	64.8	60.1	27.4	29.9	7.2	8.6
	59	97.1	99.3	1.8	1.3	1.1	0 2
	60	75.1	76.3	20.9	19.9	3.1	2.4
	61	89.3	95.1	1.5	1.8	8.9	2.1
(*o*)	62	[49.8]	61.9	31.9	28.4	[16.9]	8.2
	63	71.0	72.9	23.8	23.0	6.0	4.9
	64	80.7	87.7	14.2	10.0	2.5	2.3
	65	67.7	70.0	20.9	21.5	10.2	7.8
	66	75.1	79.1	19.2	13.6	5.4	5.8
	67	61.0	61.8	33.6	32.1	4.6	5.9
(*p*)	68	85.1	96.0	[10.4]	2.3	3.2	1.9
	69	51.7	58.5	32.7	27.4	12.9	11.9
	70	98.2	97.4	1.5	1.4	0.8	0.9
	71	55.6	53.3	33.7	35.4	10.3	10.0
	72	98.1	97.3	1.4	1.6	0.8	1.2
	73	93.9	96.6	3.6	1.6	2.7	2.5
	74	95.6	96.8	1.5	1.2	2.8	2.1
	75	91.3	92.1	2.8	3.2	5.4	5.1
	76	64.9	63.0	23.6	26.7	10.6	9.8
(*q*)	77	85.5	97.9	[9.8]	1.8	4.5	1.0
	78	56.7	56.0	31.9	31.5	8.5	10.8
	79	86.7	85.2	7.1	8.7	5.0	5.5
(*r*)	80	79.8	95.9	(9.9)	2.0	9.4	2.6
(*s*)	81	54.9	56.7	[35.7]	24.0	7.7	18.4
	82	84.7	86.9	10.8	8.5	4.1	4.0
	83	90.7	91.0	8.0	7.6	1.7	1.9
(*t*)	84	66.8	75.6	[27.2]	16.3	4.4	5.6
	85	97.0	93.7	0.9	4.1	8.6	2.1
	86	95.4	98.9	1.3	1.1	3.8	0.6
	87	52.0	54.1	33.7	28.1	12.5	15.9
	88	96.3	98.4	1.9	1.1	2.2	0.7
	89	59.4	61.6	33.7	31.8	6.1	5.9
	90	97.6	97.6	1.8	1.5	0.9	0.3
	91	68.2	74.1	27.9	23.1	3.9	3.0
	92	98.2	97.7	1.3	1.9	1.2	0.6
	93	58.6	59.2	34.1	35.1	5.6	5.0
(*u*)	94	96.7	85.5	1.4	1.4	1.8	12.6
	95	54.8	55.2	31.1	30.6	13.0	12.9
	96	95.8	95.4	2.7	2.2	1.3	1.8
	97	75.2	77.6	17.3	16.4	6.7	4.8
	98	62.0	60.0	29.4	32.8	7.8	6.7
	99	96.3	96.0	1.9	3.2	1.1	0.9
	100	62.2	62.5	29.5	27.4	8.3	7.1
	101	98.2	98.8	1.2	0.8	0.6	0.3
	102	64.4	60.4	30.5	34.2	4.3	4.8
	103	94.7	93.1	4.6	4.8	1.0	1.4
	104	80.2	97.5	13.2	14.7	5.6	4.3
	105	98.2	96.9	1.2	1.6	0.6	1.1

106	63.4	63.3	31.6	31.7	3.8	4.1
107	98.2	99.0	1.6	0.5	0.3	0.4
108	65.0	65.0	29.1	29.6	5.1	5.0
109	94.8	86.9	2.5	4.3	1.8	7.7
110	73.1	64.3	16.5	22.3	9.1	11.6
111	94.5	88.4	2.7	8.3	1.9	2.6
112	54.4	54.4	35.2	36.2	8.4	7.7
113	98.1	76.2	0.9	5.7	1.0	18.2
114	64.6	55.4	26.2	33.8	8.5	9.7
115	95.1	97.7	1.9	0.9	1.7	1.4

Without discussing in detail, at present, this instructive table, several things are evident at a glance, viz: that

1. Alternate strata of limestone and dolomite make up the mass.

This is most easily seen by running the eye down the fourth and fifth columns of figures.

It will be noticed that beds 1, 2,—beds 3a, 4, 5, 6, 7 and 8,—beds 10, 11,—beds 35, 36,—beds 45, 46,—beds 49, 50,—beds 53, 54,—beds 55, 56,—beds 62, 63, 64, 65, 66, 67,—beds 72, 73, 74, 75,—beds 79, 80,—beds 82, 83,—beds 85, 86,—beds 97, 98,—group themselves together either as high or as low magnesian beds,

It will also be noticed that such beds as 14, 33, 36, 38, 55, 64, 84, 97, 104, occupy an intermediate place between the two series.

To render this law of alternation more apparent to the eye a colored diagram is published with this volume, on which the blue spaces represent the percentage of Carbonate of lime, the yellow that of Carbonate of magnesia and the red that of Insoluble residue.

2. The dolomite layers carry the most insoluble materials, as a rule.

3. Specimens taken from the top and bottom of the cut (eighty feet apart, or less) differ *sometimes* as notably from one another as specimens taken from different beds, but *as a rule* each layer is nearly homogeneous, so far as two or three analyses can show such a rule.

4. Not one of the so-called dolomite layers has enough carbonate of magnesia to make it a true lithological dolo-

The colored diagram has been omitted as unnecessary.

mite. They are all merely more or less magnesian limestones.

5. Carbonate of magnesia is not absent from any bed in the whole series. To illustrate this I select the range of beds from No. 84 to No. 115. Out of these 32 beds—

16 = { 12 show less than 2 p. c.
3 " " " 3 p. c.
1 shows . . . . 4.6 p. c.

While of the regularly alternate remaining beds

16 = { 9 range between 36 and 30 p. c.
5 " " 30 and 25 p. c.
1 sinks to . . . 17 p. c.
1 " " . . . 14 p. c.

The alternation of the two carbonates in these 32 beds may be represented to the eye thus:—

Per cent. of Carb. Mag.	Nos. of Beds selected from the Series.														
35 and over,															
30 "			87		89		91		93		95			98	
25 "	84														
20 "															
15 "													97		
10 "															
5 "															
0 "		85,86		88		90		92		94		96			99

Per cent. of Carb. Mag.	Nos. of Beds selected from the Series.															
35 and over,													112			
30 "	100		102				106		108						114	
25 "																
20 "																
15 "											110					
10 "					104											
5 "				103												
0 "		101				105		107		109		111		113		115

It is especially remarkable that so few of the beds occupy an intermediate position, chemically considered, between nearly fixed extreme limits of lime and magnesia.

In discussing the data given in Table 1 above, my first attempt was of course to obtain something like a reliable average of the three principal elements: the carbonate of lime, the carbonate of magnesia and the insoluble residue.

To do this I first averaged the group of five beds as set off by spaces in the table; but the results were so heterogeneous that they are not worth printing; as any one may convince himself by trying any two of the groups of five as exhibited in Table 2:

TABLE II.

Beds.	Lime Carbonate		Magnesia Carb.		Insol. Res.	
	Bottom.	Top.	Bottom.	Top.	Bottom.	Top.
1 to 5, ...	394.15	399.50	82.10	84.55	21.30	15.40
6 " 10, ...	423.90	430.45	52.35	47.65	21.70	21.20
11 " 15, ...	448.40	450.70	43.35	35.85	9.00	11.30
16 " 20, ...	454.10	411.80	37.30	75.10	7.80	12.60
21 " 25, ...	399.00	395.45	78.50	80.10	21.90	23.10
26 " 30, ...	398.45	401 00	72.25	59.25	27.50	38.94
31 " 35, ...	403.80	397.35	62.20	68.55	30.80	29.90
36 " 40, ...	404.80	406.80	77.60	73.85	15.50	17.00
41 " 40, ...	430.10	405.65	62.50	69.95	15.40	23.50
46 " 50, ...	373.10	382.30	98.40	95.50	23.90	18.40
1 " 50	4129.80	4081.00	666.55	690.35	194.80	211.25
Average, .	82.59	81.62	13.33	13.81	3.99	4.22
51 to 55, ...	413.4	430.7	57.2	48.2	22.8	19.9
56 " 60, ...	395.5	392.7	76.7	76.7	24.7	27.7
61 " 65, ...	357.5	387.4	91.3	84.7	44.5	25.3
66 " 70, ...	371.6	392.8	97.3	76.8	26.9	26.4
71 " 75, ...	434.5	436.1	43.0	43.0	22.0	20.9
76 " 80, ...	373.6	398.0	82.3	70.7	38.0	29.7
81 " 85, ...	394.1	403.9	82.6	60.5	26.5	32.0
86 " 90, ...	400.7	410.6	72.4	73.5	25.5	23.4
91 " 95, ...	376.5	371.7	95.8	92.1	25.5	34.1
96—100, ...	391.5	391.4	80.8	82.0	25.2	21.3
51—100	3908.4	4015.3	779.5	708.1	283.6	260.7
Average, .	78.17	80.31	15.59	14.16	5.67	5.21
101—105, ...	435.7	428.7	50.7	55.1	12.1	11.9
106—110, ...	394.5	378.5	81.3	87.4	20.1	28.8
111—115, ...	406.7	372.1	66.9	82.9	21.5	39.6
101—115	1236.9	1179.3	198.9	226.4	53.7	80.3
Average, .	80.46	78.62	13.26	15.09	3.58	5.35
1— 50, ...	4129.80	4081.00	666.55	690.35	194.80	211.25
51—100, ...	3908·40	4015.30	799.50	708.10	283.60	260.70
100—115, ...	1236.90	1179.30	198.90	226.40	53.70	80.30
1—115	9275.10	9275.60	1644.95	1624.85	532.10	552.25
Grand average of 115 beds, ...	80.655	80.668	14.30	14.13	4.627	4.802

The reason is obvious. The alternation of magnesian and non-magnesian layers does not accord with an arrangement of them into groups of five. Were the alternation perfectly regular,—were every alternate bed magnesian,—results of some value might be got by using groups of 2, 4, 6, 8 or 10 beds. But a group of five would include either two limestone and three magnesian beds, or three limestone and two magnesian beds.

The next attempt was made with groups of ten beds; and the top and bottom analyses were thrown in together. The result as shown in Table 3 was hardly more satisfactory than before.

TABLE III.

Beds.	*Lime carb.*	*Mag. carb.*	*Insol. residue.*
1 to 10,	82.40	13.33	3.98
11 to 20,	83.25	9.57	2.03
21 to 30,	79.69	14.50	5.57
31 to 40,	80.63	14.11	4.66
41 to 50,	79.55	16·32	4.06

It was only when the whole series was simply broken up into three groups of 50, 50, and 15 beds, that any uniform distribution of the three principal elements of the analysis throughout the mass of the formation could be perceived, as shown in Table 4.

TABLE IV.

Beds.	*Lime carb.*	*Mag. carb.*	*Insol. residue.*
1 to 50,	82.15	13.57	4.11
51 to 100,	79.54	14.87	5.44
101 to 115,	79.54	14.17	4.47
1 to 115,	80.662	14.215	4.715

If the insoluble residue be neglected and the sum of the two carbonates be called 100, we get the following proportion:

Beds 1 to 115 . . . 85.02 to 14.98 = 100.

Having thus obtained the proportion of the two carbonates in the whole series of beds, the next step was to group the *low* magnesian beds together and the *high* magnesian beds together, calling the former (L) and the latter (M).

This was not easy to do for the whole series, on account of the occurrence of layers which could as well be ranked with (L) as with (M.)

For this purpose I selected 14 limestone (L) beds alternating, with singular regularity, with 15 magnesian beds (M, distinguished by the black-letter) viz: beds **87**, 88, **89**, 90, **91**, 92, **93**, 94, **95**, 96, **97**, **98**, 99, **100**, 101, **102**, 103, **104**, 105, **106**, 107, **108**, 109, **110**, 111, **112**, 113, **114**, 115; and the result was as follows:—

TABLE V.

	Lime Carbonate.		Magnesian Carb.		Insoluble.	
	Bottom.	Top.	Bottom.	Top.	Bottom.	Top.
(L)	96.62	93.47	1.97	2.58	1.24	3.57
(M)	63.83	63.00	27.93	25.52	7.25	7.24

Of the 164 percentages here represented, five are abnormal, as may be noticed by consulting the last part of Table 1. These are included, however, in Table 5.

If now we combine all the top and bottom analyses of Table 5, without excepting any, we have the following general average:—

TABLE VI.

	Lime Carb.	Magnesia Carb.	Insoluble.
(L), ...	95.05	2.27	2.40
(M), ...	63.41	28.22	7.24

but if we throw out the 5 abnormal analyses, we have the slightly different general average:—

TABLE VII.

	Lime Carb.	Magnesia Carb.	Insoluble.
(L), ...	95.77	2.06	1.42
(M), ...	63.41	28.22	7.24

which is perhaps as good a formula for the chemical distribution of the lime and magnesia constituents of our older limestone formations as we are likely to get; unless we should prefer as before one in terms of Carb. lime and Carb. magnesia=100 (rejecting the insoluble residue) thus:—

TABLE VIII.

	Lime Carb.	Magnesia Carb.	
(L), ...	97.90	2.10	100.
(M), ...	69.20	30.80	100.

To try the method in another form, I selected 57 *high* magnesian beds to compare with the remaining 58 *low* magnesian beds. The percentages given in the fourth column of figures in Table 1 were then alone used, and the following averages were obtained:

TABLE IX.

Magnesia Carbonate alone.

	(1—30)	(31—60)	(61—90)	(91—115)	(1—115)
(L)	3.010	2.620	2.25	2.00	2.53
(M)	27.960	23.560	26.05	27.04	25.89

This result is also unsatisfactory, inasmuch as a considerable number of the beds might as well have been placed in class (M) as in class (L.) No proper selection in fact can be made until careful curves of percentages are drawn and studied by comparison.

But now a difficulty of quite another order must be met.

Even were we able to classify precisely under (L) or under (M) each bed, and even could each analysis be looked upon as a perfect representative of the whole constitution of its proper bed, no possible combination of these analyses could give the true proportion of lime and magnesia in the whole group or mass of 400 feet of strata, *unless the beds were of equal thickness one to another.*

Now, in point of fact the 115 beds under discussion are of very different thicknesses; and the calculation becomes tedious enough.

The following table represents the first measurements of these beds by Mr. Sanders:

TABLE X.

