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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

LIMESTONES

OF

SOUTHWESTERN PENNSYLVANIA

BY

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., July 16, 1904.

SIR: I have the honor to transmit herewith the manuscript of a paper entitled "Limestones of Southwestern Pennsylvania," by F. G. Clapp, and to recommend its publication as a bulletin.

This report deals with a subject which is of considerable interest from an economic point of view, in consideration of the recent great extension of the Portland-cement industry. The data here presented on the limestones of southwestern Pennsylvania will serve to point out promising localities for the erection of cement plants in the coal areas of the State.

Very respectfully,

C. W. HAYES,
Geologist in Charge of Geology.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

LIMESTONES OF SOUTHWESTERN PENNSYLVANIA.

By FREDERICK G. CLAPP.

INTRODUCTION.

The rapid increase in Pennsylvania of Portland-cement making and of other industries based on limestone has led to a demand for information in regard to the character and occurrence of workable beds of that material in the western part of the State, and in response to this need the present paper, which contains a summary of our present knowledge regarding these beds, has been prepared. As only a comparatively small part of the field has yet been examined by the geologists of the United States Geological Survey, it is impossible to prepare anything like a final report or even to state details in all parts of the area, but by the assistance of descriptions and analyses made by the Second Geological Survey of Pennnsylvania, in addition to the more detailed work of the United States Geological Survey in the Brownsville, Connellsville, Masontown, Uniontown, Waynesburg, Latrobe, Kittanning, Rural Valley, Elders Ridge, Beaver, Indiana, Barnesboro, Patton, Curwensville, and Ebensburg quadrangles, it is possible to give considerable generalized information which it is hoped will be of economic value.

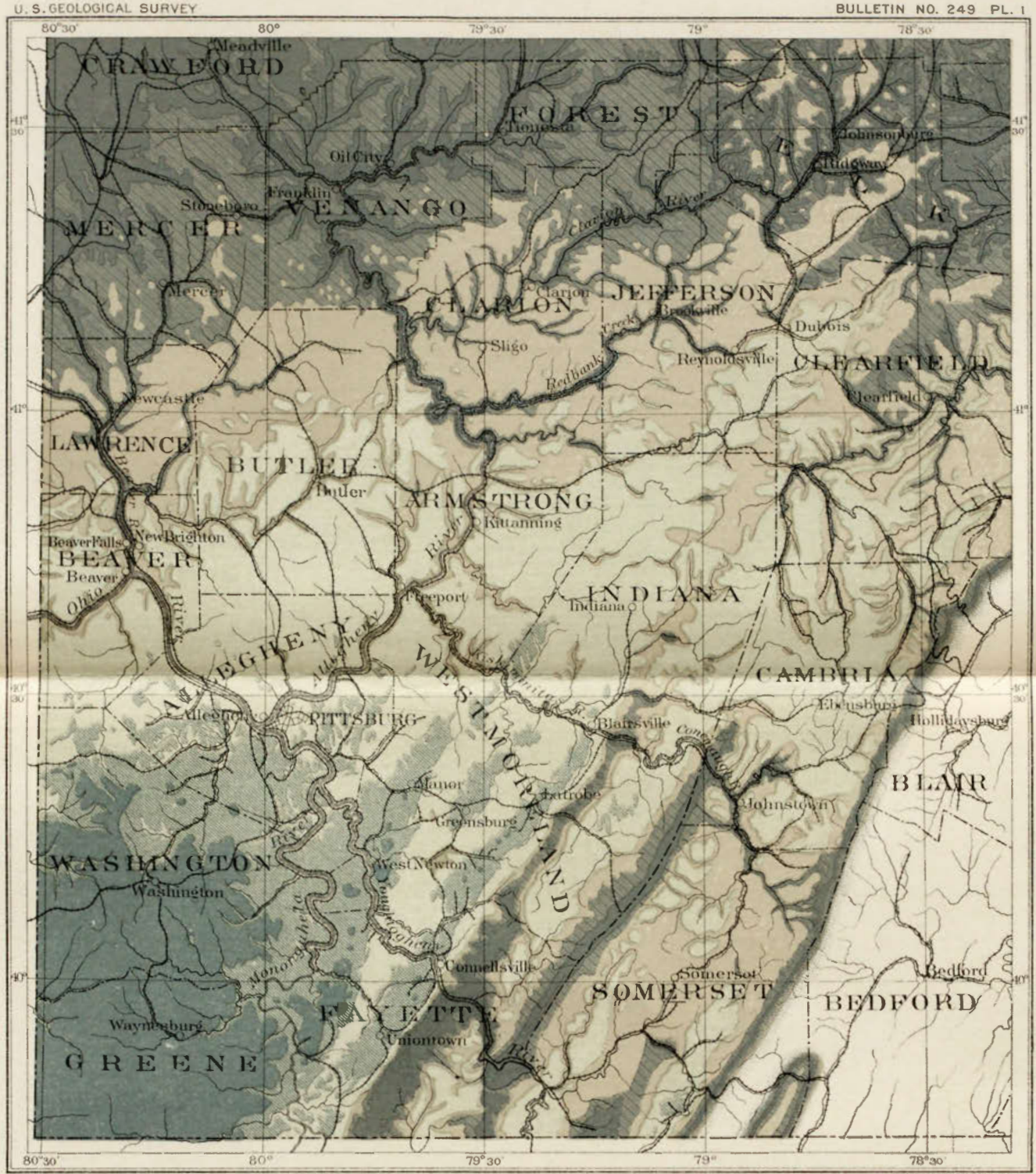
STRATIGRAPHIC DISTRIBUTION OF LIMESTONES.

The greater part of western Pennsylvania is underlain by coal-bearing rocks, in which the number of limestones is very great, though only a few of them attain workable thickness. Following is a list of the principal limestone beds, together with their maximum thicknesses and approximate stratigraphic positions:

List of principal limestones.

Formation.	Name.	Approximate stratigraphic position.	Maximum thickness.
			Feet.
Dunkard formation, or Upper Barren measures.	Upper Washington limestone (No. VI).	Top of Washington formation, 250 to 425 feet above Waynesburg coal.	30
Monongahela formation, or Upper Productive measures.	Waynesburg limestone.	20 feet below Waynesburg coal.	35
	Benwood, or Great, limestone:		
	Upper member, or Uniontown, limestone.	----------	18
	Lower member.	120 feet above Pittsburg coal.	90
	Sewickley, or Fishpot, limestone.	Over 100 feet above Pittsburg coal.	30
	Redstone limestone.	30 to 70 feet above Pittsburg coal.	10
	Pittsburg limestone.	20 feet below Pittsburg coal.	12
Conemaugh formation, or Lower Barren measures.	Elk Lick limestone.	Midway between Pittsburg and Upper Freeport coals.	6
	Ames, or Crinoidal, limestone.		8
Allegheny formation, or Lower Productive measures.	Upper Freeport limestone.	Below Upper Freeport coal.	28
	Lower Freeport limestone.	Below Lower Freeport coal.	5
	Johnstown limestone.	Below Upper Kittanning coal.	10
	Vanport, or Ferriferous, limestone.	Below Lower Kittanning coal.	22
Pottsville formation.	Upper and Lower Mercer limestones.	Between Homewood and Conoquenessing sandstones.	4
			3
Mauch Chunk formation.	Greenbrier, or Mountain, limestone.	40 to 50 feet above bottom of Mauch Chunk.	30
Pocono formation.	Loyalhanna, or Siliceous, limestone.	Upper portion of Pocono.	60
	Benezette limestones of Elk County.	----------	7

Besides the beds named in the table there are many thin and local limestones, among which the Jollytown, Little Pittsburg, Middle Washington, and Lower Washington have been given names, but are nowhere known to be of much economic importance.



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GEOLOGIC MAP OF SOUTHWESTERN PENNSYLVANIA

BY F. G. CLAPP
1904

From county atlas of the Second Geological Survey of Pennsylvania, 1885

Scale

10 0 10 20 30 40 50 miles

LEGEND

Dunkard group | Monongahela formation | Conemaugh formation | Allegheny formation | Pottsville formation | Formations below Pottsville

CHARACTER AND THICKNESS.

The thicknesses given in the table are the extreme maxima known to exist, and should not be accepted as likely to occur over wide areas. The average amounts in each case are probably considerably less than half those given. In distribution the thickest beds are toward the southwest, but even there they rarely exceed a few feet, and beds averaging over 20 feet are only about three in number. Color and texture vary through wide limits, from nearly black to light gray or white, and from hard and compact, as in the Vanport (Ferriferous), to extremely fossiliferous and shaly, as in the Ames (Crinoidal). In composition all grades occur, from calcareous clays, shales, or sandstones, to limestones which contain over 96 per cent of calcium carbonate. Magnesium carbonate is always present, sometimes amounting to less than 1 per cent, but frequently rising to 10 per cent and occasionally exceeding 30 per cent. Alumina and oxide of iron may be present in any amount below 8 per cent.

All analyses given in this paper are taken from reports of the Second Pennsylvania Survey, and were mostly made in the laboratory of that survey by Mr. A. S. McCreath and his assistants. One of the most striking features in regard to nearly all the beds is their extreme variability in texture and composition, the analyses of specimens taken from the same quarry sometimes showing great extremes.[1] Variations exist in the composition of strata from the bottom, middle, and top of a bed,[2] and it is not probable that the analysis of any single specimen represents correctly the composition of the entire output from a quarry. Suitable allowance therefore must be made in accepting figures of any analysis. Another possible source of confusion in making use of analyses here given arises from the fact that all specimens analyzed were collected many years ago, and many of the farms have since changed hands and may now be known by different names. It is likewise possible that certain place names may have gone out of usage.

DESCRIPTION BY DISTRICTS.

For convenience of discussion the area is divided into four districts—Monongahela Valley, Allegheny Valley, Beaver Valley, and Allegheny Mountains. Pl. I is a general map of southwestern Pennsylvania, showing the leading geographic features and the distribution of the geologic formations. This map is compiled chiefly from the county maps of the Second Geological Survey of Pennsylvania, corrected to date.

Pls. II and V show the outcrop of the Vanport limestone so far as known.

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[1] Leslie, P. J., and McCreath, A. S., Report of Second Geol. Survey of Pennsylvania, vol. M2, 1879, pp. 311-361, and Final Rept., vol. 1, 1892, pp. 327-336.

[2] See analyses Nos. 6, 7, 8; 35, 36, 37, 38, 39; 42, 43; 57, 58, 59; 60, 61, 62; 75, 76; 86, 87; 90, 91, 92; 97, 98, 99, on later pages

As a rule, the limestones of each region have characteristics of their own, which would make superfluous any general preface descriptive of the individual beds. The descriptions of the horizons will therefore be placed under the headings of the several districts. Where the thickness of the bed is less than 10 feet few specific localities are mentioned, as a thin bed is of comparatively little importance.

MONONGAHELA VALLEY.

This district includes approximately the area underlain by the Pittsburg coal. From a depth of nearly sea level in the southwest corner of Greene County the coal rises rapidly toward the east and north into the hilltops, and the region therefore furnishes outcrops of all beds between the Mauch Chunk shale and the upper part of the Dunkard formation. Notwithstanding the fact that limestones are more abundant in this region than in any other portion of western Pennsylvania, only a few of the beds are of economic value. These will be discussed in their stratigraphic order.

LOYALHANNA LIMESTONE.

This bed is the Siliceous limestone of the Pennsylvania reports. It shows in outcrop only where Chestnut Ridge has been cut through by the westward-flowing streams—Conemaugh River, Loyalhanna Creek, and Youghiogheny River. It has been classed by some geologists as the basal member of the Mauch Chunk formation, but in reality is a part of the Pocono sandstone, into which it merges by insensible gradations. According to Stevenson,[1] the upper portion is a conglomeratic sandstone containing numerous fragments of siliceous limestone. This portion grades gradually into the siliceous limestone proper, which is a fine-grained rock having a blue color, flint-like fracture, and no true cleavage. On its fresh surface it shows no signs of bedding, but where exposed for some time takes on a dull brown color and shows a peculiar cross-bedding. The weathered surface is very characteristic, being rough and pitted and unlike any other rock in the region. This feature is well illustrated by the photograph, Pl. VII, *B*. The large proportion of silica in the rock gives it the general appearance of a sandstone rather than of a limestone.

The Loyalhanna limestone is of greatest importance northward, being on Conemaugh River between 40 and 50 feet thick in both gaps. A similar thickness prevails in the Loyalhanna and Youghiogheny gaps, but southward the rock becomes thinner, being only about 18 feet thick on the National Pike and barely 4 feet near the State line. On Cheat River, West Virginia, it has wholly disappeared.

The limestone often occurs in two benches, separated by shale and sandstone. At a number of points it has been quarried for paving blocks and crushed for railroad ballast. Large crushing plants have been established on Conemaugh River above Blairsville, in the Loyal-

[1] Report K3, p. 52.

hanna gap above Latrobe, and in the Youghiogheny gap above Connellsville. At the last-mentioned place the quarry face has a height of 60 feet, but a part of the thickness should probably be classed as sandstone.

GREENBRIER LIMESTONE.

This is the Mountain limestone of the Second Geological Survey reports, and is the feather-edge of the Greenbrier of Virginia and probably of the Chester and St. Louis beds which occur in the Mississippi Valley, where they attain great thickness. Its greatest development in Pennsylvania is along the southern boundary of the State, where it attains a thickness of about 40 feet. Along Chestnut Ridge and Laurel Hill it outcrops about 50 feet above the Loyalhanna limestone. The Greenbrier is somewhat variable in character, the greater part being composed of thin beds of pure blue limestone, which often grade into shaly limestone and calcareous shale. In places it is very fossiliferous. No analyses are known to have been made. Its principal use is in burning for fertilizer, for which purpose it is said to yield lime of superior quality. Formerly it was used as a flux in iron smelting.

UPPER FREEPORT LIMESTONE.

This is the only limestone of the Allegheny formation known to occur in the region. It is rarely seen and may not be persistent, but is known in places to reach a thickness of 5 feet. The following analyses[1] have been made:

Analyses of Upper Freeport limestone from Westmoreland County, Pa.

	No. 1.[a]	No. 2.[b]
Insoluble residue	0.990	4.015
Calcium carbonate ($CaCO_3$)	94.643	91.982
Magnesium carbonate ($MgCO_3$)	1.144	1.664
Alumina (Al_2O_3)	2.720	1.520
Ferric oxide (Fe_2O_3)		
Sulphur	.028	.091
Phosphorus	.015	.012

[a] Second Geol. Survey of Pennsylvania, vol. M2, 1875, p. 293.

[b] Second Geol. Survey of Pennsylvania, vol. H4, 1878, pp. 245-246; analysis by D. McCreath.

No. 1.—From Kier Brothers' quarry at Salina: Fine grained, brittle; reddish gray; conchoidal fracture.

No. 2.—From Wining & Cuisan's quarry, one-half mile northwest of Kellys Station: Compact, brittle; pearl gray; conchoidal fracture; sparkles with calcite; thickness of bed, reported 4–5 feet.

[1] All the analyses given in this paper are taken from the reports of the Second Geological Survey of Pennsylvania, and were made in the laboratory of that survey by Mr. A. S. McCreath and his assistants. Where the name of the analyst is known it is given in a footnote.

PITTSBURG LIMESTONE.

Several limestone horizons occur in the Conemaugh formation, but are only locally represented by limestone. They rarely attain a thickness of 4 feet and are unimportant, being used only for fertilizing purposes. Following is an analysis of the Pittsburg limestone—a bed occurring approximately 20 feet below the Pittsburg coal; the specimen was taken from a quarry at Lemont furnace, 3 miles northeast of Uniontown:

Analysis of Pittsburg limestone from Fayette County, Pa.[a]

	No. 3.
Insoluble residue	7.360
Calcium carbonate ($CaCO_3$)	87.868
Magnesium carbonate ($MgCO_3$)	1.733
Ferrous carbonate ($FeCO_3$)	1.914
Alumina (Al_2O_3)	.135
Sulphur	.106
Phosphorus	.050

[a] Vol. M2, p. 290.

No. 3.—Comparatively soft and brittle; very irregular fracture; bluish-gray color.

REDSTONE LIMESTONE.[1]

This is a hard, gray, crystalline limestone of some value, occurring below the Redstone coal and 30 to 70 feet above the Pittsburg coal. Its principal occurrence is in the Connellsville basin, where it is rather persistent. On Redstone Creek and in the territory between this stream and Allegheny River it is of fair thickness and excellent quality, and throughout Fayette County has been quarried extensively in the past for fluxing purposes to the exclusion of all other limestones. For the same purpose it is extensively quarried in the vicinity of Wheeling, W. Va.[2] Throughout the greater part of the Monongahela Valley it is usually absent or very impure. The following analysis of the stone from the quarry at Lemont furnace indicates that if the composition given is characteristic of the bed, the percentage of magnesia is too great to allow of its having any value for Portland cement:

[1] Vol. K2, pp. 48–49.

[2] White, I. C., Stratigraphy of the bituminous coal fields of Pennsylvania, Ohio, and West Virginia: Bull. U. S. Geol. Survey No. 65, 1891, p. 63.

Analysis of Redstone limestone from Fayette County, Pa.[a]

	No. 4.
Insoluble residue	9.460
Calcium carbonate ($CaCO_3$)	66.471
Magnesium carbonate ($MgCO_3$)	17.711
Ferrous carbonate (Fe_2O_3)	5.178
Alumina (Al_2O_3)	.812
Sulphur	.080
Phosphorus	.048

[a] Vol. M2, p. 289.

No. 4.—Hard and brittle; sparkles with calcite; pearl gray; conchoidal fracture.

SEWICKLEY LIMESTONE.[1]

This is the Fishpot limestone of early reports. It underlies the Sewickley coal at an interval of about 15 feet, and has its best known development in the Connellsville basin. Toward the south it is thin and of inferior quality, improving northward, but always of irregular occurrence. The greatest thicknesses reported are from 30 to 35 feet, in the vicinity of Greenfield on Monongahela River; on Redstone Creek, in Jackson Township, Fayette County, where it is the chief source of lime for agricultural purposes, and at Brownsville. It is reported to have been quarried for use as a flux in North Union Township, Fayette County, but generally it runs too high in silica for this purpose. The following analysis shows the quality of the stone at Oliphant furnace, in Georges Township, Fayette County:

Analysis of Sewickley limestone from Fayette County, Pa.[a]

	No. 5.
Insoluble residue	10.770
Calcium carbonate ($CaCO_3$)	80.647
Magnesium carbonate ($MgCO_3$)	2.217
Ferrous carbonate ($FeCO_3$)	1.657
Iron disulphide (FeS_2)	1.125
Alumina (Al_2O_3)	.543
Sulphur trioxide (SO_3)	.052
Phosphoric oxide (P_2O_5)	.066
Water	1.010
Carbonaceous matter	1.250

[a] Vol. M2, p. 287.

No. 5.—Compact; minutely crystalline; spotted with pyrite; dark blue.

[1] Vol. K2, pp. 44–46.

If the bed maintains this composition it ought to be of value in the manufacture of Portland cement, and that such may be the case is indicated by the analysis of the same bed in Indiana County. Analyses from Somerset County give a larger percentage of magnesia, proving that the stone at those points is unsuitable for the purpose.

BENWOOD LIMESTONE.[1]

The Benwood, or Great, limestone is by far the most important limestone in the Monongahela Valley. It sometimes amounts, with its interbedded shales, to as much as 140 feet in thickness, and is present throughout nearly all the area in which the Monongahela formation outcrops. It is a double limestone, occurring between the Uniontown and Sewickley coal beds and about 120 feet above the Pittsburg coal. In the vicinity of the Pennsylvania Railroad its stratigraphic position has given it locally the name of the "120-foot limestone." The upper member, known as the "Uniontown limestone," is usually 6 to 15 feet in thickness, often impure and of a buff color, and is said to be a good natural cement rock. At Uniontown the bed is 10 feet in thickness, and has been quarried extensively for natural cement, used in the construction of the locks on Monongahela River. There are reported thicknesses of 40 feet on the West Newton pike, in Rostraver Township, Westmoreland County; of 15 feet at Markles Mill, on Sewickley Creek, and of 14 feet near Round Hill Church, in Elizabeth Township, Allegheny County.

The lower member is much more persistent than the Uniontown bed. It varies in character from a hard and pure to a very shaly limestone. It is much thicker than the Uniontown bed, usually averaging above 50 feet. The maximum thickness is reached along Monongahela River, where it is sometimes as much as 90 feet. On Sewickley Creek near Bells Mills it is 85 feet or more, and on Youghiogheny River near the Westmoreland County line, 55 feet. Toward the north it diminishes in thickness, and, where it is exposed along the Pennsylvania Railroad, varies between 7 and 28 feet. Occasionally the bed is one solid mass of limestone, but throughout the greater part of the region it is broken up into a number of strata separated by shale. The rock is often siliceous or argillaceous and sometimes ferruginous. Where extensively weathered it has become broken up into small angular fragments. The bottom of the member is said to be generally the more magnesian, although all portions are extremely high in magnesia, as indicated by the first three of the following analyses, and is nowhere known to be suitable for Portland cement. In Washington County the stone was considerably used in early days in the manufacture of natural cement.

[1] Vol. K2, pp. 37–40.

Analyses of Benwood limestone from Washington County, Pa.

	No. 6.[a]	No. 7.[b]	No. 8.[b]	No. 9.[c]
Insoluble residue	13.300	22.520	15.750	14.920
Calcium carbonate ($CaCO_3$)	68.837	48.823	47.080	47.750
Magnesium carbonate ($MgCO_3$)	14.649	20.621	28.528	30.943
Ferrous carbonate ($FeCO_3$)	3.306	3.625	7.511	5.608
Alumina (Al_2O_3)		3.523		
Sulphur	.097	.203	.069	.126
Phosphorus	.049	.051	.127	.015

[a] Vol. K, 1876, p. 388; analysis by A. S. McCreath.
[b] Loc. cit.; analysis by D. McCreath.
[c] Vol. M2, p. 285; analysis by D. McCreath.