1, . .	8′ 0″	26, . .	1′ 11″	51, . .	5′ 2″	76, . .	1′ 9″
2, . .	2′ 9″	27, . .	6′ 5″	52, .	11′	77, . .	6′ 3″
3, . .	3′ 6″	28, . .	4′ 1″	53, . .	1′ 0″	78, . .	7′ 3″
4, . .	4′ 6″	29, . .	2′ 7″	54, . .	1′ 10″	79, . .	6′ 8″
5, . .	8′ 1″	30, . .	1′ 0″	55, . .	2′ 0″	80, . .	11′ 5″
6, . .	2′ 0″	31, . .	3′ 2″	56, . .	1′ 10″	81, . .	2′ 5″
7, . .	9″	32, . .	6′ 8′	57, . .	10″	82, . .	5′ 9″
8, . .	2′ 3″	33, . .	10″	58, . .	2′ 4′	83, . .	1′ 5′
9, . .	2′ 8″	34, . .	1′ 7″	59, . .	5′ 8″	84, . .	2′ 5′
10, . .	3′ 8″	35, . .	4″	60, . .	6′ 4″	85, . .	4′ 9″
11, . .	5′ 7′	36, . .	4′ 6″	61, . .	1′ 9″	86, . .	5′ 10″
12, .	3′ 8″	37, . .	10″	62, . .	14 0″	87, . .	6′ 5″
13, . .	12′ 8″	38, .	4′ 2″	63, . .	2′ 10″	88, . .	10′ 8″
14, .	4′ 4″	39, . .	3′ 2″	64, . .	6′ 6″	89, . .	3′ 9″
15, .	2′ 9″	40, . .	1′ 2″	65, . .	3′ 8″	90, .	5′ 0″
16, . .	2′ 8″	41, . .	2′ 3″	66, . .	4′ 6″	91, . .	8′ 9″
17, . .	1′ 0″	42, . .	3″	67, . .	5′ 6″	92, .	1′ 2″
18, . .	1′ 1″	43, . .	3′ 6″	68, . .	3′ 7″	93, . .	6′ 6″
19, . .	2′ 0″	44, .	10″	68, . .	5′ 0″	94, . .	5′ 6″
20, . .	1′ 2″	45, . .	5″	70, . .	2′ 3″	95, . .	4′ 6′
21, . .	2′ 0″	46, . .	2″	71, . .	1′ 2″	96, . .	11′ 3″
22, . .	1′ 4″	47, . .	6″	72, . .	2′ 3″	97, . .	8′ 0″
23, . .	6′ 11″	48, . .	1′ 10″	73, . .	3′ 10′	98, . .	10′ 4″
24, . .	7″	49, . .	4′ 0″	74, . .	6′ 0″		
25, . .	9″	50, . .	5″	75, . .	5 3″		372′ 9″

If, for instance, we take a hypothetical case, and imagine one half of a series of one hundred beds to be of limestone carrying an average of two per cent. of carbonate magnesia, and the other half to be beds of limestone carrying an average of thirty per cent., and if we suppose that the thicknesses of the first fifty beds averaged one foot, and those of the second fifty averaged six and a half feet (total, 375 feet,*) it would give a totally false result to calculate, thus:

$$\left.\begin{array}{l}\textit{50 beds, at 2.00 } \text{per cent.,}\\ \textit{50 beds, at 30.00 } \text{per cent.,}\\ \textit{100 beds, } \text{at } \textit{16.00 per cent.,}\end{array}\right\}\text{Carbonate of Magnesia.}$$

On the contrary, the calculation should run thus:

$$\left.\begin{array}{l}\left.\begin{array}{l}50\times1' \times 2 \text{ p. c.} = 100\\ 50\times6.5'\times 30 \text{ p. c.} = 9750\end{array}\right\}\begin{array}{c}\text{per cent.}\\ 9850.\end{array}\\ \left.\begin{array}{l}50\times1' = 50'\\ 50\times6.5' = 325'\end{array}\right\} \quad . \quad . \ . \ . \quad 375'\end{array}\right\}\text{per cent. } 26.7.$$

* Approximately the total thickness of our series of 115 beds.

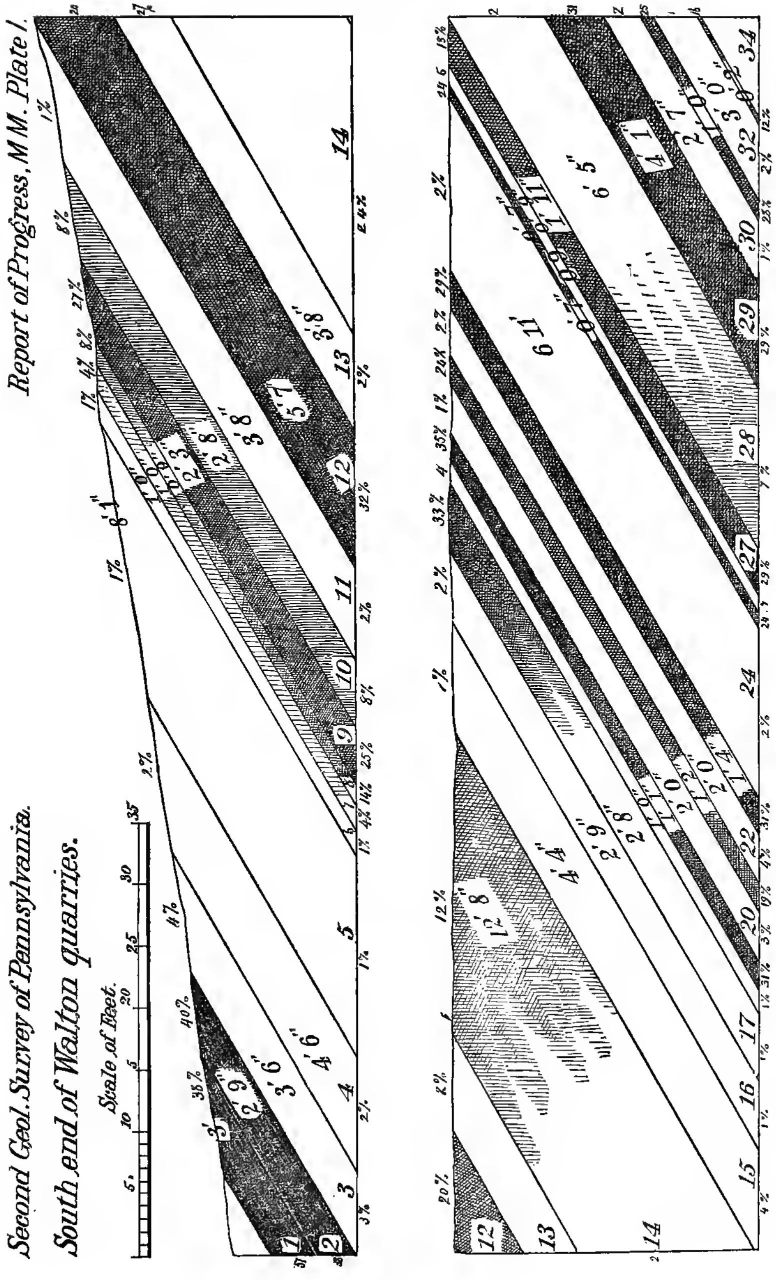
If, on the other hand, to change the form of the illustration, the thirty per cent. went to the one foot beds, and the two per cent. went to the six and a half foot beds, the per centage of the whole 375 feet would be only $\frac{2150}{375}=5.73$.

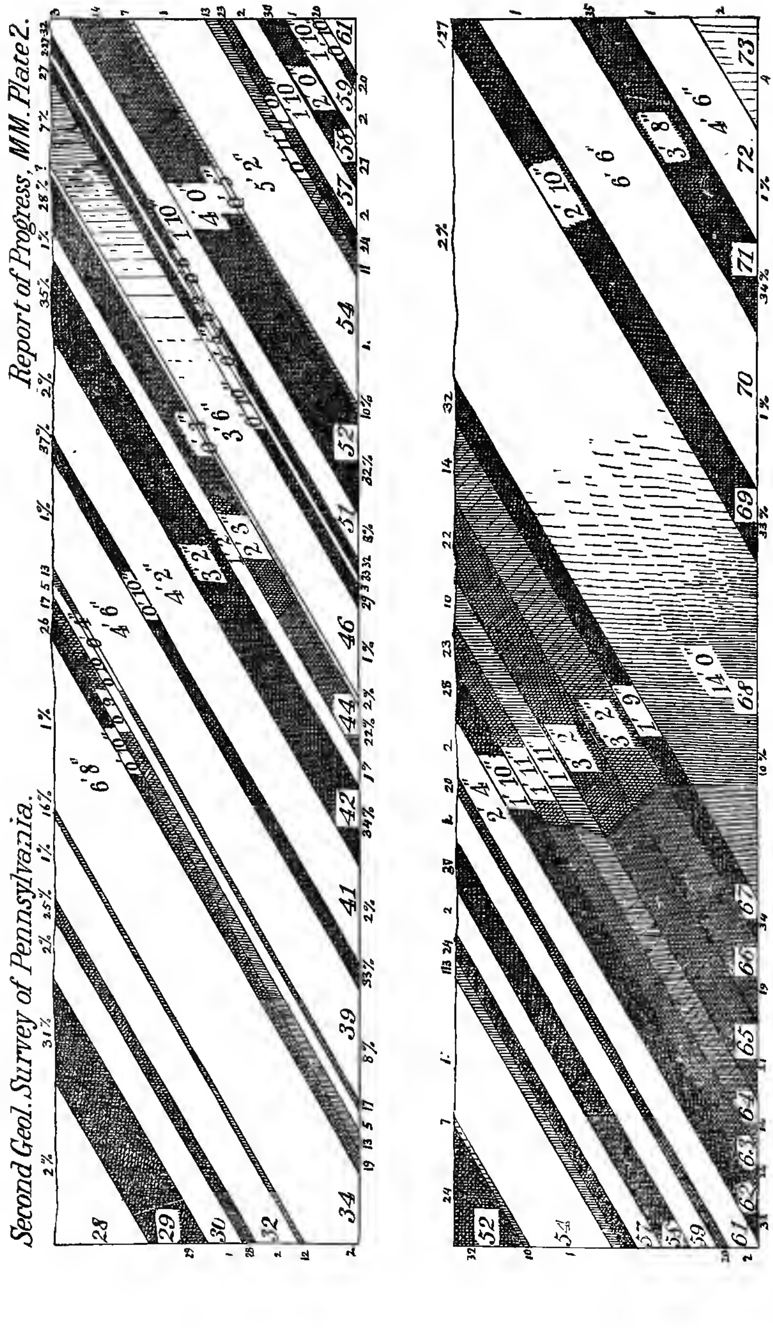
Changes however were afterwards made by Mr. Hartshorne, who saw reasons for subdividing some of the members of Mr. Sanders' series, and thus made 115 beds out of the original 98 represented in Table 11:

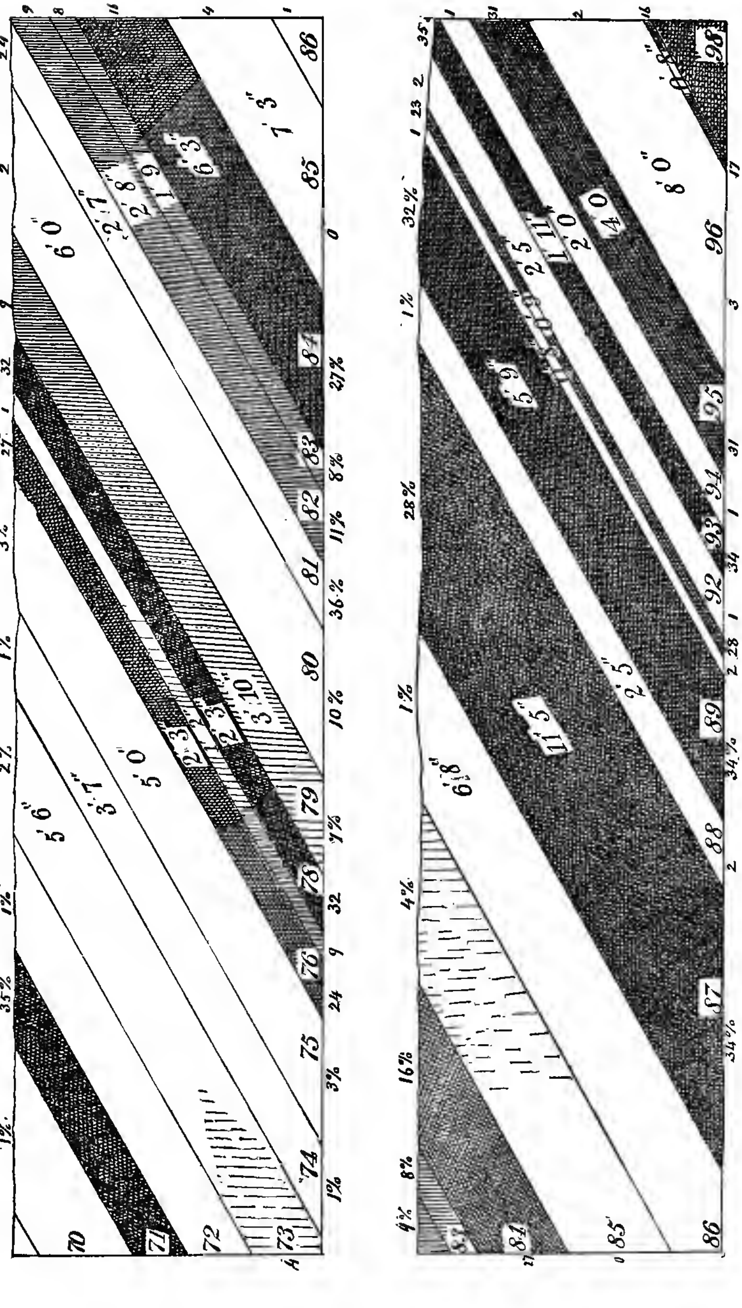
Table XI.

1, . .	3'	0''	31, . .	1'	0''	61, . .	2'	4''	90, . .	0'	8''
2, .	2	9	32, . .	3	0	62, . .	1	10	91, . .	0	9
3, . .	3	6	33, . .	0	2	63, .	1	11	92, . .	2	5
4, . .	4	6	34, . .	6	8	64, . .	1	11	93, . .	1	11
5, . .	8	1	35, . .	0	10	65, . .	3	2	94, . .	2	0
6, . .	1	0	36, . .	0	9	66, . .	3	2	95, . .	4	0
7, . .	1	0	37, . .	0	10	67, . .	1	9	96, . .	8	0
8, . .	0	9	38, . .	0	4	68, .	14	0	97, . .	0	8
9, . .	2	3	39, .	4	6	69, . .	2	10	98, . .	10	6
10, . .	2	8	40, . .	0	10	70, . .	6	6	99, . .	3	0
11, . .	3	8	41, . .	4	2	71, . .	3	8	100, . .	1	8
12, . .	5	7	42, . .	3	2	72, . .	4	6	101, .	1	4
13, . .	3	8	43, . .	1	2	73, . .	5	6	102, . .	5	6
14, . .	12	8	44, .	2	3	74,	3	7	103, . .	0	11
15, . .	4	4	45, . .	0	3	75, . .	5	0	104, . .	4	6
16, . .	2	9	46, . .	3	6	76, . .	2	3	105, . .	2	3
17, . .	2	8	47, . .	0	10	77, . .	1	2	106, .	0	10
18, . .	1	0	48, .	0	5	78, . .	2	3	107, . .	1	9
19, . .	1	1	49, . .	0	2	79, . .	3	10	108, . .	4	10
20, . .	2	0	50, . .	0	6	80, . .	6	0	109, . .	2	0
21, .	1	2	51, . .	1	10	81, . .	2	7	110, .	3	0
22, . .	2	0	52, . .	4	0	82, . .	2	8	111, . .	5	6
23, .	1	4	53, . .	0	5	83, . .	1	9	112, . .	1	7
24, .	6	11	54, . .	5	2	84, . .	6	3	113, .	5	6
25, .	0	7	55, . .	0	11	85, . .	7	3	114, .	5	6
26, . .	0	9	56, . .	1	0	86, .	6	8	115, . .	14	6
27, .	1	11	57, . .	1	10	87, . .	11	5			
28, . .	6	5	58, .	2	0	88, .	2	5		370'	10'
29, .	4	1	59, . .	1	10	89, .	5	9			
30, . .	2	7	60, . .	0	10						