No. 6.—One mile north of Canonsburg: Upper layer, very hard and compact, like conglomerate, bluish gray.

No. 7.—One mile north of Canonsburg: Middle layer, compact, somewhat shaly, color bluish gray.

No. 8.—One mile north of Canonsburg: Lower layer, hard, compact, unctuous, pearl gray.

No. 9.—Property of Dr. Sharer, in Somerset Township, 8 miles from Washington.

WAYNESBURG LIMESTONE.[1]

The Waynesburg limestone, which is a rock of good quality, with a probable maximum thickness of about 20 feet, occurs a short distance below the Waynesburg coal. On Redstone Creek, in Franklin and Redstone townships, it amounts to 15 or 20 feet. On Browns Run, in German Township, Fayette County, it is reported by Stevenson as swelling to 35 feet; but elsewhere such a thickness is unknown. The common thickness varies between 8 and 15 feet. The stone makes a strong but rather dark lime. It is accessible at many places throughout Fayette, Westmoreland, eastern Greene, and southeastern Washington counties.

LIMESTONES OF THE DUNKARD FORMATION.

Scattered throughout the Dunkard formation are abundant limestone beds, which have been described by the Second Survey and numbered from I to XIV inclusive.[2] At the time this bulletin is submitted these have not been studied by the present survey, but from Stevenson's investigations it appears that few of them are of sufficient thickness or quality to be of value. The following table, compiled from the descriptions given in Volume K, gives the principal features of the several beds:

[1] Vol. K2, pp. 35-36.

[2] Stevenson, Vol. K.

Tables of limestones in the Dunkard formation.

[Abstracted from Vol. K, Stevenson, 1875.]

Stevenson's name.	Other names.	Approximate stratigraphic position.	Maximum thickness, in feet.	Characteristics.	General distribution.	Localities of extreme thickness.
XIV		80 feet above limestone XIII.	8	Dark blue; earthy; minute crystals of blende and occasional fish scales.	Scattered localities in western Greene County.	
XIII		Below Gilmore sandstone.	4	Dull blue; earthy; with shale	do	Browns Fork 1 mile above Ninevah, Greene County; mass of limestone and shale 15 feet.
XII		230 feet above Upper Washington limestone.	15	Usually thin; contains much shale.	Western Greene and southwestern Washington counties.	Head of Robinsons Fork, East Finley Township, Washington County; 8 feet.
XIa, XIb			2½			Very local limestones.
X		100 feet above limestone IXb.	5	Dark blue and earthy; sometimes brecciated.	Western Greene and southwestern Washington counties.	
IXa		70 to 100 feet above limestone VIII.	10	Usually very impure	Southwestern Greene County.	McCourtneys Fork below White Cottage; 6 to 8 feet. Grays Fork at mouth of Scotts Run; 6 to 10 feet.
IXb			10	do	do	Clover Run.
VIII				Impure and not persistent		
VII				Usually earthy	Central Greene County	
VI	Upper Washington limestone.	Top of Washington formation.	30	Usually pure; usually weathers snowy white; color generally dark blue-gray.	Washington and Greene counties.	See page 20.
V	Jollytown limestone.[a]	20 to 30 feet below Upper Washington limestone.	10			
IV	Middle Washington limestone.	40 to 70 feet above Washington coal.	15	Hard and coarsely brecciated; weathers to dull gray, tinged with yellow.	Washington and Greene counties.	
III			8	Massive; fresh fracture glistens with calcite; weathers rusty yellow; very fossiliferous.	Washington County	

II	Lower Washington limestone.	6 to 20 feet above Washington coal.	8	Light blue to buff	Washington and Greene counties.	
Ib		2 to 10 feet below the Little Washington coal.	20(?)	Dark blue; weathers bluish white; slaty structure.	Everywhere accompanies the Washington coal.	About 2 miles north of Williamsport pike, near west border of South Strabane Township, Washington County; 8 feet.
Ia	Colvins Run limestone.[b]	Between Waynesburg A coal and Waynesburg B coal.	10	Massive, compact; very impure; exfoliates on weathering; sometimes brecciated and ferruginous.	Greene and Washington counties.	

[a] White, I. C., in Bull. U. S. Geol. Survey No. 65, 1891, p. 34, defines the Jollytown limestone as a bed occurring at an interval of 25 to 30 feet below the Dunkard coal; Stevenson's usage, however, has the priority of sixteen years.

[b] White, I. C., op. cit., p. 39.

UPPER WASHINGTON LIMESTONE.

This is the principal and only important limestone bed of the Dunkard formation. It occurs 250 to 425 feet above the Waynesburg coal, and is widely distributed throughout Greene and Washington counties. It is usually easily recognized by its weathered surface, which is almost snowy white, with a slight tinge of blue. Throughout the greater part of Washington County the rock has, on fresh fracture, a very dark blue-gray to bluish black color, which is to be considered characteristic of the bed. It varies in thickness from 4 to 15 feet, but greater thicknesses are occasionally reported. The tunnel of the Baltimore and Ohio Railroad, about 1 mile east of Washington, cuts through the bed, exposing nearly 20 feet of solid limestone. A section on Cemetery Hill, near Washington, is reported to show a mass of limestone and shale 30 feet 3 inches in thickness, subdivided as follows:

Section of Upper Washington limestone near Washington, Pa.[1]

	Ft.	In.
Limestone, laminated, argillaceous	2	0
Dark shale	5	0
Calcareous shale	6	0
Shale with vegetable markings	2	0
Limestone	0	10
Bituminous shale	0	10
Limestone	2	0
Calcareous shale	1	3
Limestone	1	6
Shale	0	10
Limestone	3	0
Shale	2	0
Limestone	3	0
Total thickness	30	3

The stone has been burned in many places for a fertilizer. Following is an analysis of a sample from the railroad tunnel east of Washington, which indicates that if the quality of the stone is constant it should be of fair quality for the manufacture of cement. At this point the bed consists of nearly 20 feet of solid limestone.

[1] Vol. K, p. 46.

Analysis of Upper Washington limestone near Washington, Pa.[a]

	No. 10.
Insoluble residue	17.380
Calcium carbonate ($CaCO_3$)	72.866
Magnesium carbonate ($MgCO_3$)	3.813
Alumina (Al_2O_3)	2.929
Ferric oxide (Fe_2O_3)	
Sulphur	.155
Phosphorus	.061

[a] Op. cit., p. 388; analysis by D. McCreath.

No. 10.—From middle of bed; hard, compact, bluish-gray limestone; conchoidal fracture.

ALLEGHENY VALLEY.

This region includes the lower portion of the Allegheny Valley and its tributaries, underlain principally by rocks of the Pottsville, Allegheny, and Conemaugh formations. Isolated patches of the Monongahela, however, occur in the southern portion, and in the northern part the Pocono and Mauch Chunk rise above water level. The limestones range from those of the Pocono formation up to the Sewickley.

BENEZETTE LIMESTONE.

At a few points in Elk County a triple bed of limestone, supposed to be of Pocono age, has been found about 200 feet below the Olean conglomerate. The upper bed is reported as having a probable maximum thickness of not over 7 feet, the others being considerably thinner. The lower bed has been burned, and is said to make an excellent fertilizer. Analyses have been made of the upper and middle beds, specimens of which were taken from a point on Caledonia road 1 mile west of the village of Benezette.

Analyses of Benezette limestone from Elk County, Pa.[1]

	No. 11.	No. 12.
Siliceous matter	50.670	15.980
Calcium carbonate ($CaCO_3$)	36.785	76.143
Magnesium carbonate ($MgCO_3$)	1.408	1.740
Alumina (Al_2O_3)	10.070	3.680
Ferric oxide (Fe_2O_3)		

[1] Vol. M3, 1881, p. 93.

MERCER (TIONESTA) LIMESTONE.

This is of uncertain occurrence, but is known to be present at a few points. An analysis has been made of a specimen from Kelly's quarry on the Saddle Bags tract, 4 miles east of Tionesta, on Tionesta Creek, Forest County, where the thickness is from 2 to 3 feet.

Analysis of Mercer limestone from Forest County, Pa.[a]

	No. 13.
Siliceous matter	55.160
Calcium carbonate ($CaCO_3$)	40.642
Magnesium carbonate ($MgCO_3$)	1.172
Alumina (Al_2O_3)	2.120
Ferric oxide (Fe_2O_3)	
Phosphorus	.018

[a] Op. cit., p. 90.

No. 13.—Coarse grained; appearance sandy; very hard and tough; bluish gray.

VANPORT LIMESTONE.

This bed, usually known as the Ferriferous, is without doubt the most widespread and available limestone for Portland-cement manufacture in western Pennsylvania, outcropping over large parts of Jefferson, Clarion, Armstrong, northern Butler, and Lawrence counties, and appearing occasionally in northern Indiana, Beaver, and Venango counties, but dying out along a line drawn in a northeast-southwest direction through the middle of Indiana and the western part of Clearfield counties. Although not always present, even in those counties where it is best developed, it is the most persistent stratum known in western Pennsylvania, and therefore a good key to the geologic structure. The approximate outcrop in the Allegheny Valley is shown on Pl. II. In stratigraphic position it occurs below the Lower Kittanning coal and fire clay, from which it is sometimes separated by sandstone, but more often by a thin bed of limonite, known as the "buhrstone ore bed."

The limestone is of good quality throughout. It is usually compact and brittle, with an irregular fracture, and has a grayish color. It is occasionally very fossiliferous, containing a genuine marine fauna, consisting of crinoids, corals, brachiopods, lamellibranchs, univalves, etc. The maximum known thickness is 22 feet. This limestone, as shown by analyses, is the only bed in western Pennsylvania which almost universally contains less than 2 per cent of magnesium carbonate. The only specimen of this bed containing more magnesium carbonate is from Benezette, Elk County, and shows over

6 per cent. The siliceous matter is likewise usually very low, while the proportion of calcium carbonate is high, running between 86 and 96 per cent. The stone is now used for the manufacture of Portland cement at one plant, and there is every reason to believe it will be extensively used for this purpose in the future. It also makes excellent ballast, flux, road metal, and fertilizer.

Indiana County.—Four feet five inches of the Vanport limestone was penetrated by a diamond-drill hole on Ramsay Run, and its outcrop is found at one point on the north side of Yellow Creek; but with these exceptions the bed is known only in the northern part of the county, where it outcrops on Mahoning Creek with a thickness of 4 or more feet. A specimen from Isaac Simpson's quarry, one-half mile southwest of Richmond, gave the following analysis:

Analysis of Vanport limestone from Indiana County, Pa.[a]

	No. 14.
Insoluble residue	2.090
Calcium carbonate ($CaCO_3$)	92.857
Magnesium carbonate ($MgCO_3$)	1.589
Alumina (Al_2O_3)	2.030
Ferric oxide (Fe_2O_3)	
Sulphur	.187
Phosphorus	.035

[a] Vol. H4, p. 264.

No. 14.—Hard and tough; fossiliferous; fracture irregular; color, dark bluish gray.

Armstrong County.—In the southern part of Armstrong County outcrops of the limestone are only occasional, but from Kittanning northward the horizon is above water level along Allegheny River and appears in several of the larger side valleys. Pl. III, from a photograph taken at the Kittanning Clay Manufacturing Company at Kittanning, shows a section included between the bottom of the Vanport limestone and the top of the Lower Kittanning coal. The limestone and coal are here separated by a few inches of buhrstone ore and 15 to 30 feet of shale and fire clay. Pl. IV, *A* and *B*, are nearer views of part of the quarry. The buhrstone ore bed is the dark stratum beneath the shovel in Pl. IV, *B*.

At Mahoning the limestone is quarried and shipped to Kittanning, where it is used by the Kittanning Iron and Steel Manufacturing Company as a flux. At West Winfield, on the edge of Butler County, the bed has a thickness of 21 feet. It is extensively mined and shipped by A. G. Morris, who is working practically the whole thickness and has probably the largest limestone quarry in western Penn-

JULIUS BIEN & CO. LITH. N.Y.

MAP OF A PORTION OF THE ALLEGHENY VALLEY AND VICINITY

SHOWING OUTCROP OF VANPORT LIMESTONE

BY F. G. CLAPP
1904

From a map published by the Second Geological Survey of Pennsylvania 1892

Scale

10 0 10 20 miles

sylvania. Analyses of stone from this vicinity are wanting, but several have been made from points throughout Armstrong County. The usual thickness is only from 6 to 10 feet, as shown in the following table:

Analyses of Vanport limestone from Armstrong County, Pa.

	No. 15.[a]	No. 16.[b]	No. 17.[c]	No. 18.[d]	No. 19.[e]	No. 20.[f]	No. 21.[g]
Insoluble residue	3.420	0.790	2.100	0.370	2.110	3.220	2.300
Calcium carbonate ($CaCO_3$)	93.246	96.007	94.185	96.785	95.567	93.292	94.721
Magnesium cabonate ($MgCO_3$)	1.740	1.498	1.483	1.278	1.422	.968	1.044
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	1.667	1.462	2.089	1.000	.930	1.713	1.388
Sulphur	-------	-------	-------	.060	-------	-------	-------
Phosphorus	.032	.034	.031	.029	.035	.047	.047
Thickness in feet	8 to 10	9	7	8	-------	-------	-------

[a] Vol. H5, p. 97; analysis by McCreath.
[b] Op. cit., p. 169; analysis by McCreath.
[c] Op. cit., p. 64; analysis by McCreath.
[d] Vol. M2, p. 298.
[e] Vol. M3, p. 85.
[f] Op. cit., p. 86.
[g] Op. cit., p. 85.

No. 15.—Cowanshannock Creek, west edge of Cowanshannock Township: Coarse; grayish; very fossiliferous.

No. 16.—Mahoning Creek, at Stewardson Furnace.

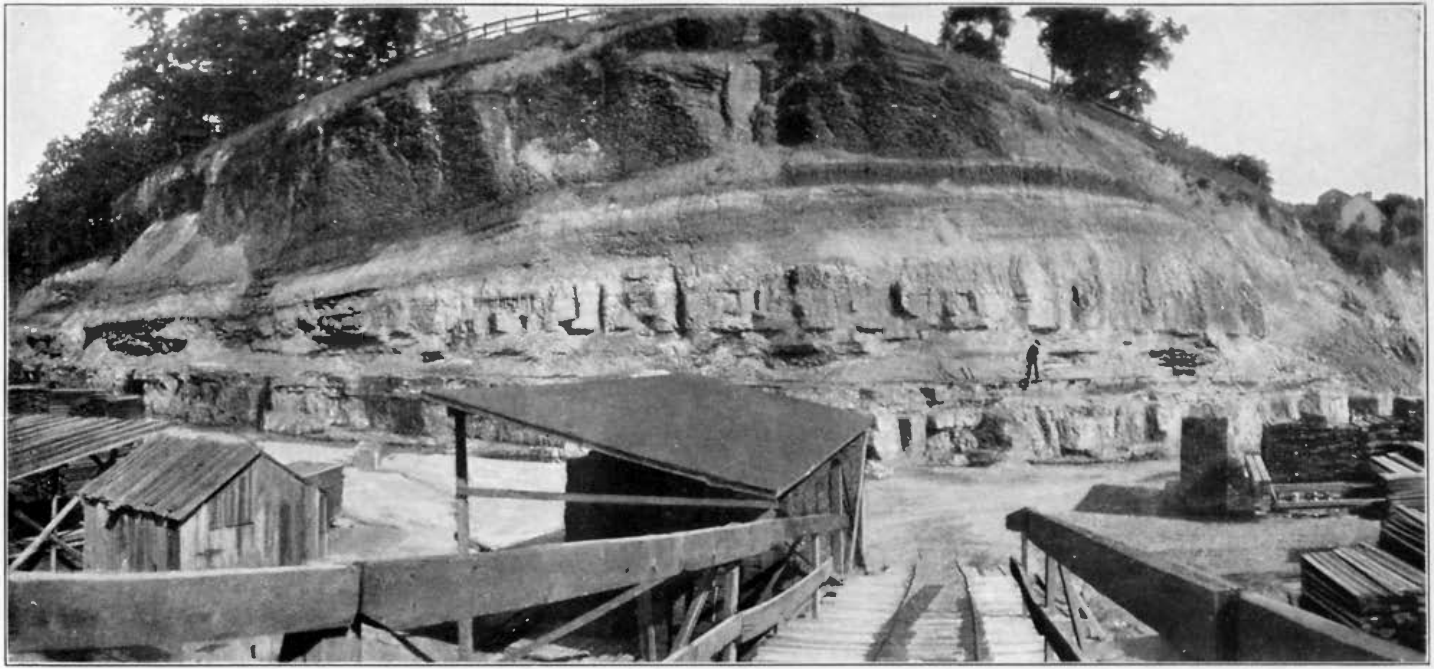
No. 17.—Crooked Creek, between Mr. George's and pottery: Bluish gray; compact; brittle; richly fossiliferous: the lime is dark, but good, breaking down into a soft fine powder.

No. 18.—Pine Creek furnace, 6 miles northeast of Kittanning: Compact; bluish gray; irregular fracture.

No. 19.—Ross Reynold's limestone, one-half mile north of Kittanning: Fine grained; fossiliferous; mottled with calcite; rather tough; light pearl gray.

No. 20.—P. Graff, near Buffalo Mills: Fine grained; brittle; more or less stained with ferric oxide; fracture rough, somewhat conchoidal; color, dark gray.

No. 21.—J. A. Colwell's quarry, one-fourth mile northwest of Mahoning furnace: Rather compact and fine grained, full of fossil casts; bluish gray; conchoidal fracture.



VANPORT LIMESTONE IN QUARRY OF KITTANNING CLAY MANUFACTURING COMPANY, KITTANNING, PA.

(Photograph by M. R. Campbell.)

Following is a more detailed analysis of a specimen from Stewardson furnace, 1 mile east of the mouth of Madison Creek, in Madison Township:

Analysis of Vanport limestone from Stewardson furnace, Armstrong County, Pa.[a]

	No. 22.
Calcium carbonate ($CaCO_3$)	95.585
Magnesium carbonate ($MgCO_3$)	.907
Silica (SiO_2)	2.030
Alumina (Al_2O_3)	.174
Ferric oxide (Fe_2O_3)	1.114
Manganic oxide (Mn_2O_3)	.206
Sulphur trioxide (SO_3)	.064
Phosphoric oxide (P_2O_5)	.082
Water	.150

[a] Vol. M3, p. 85.

No. 22.—Fine grained; full of fossil casts; pearl gray to reddish gray; fracture rough, slightly conchoidal.

Clarion County.—According to the Second Survey, although the limestone is sometimes absent over wide areas, it has nevertheless more than 450 linear miles of outcrop in Clarion County. The thickness averages about 8 feet in the western townships and occasionally runs as high as 15 feet. In the past the stone has been considerably used as a furnace flux. Four analyses have been made, as follows:

Analyses of Vanport limestone from Clarion County, Pa.[a]

	No. 23.	No. 24.	No. 25.	No. 26.
Insoluble residue	1.110	1.780	1.960	2.190
Calcium carbonate ($CaCO_3$)	96.428	95.196	95.532	95.232
Magnesium carbonate ($MgCO_3$)	1.202	1.265	.930	.407
Alumina (Al_2O_3) + Ferric oxide (Fe_2O_3)	.867	1.529	1.050	1.310
Phosphorus	.023	.081	.070	.061

[a] Vol. M3, p. 87.

No. 23.—Barger quarry, Perry Township: Rather coarse grained; mottled with calcite; bluish gray.

No. 24.—Sligo furnace, Piney Township: Fine grained; rather tough; stained with ferric oxide; light bluish gray.

No. 25.—Hindman's quarry, Clarion Township: Fine grained; mottled with calcite; rather brittle; bluish gray.

No. 26.—On Long Run, Porter Township: Brittle; more or less stained with ferric oxide; generally pearl gray; bed 5 to 6 feet thick, overlain by 9 inches of carbonate ore.

Jefferson County.—Over three-fourths of Jefferson County the bed has extensive outcrops, with a maximum thickness of from 4 to 6 feet; but toward the southeast it dies out entirely, and in Clearfield County is unknown.

Analyses of Vanport limestone from Jefferson County, Pa.

	No. 27.[a]	No. 28.[b]	No. 29.[b]	No. 30.[b]
Insoluble residue	1.280	1.300	1.910	2.040
Calcium carbonate ($CaCO_3$)	96.578	96.428	94.392	93.643
Magnesium carbonate ($MgCO_3$)	.832	.908	1.702	1.816
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	.780	.990	1.315	1.310
Phosphorus	.037	.034	.031	.030

[a] Vol. M3, p. 90. [b] Op. cit., p. 89.

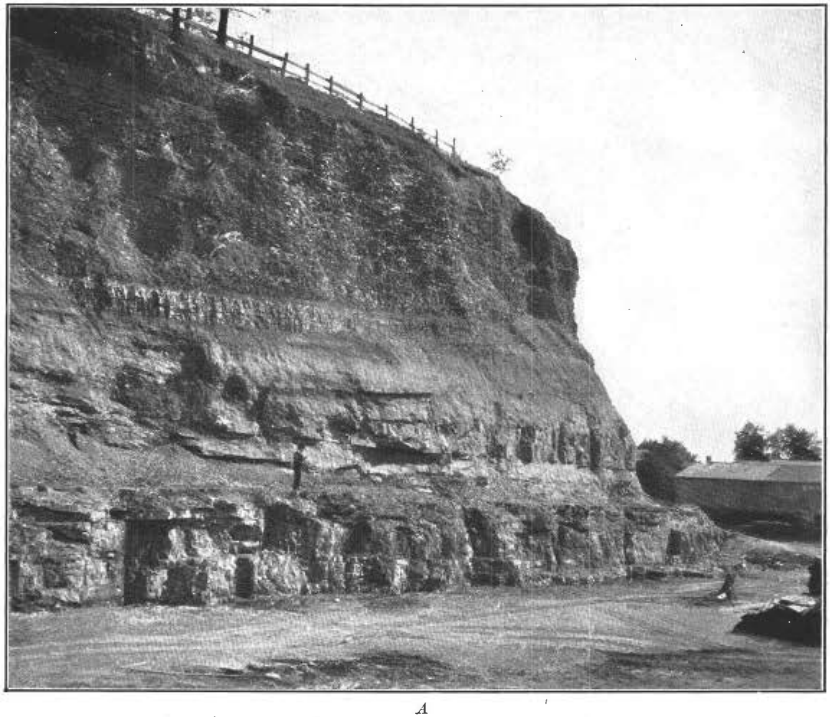
No. 27.—Samuel Shield's property, 1 mile north of Dowlingville: Rather fine grained; fossiliferous; sparkles with calcite; pearl gray.