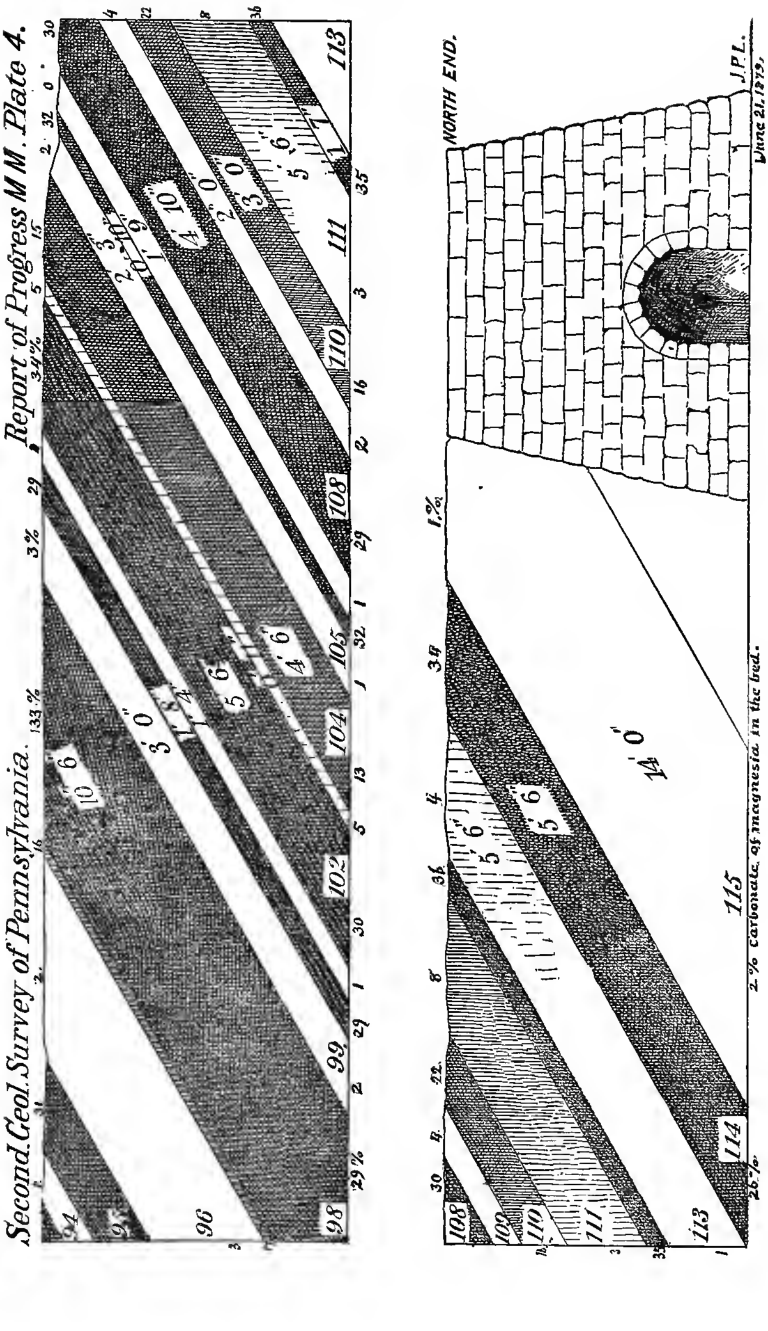
The diagram section accompanying this table will show to the eye the proportionate sizes of the bed, as well as the distribution of the magnesian beds throughout the mass.


Report of Progress, MM. Plate I.
Second Geol. Survey of Pennsylvania.
South end of Walton quarries.
Scale of Feet.


Second Geol. Survey of Pennsylvania.
Report of Progress, MM. Plate 2.



Second Geol. Survey of Pennsylvania. Report of Progress MM. Plate 3.


Second Geol. Survey of Pennsylvania.
Report of Progress M M. Plate 4.
NORTH END.
2 % carbonate of magnesia in the bed.
J.P.L.
June 21, 1879.

Treating the beds according to their thicknesses and by the formula given above, and taking only the analyses given in columns 1 and 3 of Table 1 for that purpose, we get the results shown in Table 12.

TABLE XII.

Beds.		*Lime carb.*	*Mag. carb.*
1— 5,		1840	252
6— 10,		684	96
11— 15,		2710	245
16— 20,		900	47
21— 25,		1064	227
26— 30,		1233	225
31— 35,		1754	219
36— 40,		623	87
41— 45,		900	174
46— 50,		480	53
	132.6′	12188	1625
		92%	12.2%
51— 55,		1027	40
56— 60,		657	103
61— 65,		809	200
66— 70,		2318	365
71— 75,		1963	170
76— 80,		1180	225
81— 85,		1664	313
86— 90,		1870	603
91— 95,		824	105
96—100,		1865	379
	179′	14177	2503
		79.25%	14%
101—105,		1162	236
106—110,		939	223
111—115,		2882	247
	59.5′	4983	706
		83.75%	11.86%

It appears by the first fifty beds that *the method involving thickness as a factor* gives 9.4 per cent *more* lime carbonate and 1.13 per cent *less* magnesia carbonate than the method of simply averaging the total percentage as if the beds were all equal.

The second fifty beds give 1.08 *more* lime carbonate and 1.59 *less* magnesia carbonate.

The remaining fifteen beds give 3.29 *more* lime carbonate and 1.40 *less* magnesia carbonate.

And taking the whole series thus treated we have the following result:

Feet of rock.	*Lime carb.*	*Mag. Carb.*
132.6,	12188	1625
179.0,	14177	2503
59.5,	4983	706
371.1	31348	4834
Percentage of whole mass on a basis of thicknesses,	84.470	13.020
Compare table 2,	80.655	14.300
Compare table 4,	80.662	14.215

The facts brought to light by the investigation are as follows:

1. Taking 115 beds, with a total thickness of 371 feet, from the lower middle part of the great magnesian limestone formation No. II—the "Calciferous Sandstone" of New York, and probably of Siluro-Cambrian age—and subjecting them individually to chemical analysis, they are seen to belong to two well marked lithological species; *one*, a limestone, carrying 2 or 3 per cent of magnesia carbonate and 1 or 2 per cent of insoluble materials; *the other*, a dolomitic limestone, charged with from 25 to 35 per cent of magnesia carbonate and an average of over 7 per cent of insoluble matter, rising in some cases to 10 and 15 per cent or even more.

2. These two species alternate, not in the same bed, but in separate beds sharply distinguished from each other and traceable across the exposure, a distance of from 80 to 100 feet.

3. The planes of separation are in most cases those of ordinary deposition

4. No current or cross or false bedding is visible.

5. Some of the beds of both species are only a few inches thick; others are 6 or 8 feet thick; and there seems to be no rule connecting either species with the thin or with the thick beds.

6. Sometimes a bed of limestone only 5 or 6 inches thick crosses the exposure between two equally thin beds of dolomite; yet there is no appearance of gradation in the deposits, nor in their chemical composition. The same percentages of carbonate of magnesia are found at both extremities of the exposure.

7. In a few cases there is a decided difference in the amount of magnesia at one or other end of the exposure; but whether this be due to some error in the investigation, or to a radical change of composition along the bed which exhibits it, is not certain.

8. There are thick masses of limestone strata with comparatively thin magnesian layers in their midst; and vice versa, there is sometimes a considerable thickness of magnesian rock parted by thin layers of nearly pure limestone.

9. There are a few layers of an intermediate species; but these are not numerous enough to destroy the remarkable and sudden contrasts of alternate layers of limestone with 2 or 3 per cent of magnesia and layers with 25, 30, 35 or more per cent. In fact the extreme limits are often directly and repeatedly in contact with each other.

10. The largest percentage of silicate of alumina is almost invariably found in the high magnesian layers.

The only generalization I can make from the above data is a negative one, namely: that no theory of percolation can account for the facts; that no theory of more rapid dissolution of carbonate of lime, leaving a growing charge of carbonate of magnesia behind, will apply to rocks which are neither honeycombed nor visibly porous, nor unusually cleft, nor otherwise disturbed; and that any theory to account for the presence of the magnesia must treat the layers of both species as equally mechanical sediments; especially, seeing that the larger part of the insoluble matter resides in those which contain most magnesia; while magnesia is present in all of both kinds.

1008 Clinton Street, Philadelphia, June 23, 1879.

TABLE *showing the Specific Gravity of some Limestones.*

NUMBER OF BED.	SPECIFIC GRAVITY.
Bed L, at R. R. level,	2.82
Bed L, top of cut,	2.85
Bed LI, at R. R. level,	2.71
Bed LI, top of cut,	2.75
Bed LII, at R. R. level,	2.80
Bed LII, top of cut,	2.78
Bed LIII, at R. R. level,	2.73
Bed LIII, top of cut,	2.72
Bed LIV, at R. R. level,	2.71
Bed LIV, top of cut,	2.70
Bed LV, at R. R. level,	2.72
Bed LV, top of cut,	2.72
Bed LVI, at R. R. level,	2.74
Bed LVI, top of cut,	2.75
Bed LVII, at R. R. level,	2.69
Bed LVII, top of cut,	2.69
Bed LVIII, at R. R. level,	2.80
Bed LVIII, top of cut,	2.79
Bed LIX, at R. R. level,	2.68
Bed LIX, top of cut,	2.69

CHAPTER VII.

Miscellaneous.

In this chapter are included the analyses of specimens of marl, limestone, shale, barite, sand, iron ore, &c., which have not been classified geologically.

§ 77. *Marls.*

The only specimens of marl thus far examined are from the deposit at Harmonsburg. It occurs in Summit township, Crawford county, on the adjoining farms of Almon Whiting and Benjamin Brown. The bed is estimated to contain eighty acres. It lies about one mile N. N. E. of the north end of Conneaut lake, on a little stream emptying into the lake at Gregher's mill, and at an elevation above the present lake surface of say twenty feet. It is a lenticular deposit, thin at the edge, and thick at the center, occupying the principal part of a small swamp or basin between low hills of drift. A stratum of peat, about two feet thick, overlies the marl and supports the swamp vegetation covering the surface.

Pits have been sunk where the marl is fifteen feet thick, and a boring near the center of the deposit was carried down twenty-two feet without reaching its base. The bed, therefore, may be said to be from three feet to twenty-two feet in thickness.

Geologically speaking, the deposit is of recent date. It lies within the walls of an old river valley, now holding more than three hundred feet of northern drift, brought down by the ice of the Glacial epoch, and cannot, therefore, be as old as the drift. It probably accumulated when the waters of the Conneaut lake stood at a higher level than at present; or this swamp may have been an independent lakelet which has since been drained by the gradual lowering of its outlet leading into Conneaut lake. The indications are that it was a deposit made in shallow water, for a precisely similar bed (except as to the peat, which no doubt has accumulated since the lakelet was drained) is now found at the bottom of Cassadaga lake, Chautauqua county, New York, covered by from ten feet to thirty feet of water. Large quantities of the material have been raised by dredging, and prepared for use. The Cassadaga marl is more compact than the Harmonsburg marl in consequence of not being so thickly pierced by the long, vertical rootlets so noticeable in the latter; but the two deposits are evidently of the same character and belong to the same age.

Ever since 1830, occasional crude attempts have been made to dig this Harmonsburg marl, and convert it into lime for mechanical and agricultural purposes. The mortar used in several brick buildings in Meadville, built more than thirty years ago, was made from lime manufactured here, and it is said to stand the test of time well.

But no successful attempt to permanently utilize the marl seems to have been made until about the year 1874, when Mr. Almon Whiting erected a dry-house and stone lime kiln, and secured a steam engine and pumps for relieving the pits from water while cutting the material. Since that time quite a business has been established, both in the manufacture of lime and fertilizers.

The peat is first stripped off, and then the marl is cut out in brick-shaped blocks, and corded up to dry. This work is usually done in the month of June, and in August it will be sufficiently dry to be burnt. The process of burning occupies three days and nights. In dry weather, this is done by piling up in the open air alternate layers of wood and marl as high as convenient, but when the weather is wet, the burning is carried on in a kiln in the usual way. The product is then run through a mill and ground so fine that it can be applied to the land by means of the common grain drills, with proper attachments.

A considerable quantity of this marl has already been used for agricultural purposes, and where the soil is dry and in a suitable condition the results have proved very beneficial.

I am indebted to Mr. John F. Carll, Geologist in charge of the Survey of the Oil Regions, for most of the facts in the above notes.

The composition of the marl is shown by the following analyses:

Crawford County.

	(91a)	(91b)	(91c)
Lime,	49.129	59.800	44.997
Magnesia,	.839	1.405	1.163
Bisulphide of iron,	.429	.000	.071
Sesquioxide of iron,	.170	.850	.860
Alumina,	.020	.810	.808
Potash,	.116	.322	.538
Sulphuric acid,	.222	.841	.877
Phosphoric acid,	.023	.042	.062
Carbonic acid,	39.356	13.590*	33.890*
Water,	2.190	12.950	1.340
Carbonaceous matter,	6.510	1.010	3.900
Silica,	1.052	7.940	11.541
	100.056	99.560	100.047

(*91a*) *Harmonsburg marl.* Raw marl; selected block.

(*91b*) *Harmonsburg marl.* Mixed masses of marl taken from different pits and at varying depths, and burnt in close kiln to a white heat.

(*91c*) *Harmonsburg marl.* Marl burnt in open air to a red heat.

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§ 78. *Limestone Nodules.*

The discovery of these nodules of greenish limestone created considerable local excitement as it was supposed they contained quite a large per centage of nickel. A thorough examination failed to show even a trace of this metal. The character of the nodules is sufficiently shown by the following analysis made by David McCreath.

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*Samples have probably absorbed considerable carbonic acid, from long exposure in the laboratory.

Somerset County.

	(584) Burkit.
Carbonate of lime,	51.921
Carbonate of magnesia,	3.639
Carbonate of iron,	3.069
Protoxide of manganese,	.586
Alumina,	3.317
Sulphur,	.081
Phosphorus,	.102
Insoluble residue,	37.940
	100.655

(*584*) *Concretionary nodules of greenish limestone*, found on the farm of Mr. Burkit, a few miles south-east of Buckstown, Somerset county. See Report HHH, p. 6.

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§ 79. *Limestones.*

Somerset County.

	(404) Harshberger.
Carbonate of lime,	80.588
Carbonate of magnesia,	8.445
Carbonate of iron,	3.314
Carbonate of manganese,	1.400
Bisulphide of iron,	.371
Alumina,	.455
Phosphorus,	.026
Insoluble residue,	4.803

(*404*) *J. Harshberger's quarry*, on Ben's Creek, one mile south south-west of Forwardstown, Somerset county. See Report HHH, pp. 222, 223.

Compact; rather coarse grained; spotted with pyrites; bluish black.

	Indiana County. (770) Doty.	*Huntingdon County.* (785) Barr.
Carbonate of lime,	65.892	88.687
Carbonate of magnesia,	9.686	1.850
Oxide of iron and alumina,	5.710	1.439
Sulphur,	.292	.164
Phosphorus,	.016	.004
Insoluble residue,	16.540	8.230

(*770*) *G. M. Doty's quarry*, five miles north-east from Blairsville, Indiana county. *Limestone one hundred and twenty feet below Pittsburgh coal bed.*

Compact, brittle; bluish grey, with irregular fracture. Sparkles with calcite. Emits a strong argillaceous odor when breathed upon.

(*785*) *John Barr's quarry,* four and a half miles from McAleavy's fort, Huntingdon county. Limestone occurring 80′± feet below fossil ore.