No. 28.—Property of A. Enty, one-half mile southeast of Worthville: Fine grained; brittle; fossiliferous; light bluish gray.

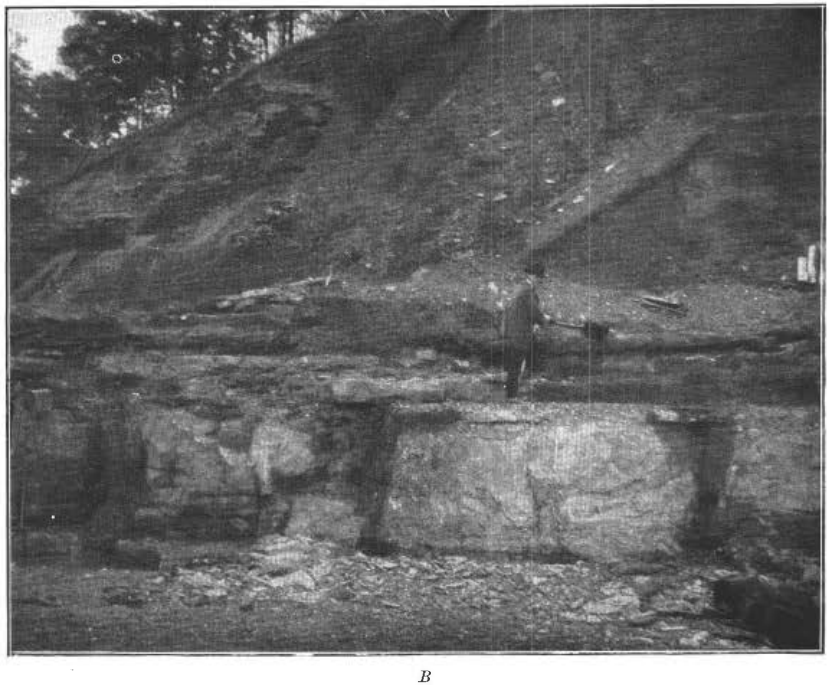
No. 29.—C. Bovaird, 3 miles northwest of Brockwayville: Fine grained; brittle; pearl gray.

No. 30.—Property of William Hanna, 2 miles northeast of Sprankles Mills: Hard and tough; fine grained; full of fossil casts; dark bluish gray.

Elk County.—Little is known of the limestone in this county, but from analyses made by the Second Survey it is thought to be more variable in quality than in any other portion of the region. It is here known as the Clermont limestone, has a maximum thickness of from 7 to 10 feet, and has been quarried on a small scale.



A



B

VANPORT LIMESTONE IN QUARRY OF KITTANNING CLAY MANUFACTURING COMPANY, KITTANNING, PA.

(Photographs by M. R. Campbell and Charles Batts)

Analyses of Vanport limestone from Elk County, Pa.

	No. 31.[a]	No. 32.[b]	No. 33.[a]	No. 34.[b]	No. 35.[b]
Insoluble residue	2.390	8.390	3.370	7.370	1.630
Calcium carbonate ($CaCO_3$)	86.910	85.714	91.785	86.214	94.357
Magnesium carbonate ($MgCO_3$)	6.659	1.170	1.808	1.785	1.634
Alumina (Al_2O_3) + Ferric oxide (Fe_2O_3)	2.205	3.422	1.710	2.610	1.638
Phosphorus	.017	.069	.032	.050	.031

	No. 36.[b]	No. 37.[b]	No. 38.[b]	No. 39.[b]
Insoluble residue	2.200	61.670	38.950	41.690
Calcium carbonate ($CaCO_3$)	94.107	27.857	54.553	49.732
Magnesium carbonate ($MgCO_3$)	1.369	.983	1.135	1.331
Alumina (Al_2O_3) + Ferric oxide (Fe_2O_3)	1.626	3.830	3.030	3.650
Phosphorus	.063	.062	.104	.238

[a] Vol. M3, p. 91. [b] Op. cit., p. 92.

No. 31.—G. W. Winslow's farm, 2 miles northeast of Benezette: Rather coarse grained; brittle; mottled; thickness, 10 feet.

No. 32.—Kylers Corner, Fox Township, on east side of Little Toby Creek: Very fine grained; brittle; fracture conchoidal; color, bluish gray.

No. 33.—Brandy Camp post-office, Horton Township: Rather coarse grained; brittle; mottled with calcite: bluish gray.

No. 34.—One mile east of J. S. Chamberlain's farm, from branch of Toby Creek, Fox Township: Very fine grained and brittle; fracture, subconchoidal; dark bluish gray.

No. 35.—General Kane's quarry, Jones Township; Johnson Run coal basin, 4 miles east of Wilcox (upper bed): Fine grained and very brittle; more or less stained with iron oxide; reddish gray.

No. 36.—General Kane's quarry, Jones Township; Johnson Run coal basin, 4 miles east of Wilcox (lower bed): Rather fine grained; brittle; mottled with calcite; dark bluish gray.

No. 37.—Oyster's quarry, Brockport, Horton Township (middle bed): Fine grained; brittle; argillaceous; dark blue.

No. 39.—Oyster's quarry, Brockport, Horton Township: Appearance, shaly; fossiliferous; bluish black; thickness in this quarry, 7 feet or more.

JOHNSTOWN LIMESTONE.

This is an impure limestone occurring directly beneath the Upper Kittanning coal and fire clay. Although it has been observed at widespread localities throughout the western part of the State, it is not supposed to be at all persistent, as it is frequently known to give

way to ore-bearing shales, and sometimes disappears entirely. On account of having been used for natural cement at its type locality at Johnstown, the limestone has hitherto been known as the Johnstown cement bed. The composition, however, is extremely irregular, the calcium carbonate varying anywhere between 34 and 92 per cent and the magnesium carbonate from 1.4 to 21 per cent. This variation renders the term "cement rock" hardly appropriate, and the word "limestone" is therefore substituted. The frequent large percentage of silica and other impurities is illustrated by the following analysis:

Analysis of Johnstown limestone from the type locality at Johnstown, Pa.[a]

	No. 40.
Insoluble residue	27.873
Calcium carbonate ($CaCO_3$)	34.301
Magnesium carbonate ($MgCO_3$)	21.650
Ferrous carbonate ($FeCO_3$)	8.700
Alumina (Al_2O_3)	3.390
Iron disulphide (FeS_2)	1.268
Phosphorus	.049

[a] Vol. H2, p. 153.

No. 40.—Hard and brittle; bluish gray; shows considerable pyrites; emits strong argillaceous odor when breathed upon.

On Black Lick Creek the bed is reported to be extensively quarried and to have a thickness of 10 feet. In this region and still farther east it was formerly supposed to be identical with the Ferriferous limestone and is spoken of as such in the early reports. In Jefferson County it is nearly always present, but is of an impure, ferruginous nature. In northern Indiana, Armstrong, Clarion, Butler, and Elk counties it is probably only locally present and always thin.

Analyses of Johnstown limestone from Indiana, Jefferson, Armstrong, and Elk counties, Pa.

	No. 41.[a]	No. 42.[b]	No. 43.[b]	No. 44.[c]
Insoluble residue	13.790	32.790	15.060	[d] 33.900
Calcium carbonate ($CaCO_3$)	78.768	36.214	58.750	51.410
Magnesium carbonate ($MgCO_3$)	2.421	16.883	16.005	3.962
Ferrous carbonate ($FeCO_3$)	-------	8.078	-------	-------
Alumina (Al_2O_3)	3.540	4.360	7.380	7.790
Ferric oxide (Fe_2O_3)		-------		
Sulphur	.097	.056	.041	-------
Phosphorus	.018	.056	.085	.033

	No. 45.[c]	No. 46.[e]	No. 47.[e]	No. 48.[f]
Insoluble residue	8.020	23.840	22.280	36.860
Calcium carbonate ($CaCO_3$)	82.393	53.750	64.160	50.357
Magnesium carbonate ($MgCO_3$)	1.891	9.989	1.838	2.467
Ferrous carbonate (Fe_2CO_3)	-------	-------	-------	-------
Alumina (Al_2O_3)	4.653	7.730	7.450	7.040
Ferric oxide (Fe_2O_3)				
Sulphur	-------	-------	-------	-------
Phosphorus	.300	.131	.305	.054

[a] Vol. H3, p. 190.
[b] Vol. H4, p. 221; analysis by A. S. McCreath.
[c] Vol. M3, p. 89.
[d] The ignited "insoluble residue" contains silica, 27.570 per cent; alumina, 4.800 per cent; ferric oxide, trace; lime, trace; magnesia, 0.245 per cent.
[e] Op. cit., p. 85.
[f] Op. cit., p. 92.

No. 41.—Tyhawk's quarry, 1 mile east of Black Lick Station, Indiana County (main bench): Compact; bluish gray; irregular fracture.

No. 42.—A. Gorman's quarry, 2 miles southwest of Smithport, Indiana County (upper portion): Hard and tough, with rough, irregular fracture and pearl-gray color; emits a strong argillaceous odor when breathed upon.

No. 43.—A. Gorman's quarry, 2 miles southwest of Smithport, Indiana County (lower portion): Hard and tough, with irregular fracture and bluish-gray color; emits a strong argillaceous odor when breathed upon; thickness in this quarry, 10 feet, with three thin clay partings.

No. 44.—N. B. Lane's property, 1 mile southeast of Brockwayville, Jefferson County: Hard and tough; argillaceous; more or less stained with iron oxide; color, generally dark gray.

No. 45.—John Iler's property, 1 mile northwest of Perrysville, Jefferson County: Rather hard and tough; fracture irregular, rough; dark bluish gray.

No. 46.—M. Davis's limestone, 1 mile southeast of Cochrans Mills, Armstrong County (outcrop specimen).

No. 47.—George S. Putney's limestone at Putneyville. Armstrong County: Rather coarse grained; hard and tough; bluish gray; irregularly stained with carbonaceous matter.

No. 48.—J. C. McAllister's farm, Horton township, Brandy Camp post-office, Elk County: Appearance sandy; rather course grained; very hard and tough; light bluish gray.

LOWER FREEPORT LIMESTONE.

In chemical composition, appearance, and other characteristics, this limestone is almost the exact counterpart of the Johnstown limestone. It is the most variable limestone of the Allegheny formation, being uncertain both in thickness and in quality. It is reported at many points, but probably is not persistent for long distances, and is not known to have anywhere a greater thickness than 5 feet.

Analyses of Lower Freeport limestone from Indiana, Jefferson, and Elk counties, Pa.

	No. 49.[a]	No. 50.[b]	No. 51.[c]	No. 52.[c]
Insoluble residue	5.502	8.210	8.400	2.070
Calcium carbonate ($CaCO_3$)	82.331	88.232	87.035	92.857
Magnesium carbonate ($MgCO_3$)	8.021	1.371	1.558	1.680
Alumina (Al_2O_3)	2.630	1.960	2.170	2.320
Ferric oxide (Fe_2O_3)				
Sulphur	.102	.048	-------	-------
Phosphorus	.017	.017	.057	.019

	No 53.[d]	No. 54.[e]	No. 55.[e]	No. 56.[e]
Insoluble residue	7.940	21.250	13.680	6.540
Calcium carbonate ($CaCO_3$)	82.000	57.321	69.357	81.875
Magnesium carbonate ($MgCO_3$)	6.311	8.854	9.308	7.189
Alumina (Al_2O_3)	2.736	7.940	4.835	2.750
Ferric oxide (Fe_2O_3)				
Phosphorus	.015	.038	.077	.066

[a] Vol. M2, p. 293.
[b] Vol. H4, p. 228; analysis by A. S. McCreath.
[c] Vol. M3, p. 88.
[d] Op. cit., p. 86.
[e] Op. cit., p. 91.

No. 49.—P. Brown's quarry, 4½ miles northeast of Blairsville, on Cambria and Indiana pike, Indiana County: Compact, brittle; bluish gray; irregular fracture.

No. 50.—S. Palmer's quarry, three-fourths of a mile northwest of Deckers Point, Indiana County: Irregularly seamed with white crystalline calcium carbonate; exceedingly brittle; rough irregular fracture and bluish-gray color.

No. 51.—N. B. Lane's property, 1 mile southeast of Brockwayville, Jefferson County: Fine grained, hard, and brittle; brownish gray.

No. 52.—Evans Round Top, one-half mile east of Corsica, Jefferson County: Fine grained, hard, and brittle; brownish gray.

No. 53.—Three miles northeast of Reimersburg, Toby Township, Clarion County: Very hard and tough; mottled and stained with ferric oxide; generally bluish gray.

No. 54.—T. Fox's farm, Horton Township, Mead Run, three-fourths mile north of Brockport, Elk County: Fine grained and brittle; fracture subconchoidal, bluish gray; known as "K limestone."

No. 55.—J. C. McAllister's farm, Horton Township, Elk County: Rather fine grained and brittle; fracture subconchoidal; bluish gray; known as "K limestone."

No. 56.—J. S. Chamberlain's farm, Horton Township, Brandy Camp Creek. 1½ miles south of Brandy Camp post-office, Elk County: Rather fine grained and brittle; conchoidal fracture; light bluish gray.

UPPER FREEPORT LIMESTONE.

Although probably not persistent over large areas, this bed is of considerably greater importance than the preceding one. It is known to be present at a great number of points throughout the Allegheny Valley. Usually it is less than 6 feet, but occasionally swells to much greater thickness, as in the ravine of Fort Run, near Manorville, in Armstrong County, where, with its interstratified beds, it is nearly 28 feet thick and has been extensively quarried by A. J. Dull & Co. The Second Survey reports the following section at this place:

Section of Upper Freeport limestone near Manorville, Pa.[1]

	Ft.	In.
1. Limestone	1	3
2. Clay	0	8
3. Limestone, impure	1	0
4. Slate	2	2
5. Limestone	4	5
6. Clay slate and impure limestone	2	5
7. Limestone, dark colored	2	2
8. Slate and impure limestone	3	2
9. Limestone	2	10
10. Slate and clay	1	3
11. Limestone, called "glassy layer"	2	7
12. Limestone	4	0
Total	27	11

Benches numbered 5, 9, and 11 of this section have been analyzed, with the following results:

Analyses of Upper Freeport limestone from near Manorville, Pa.[a]

	No. 57.	No. 58.	No. 59.
Insoluble residue	4.830	7.310	4.520
Calcium carbonate ($CaCO_3$)	89.303	82.589	89.857
Magnesium carbonate ($MgCO_3$)	1.900	5.751	2.898
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	2.002	3.367	1.860
Phosphorus	.021	.063	.017

[a] Vol. H5, p. 257; analyses by McCreath.

No. 57.—Bench No. 5: Very compact and fine grained; dark pearl gray; conchoidal fracture.

No. 58.—Bench No. 9: Fine grained, hard, and tough; somewhat argillaceous; dark pearl gray; conchoidal fracture; small crystals of pyrite throughout the section.

No. 59.—Very compact and fine grained; slightly mottled with calcite; pearl gray; conchoidal fracture.

[1] Vol. H5, p. 256.

Between Manorville and Kellys Station, in the vicinity of Logansport, the stone has been extensively quarried in the past for use as a flux, for which purpose it is well suited. It is also supposed to be a good limestone for use as a Portland-cement material.

The following section is reported from Mahaffey's quarry, Logansport:

Section of Upper Freeport limestone at Logansport, Pa.[1]

	Ft.	In.
1. Limestone	1	7
2. Limestone, impure	0	8
3. Limestone	2	4
4. Limestone, impure	0	10
5. Clay and slate	1	3
6. Limestone, impure	0	7
7. Limestone, "glassy layer"	5	6
Total	12	9

Analyses from benches 1, 4, and 7 of this section give the following percentages:

Analyses of Upper Freeport limestone from Logansport, Pa.[a]

	No. 60.	No. 61.	No. 62.
Insoluble residue	0.830	2.200	3.170
Calcium carbonate ($CaCO_3$)	96.453	93.214	93.571
Magnesium carbonate ($MgCO_3$)	1.445	2.065	1.324
Alumina (Al_2O_3)	.964	1.340	1.207
Ferric oxide (Fe_2O_3)			
Phosphorus	.007	.004	.029

[a] Loc. cit.; analyses by McCreath.

No. 60.—Bench No. 1: Fine grained and brittle; dark pearl gray.

No. 61.—Bench No. 4: Fine grained and tough; dark pearl gray.

No. 62.—Bench No. 7: Very compact and fine grained; hard and tough; light pearl gray; conchoidal fracture.

It was formerly quarried for flux by the Kittanning Iron and Steel Manufacturing Company, but owing to the greater cost of quarrying than the Vanport, its use has been discontinued.

At several other points in Armstrong County workable thicknesses are reported by the Second Survey, and the following analyses have been made, showing the stone to be of fair quality for flux and cement.

[1] Loc. cit.

Analyses of Upper Freeport limestone from Armstrong County, Pa.

	No. 63.[a]	No. 64.[a]	No. 65.[a]	No. 66[b].
Insoluble residue	1.850	1.920	5.030	9.520
Calcium carbonate ($CaCO_3$)	94.642	94.928	88.839	84.857
Magnesium carbonate ($MgCO_3$)	1.574	1.210	1.513	1.868
Alumina (Al_2O_3)	} 1.182	1.246	2.557	2.568
Ferric oxide (Fe_2O_3)				
Phosphorus	.012	.018	.021	.024

[a] Vol. M3, p. 84. [b] Op. cit., p. 83.

No. 63.—S. Monroe's quarry, 2 miles southwest of Slate Lick: Fine grained; tough; dark pearl gray.

No. 64.—William Marshall's quarry, one-half mile east of Dayton: Fine grained; tough, mottled with calcite; dark gray; fracture conchoidal.

No. 66.—W. R. Hamilton's land near coal mine 1½ miles north of Putneyville: Fine grained; tough; dark gray.

In Indiana County a thickness of 10 feet is reported at Groft Brothers' quarry near Chambersville, where it has been worked in the past; at Goods Mill on Little Mahoning Creek; at the Dick farm on Two Lick Creek, and possibly at several other localities. Usually, however, the thickness is considerably less than 10 feet.

Analyses of Upper Freeport limestone from Indiana County, Pa.

	No. 67.[a]	No. 68.[b]	No. 69.[c]	No. 70.[d]	No. 71.[d]
Insoluble residue	9.150	6.021	27.230	14.980	5.430
Calcium carbonate ($CaCO_3$)	84.407	84.125	54.768	72.264	89.821
Magnesium carbonate ($MgCO_3$)	2.800	5.198	8.627	6.493	1.801
Alumina (Al_2O_3)	} 2.120	3.220	6.930	4.190	1.700
Ferric oxide (Fe_2O_3)					
Sulphur	.188	.073	.112	.068	.133
Phosphorus	.018	.014	.017	.029	.027

[a] Vol. H4, p. 254; analysis by McCreath. [c] Vol. H4, p. 179; analysis by A. S. McCreath.
[b] Vol. M2, p. 292. [d] Vol. M2, p. 292.

No. 67.—Groft Brothers' quarry, 1 mile east of Chambersville: Compact; brittle; dark bluish gray; irregular fracture.

No. 68.—Rev. S. Brown's quarry, 1½ miles southwest of Five Points: Compact; brittle; sparkles with calcite; bluish gray; subconchoidal fracture.

No. 69.—C. Livengood's quarry, 3 miles southeast of Blairsville: Compact; brittle; bluish gray; irregular fracture; sparkles with calcite; strong argillaceous odor; thickness, 3 feet or more.

No. 70.—D. R. Griffith's quarry, 1½ miles southeast of Homer: Compact; brittle; dark bluish gray; irregular fracture; strong argillaceous odor.

No. 71.—S. C. Hazlett's quarry, 2 miles north of Jacksonville: Compact; brittle; bluish gray; subconchoidal fracture.

In Jefferson County the limestone is occasionally reported, but its greatest known thickness is only 6 to 8 feet. It has been burned on a very limited scale for enriching the soil.

Analyses of Upper Freeport limestone from Jefferson County, Pa.[a]

	No. 72.	No. 73.	No. 74.	No. 75.	No. 76.
Insoluble residue	3.130	6.770	6.170	16.660	3.480
Calcium carbonate ($CaCO_3$)	91.875	88.928	89.107	48.571	90.000
Magnesium carbonate ($MgCO_3$)	2.421	1.589	1.611	23.762	2.860
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	1.312	1.740	2.140	7.250	1.285
Phosphorus	.012	.023	.024	.032	.011

[a] Vol. M3, p. 88.

No. 72.—Property of D. Hopkins, 2 miles northeast of Frostburg: Very fine grained; brittle; mottled with calcite; pearl gray.

No. 73.—Property of A. Hoffman, 2 miles northeast of Woodville: Fine grained; brittle; mottled with calcite; pearl gray.

No. 74.—N. B. Lane's property, 1 mile southeast of Brockwayville: Fine grained; brittle; sparkles with calcite; generally pearl gray.

No. 75.—John Iler's property, 1 mile northwest of Perrysville (upper bench): Hard and tough; appearance sandy; fracture, irregular; color, light pearl gray.

No. 76.—John Iler's property, 1 mile northwest of Perrysville (lower bench): Rather fine grained; comparatively brittle; mottled with calcite; bluish gray.

In Elk and Clarion counties the limestone is not well known, but a general idea of its character may be gained from the following analyses:

Analyses of Upper Freeport limestone from Elk and Clarion counties, Pa.