Dark bluish grey; hard and compact; seamed with cal cite; coated with iron oxide. (S. S. H.)

Westmoreland County.

	(*546*) *Freeman.*
Carbonate of lime,	42.357
Carbonate of magnesia,	4.037
Carbonate of iron,	4.142
Alumina,	6.002
Sulphur,	.506
Phosphorus,	.590
Insoluble residue,	38.240

(*546*) *On land of John Freeman,* seven miles from Mt. Pleasant, Westmoreland county. *So-called "Black ore."*

Compact, very sandy looking; dark bluish grey. (D. McC.)

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§ *80. Conglomerate of Limestone and Red Shale.*

Huntingdon County.	(*950*) *Robertsdale.*	(*951*) *Diggins.*
Carbonate of lime,	52.571	46.232
Carbonate of magnesia,	2.081	2.560
Oxide of iron,	4.536	5.179
Sulphur,	.056	.056
Phosphorus,	.118	.169
Insoluble residue,	42.460	34.640

(*950*) *Conglomerate of limestone and red shale,* found near Robertsdale, Huntingdon county. Specimen from the outcrop, and very much weathered.

Hard; somewhat cellular; sparkles with calcite. Color, dark brown to reddish brown. (S. S. H.)

(*951*) *Conglomerate of dark grey limestone and red shale,* on Joseph Diggins' farm, one and three quarter miles east of Broad Top City, Huntingdon county.

Hard and compact; reddish brown. (S. S. H.)

§ 81. *Phosphatic Pebbles.*

In the shot block ore lying below the Bird-eye fossil ore and about 150 feet above the Medina Sandstone, occur small rounded, shot-like pebbles. These consist for the most part of an impure phosphate of lime, as shown by the following analysis.

Juniata County.

	(17) *Robinson.*	
Lime,	20.825	
Magnesia,	.486	
Phosphoric acid,	16.208	= 35.38 per cent. phosphate of lime.
Oxide of iron,	18.143	
Alumina,	9.029	
Silica,	35.540	
	100.141	

(*17*) *Phosphatic pebbles found in "Shot Block Ore,"* on land of John Robinson, Lost Creek Ridge, Licking Creek Valley, Juniata county. See analysis of ore, (17) p. 239.

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§ 82. *Barite.*

In the Lower Helderberg Limestone, Formation No. VI, and in the Siluro-Cambrian Limestone, Formation No. II, occur occasional pockets of barite (sulphate of baryta.) A considerable quantity of this has been mined and shipped to market by the Harrisburg Mining Company from a deposit near Fort Littleton in Fulton county.

The analyses given underneath show the composition of specimens from different localities. A small per centage of sulphate of strontia usually accompanies the barite; its absence therefore in all of the specimens examined is to be particularly noticed.

	Fulton County.		*Blair County.*	*Frank'in County.*	
	(699)	*(345)*	*(698)*	*(735)*	*(582)*
	Locke.	*Locke.*	*Galbraith.*	*Shockey.*	*Shockey.*
Sulphate of baryta, ...	95.22	96.91	97.08	95.91	98.65
Sulphate of strontia, . .	none.	none.	none.	none.	none.
Oxide of iron and alumina,	.38	.31	.76	.24	.14
Oxide of manganese, . . .	.05	none.	none.	none.	none.
Lime, ...	.59	trace.	none.	.17	trace.
Magnesia, ...	.18	trace.	trace.	.11	trace.
Carbonic acid, ...	.65	none.	none.	none.	none.
Water, ...	.23	.08	.32	.09	.20
Silicic acid, ...	2.45	2.35	1.74	2.80	1.11
	99.75	99.65	99.90	99.32	100.10

(*699*) *From land of Silas Locke*, a half mile north-east of Fort Littleton, Fulton county. *Average as mined by the Harrisburg Mining Co.* Found in the Lower Helderberg Limestone, Formation No. VI.

Massive and granular; bluish grey.

(*345*) *From land of Silas Locke; surface specimen.* Found in the Lower Helderberg Limestone, Formation No. VI.

Specimen has the same general appearance as No. (699.)

(*698*) *On Col. Galbraith's farm*, Sinking Valley, Blair county.

Cellular; the cells much stained by ferric oxide; reddish grey.

(*735*) *On Christian Shockey's land*, two and a half miles south of Waynesboro', Franklin county.

Granular; also in radiating columnar masses; color, white to bluish white; luster, generally vitreous.

(*582*) *Same general locality as the previous specimen.*

Granular; also slightly fibrous; generally very white; some of the pieces slightly stained with iron oxide. Powder, white with brownish tinge. (D. McC.)

§ 83. *Azoic Slate.*

York county.	(653) *Peach Bottom Slate.*
Silicic acid,	55.880
Alumina,	21.849
Ferrous oxide,	9.033
Manganous oxide,	.586
Cobaltous oxide,	trace.
Titanic acid	1.270
Lime,	.155
Magnesia.	1.495
Soda,	.460
Potash.	3.640
Carbon,	1.974*
Water,	3.385
Iron di-sulphide,	.051
Sulphuric acid,	.022
	99.800

(653) *Peach Bottom roofing slate* from J. Humphrey & Co.'s quarry, three miles south-west of Peach Bottom, York county.

Dark bluish black massive slate.

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§ 84. *Oriskany Glass Sand.*

This is sometimes a bed of pure white sand from 90 to 100 feet in thickness ; but at some places it is so much discolored by iron oxide that it is rendered useless for the manufacture of glass.

It is fully described in Report F. pp. 78, 79, 80.

An average specimen of the white sand shows the following :

Mifflin County.	(736) *Juniata Sand Co.*
Silica,	98.84
Alumina,	.17
Oxide of iron,	.34
Oxide of manganese,	trace.
Lime,	trace.
Magnesia,	trace.
Loss on ignition,	.23
	99.58

* Average of three determinations by different methods.

(*736*) *Juniata Sand Co.'s mine*, three and a half miles from Lewistown, Mifflin county.

Granular and very white.

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§ *85. Cellular Quartz.*

The specimen, found in the limestone of Formation No. II in Sinking valley, Blair county, was analysed as it was supposed to carry considerable zinc.

It consists of a mass of cellular quartz containing numerous drussy cavities lined with quartz crystals more or less stained with ferric oxide. Some portions of the mass have the general appearance of calamine (hydrous silicate of zinc,) but the specimens contain no zinc.

Blair County.	(*1003*) *Galbraith.*
Silica,	94.89
Oxide of iron and alumina,	3.28
Oxide of manganese,	trace.
Oxide of cobalt,	.17
Lime,	.06
Magnesia,	.18
Water,	.97
	99.55

(*1003*) *On Col. Galbraith's farm*, Sinking Valley, Blair county.

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§ *86. Ferruginous Sand-rock.*

In Huntingdon county this rock is known among the farmers as the "red rock" and is generally supposed to carry sufficient iron to make it valuable as an ore. It colors the upper layer of the Medina sandstone red.

Its average composition is shown by the following analyses.

Huntingdon County.	(*945*)	(*952*)	(*955*)
Iron,	18.491	17.425	17.060
Sulphur,	.047	.043	——
Phosphorus,	.179	.202	——
Insoluble residue,	64.340	69.470	69.940

(*945*) *Hard silicious ore found on the terrace of Broad Mountain*, one fourth mile north-east of Greenwood furnace, Huntingdon county. It colors the upper layer of the Medina sandstone red.

(*952*) *Ferruginous sandstone, known as the "Red rock,"* found on Green Sea Mountain, two miles from McAleavy's fort, Huntingdon county.

(*955*) *"Red rock," from Robert Fleming's mine*, near Monroe furnace, Huntingdon county.

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§ 87. *Ferruginous Shale.*

In "Shutler's Hill," south-east of Tioga village, some 200 feet, more or less, of Catskill rocks, principally red shale and sandstone, may be seen, dipping to the southward. These strata have been further exposed by excavations made in search of an ore said to combine new and wonderful properties. Indeed, the hill has been honeycombed with shafts and trenches, and much time and money wasted. (G. pages 77, 78.)

Many absurd claims have been made on behalf of this so-called ore, but a most thorough analysis has failed to find anything unusual in it. It is simply a ferruginous shale carrying the usual constituents of that rock, and contains absolutely nothing aside from what is shown in the following analysis.

Tioga County.	*(339)* "*Hathaway Ore.*"	
Silica,	59.630	
Alumina,	18.560	
Sesquioxide of iron,	8.571	= 6.00 per cent. iron.
Sesquioxide of manganese,	.290	
Lime,	.672	
Magnesia,	2.252	
Potash and soda,	5.109	
Sulphuric acid,	.123	= .050 per cent. sulphur.
Phosphoric acid,	.279	= .122 per cent. phosphorus.
Titanic acid,	trace.	
Water,	4.560	
	100.046	

(*339*) "*Hathaway Ore*," in "Shutler's Hill," opposite Tioga, Tioga county. Ferruginous shale, carrying numerous small scales of mica.

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§ *88. Red Hematite Ore from the Coal Measures.*

Red hematite iron ore is of unusual occurrence in the Coal Measures.

Occasional nodules have been found in Pennsylvania; and Dr. T. Sterry Hunt has observed numerous specimens of this valuable ore in the Coal Measures of the Hocking valley in Ohio.

An analysis of a specimen shows it to have the following composition:

Fayette County.	(*52*) *Youghiogheny valley.*
Metallic iron,	52.200
Sulphur,	.131
Phosphorus,	.080
Water,	1.790
Insoluble residue,	18.320

(*52*) *Red hematite from the Barren Measures*, in the Youghiogheny Valley, Fayette county. See Report L, p. 111.

Exceedingly hard and tough arenaceous red hematite.

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§ *89. Carbonate Iron Ore.*

Sullivan County.	(*815*) (*Ganoga.*)
Metallic iron,	32.000
Sulphur,	.040
Phosphorus,	.204
Insoluble residue,	19.420

(*815*) *Carbonate ore found near Ganoga Lake*, Sullivan county. See Report GG.

More or less oxidized; color, greenish grey to reddish brown.

§ 90. *Paints.*

The following are the analyses of two specimens of paint produced by the calcination of iron pyrites.

Mercer County.	*(1006a) Oriental Paint Co.*	*(1006b) Oriental Paint Co.*
Sesquioxide of iron,	66.143	77.143
Protoxide of iron,	6.300	5.142
Bisulphide of iron,	.415	.405
Alumina,	.697	.543
Lime,	.160	.160
Magnesia,	.100	.100
Sulphuric acid,	13.110	7.334
Silica,	3.880	3.980
Water and carbonaceous matter,	9.195	5.194
	100.000	100.000

(*1006a*) *Oriental Paint Co.'s paint*, Jamestown, Mercer county.

Produced by roasting iron pyrites, &c.

(*1006b*) Same as No. (1006a), but leached.

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§ 91. *Iron Pyrites.*

The analysis given underneath shows the composition of a specimen of iron pyrites from the Coal Measures. It is used for producing paint in the works of the Oriental Paint Co. at Jamestown, Mercer county.

Mercer county.	*(1006c) Oriental Paint Co.*
Bisulphide of iron,	96.161
Bisulphide of copper,	trace.
Alumina,	.653
Lime,	.450
Magnesia,	.140
Silica,	.680
Undetermined,	1.916
	100.000

(*1006c*) *Iron pyrites used in Oriental Paint Co.'s Works* for producing paint. Analysis of pyrites made by Mr. John M. Stinson, under my direction.

§ 92. Weathered Coals.

Clinton county.	(541) Tangascootac coal, [Lower bed.]	(542) Tangascootac coal, [Upper bed.]
Water,	.550	.730
Volatile matter,	20.845	18.190
Fixed carbon,	67.801	57.719
Sulphur,	.659	.981
Ash,	10.145	22.380
	100.000	100.000
Fuel ratio,	1 : 3.25	1 : 3.17
Coke, per cent.,	78.605	81.080
Color of ash,	grey.	grey.

(*541*) *Tangascootac coal*, ten miles west from Lock Haven, on S. fork of Tangascootac creek, Clinton county. *Lower bed, probably bed A.* Coal mined eight years ago, October 8, 1875. Analysed by D. McCreath, October, 1876.

Coal has a dull luster, and is somewhat iridescent.

(*542*) *Tangascootac coal*, ten miles west from Lock Haven, on S. fork of Tangascootac creek, Clinton county. *Upper bed, probably bed B.* Mined not less than twenty-two years ago, and exposed all that time, October 7, 1875. Analysed by D. McCreath, October, 1876.

Coal has a dull resinous luster, and is seamed with slate and iron pyrites.

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§ 93. Coal Ash.

Clinton county.	(806b) McIntyre.
Silica,	47.585
Alumina,	40.117
Sesqnioxide of iron,	6.143
Titanic acid,	1.190
Lime,	.960
Magnesia,	.731
Sulphuric acid,	.932
Phosphoric acid,	.123
Potash and soda,	1.486
	99.267

(*806b*) *Coal ash* from *McIntyre Coal Co.'s coal*, Drift No. 2; Bed E. Coal contains 9.125 per cent. ash. See coal analysis No. (806a,) page 47.

§ 94. *Analyses of Coals Grouped According to Counties.*

Under this section are grouped the analyses of coals which have been given in detail in the body of this report.

The analyses from each county are given under their proper heading, so that the general character of the coals from each county may be seen at a glance.

For convenience of reference the number of the analysis and the page of the report on which the detailed analysis is recorded, are added to the tables.

No. of analysis.	Page of Report.	NAME OF COAL.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.
		Greene county.					
164	4	Minor,	1.230	33.135	49.115	1.705	14.815
154	6	Minor,	1.175	35.615	49.725	2.280	11.205
8	4	Stevenson,	1.036	38.304	48.966	2.726	8.968
155	6	Sayers,	1.265	34.685	49.590	1.270	13.190
156	6	Lippincott,	1.235	36.185	46.723	2.972	12.885
153	6	Orr,	.920	33.710	52.064	1.121	12.185
157	6	Shape,	1.200	38.860	49.402	2.345	8.190
158	6	Price,	1.000	35.675	50.846	1.694	10.785
7	6	Groom,	1.180	32.344	51.582	1.306	13.588
5	9	Lucas,	1.790	35.400	56.818	1.152	4.840
9	9	Whitely creek,	1.500	30.428	55.038	1.406	11.628
10	9	Gray,	1.088	34.012	51.783	2.261	10.856
160	13	Vernon,	1.020	38.490	45.895	2.905	11.690
159	16	Vernon,	1.040	37.225	56.608	.982	4.145
161	16	Vernon,	.850	38.580	54.185	1.290	5.095
6	16	Maple Farm,	1.030	36.490	59.051	.819	2.610
162	19	Miller,	.900	38.390	52.649	1.941	6.120
		Washington county.					
147	4	Henderson,	1.695	39.150	46.658	1.972	10.525
151	5	James,	1.385	37.210	42.335	3.710	15.360
152	5	Hill,	.770	36.115	48.554	2.146	12.415
150	5	Rogers,	.740	36.040	46.890	2.375	13.955
148	7	Denning,	1.810	38.520	51.181	1.179	7.310
149	7	Moninger,	1.190	36.585	43.489	2.806	15.930
146	10	Teeple,	1.060	33.590	48.688	2.367	14.295
145	13	Patterson,	.775	36.770	51.467	2.098	8.890
139	13	Magee,	1.510	40.510	41.324	7.566	9.090
177	13	Bushfield,	1.730	37.735	54.561	1.499	4.475
165	13	Thomas,	1.080	40.350	50.311	2.594	5.665
166	13	New Eagle Works,	1.180	35.830	58.154	.761	4.075
181	14	Liddell,	.650	35.075	55.030	1.910	7.335
135	14	Reed,	1.110	35.315	57.332	.648	5.595
136	14	Neil,	1.000	35.350	55.010	.895	7.745
137	14	West,	1.220	35.420	60.537	.658	2.165
138	14	White,	.890	36.810	55.312	.643	6.345
180	17	Ashurst,	1.010	40.995	48.769	2.206	7.020
179	18	Magee,	1.130	38.720	40.253	3.722	16.175
142	18	New Eagle Works,	1.140	35.275	58.167	.758	4.660
143	18	Liddell,	1.425	36.880	56.829	.796	4.070

No. of analysis.	Page of Report.	NAME OF COAL.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.
140	18	Neil,	1.120	34.655	60.414	.766	3.045
141	18	White,	1.290	34.125	57.975	.586	6.020
134	20	Harding,	1.540	37.825	57.063	.762	2.810
144	20	Thomson,	1.095	39.790	55.033	1.172	2.910
178	20	Redd,	.680	38.525	55.920	.855	4.020
690*a*	20	Slocum,	1.130	38.040	52.670	1.450	6.710
690*b*	20	Slocum,	1.150	36.920	52.067	.748	9.115
690*c*	20	Slocum,	1.320	35.410	59.545	.640	3.085
690*d*	20	Slocum,	1.410	35.835	58.058	.677	4.020
		Beaver county.					
173	40	Todd,	1.500	39.870	46.960	4.595	7.075
182	40	Todd,	1.370	37.800	54.463	1.587	4.780
172	40	Swearingen,	2.080	39.520	54.691	1.249	2.460
174	40	Wilson,	1.530	41.380	49.798	2.467	4.825
171	40	Cotter,	1.660	37.065	51.351	2.709	7.215
175	54	Diehl,	1.770	38.620	56.333	.717	2.560
176	54	Bryan,	2.090	35.700	59.685	.580	1.945
507	54	Dougherty,	3.090	37.915	56.980	.495	1.520
486*a*	54	Mansfield,	1.780	40.760	49.391	3.379	4.690
486*b*	54	Mansfield,	1.160	48.015	38.241	.599	11.985
513	54	Middleton,	2.680	36.205	53.804	2.391	4.920
511*a*	64	Mendenhall,	1.850	41.260	43.263	4.177	9.450
515*a*	64	Couch,	2.080	39.285	48.818	1.927	7.925
509*a*	64	Hulmes,	2.200	39.440	50.705	.825	6.830
511*b*	65	Mendenhall,	2.270	38.870	50.173	2.322	6.365
514	65	Fish,	2.160	40.885	49.488	1.767	5.700
515*b*	65	Couch,	2.370	36.470	51.845	1.170	7.545
509*b*	65	Hulmes,	2.400	38.110	54.619	.791	4.080
510	66	Fell,	1.450	34.270	36.193	3.357	24.730
508	66	Ross & Smith,	1.620	39.385	43.603	2.822	12.570
		Lawrence county.					
626	37	Miller,	1.940	39.265	55.828	.727	2.240
635	37	Miller,	1.930	40.125	55.606	.849	1.490
623	52	McConnell,	1.950	40.860	53.531	1.199	2.460
630	52	Woolley,	2.340	39.480	55.774	.741	1.665
632	52	Granniss,	2.100	41.210	54.163	.587	1.940
627	53	Lee & Patterson,	2.170	39.610	55.591	.789	1.840
624	53	Armstrong,	1.660	40.760	50.008	2.572	5.000
629	53	Rogers,	1.990	39.990	52.286	1.734	4.000
625	53	Brown,	2.710	39 220	55.693	.567	1.810
631	53	Brown,	3.055	38.260	53.585	.675	4.425
628	66	Sharpless & Kincaid,	2.670	38.790	54.994	.956	2.590
637	66	Nelson,	1.930	42.445	49.823	1.832	3.970
636	97	Miller,	1.190	48.140	44.084	1.951	4.635
633	98	Brown,	2.030	42.147	44.233	4.087	7.503
		Butler county.					
488	37	Cable,	1.740	42.450	45.551	4.104	6.155
472	37	Wilson,	1.500	43.860	47.415	2.700	4.525
932	41	Unionville,	2.110	37.570	51.248	1.890	7.178
485	48	Schantz,	2.290	33.580	55.772	1.158	7.200
502	55	Fiedler,	1.390	41.265	48.029	3.061	5.715
470	55	Melvin,	1.455	43.250	49.716	2.109	3.470
487	55	Bieber,	1.300	40.220	42.661	2.404	13.415

No. of analysis.	Page of Report.	NAME OF COAL.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.
934	55	McGarvey,	1.610	40.300	49.456	.739	7.895
933	63	Studebaker,	2.270	40.990	46.794	1.871	8.075
935	63	Mercer Company,	2.430	36.735	47.858	.767	12.210
936	63	Mercer Company,	2.920	38.495	54.138	.842	3.605
		Indiana county.					
683	17	George,	1.680	34.975	57.000	.665	5.680
680	15	Evans,	1.040	36.940	50.850	1.495	9.705
677	15	Ashbaugh,	1.110	37.555	53.639	1.436	6.260
685*a*	15	Doty,	1.370	29.130	58.461	.849	10.190
685*b*	15	Smith,	1.130	28.895	56.409	2.571	10.995
679	19	Evans,	1.460	31.995	53.788	.997	11.760
684	27	Sloan,	.850	27.385	49.748	3.017	19.000
688	41	Groft Bros.,	.950	31.420	55.215	1.215	11.200
673	41	Beatty,	.990	31.760	52.190	4.625	10.435
682	41	Hazlett,	1.180	26.500	56.697	.671	14.970
621	42	Griffith,	.590	28.710	52.488	5.462	17.750
619	42	Griffith,	.700	29.680	63.766	1.719	4.135
620	42	Indiana Coal Co.,	.800	25.770	70.224	.621	2.585
678	42	Waddle,	1.220	32.570	59.689	2.151	4.370
616	43	Snyder,	.770	27.800	67.537	.718	3.175
615	43	Rugar,	.600	26.531	61.525	.629	10.715
617*a*	43	Harris,	.660	24.467	71.900	.588	2.385
617*b*	43	Harris,	.450	24.215	60.947	1.173	13.215
687	43	Marlin,	1.100	31.890	60.736	1.279	4.995
689	48	Brady,	.920	31.320	57.266	2.669	7.825
681	48	Forsythe,	1.010	28.505	55.380	.700	14.405
674*a*	57	Lowry,	.880	23.375	50.324	.621	24.800
674*b*	57	Lowry,	.870	24.485	52.964	.621	21.060
674*c*	57	Lowry,	1.320	30.320	66.083	.654	1.623
686	58	Jeffries,	.860	31.535	59.093	3.162	5.350
676	58	Walker,	1.270	28.930	60.175	.950	8.675
675	58	Walker,	1.240	29.630	65.172	.503	3.455
618	71	Indiana Coal Co.,	.920	24.356	62.218	4.916	7.590
622	85	Meldren,	.560	27.880	61.920	3.610	6.030
		Westmoreland county.					
638*a*	15	McFarland,	1.275	25.195	65.517	2.248	5.765
638*b*	17	McFarland,	1.190	26.080	59.789	3.116	9.825
473*a*	22	Westmoreland Coal Co.,	1.410	37.655	54.439	.636	5.860
473*b*	22	Westmoreland Coal Co.,	1.310	37.100	55.004	.636	5.950
473*c*	22	Westmoreland Coal Co.,	1.560	39.185	54.352	.643	4.260
505*a*	23	Penn Gas Coal Co.,	1.780	35.360	59.290	.680	2.890
505*b*	23	Penn Gas Coal Co.,	1.280	38.105	54.383	.792	5.440
505*c*	23	Penn Gas Coal Co.,	1.490	37.153	58.193	.658	2.506
489	24	Fulton & Pinkerton,	1.200	32.955	54.830	.635	10.380
480	24	Greensburg Coal Co.,	1.020	33.495	61.344	.861	3.280
482	24	Horner,	1.200	33.600	58.491	.794	5.915
474	24	Hunter,	1.250	42.110	48.820	2.075	5.745
476	24	Kunkle,	.970	37.845	53.234	1.541	6.410
495	24	Saltzburg Coal Co.,	1.070	35.515	56.458	2.257	4.700
506	25	Saxman,	1.590	30.945	63.489	.796	3.180
475	26	Seanor,	1.010	32.980	62.962	.788	2.260
503	26	Lomison,	.830	31.030	62.819	.746	4.575
471	26	Millwood Coal Co.,	1.240	30.715	63.799	.621	3.625
483	26	Seaton,	.580	24.850	64.779	3.496	6.295

No. of analysis.	Page of Report.	Name of Coal.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.
484	26	Cauffield,	1.050	25.170	69.602	.668	3.510
479	26	Kehoe,	.930	27.365	49.651	.859	21.195
481	26	Chambers,	1.140	29.880	62.227	.668	6.085
477	26	Anderson,	.880	31.720	61.072	1.143	5.185
940	44	Kier Bros.,	1.060	33.955	54.392	1.058	9.535
478	44	Snodgrass,	.890	34.100	56.088	3.932	4.990
691	44	Lyon,	.770	23.910	64.526	4.789	6.005
692	67	Hall,	.780	20.405	69.570	3.285	5.960
		Fayette county.					
500	9	Woolsey,	1.060	34.805	53.538	2.432	8.165
498	21	Beal,	1.020	31.840	61.844	.736	4.560
501	21	McCormack heirs,	.960	33.635	60.200	.905	4.300
496	21	Townsend,	.890	34.545	59.450	.895	4.220
30	22	Frick & Co.,	1.260	30.107	59.616	.784	8.233
499	22	Kendall,	1.040	32.815	60.241	1.249	4.655
497	22	Swan heirs,	.930	33.710	59.391	.909	5.060
696	44	Potter,	.870	27.255	61.759	2.031	8.085
695*b*	44	Fayette Furnace,	.930	24.545	69.956	1.414	3.155
693	48	Mitchell,	.700	25.470	54.673	3.673	15.485
695*a*	67	Fayette Furnace,	.860	21.815	59.417	4.398	13.510
694	70	Potter,	.860	26.490	65.570	2.025	5.055
		Somerset county.					
350	10	Keystone,	1.290	20.865	67.201	1.839	8.805
458	27	Beachy,	1.680	21.010	69.016	.764	7.530
443*a*	27	Wilhelm,	1.190	21.000	66.907	.713	10.190
443*b*	27	Wilhelm,	1.570	21.450	69.986	.679	6.315
459	27	Yoder,	1.465	21.285	69.677	.693	6.880
456	28	Livengood & Keim,	1.665	22.350	68.744	1.246	5.965
349	28	Keystone,	1.050	19.610	70.239	.761	8.340
457	28	Cumberland & Elk Lick,	1.385	21.470	69.352	.763	7.030
460	28	Saylor Hill,	1.630	19.965	66.510	.775	11.120
399	31	Berkey,	.890	20.525	65.903	1.142	11.540
461	32	Walker,	1.945	21.935	68.554	1.161	6.405
428	32	Coleman,	2.010	20.535	68.321	.744	8.390
442	32	Fritz,	1.625	22.760	67.467	.803	7.345
410	32	Berkey,	1.110	20.505	63.470	3.785	11.130
396	33	Weighley,	1.000	18.175	53.521	5.384	21.920
372	34	Price,	.870	20.330	68.944	1 176	8.680
351	36	P. & B. C. C. & I. Co.,	.920	22.950	66.999	3.096	6.035
46	36	P. & B. C. C. & I. Co.,	1.555	23.480	63.483	4.037	7.445
398	45	S. & M. P. R. R. Co.,	.860	16.885	66.055	.585	15.615
383	49	Reitz,	.940	19.060	70.659	1.291	8.050
371	49	Garrett Coal Co.,	1.020	17.135	66.679	.676	14.490
397	59	Beam,	.820	17.235	74.881	.519	6.545
446	59	Trevorrow,	.670	14.530	74.800	.635	9.365
401	59	Wilt,	.600	15.415	70.632	1.748	11.605
314	59	Pile,	.950	16.540	71.206	2.409	8.895
447	59	Wigle,	.850	16.850	69.578	2.587	10.135
400	71	Liston Bros.,	.910	21.960	64.597	2.298	10.235
382	71	Zimmerman,	.630	15.565	67.420	3.590	12.795
381	71	Clark,	.770	15.870	76.925	.690	5.745
377	87	Heinemeyer,	.600	26.000	55.683	2.167	15.550

No. of analysis.	Page of Report.	Name of Coal.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.
		Cambria county.					
378	34	Brown,	.820	19.155	70.175	.445	9.405
379	34	Brown,	.550	17.325	61.632	1.033	19.460
375	45	Kindport,	.880	24.630	68.333	1.227	4.930
374	45	Garman,	1.260	25.185	66.797	.568	6.190
192	45	Dysart & Co.,	.715	22.250	70.518	1.459	5.058
373	49	Luly,	.800	24.635	72.436	.559	1.570
439*b*	59	Ramsey,	1.745	23.590	68.805	.535	5.325
2	59	Cambria Iron Co.,	1.140	17.180	73.424	1.408	6.848
439*a*	67	Ramsey,	1.355	24.581	63.101	.643	10.320
1	72	Cambria Iron Co.,	1.185	16.540	74.456	1.860	5.959
307	72	Cambria Iron Co.,	1.100	17.240	73.145	2.352	6.163
316	72	Martin,	.840	18.535	77.132	.573	2.920
191	72	Dysart & Co.,	.615	17.935	76.503	.602	4.345
311	73	Mellon,	.850	22.590	66.694	3.126	6 740
425	73	Mellon,	.880	22.755	68.340	1.905	6.120
313	73	Wirtner,	.750	21.930	61.597	2.253	13.470
304	74	Bell's Gap R. R. Co.,	.630	24.230	59.216	2.239	13 685
305	74	Bell's Gap R. R. Co.,	.710	26.065	64.806	1.509	6.910
306	74	Bell's Gap R. R. Co.,	.970	26.130	63.624	2.581	6.695
348	74	Brotherline,	1.340	25.425	64.541	.734	7.960
444	86	Shoemaker,	1.360	23.480	69.945	.955	4.260
445	86	Shoemaker,	.840	22.710	49.417	8.853	18.180
376	86	Moore,	.690	20.595	74.690	.850	3.175
312	86	Moore,	.340	17.360	58.294	1.806	22.200
310	86	Cambria Iron Co.,	1.470	17.930	75.508	.567	4.525
		Blair county.					
302	46	Dennison, Porter & Co.,	.960	26.400	65.586	2.274	4.780
309	46	Kittanning Coal Co.,	1.190	26.975	64.357	2.728	4.750
3	74	Cambria Iron Co.,	1.400	27.225	61.843	2.602	6.930
303	74	Dennison, Porter & Co.,	.910	26.340	64.373	1.792	6.585
411	75	Glen White,	.940	29.660	59.912	.978	8.510
412	75	Glen White,	1.040	28.010	49.244	4.501	17.205
308	75	Baker,	.950	28.915	63.462	.983	5.690
384	75	Baker,	.900	25.630	51.305	4.400	17.765
402	89	Woodcock,	1.260	26.290	66 133	.567	5.750
		Huntingdon county.					
75	60	Robertsdale Colliery,	.450	16.210	70.601	4.170	8.569
76	60	Robertsdale Colliery,	.535	15.910	71.898	3.434	8.223
77	67	Robertsdale Colliery,	.395	16.140	72.942	2.483	8.040
78	67	Robertsdale Colliery,	.560	16.002	73.091	1.115	9.232
206	68	Alloway Colliery,	.250	14.510	77.042	1.338	6.860
187	89	Savage Colliery,	.390	18.165	75.421	.994	5.030
188	89	Taylor Colliery,	1.020	17.840	74.623	.797	5.720
814	89	Dougherty Colliery,	.210	17.540	67.154	1.496	13.600
		McKean county.					
720*a*	69	Coal Pit Bed,	5.960	36.385	51.673	.677	5.305
720*b*	69	Coal Pit Bed,	7.710	33.705	55.868	.802	1.915
715	76	Buffalo Coal Co.,	1.470	38.710	44.561	4.839	10.420
717	90	Spring Bed,	1.780	36.270	47.791	5.069	9.090
718	90	Rochester,	1.330	27.170	26.906	10.259	34.335
614*a*	91	Bond Vein,	.670	36.065	48.417	1.058	13.790
614*b*	91	Bond Vein,	1.030	37.630	51.237	1.553	8.550