	No. 77.[a]	No. 78.[b]	No. 79.[b]
Insoluble residue	12.290	5.320	1.800
Calcium carbonate ($CaCO_3$)	80.357	82.678	93.803
Magnesium carbonate ($MgCO_3$)	1.619	8.248	2.270
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	3.610	1.365	.765
Phosphorus	.086	.022	.008

[a] Vol. M3, p. 91. [b] Op. cit., p. 86.

No. 77.—J. S. Hyde's farm, Horton Township, 1 mile south of Brandy Camp post-office on Brandy Camp Creek, Elk County: Rather coarse grained; brittle; fracture irregular; light bluish gray.

No. 78.—Reichert's quarry, Perry Township, Clarion County: Rather fine grained; mottled with calcite; dark pearl gray.

No. 79.—New Athens, Madison Township, Clarion County: Rather fine grained; mottled and seamed with calcite; dark gray.

Summarizing, it may be said for the Upper Freeport limestone that, while of very irregular occurrence, it is frequently of workable thickness, and nearly always contains a fairly high percentage of lime, low percentage of magnesia, and low percentage of phosphorus, rendering the product suitable for Portland cement, flux, or fertilizer.

LIMESTONES OF THE CONEMAUGH FORMATION.

Between the Upper Freeport and Pittsburg coal beds no persistent bed of limestone is known, although the impure Ames bed is present at scattered points throughout the western portion of the valley, and the Pittsburg limestone occurs on a few of the hilltops in the southern part of Indiana and Armstrong counties and northern Westmoreland County. A specimen from A. H. Fulton's quarry, in the latter bed at West Lebanon, shows the following composition:

Analysis of Pittsburg limestone from Indiana County, Pa.[a]

	No. 80.
Insoluble residue	10.327
Calcium carbonate ($CaCO_3$)	82.768
Magnesium carbonate ($MgCO_3$)	2.875
Alumina (Al_2O_3)	2.830
Ferric oxide (Fe_2O_3)	
Sulphur	.156
Phosphorus	.011

[a] Vol. M2, p. 289.

No. 80.—Generally compact and brittle; irregular fracture; bluish-gray color; seamed with bluish-black limestone.

Besides the beds mentioned, there are a number of more or less local beds known at scattered localities. A number of these have been analyzed, but the following instances are the only ones of which the exact stratigraphic position is known:

Analyses of local limestones in the Conemaugh formation, in Jefferson and Indiana counties, Pa.

	No. 81.[a]	No. 82.[a]	No. 83.[a]	No. 84.[b]
Insoluble residue	9.780	11.780	2.390	16.540
Calcium carbonate ($CaCO_3$)	75.357	77.143	92.500	65.892
Magnesium carbonate ($MgCO_3$)	9.330	4.691	2.497	9.686
Alumina (Al_2O_3)	4.230	3.790	1.530	5.710
Ferric oxide (Fe_2O_3)				
Sulphur				.292
Phosphorus	.017	.073	.023	.016

[a] Vol. M3, p. 87. [b] Vol. M2, p. 366.

No. 81.—Property of James Smith, 2 miles northeast of Big Run, Jefferson County; about 125 to 150 feet above Upper Freeport coal: Fine grained, rather hard and tough; pearl gray.

No. 82.—Property of Jacob Smith, 2 miles north of Big Run, Jefferson County; about 150 to 175 feet above Upper Freeport coal: Fine grained; rather brittle; conchoidal fracture; irregularly seamed with calcite; dark bluish gray.

No. 83.—Property of James Smith, 2 miles northeast of Big Run, Jefferson County; about 200 to 225 feet above Upper Freeport coal: Rather coarse grained; brittle; bluish gray.

No. 84.—G. M. Doty's quarry, 5 miles northeast of Blairsville, Indiana County; about 120 feet below Pittsburg coal: Compact; brittle; bluish gray; irregular fracture; sparkles with calcite; emits strong argillaceous odor when breathed upon.

SEWICKLEY LIMESTONE.

Only in the extreme southern part of Indiana County are any rocks of the Monongahela or Dunkard formations present, and descriptions given under the heading "Monongahela Valley" will in general apply to limestones in these formations running across the divide into Allegheny Valley. The following is an analysis of the Sewickley limestone:

Analysis of Sewickley limestone from Indiana County, Pa.

	No. 85.[a]
Insoluble residue	12.160
Calcium carbonate ($CaCO_3$)	79.821
Magnesium carbonate ($MgCO_3$)	3.601
Alumina (Al_2O_3)	3.020
Ferric oxide (Fe_2O_3)	
Sulphur	.117
Phosphorus	.018

[a] Vol. H4, p. 159; analysis by A. S. McCreath.

No. 85.—Sewickley limestone from Robert Smith's quarry at Smiths Station, 2 miles northeast of Blairsville: Compact; brittle; sparkling with calcite; bluish gray; irregular fracture.

BENWOOD LIMESTONE.

The Benwood limestone is known in this region only on Elders Ridge and at one or two minor localities. On Elders Ridge it occurs in several layers separated by variable intervals of shale, the whole deposit being reported to be at least 25 feet thick. The limestone is reported on the J. and R. Smith farms, and outcrops on several rounded knobs in the vicinity, capped by a thin-bedded sandstone regarded as the division between the upper and lower parts of the Benwood limestone. Only fragmentary patches of the limestone are preserved, but what is left of it is smooth, light gray, and nonfossiliferous. It makes a strong lime, excellent for fertilizing purposes, and can be quarried at little expense.

BEAVER VALLEY.

Under this head will be discussed the few limestones of Beaver, Butler, and Lawrence counties.

MERCER LIMESTONES.

In the "Mercer group," which occupies the middle of the Pottsville formation and occurs at an interval ranging from 110 to 135 feet below the Vanport limestone, there are in Lawrence County two beds, known as the Upper and Lower Mercer limestones. Of these, the lower is the more persistent, being reported as almost universally present, but is always thin, with a maximum thickness of only 1 to 3 feet. On account of its great persistence it is valuable as a key rock in the region.

The horizon of the Upper Mercer limestone is 20 to 35 feet above the lower bed. Although not so commonly present, it is sometimes of slightly greater thickness, occasionally as much as 4 feet. Neither of the beds, however, can be considered as having economic value.

VANPORT LIMESTONE.

In Beaver Valley, as in the Allegheny Valley, the Vanport limestone is the most persistent, thickest, purest, and most massive limestone of the series. Its outcrop is shown by the blue line on Pl. V.

Beaver County.—Over southern Butler and the greater part of Beaver the Vanport limestone lies deep beneath the surface, but along Ohio River it occurs above water level. It has a thickness of 18 feet at Vanport, its type locality, 16 feet at Industry, 8 feet at Merrill, and 10 feet at Fallston, on Beaver River; elsewhere where observed it is less than 5 feet thick, usually less than 1 foot, and is sometimes entirely absent.

The following section is reported in Tygart's quarry, at Vanport:

Section of Vanport limestone at Vanport, Pa.[1]

	Feet.
Gray limestone	7
Shale	1
Gray limestone	5
Blue limestone	5
Total	18

The division of the limestone into the "gray" upper portion and the "blue" lower portion is usually well marked throughout the region. In the first two of the following analyses from Power's quarry, No. 86 is from the upper and No. 87 from the middle stratum.

Analyses of Vanport limestone from Power's quarry, near Vanport, Pa.[a]

	No. 86.	No. 87.	No. 88.	No. 89.
Insoluble residue	7.030	4.780	4.800	2.770
Calcium carbonate ($CaCO_3$)	88.464	91.607	91.089	93.482
Magnesium carbonate ($MgCO_3$)	1.445	1.566	1.587	1.544
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	2.324	1.291	1.589	1.823
Sulphur	.097	.290	.047	.030
Phosphorus	.029	.030	.040	.047

[a] Vol. M2, p. 297.

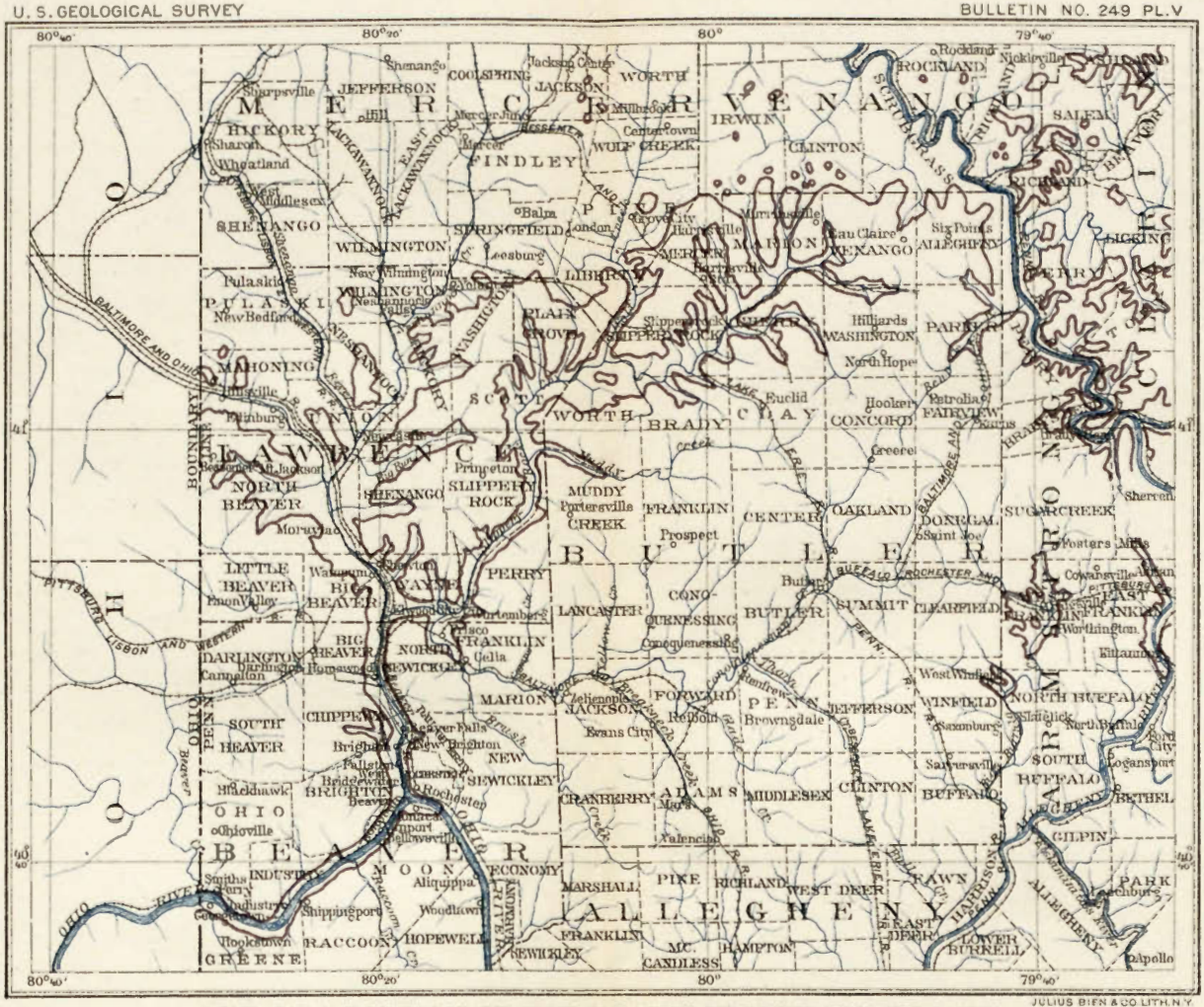
No. 86.—Upper stratum: Compact, very brittle; irregular fracture; color, dull gray and reddish gray.