No. of analysis.	Page of Report.	Name of Coal.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.
614*c*	91	Bond Vein, ...	.710	32.980	46.867	2.943	16.500
716*a*	91	Hamlin Bed, ...	1.210	36.895	52.593	2.037	7.265
716*b*	91	Hamlin Bed, ...	1.060	28.990	35.588	.977	33.385
719	92	Rock Seam, ...	1.860	34.630	47.304	2.491	13.715
		Potter county.					
704*a*	76	West Branch Pine Creek,	3.070	30.970	55.170	.975	9.845
704*b*	76	West Branch Pine Creek,	.950	31.700	56.500	1.000	9.850
1000	77	McLean, ...	1.150	34.185	54.276	1.059	9.330
		Tioga county.					
672	61	Fall Brook Coal Co., . . .	1.460	21.600	65.120	2.820	9.000
669	61	Blossburg Coal Co., . . .	1.180	21.586	71.574	.907	4.753
665	61	Morris Run Coal Co., . .	.950	19.830	60.759	6.856	11.605
654	61	Fall Brook Coal Co., . . .	1.970	20.105	68.360	1.795	7.770
706	77	Bache, ...	2.240	20.045	70.357	.588	6.770
707	77	Bache, ...	2.380	20.005	70.055	.565	6.995
705	77	Mitchell, ...	1.810	20.350	68.126	.569	9.145
671	78	Fall Brook Coal Co., . .	2.260	20.240	71.847	.548	5.105
601*a*	78	Blossburg Coal Co., . .	1.190	20.755	71.697	1.023	5.335
601*c*	78	Blossburg Coal Co., . .	.940	20.640	64.306	.914	13.200
601*b*	78	Blossburg Coal Co., .	1.110	18.790	63.428	.602	16.070
664	79	Morris Run Coal Co., .	1.120	18.570	72.097	.583	7.630
657*a*	79	Fall Brook Coal Co., . . .	1.050	18.540	69.934	.661	9.815
703	80	Knox & Billings, ...	3.260	27.860	61.421	.804	7.655
658*a*	92	Fall Brook Coal Co., . .	.790	20.965	65.465	.725	12.055
655	93	Fall Brook Coal Co., . . .	1.560	20.740	66.587	.773	10.340
656	93	Fall Brook Coal Co., . . .	2.820	17.975	71.326	.634	7.245
		Bradford county.					
660	80	Barclay Coal Co., . .	.730	17.220	69.840	.795	11.415
661*a*	80	Barclay Coal Co., . . .	.760	16.405	62.172	.613	20.050
662*a*	80	Barclay Coal Co., ...	.880	16.660	73.257	.643	8.560
663	80	Barclay Coal Co., ...	.770	17.110	70.744	.776	10.600
668*a*	82	Schroeder, ...	.940	17.845	72.155	.670	8.390
668*b*	82	Schroeder, ...	.850	16.755	69.390	.715	12.290
659	87	Barclay Coal Co., ...	.850	16.625	67.292	.498	14.735
		Lycoming county.					
806	47	McIntyre Coal Co., . . .	.950	17.940	71.151	.834	9.125
805	47	McIntyre Coal Co., . . .	1.170	17.120	73.682	.843	7.185
		Sullivan county.					
315	82	S. L. & S. R. R. Co., . . .	1.295	8.100	83.344	1.031	6.230
666*a*	82	S. L. & S. R. R. Co., . . .	1.840	9.835	76.788	.647	10.890
666*b*	82	S. L. & S. R. R. Co., . . .	1.800	9.650	82.373	.622	5.555
666*c*	82	S. L. & S. R. R. Co., . . .	2.220	9.405	81.267	.618	6.490
937	83	S. L. & S. R. R. Co., . . .	2.340	8.440	80.949	.726	7.545
812*a*	84	Lippincott & Mercur, . .	.930	12.410	75.611	.574	10.475
812*b*	84	Lippincott & Mercur, . .	.810	13.060	71.679	.581	13.870
667	94	S. L. & S. R. R. Co., . . .	5.815	15.085	62.329	.479	16.297
803	94	S. L. & S. R. R. Co., . . .	4.130	15.270	67.362	.523	12.715
938	94	S. L. & S. R. R. Co., . . .	7.930	21.410	54.099	.551	16.010
939	94	S. L. & S. R. R. Co., . . .	2.910	11.780	81.672	.598	3.040
813	95	Hall, ...	6.830	21.930	55.413	.387	15.440

§ 95. ANTHRACITE SLACK.

On the utilization of Anthracite Slack Coal by coking with a mixture of Bituminous Coal. By FRANKLIN PLATT.

At the end of Chapter V of Report L,* there has been given a condensed description of a method now used in Wales for coking Anthracite Slack Coal or crushed Anthracite Coal.

The process as used there is as follows:

After crushing and washing the coal, the coking oven was charged with

60 per cent. of Anthracite slack or crushed coal.
35 per cent. of Bituminous coal or slack.
5 per cent. of Pitch.

This was covered o er in the oven with about two inches of bituminous coal, "to prevent the burning off of the pitch at first," and then coked 72 hours in a Belgian oven. Various details are given of the specific gravity, character and efficiency of this coke: but no record of analyses of the materials used in the mixture.

In view of the statements made as to the success of this method of coking in Wales, and the record of the trial of a large amount of the coke in the furnace stack at the Landore works, the Board of Commissioners of the Second Geological Survey of Pennsylvania requested the Chief Geologist to have tests made for utilizing Anthracite Slack Coal by mixing it with Bituminous Coal and Pitch as had been tried in Wales, and in other and varying proportions of the different constituents, for forming a coke. Under instructions from Prof. J. P. Lesley, Chief Geologist, such examinations have been made as were deemed necessary to answer the question as to whether it was possible to form economically from Anthracite Slack and Bituminous Coal a coke which would be an efficient fuel in blast furnace stacks, and for other purposes for which coke is used.

The Welsh Anthracite, used in the experiments at Swansea, Wales, is a soft anthracite coal holding from 6.5 to 8.5

* Report L, 1875, pp. 85–87.

per cent, of volatile matters. It was deemed advisable to secure as nearly as possible a similar fuel for the first tests made here and application was therefore made to J. Imbrie Miller Esq., Vice President of the Mineral Mining and Railroad Company, for permission to select the necessary Anthracite Slack from his Shamokin mines. This was at once granted, and eleven tons of the slack coal from the Cameron Colliery, near Shamokin, Northumberland county, Pennsylvania, were selected at the colliery and forwarded to Johnstown for use in the tests. A. J. Cassatt, Esq., Vice President of the Pennsylvania Railroad Company kindly furnished the requisite transportation needed to bring the different materials together at Johnstown.

On application to D. J. Morrell, Esq., General Manager of the Cambria Iron Company, he furnished the use of the necessary Belgian Coking ovens at Johnstown, Cambria county, and also gave such Bituminous Coal as was needed in the experiments.

In giving the various tests, without entering into detail of each one, it may be said that they were made in conjunction with Jno. Fulton, Esq., General Mining Engineer, and T. T. Morrell, Esq., Chemist of the Cambria Iron Company. Dan'l. N. Jones, Esq., Chief Engineer of the Company, conducted the tests for the comparative calorific efficiency of the anthracite coke in the cupola of the foundry, and Mr. Jno. McFadyen, Chief Coker, conducted the oven tests most carefully and skillfully.

The materials used were

1. Anthracite slack coal from the Cameron Colliery, Shamokin. This slack was made up partly of fine coal dust, and partly of small pieces of coal, ranging in size from a pea up to an olive, "shot coal" as it is called, with some few larger pieces. It was chosen, as far as possible, clean and free from slate.

An analysis of clean lump coal from this colliery, made at the Laboratory of the Survey, by A. S. McCreath, chemist, showed:

Water at 225°,	1.815
Volatile matter,	6.180
Fixed carbon,	86.748
Sulphur,	.755
Ash,	4.502
	100.000
Color of ash,	reddish grey.

This analysis shows the general character of the material which could be used, after thoroughly washing the slack; though, of course, the washed slack would not be quite so clean as the lump coal.

The anthracite slack coal actually used in the experiments, representing an average of the eleven tons employed, was analyzed by Mr. McCreath, and showed:

Water at 225°,	2.280
Volatile matter,	6.620
Fixed carbon,	75.725
Sulphur,	1.195
Ash,	14.190
	100.000
Color of ash,	reddish grey.

2. Bituminous slack coal, from Latrobe, Westmoreland county, Pennsylvania. This slack came from a mine working the Pittsburg Coal Bed. It showed considerable slate and iron pyrites. An average specimen of it forwarded to the State laboratory, yielded, on analysis, (D. McCreath):

Water at 225°,	.810
Volatile matter,	29.330
Fixed carbon,	57.399
Sulphur,	1.398
Ash,	11.063
	100.000
Coke, per cent.,	69.86
Color of ash,	reddish grey.

3. Clean, dry, vegetable pitch, ship pitch. Gas coal tar would doubtless have answered as well, but the dry pitch was more desirable, on account of the difficulty in mixing the tar with the coal without any mixing machinery. A specimen of the pitch forwarded to the Laboratory yielded on analysis, (McCreath):

Volatile combustible matter,	99.317
Sulphur,	.028
Ash,	.655
	100.000

The Anthracite Slack Coal was intentionally selected partly as coal dust, and partly as fine coal in order to see by charging different ovens, first with fine anthracite dust and then with the mingled dust and small coal, whether the fine coal prevented the formation of a coherent coke. If so, only dust could be used in future experiments, and anthracite slack, to prepare it for this process would need to pass through a crusher to fit for use in coking.

As soon as possible after the experiments were ordered the Anthracite slack was selected at the Cameron Colliery and shipped to Johnstown by Mr. Chester, Superintendent of the Colliery.

Numerous experiments were made in Mr. Morrell's laboratory in Johnstown, the coking being done in crucibles of various sizes, and with widely varing proportions of Anthracite slack, Bituminous slack, and Pitch. Without entering into details of every test it may be said that the proportions varied from 50 anthracite and 50 bituminous, down to 80 anthracite and 20 bituminous.

The results showed that the limit of reduction of proportion of bituminous coal to be admixed with the anthracite slack had been reached and passed.

Fifty per cent. of Anthracite Slack and 50 per cent. of Bituminous Coal made a firm, tough, silvery, strong coke; 60 per cent. of Anthracite Slack and 40 per cent. of Bituminous Coal made a coke very decidedly weaker; 66⅔ per cent. of Anthracite Slack and 33⅓ per cent. of Bituminous Coal made a coke much weaker still. The other tests made with mixtures containing larger percentages of Anthracite Slack and less of Bituminous Coal, produced a coke entirely worthless for purposes requiring the carrying of any burden, and in fact scarcely cohering.

Nor was the decrease in strength in the coke directly proportional to the decrease in the percentage of Bituminous Coal; but it fell off sharply, and with marked changes in strength where the Bituminous Coal percentage had been only slightly diminished.

In so far as the Laboratory experiments could be accepted as a guide it was clearly useless to charge into the Belgian Oven any proportion lower than 60 per cent. of Anthracite Slack to 40 per cent. of Bituminous Coal.

In the experiment made in Wales for coking the anthracite dust or slack, the admixture of 5 per cent. of Pitch was dwelt upon as a feature of importance. Yet in these laboratory tests it entirely failed to give any evidence of the value assigned to it. Several trials were made, coking first a certain mixture of anthracite slack without any pitch, and then afterward with the pitch or coal tar to the proportion of 5 per cent. added and mixed, and it was impossible to note any special improvement in the coke. One value it probably has, that of burning up more readily than the volatile matters of the coal, and thus supplying heat at first when it is needed. In the case of charging into a chilled oven this would be of service; but where the oven used is sufficiently hot, the mixture of anthracite slack and bituminous coal, without any pitch at all, makes apparently an equally good coke.

There was no evidence in the laboratory tests that the anthracite slack coked at all. It simply furnished its volatile matters, 6 per cent., to assist in burning. In order however to be sure that it did not coke at all, even to the smallest extent, mixtures of anthracite dust finely powdered, and vegetable pitch or gas coal tar in varying proportions, ranging from 5 to 25 per cent. of the mass, were burned in a platinum crucible, over a Bunsen burner. Not the slightest trace of coking appeared; agreeing in this respect with what had been shown by the previous tests.

After these preliminary trials, tests were made in the thirty inch wide Belgian Ovens of the Cambria Iron Company at Johnstown.

The Anthracite Slack and the Bituminous Slack Coal were used without washing. For the first charge the Anthracite Slack was taken simply by the run of the car load, dust and fine coal mixed, about in the proportion of one half fine dust and one half small pieces of coal, ranging in size from a pea to an olive. The charge was made up of

4800	pounds of	Anthracite Slack	Coal,	Shamokin.
2800	"	Bituminous	"	Latrobe.
400	"	Pitch.		
8000	pounds.			

In addition the charge was covered over to a depth of 2 inches with Bituminous Slack coal, using in this 500 pounds. There being no apparatus for thoroughly mixing the different constituents it was imperfectly done by hand.

The charge was made into a hot oven, and was burned for 72 hours.

This was clearly too long a time: for the coke mass was burned away considerably to ash on the top, so considerably in fact that no weight was taken of the coke to ascertain the average percentage of yield. This was found from future charges.

The coke came out in a mass, and was watered outside of the oven. It was compact and required to be broken up. It showed a conglomerate of anthracite pieces and dust, held in a matrix of coke, and was bright, silvery and open, yet apparently dry and holding only a moderate amount of water. The Latrobe coal charged into the oven makes by itself an open coke, and the anthracite pieces mixed with it in this charge had made the coke more open instead of more dense and compact.

A specimen of this coke forwarded to the State Laboratory yielded on analysis (A. S. McCreath):

"Water at 225°,	2.532	average of 4
Volatile matter,	.997	" 3
Fixed carbon,	80.703	
Sulphur,	1.187	
Ash,	14.761	
	100.000	
Color of ash,	red with white specks.	

"The coke has a silvery luster generally, is moderately compact, but crumbles readily when struck with a hammer. The particles of Anthracite Slack are well cemented together but are not so much fused as not to be easily recognized throughout the mass. The coke carries a large amount of slate which will materially interfere with its energy in the blast furnace. It decrepitates slightly on being heated. When received it was very wet, but on exposure to the air it readily parts with a large percentage of the moisture."

In explanation of the large percentage of ash in the coke it must be remembered that the Latrobe coal was unwashed and held over 11 per cent. of ash: and that the anthracite slack holding over 14 per cent. of ash was also unwashed. The coke therefore was of course much more slaty than it would be after proper preparation of the constituents.

In order to test the advisability of using fine anthracite dust in preference to the ordinary run of the slack as used in Charge I, the anthracite slack coal was sifted and only the fine dust was used in Charge II. It was decided also to test in the same charge the question of coking without any admixture of pitch, and the oven was therefore charged in two parts, made up thus:

1st half.	2,400	pounds	Anthracite dust. Shamokin.
	1,400	"	Bituminous Slack. Latrobe.
	200	"	Pitch.
2nd half.	2,000	"	Anthracite dust.
	2,000	"	Bituminous Slack.
	500	"	Bituminous Slack used in covering.
	8,500	pounds in all.	

This was charged into a hot oven, covered over with bituminous coal to the depth of two inches, and coked 48 hours, instead of 72 hours as before. The ingredients were mixed together by hand, of course imperfectly, in the absence of any machinery for mixing.

The coke from the first half, that containing the pitch in the charge, was bright and open, but only tolerably compact. A specimen of this coke was forwarded to the State Laboratory and yielded on analysis, (A. S. McCreath :)

Water @ 225°,	.200
Volatile matter,	.584
Fixed carbon,	85.697
Sulphur,	1.050
Ash,	12.469
	100.000
Color of ash,	reddish grey.

This is in every respect a better coke than that made in Charge I. The unexpelled volatile matter is only .584, while before it was .997; the ash is 12.469 while in Charge I it was 14.761: and the sulphur is somewhat lower than before. The most striking difference however is in the percentage of water in the coke; in Charge II it is only .200 per cent. and in Charge I it was 2.352 per cent.

The coke from the second half of Charge II, that made from 50 per cent. Anthracite fine dust and 50 per cent. Bituminous Slack Coal, came from the oven as a tough, bright, firm, silvery coke, and to all appearances far superior as a fuel to the cokes previously made. Specimens of this coke, as of the others previously made, showed great variations in character owing to the imperfect mixing of the constituents; some pieces of coke being made up largely of coke from the Latrobe Coal alone, while others were unduly weak from too small a percentage of the Bituminous Coal. The coke moreover showed, as in all the previous cases, thoroughly burned into a firm coke on the sides of the oven, but much softer and less perfectly made in the interior. A fair average specimen forwarded to the State Laboratory yielded on analysis (A. S. McCreath):

Water at 225°,	.230
Volatile matter,	.559
Fixed carbon,	84.419
Sulphur,	1.021
Ash,	13.771
	100.000

Color of ash, ... reddish grey.

The percentage of ash in this coke is heavy, as would necessarily follow from using the unwashed anthracite and bituminous slack coals. A very noticeable feature however is the low percentage of water, only .230. This is unusually low for a coke made in a Belgian oven and watered outside; and every reduction in percentage of water adds at once to the calorific efficiency of the coke.

In order to test whether a smaller percentage of bituminous coal admixed would not yet suffice to make a firm coke, Charge III was made up of 60 per cent. of anthracite fine sifted dust, and 40 per cent. of Bituminous Slack Coal. The amounts charged were:

3,200 pounds Anthracite fine dust.
2,134 pounds Bituminous Slack.

This was put into a hot oven and coked for forty-eight hours. The coke showed a much darker colored mixture of anthracite dust and coke, and very decidedly less able to bear a burden than the cokes previously made. In this case also, while the sides showed perfectly burned coke, the interior of the mass was only partially coked. In these cokings much difficulty was experienced from the formation of a thick crust, within six to eight hours after beginning the coking; and this crust required to be broken up before the coking of the interior could proceed.

An average specimen of this coke forwarded to the laboratory of the Survey yielded, on analysis, (McCreath):

Water at 225°,	.260
Volatile matter,	.754
Fixed carbon,	83.756
Sulphur,	1.398
Ash,	13.832
	100.000
Color of ash,	reddish grey.

This coke is not quite equal in character to those preceding it, and is not strong or tough. It shows, however, the same remarkably low percentage of water.

The average yield of coke in the experiments in Wales is given at 80 per cent. of the weight of the charge. In Charge II at Johnstown the coal charged into the oven amounted in all to 8300 pounds, of which 4400 pounds were Anthracite dust and 3900 pounds, this including the covering coal, were Bituminous Slack Coal.

The yield of coke was 6162 pounds, or 73½ per cent. of the weight of the charge.

Taking the analyses of the Anthracite and Bituminous slacks it is seen that the theoretical yield of coke should be, if no fixed carbon were burned off in coking,

Anthracite culm,	4400 pounds @ 90 per cent.,	. . .	3960
Bituminous slack,	3900 " " 70 "	. . .	2730
			6690

This would be 80 per cent. of the coal charged. The loss of carbon was therefore $6\frac{1}{2}$ per cent.

The theoretical yield of coke from different mixtures, allowing that no fixed carbon was burned off in coking, would be

Anthracite slack, 60 per cent., Bituminous " 35 " Pitch 5 "	}	yield 78.5 per ct. of coke.
Anthracite slack, 50 per cent., Bituminous slack, 50 per cent.,	}	yield 80 per cent. of coke.
Anthracite slack, 60 per cent., Bituminous slack, 40 per cent.,	}	yield 82 per cent. of coke.
Anthracite slack, $66\frac{2}{3}$ per cent., Bituminous slack, $33\frac{1}{3}$ per cent.,	}	yield $83\frac{1}{3}$ per ct. of coke.

Probably about 5 to 6 per cent. below these theoretical yields could be realized in practical working in Belgian Coking Ovens.

These cokes were tested at Johnstown by Mr. Fulton for their burden bearing capacity and the results are embodied in the the table below. The coke made from 60 per cent of anthracite culm and 40 per cent of bituminous coal was so weak and valueless that it was excluded from tests of strength.

TABLE *exhibiting the physical properties of "conglomerate coke," produced from the following mixtures of anthracite culm, bituminous slack or small coal and pitch. Coked in Belgian ovens.*

COMPOSITION.	GRAMMES IN 1 CUBIC INCH.		POUNDS IN 1 CUBIC FOOT.		Per cent. of coke	Per cent. of cells.	Compressive strength per cubic inch in pounds, (¼ ult. strength taken.)	Height of furnace charge which can be supported without crushing (in feet.)
	Dry.	Wet.	Dry.	Wet.				
a. Anthracite culm, 60 per cent., Bituminous slack, 35 per cent., Pitch, 5 per cent.,	21.7	25.7	82.7	99.5	83.1	16.9	66	30
b. Anthracite culm, 50 per cent., Bituminous slack, 50 per cent.,	24.3	29.8	92.1	113.5	81.1	18.9	128	53
c. Anthracite culm, 50 per cent., Bituminous slack, 50 per cent.,	22.1	28.0	84.02	107.0	78.7	21.3	184	75

a. First trial—Unscreened anth. culm—72 hour coke, ovens 30 in. wide.
b. Second trial—Screened anth. culm, fine—48 hour coke, ovens 30 in. wide.
c. Third trial—Same conditions, better coked—ovens 30 in. wide.

A careful examination of the masses of coke from the four charges made in the Johnstown thirty inch wide Belgian ovens, the analyses of the cokes, and the tests for strength, develope some points which may be considered as decided by these first tests.

The mixture of pitch with the slack coals was dwelt upon as necessary in the Welsh test: yet the records of both the laboratory tests and the Belgian oven charges at Johnstown *indicate that the pitch is of little, if any, consequence, and can be entirely dispensed with.*

In examining the cokes made it is clearly shown that the complete coking only extends inwards about 8 to 10 inches from the sides, the middle of the mass being in every case much less perfectly coked. These well coked sides are much stronger and better coke than any taken for testing; *and the best of it is what would be yielded by coking the mixture in long narrow ovens.*

The facts as stated in the previous pages show, that a fuel can be made from anthracite and bituminous slack coals *which will answer for the uses to which the bituminous coke is usually applied.*

These first charges were imperfectly mixed, owing to the absence of any mixing machinery: and as they were test charges, part of the coke was somewhat over burned and a part not perfectly coked; yet with these draw backs the experiments for strength show that the mixture of Anthracite Slack 50 per cent. and Bituminous Slack 50 per cent., coked 48 hours in a thirty inch Belgian coking oven *produced a fuel which is capable of bearing the burden of a seventy-five foot furnace stack.* This is as heavy a burden as any coke is likely to be called upon to bear.

The mixture of Anthracite slack 60 per cent, Bituminous slack 35 per cent., and Pitch 5 per cent., coked in the same oven for 72 hours *produced a coke only able to bear the burden a thirty foot furnace stack:* too weak, therefore, for practical blast furnace use, though available for many other purposes.

The coke from these charges was used in the blast furnaces at Johnstown: its small quantity rendering it impossible to give any comparative results as to its value as compared with the ordinary bituminous coke in use at that place.

Tests for the Comparative Calorific Efficiency.

In order to make the needful tests of the practical value of the Anthracite coke it was necessary to make a sufficient quantity for comparative tests in the cupola of the foundry at Johnstown.

A car load of Anthracite slack was shipped to Johnstown from the Cameron Colliery at Shamokin: the car representing the general average of the slack, being about one half "shot coal" and one half fine coal dust.

An average specimen of the slack gave by analysis: (A. S. McCreath.)

Water @ 225°,	3.170
Volatile matter,	6.842
Fixed carbon,	76.636
Sulphur,	1.355
Ash,	11.997
	100.000
Color of ash,	reddish grey.

The slack had been exposed for 11 days in transportation and was much water soaked: hence the unusually high percentage of water.

This was coked with slack coal from the mines at Latrobe. A specimen of this bituminous slack yielded on analysis: (A. S. McC.)

Water at 225°,	2.020
Volatile matter,	29.555
Fixed carbon,	57.163
Sulphur,	1.622
Ash,	9.640
	100.000
Coke, per cent.,	68.425
Color of ash,	reddish grey.

These slack coals were mixed as before, in the proportion of one half of each, and were burned seventy-two hours in the Belgian oven.

The resultant "coke" was inferior in strength to that made in previous experiments. In fact it was so obviously an inferior fuel that it was not deemed worth while to test it alongside of Connellsville coke.

It having been determined upon to test, at the same time, an "anthracite coke" made from Lykens Valley Anthracite Slack and Connellsville Coal, a car load of Slack coal was forwarded from Williamstown, Dauphin county, to Johnstown. The slack was kindly selected by Major Anthony, the Superintendent, and represents the average run of slack coal, as daily made at the Lykens Valley collieries. A specimen of this slack yielded, on analysis, (A. S. McCreath):

Water at 225°,	1.930
Volatile matter,	7.253
Fixed carbon,	82.019
Sulphur,	.525
Ash,	8.273
	100.000

As additional evidence as to what is the average character of the coal, the following analyses of the cleaned and prepared Lykens coal show (A. S. McCreath):

	I.	*II.*
Water at 225°,	2.270	2.155
Volatile matter,	8.830	8.170
Fixed carbon,	78.831	79.878
Sulphur,	.676	.561
Ash,	9.393	9.236
	100.000	100.000

No. 1 was freshly mined coal, analysed March 14, 1876.

No. 2 was same coal, exposed to the weather for nine months, and analysed December 14, 1876.

The analyses are interesting as showing how slight is the weather effect on anthracite coal.

The Connellsville Coal used to mix with the Lykens Valley Slack was a car load of coal, average run of mine, presented to the Survey for the purpose by Mr. Wickham, Superintendent of the Connellsville Gas Coal Company, and came from the mine of the company, near Connellsville, Fayette County, Penna.

A specimen of the coal yielded on analysis (A. S. McCreath):

Water at 225°,	.950
Volatile matter,	29.662
Fixed carbon,	55.901
Sulphur,	1.931
Ash,	11.556
	100.000
Coke, per cent.,	69.388.
Color of ash,	reddish grey.

As showing the weather waste of this Connellsville coal, Mr. McCreath's analyses show:

	I.	II.
Water at 225°,	1.260	1.450
Volatile matter,	30.107	28.790
Fixed carbon,	59.616	60.274
Sulphur,	.784	.751
Ash,	8.233	8.735
	100.000	100.000
Color of ash,	reddish grey.	reddish grey.

No. 1 was freshly mined coal, analysed Oct. 23, 1875.

No. 2 was the same coal, exposed to the weather for over 13 months, and re-analysed Dec. 14, 1876.

The oven was charged as follows:

	Lbs.
Anthracite, Lykens Valley,	4475
Bituminous, Connellsville,	4475
	8950
Coke yielded,	6764
Loss in coking,	2186

or $24\frac{3800}{8950}$ per cent.

The above is Mr. McFadyen's report.

The coke yielded was firm, coherent, bright looking, and better than any previously made.

A specimen of it yielded on analysis (D. McCreath):

Water,	0.250
Volatile matter,	0.490
Fixed carbon,	88.420
Sulphur,	0.855
Ash,	9.985
	100.000
Color of ash,	reddish cream.

The analysis shows a well burned coke, low in percentages of water, sulphur and ash.

A sufficient quantity of this coke was turned over to Mr. Dan'l. N. Jones, Chief Engineer of the Cambria Iron Company, to test for comparative calorific efficiency. Mr. Jones consented to test it alongside of Connellsville Coke in the cupola of the foundry. He makes the following clear and brief report as to its behavior:

JOHNSTOWN, PA., *March 9, 1877.*

JOHN FULTON, Esq.:

Brief statement of tests made at Cambria Iron Company's foundry—comparative value of Connellsville coke and Anthracite coke.

The usual practice on the cupola used for this experiment is when using Connellsville fuel.

Coke for Bed, = *1000* lbs.
Coke for Charge, = *176* lbs. Iron, *1500* lbs.
Speed of melting, = *5 tons iron per hour.*

When using Anthracite coke our practice was—

Coke for Bed, *1400* lbs.
Coke for Charge, *220* lbs. Iron, *1500* lbs.
Speed of melting, = *6½ tons in two hours.*

1st Trial.—Used two charges of Anthracite on last run of cupola. Iron dull—apparently much cinder.

2d Trial.—Three charges of Anthracite on last run of cupola. Iron "lived well," and maintained its fluidity.

3d Trial.—Four charges Anthracite last run of cupola. Indications of slow melting towards last.

4th Trial.—Fourteen hundred lbs. Anthracite for Bed, and seventeen hundred and sixty lbs. for eight charges, with twelve thousand lbs. iron. Iron hot; melting slow; first hour, three tons; second hour, three and a half tons; seemed to crush badly and throw off many more sparks than usual with Connellsville.

The above indicates a lower melting capacity, and more time necessary to do the same work. However, this does not prove that better results may not be obtained by further tests. Another feature is, that it crumbles badly in handling.

Also seems to leave a cinder in cupola very hard to separate from the brick when cleaning.

Yours truly,

DANIEL N. JONES.

The above statement requires no elaboration, and it needs only to repeat that as compared with Connellsville Coke, the *anthracite Coke has a lower melting capacity, requires more time to do the same work, and crumbles badly in handling.*

In view of the above it is not necessary to enter into calculations to show the cost at which "Anthracite Coke" could be produced in large quantities.

If the material as made at the Johnstown ovens be a fair sample of what might be expected as the average product, and the record of the charges as given above is evidence that much care was exercised, the conglomerate fuel could not compete at present either with coke or anthracite coal.

Washing the Coals.

In all the experiments as given above, neither the Anthracite nor Bituminous slack coals were washed.

To show the improvement in the character of the material effected by skillful washing, the following extract is given, taken from a paper by *Mr. E. D. Meier*, M. E., on *Coal washing in Illinois.*

"Sundry specimens of lump and nut coal from mines on the Pittsburgh Railroad were sent to Cologne, Germany, there ground and sized, then washed on the Osterspey jig, and afterwards coked at the gas works there. The gas was found to be very good, and the coke sufficiently pure for blast or cupola furnace use. The sizing had been perfect and the washing double in each case. The results average as follows:

Lump Coal:	crushed	13.94	per cent.	ash.	Washed 6 per cent. ash and 1.4 per cent. sulphur.
	"	4.4	"	sulphur.	
Nut Coal:	"	15.57	"	ash.	
	"	2.99	"	sulphur.	

with a loss of from 35 to 40 per cent. in washing. The coke from this averaged 10 per cent. ash and 1.02 per cent. sulphur and showed a coking loss of 40 per cent. This quantity, 60 to 65 per cent. of wash coal out of the crude mass, was considered possible only when arrangements were made for re-crushing and then re-washing the middlings. The consumption of water was not given. Nearly 25 per cent. of the sulphur was found to be in the dust under 0.04 inch. Five analyses of as many different kinds of coke much used in iron smelting in Westphalia were added, running from 9.8 to 12.7 per cent. ash and 1.3 to 2.19 per cent. sulphur, and the desirable limits for good coke given as 12 per cent. ash and 1.75 per cent. sulphur, which is somewhat lower in ash, but higher in sulphur, than the average of the Ohio river cokes coming to this market."

The following analyses represent the effect of washing upon the coking coal of the Cambria Iron Co. at Johnstown:

	Analysis of coal before washing.	*Analysis of coal after washing.*
Volatile matter,	20.33	23.01
Fixed carbon,	70.83	73.66
Sulphur,	2.73	0.439
Ash,	8.83	3.33
Coke, per cent.,	79.67	76.99

Efficiency of cellular coke as compared with dense coke.

The following letter of Mr. Lander's as to the efficiency of some coke made in the Gobeit oven, as compared with coke made in the Beehive oven, and the reply of Mr. Fulton make a contribution to our knowledge of cokes. The letters need no comment and are submitted without it:

KEMBLE FURNACES, *December 16, 1876.*

JOHN FULTON, Esq.:

DEAR SIR: I have just finished my experiment with the coke made from the Gobeit Oven, and as these are similar, in many respects, to the Belgian, I wish to draw your attention to a fact developed, which you may, or may not, be acquainted with. We obtain about 55 per cent. to 60 per cent. yield in our Bee Hives. In the Gobeit, the inventor claimed to have got 75—say an average of 70 per cent. Of course this is in weight, and not bulk. On the furnace, to carry out the same principle, we use 1900 ℔s. coke to one charge, carrying 2900 of ore. When I put his coke on, 4 barrows of it weighed 2300 ℔s., or 400 ℔s. more than ours. For this theory to be correct, I ought to have increased the burden in same proportion, but I could not; and the fact is, that with 1900 ℔s. of our coke, we do the same work as he does with 2300. Where, then, does the boasted increase of yield come in? I think this is an important fact. People with Belgian Ovens claim that they obtain 20 per cent. more out of a ton of coal than we do; but my experiment shows to me plainly, that it just takes so much more coke to carry the same burden. In the one plan, the coke is condensed and lessened in bulk, and weighs heavy. In the Bee Hive, it is open, porous, and large in bulk, compared with the other. In running the furnace, I think you will admit it is unsafe to weigh the coke. To-day it may be dry; to-morrow it may be wet, and so much increased in weight. To be safe, you must go by bulk, or the same number of barrows of coke to a charge, all the time, regardless of weight. In my experiment, we had to use the same number of barrows. In the one oven, they weighed 1900; in the other, 2300. Now, what does the boasted increase of yield amount to? It is a very nice question, and an important one. I do not know if you have thought of it, or have ever seen the same experiment tried; and I merely write to you, to compare views. To me, it seems, that in an oven yielding 75 per cent., there is no more carbon than in an oven yielding 55 per cent., in same bulk, and this boasted increase of yield is fictitious. I should like to hear from you on the subject. I confess, I am surprised at the results in our case, and my eyes have been considerably opened. While this coke was on the furnace, it took 5196 lbs. to one ton of iron. When our Bee Hive was on, it took 4156 lbs., or 1140 lbs. of coke more to a ton of iron than ours. I also found that it was difficult to reduce this coke. The iron ore, &c., would melt before it did. The charges would not run regular, and the iron was simply execrable. I have had enough of fluid ovens, and am convinced there is nothing in them, except saving of labor. I should like to hear from you on the subject.

Yours, very truly,

W. LANDER.

JOHNSTOWN, PA., *December 18, 1877.*

W. LANDER, Esq.,

Superintendent Kemble Furnaces, Riddlesburg, Pa.:

DEAR SIR: Your favor of 16th received, giving me your very interesting experience with the Beehive and Gobeit oven coke in your furnaces, at Riddlesburg.

You will bear me out, when I call it to mind, that from the first I predicted the failure of the Gobeit oven coke, just on the grounds you now submit: that it would, with its deep charges, produce a dense coke, which would be difficult and slow of combustion in the furnace, and hence undesirable.

Of course, not until now could the facts in your case be given, but I was very confident that you would, in practice, arrive at these conclusions, sooner or later.

The want in coke is not *density*, but an open cellular structure, admitting the furnace gases in the preparation of the fuel for a rapid and energetic combustion in the zone of fusion.

The claim of producing a larger percentage of coke in Gobeit or Belgian ovens over Beehives is correct. The heat from the gases in the former is utilized, saving the carbon of the coal. The objection to this family of ovens (Belgian) does not rest at all on this fact, but on the dense physical structure of the coke produced.

Logically, two pounds of coke, no matter how made, should perform double the work of one pound ; but in this respect it is found that, other things being equal, the result depends mainly on the physical structure of the coke. In the present case, you report that 1900 lbs. of coke made in Beehive ovens performs the same calorific work in your furnace that 2300 lbs. of Gobeit oven coke does, showing a loss in the use of the latter of 17.39 per cent.

If the average of 63 per cent. be taken for the work of the Beehive oven, and 70 per cent. as the product of the Gobeit or Belgian oven, then the loss in the former over the latter is 10 per cent.—in other words, the loss in furnace work from dense coke (Gobeit) is largely in excess of the loss made in coking open structure coke, (Beehive,) and that in taking all the factors into consideration the apparent wasteful burning of carbon in the Beehive ovens is more than compensated by the superior energy of its coke over the Gobeit or Belgian plan, and hence the former method of coking should be continued for your coal, at least until a better one is devised.

You say that in the test of Gobeit coke, that "the iron ore would melt before the coke was brought into full heat, and that the iron was simply execrable." This condition of furnace would result from the use of *dense coke* lowering the zone of fusion and retaining an undue proportion of silicon. With an open celled energetic fuel the furnace could be "driven" raising the zone of fusion, oxidising a large portion of silicon and yielding an open granular graphitic pig metal.

Very respectfully,

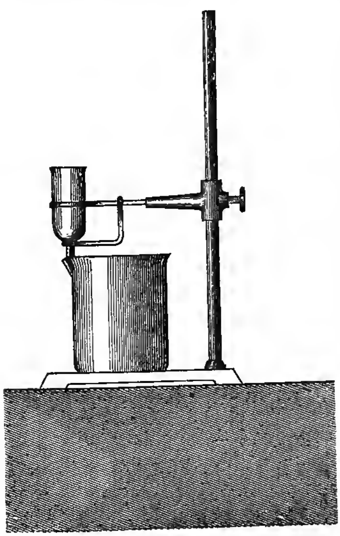
JNO. FULTON.

§ 96. *Determination of Carbon in Iron or Steel.*

The accurate determination of small quantities of carbon in iron or steel is one of the most difficult problems in analytical chemistry.

The following method has been found to give entirely satisfactory results:

Three grammes of the iron or steel are added to 200 cubic centimetres of a saturated neutral solution of the double chloride of copper and ammonium. Decomposition immediately takes place, the iron and copper replacing each other. In order to aid solution the mixture is frequently stirred and after a few minutes a gentle heat may be applied. In about fifteen minutes the iron will be completely decomposed, and the excess of the double salt will have re-dissolved any metallic copper which may have separated out. The solution is so neutral at this point that upon heating a film of oxide of iron forms, but this can be easily removed by a few drops of hydrochloric acid, and the mixture is ready for filtration. The carbon is collected in the filtering tube shown in the annexed cut, the end of which is stopped first with angular pieces of glass and then *loosely* with ignited asbestos. A small quantity of hot water is first run through the filter; the solution is then added, and the residue is washed free from chlorides. If, as sometimes happens, a small quantity of the basic chloride of copper separates out, it can readily be removed by a little of the double chloride solution and the residue washed as before. To see if any of the carbon passes through the filter, the filtrate is mixed with strong hydrochloric acid (to prevent the separation of any



Filtering Tube and Stand used in Carbon Determinations.

basic chloride of copper) and then diluted; by this means any particles of carbon may be easily recognized. If, however, the filter has been properly made, the solution filters rapidly and all the carbon is retained on the asbestos.

The asbestos and carbon while still wet are transferred to a platinum boat, the filtering tube being wiped out with asbestos held in platinum pointed forceps, and thoroughly dried at 100° C. The boat is then put into the tube B, shown in the accompanying plate, and the carbon burned off in a stream of oxygen.

The apparatus * consists of a ten burner gas combustion furnace A, 13 inches long, through which runs the porcelain or glass tube B. This tube should be about 25 inches long and $\frac{3}{4}$ inch internal diameter. It should project 6 inches outside the furnace at each end, and the heat prevented from reaching the ends of the tube by the sheet iron screens L. The tube is filled from the center to the front of the furnace with coarse black oxide of copper. It is fitted at the forward end with the U tube G, filled with chloride of calcium, to which is attached another U tube H, filled with pumice saturated with sulphate of copper and heated until the sulphate has become anhydrous. To H is attached the Liebig bulb I, filled with a solution of potassium hydrate (sp. gr. 1.27), and the drying tube J, filled partly with pieces of potassium hydrate and partly with chloride of calcium. I and J constitute the apparatus for absorbing the carbonic acid, and to the end of J is attached the small tube K filled with chloride of calcium or potassium hydrate, to prevent J from absorbing moisture from the air during the progress of the combustion. O is the oxygen holder, M the purifying apparatus and F the air bottles.

The combustion is conducted in the following manner: The platinum boat containing the carbon residue is put into the tube B and pushed up against the oxide of copper with the rod C. The tube is then tightly closed with the cork P, the absorption apparatus, which has previously been

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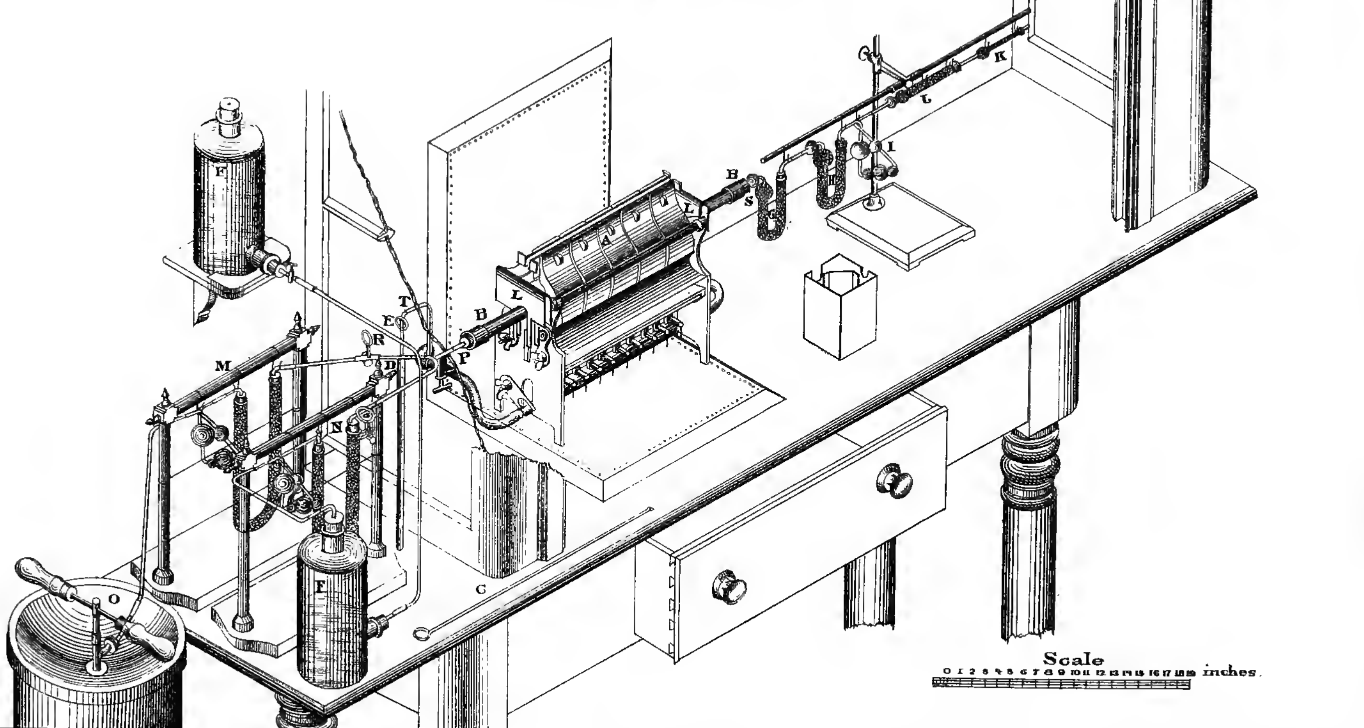
* Through the courtesy of Mr. Andrew A. Blair I am permitted to use the sketch of this apparatus given in his "Methods of Analysis of Iron, Steel, Copper," &c. Washington, 1879.

APPARATUS FOR CARBON DETERMINATIONS
By A. S. Mc Creath,
Chemist in charge of the laboratory at Harrisburg.



weighed, is attached, the pinch-cock R is opened and Q closed. A slow stream of oxygen is started through the apparatus. The tube B is carefully heated beginning at the forward end, in order to heat the oxide of copper well before the boat is heated. When all the burners are lighted, which usually takes about 30 minutes, they are allowed to burn turned on full for 25 minutes, the tube being at a full red heat all the time. The supply of oxygen is then stopped, the pinch-cock R put on and Q taken off, and a slow stream of air started through the apparatus to drive out the oxygen. This is done by pouring water into the upper bottle F, and allowing it to run into the lower one, in this way forcing the air through the apparatus. The lights are lowered together gradually, to avoid cracking the tube, and finally put out. The absorption apparatus is then weighed; the difference between the first and second weighings is carbonic acid from which the percentage of carbon is readily calculated.

In laboratories not supplied with gas, the carbon can be conveniently oxidized by means of chromic acid and the resulting carbonic acid collected and weighed in the usual way. For a full description of this method see my paper published in the Transactions of the American Institute of Mining Engineers, Vol. V, page 575.

INDEX TO REPORT MM.

A—Alphabetical Index of Owner's Names, &c.

B. Alphabetical Index of Counties.

C.—Index of Analyses.

To find by the number of any analysis in the record book of the Harrisburg Laboratory, its place by page in this volume.

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