No. 87.—Middle stratum: Compact and tough; sparkling with calcite; spotted with pyrites; color, pearl gray and reddish gray.

No. 88.—Tygart's quarry, one-half mile below Vanport (lower bench): Hard and brittle; irregular fracture; sparkling with calcite; color, bluish gray and reddish gray.

No. 89.—Severn's quarry, one-half mile below Vanport (upper bench): Exceedingly brittle; irregular fracture; color, generally reddish gray.

[1] Vol. Q, p. 61.



JULIUS BIEN & CO. LITH. N.Y.

MAP OF A PORTION OF THE BEAVER VALLEY AND VICINITY

SHOWING OUTCROP OF VANPORT LIMESTONE

BY F. G. CLAPP
1904

From a map published by the Second Geological Survey of Pennsylvania, 1893

Scale

10 0 10 20 miles

The upper of the two beds is now burned extensively at Vanport for lime, which is of high quality and excellent as a flux for iron, for which purpose it was once shipped extensively to Pittsburg. The lower bed is usually rejected, but there is no known reason why this portion should not be suitable for the same purpose. At the time of the construction of the Erie and Pittsburg Canal the limestone was used in manufacturing natural cement for the locks.

Lawrence County.—In Lawrence County the Vanport limestone is very extensively present, underlying nearly two-thirds of the county. It often attains greater thickness than in Beaver County, frequently expanding to 15 feet, and sometimes as much as 20 feet, in thickness. The rock is extensively quarried for furnace flux at Newcastle, and at other points throughout the county. One of the Newcastle quarries is shown in Pl. VI. At Wampum, on Beaver River, the bed is 25 feet thick, and is quarried by the Crescent Portland Cement Company, which manufactures a cement of superior quality. The following analyses of stone from the upper, middle, and lower strata were made for the company:

Analyses of Vanport limestone from Wampum, Pa.[a]

	No. 90.	No. 91.	No. 92.
Lime (CaO)	[b]49.31	[c]50.16	[d]52.04
Magnesia (MgO)	[e].75	[f].42	[g].43
Silica (SiO_2)	4.50	4.14	2.31
Alumina (Al_2O_3)	.21	.21	.24
Ferric oxide (Fe_2O_3)	1.77	1.77	1.18
Manganous oxide (MnO)	.20	1.20	.22
Sulphur	.06	.20	.17
Phosphoric oxide (P_2O_5)	.07	.05	.04
Carbon dioxide (CO_2)	40.54	39.87	41.72
Water and organic matter	2.59	2.03	1.65

[a] Vol. Q2, p. 107; analysis by Robertson Brothers, of Pittsburg.
[b] Corresponds to approximately 87.90 per cent of $CaCO_3$.
[c] Corresponds to approximately 89.56 per cent of $CaCO_3$.
[d] Corresponds to approximately 92.93 per cent of $CaCO_3$.
[e] Corresponds to approximately 1.57 per cent of $MgCO_3$.
[f] Corresponds to approximately 0.88 per cent of $MgCO_3$.
[g] Corresponds to approximately 0.90 per cent of $MgCO_3$.

No. 90.—Upper portion.
No. 91.—Middle portion.
No. 92.—Lower portion.

Following are other analyses from Lawrence County:[1]

Analyses of Vanport limestone from Lawrence County, Pa.

	No. 93.	No. 94.	No. 95.	No. 96.
Insoluble residue	3.070	1.970	2.080	2.790
Calcium carbonate ($CaCO_3$)	93.340	95.768	94.785	94.214
Magnesium carbonate ($MgCO_3$)	1.460	1.097	1.369	1.732
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	1.563	.632	1.187	.805
Sulphur	.123	.088	.123	.165
Phosphorus	.047	.017	.032	.020

No. 93.—Green's, Marquis's, and Johnson's quarries near Newcastle, Lawrence County: Compact, brittle; sparkling with calcite; bluish gray and pearl gray; irregular fracture.

No. 94.—McCord's quarry, 3 miles northwest of Mount Jackson, North Beaver Township, Lawrence County: Compact, brittle; sparkling with calcite; pearl gray; irregular fracture.

No. 95.—Moffit's quarry, 2 miles north of Croton, Lawrence County: Compact, brittle; sparkling with calcite; bluish gray and pearl gray; irregular fracture.

No. 96.—J. K. Shinn & Bros.' quarry near Wampum, Big Beaver Township, Lawrence County: Compact, brittle; sparkling with calcite; bluish gray.

LOWER FREEPORT LIMESTONE.

This limestone is known only occasionally in the region. On Elkhorn Run, in Beaver County, it has a thickness of 5 feet; at Beaver Falls, of 3 feet; in Bradys Run, of 5 to 8 feet; on Island Run of 5 feet; and in South Beaver Township, of 4 to 9 feet South Beaver is supposed to be the only township in which it has been burned. No analyses are known to have been made.

UPPER FREEPORT LIMESTONE.

Like the Lower Freeport limestone, this is irregularly present in the region. It sometimes appears only as nodules, is nearly always very thin, and is absent over large areas. In South Beaver Township, in Beaver County, and possibly in Lawrence County, it has been burned for lime. The following are the maximum thicknesses observed in Beaver County—5 feet at Monaca, 5 feet at a point 4 miles east of New Brighton, 4 feet on Raccoon Creek, 5 to 7 feet on Island Run, and 6 to 8 feet in South Beaver Township. In Lawrence County nothing is known of the limestone except that at several points it is said to range from 5 to 10 feet in thickness. No analyses are known.

[1] Vol. M2, p. 287.

VANPORT LIMESTONE QUARRIES AT NEWCASTLE, PA.

(Photograph by M. R. Campbell.)

AMES LIMESTONE.

Several beds exist in the Conemaugh formation, but all are thin and of little or no value. The most persistent bed is the Ames limestone (Crinoidal), an impure and very fossiliferous bed averaging 230 feet below the Pittsburg coal. The rock is often entirely composed of crinoid stems and spines and other fossils closely packed together, forming a limestone unlike any other Carboniferous bed. This bed, on account of its dark-bluish-gray or greenish-gray color and peculiar fossiliferous appearance, is an excellent reference datum over wide areas. It is, however, of no economic value, being difficult to burn, and is seldom used even for fertilizer. In thickness the bed ranges up to about 6 feet, and is occasionally double.

ALLEGHENY MOUNTAINS.

The greater part of this region, including Clearfield, Cambria, and Somerset counties, is underlain by the Coal Measures, which have their eastern limit along the Allegheny Front, near the boundary of Blair and Bedford counties. East of this line the rocks have been eroded in places as deep as the Ordovician formations, while to the west all horizons are exposed from the Mauch Chunk to the base of the Monongahela formation. Only the region west of the main mountain crest will be considered in this report.

Of the limestones of this district very little is known, only small areas having been covered by the present survey. From what has been seen the limestones seem to be of comparatively little value. Following are the most important features in regard to the several beds:

LOYALHANNA LIMESTONE.

This bed is well shown along the Pennsylvania Railroad, wherever its horizon is exposed, at points from Blairsville to the Allegheny Front, above Altoona. It is easily identified by its peculiar weathering, which is well shown in Pl. VII, *A*. This is reproduced from a photograph taken at the "Viaduct," 1 mile east of Mineral Point, Cambria County. It is equally well shown at Allegrippus, just above the Horseshoe Curve (Pl. VII, *B*), and where Laurel Hill and Chestnut Ridge are cut by the Conemaugh west of Johnstown. Near the last-named place it is quarried extensively and crushed for railroad ballast.

JOHNSTOWN LIMESTONE.

This is the "cement bed" of the Pennsylvania reports, so called because it was once quarried for natural cement.[1] In this region it was earlier known as the Ferriferous limestone, being confused with the Vanport bed, which exists farther west. Allowance for this mis-

[1] See analysis No. 40, p. 28.

taken correlation must therefore be made when consulting the Cambria and Indiana counties reports. In Clearfield County the Johnstown limestone is almost or quite unknown, but throughout the greater part of Somerset and Cambria it is supposed to be nearly always present where its horizon outcrops, and in Somerset is a fairly good key rock. Usually it is a compact, brittle, bluish-gray limestone, with a probable maximum thickness of from 6 to 8 feet. Generally it contains high percentages of magnesia, iron, alumina, and silica, as shown by the following analyses from various points in Somerset County:

Analyses of Johnstown limestone from Somerset County, Pa.

	No. 97.[a]	No. 98.[b]	No. 99.[a]	No. 100.[c]	No. 101.[d]
Insoluble residue	3.950	12.020	10.760	17.770	3.850
Calcium carbonate ($CaCO_3$)	92.298	54.321	69.264	52.940	90.544
Magnesium carbonate ($MgCO_3$)	1.483	23.088	13.773	16.060	2.134
Manganous carbonate ($MnCO_3$)	Trace.	Trace.	Trace.	.....	.....
Ferrous carbonate ($FeCO_3$)	1.167	8.492	4.739	5.800	1.503
Alumina (Al_2O_3)	.359	1.626	.403	4.440	.261
Sulphur	.097	.127	.106	.088	.464
Phosphorus	.018	.051	.047	.058	.013
Carbonaceous matter	.550	.980	.590	.....	.....

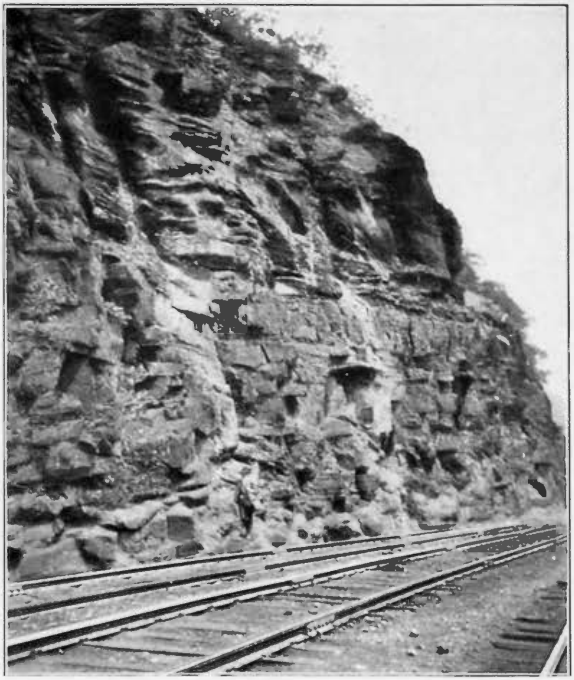
	No. 102.[e]	No. 103.[f]	No. 104.[g]	No. 105.[d]	No. 106.[h]
Insoluble residue	13.860	4.970	5.640	6.040	24.780
Calcium carbonate ($CaCO_3$)	50.160	79.478	88.139	86.778	63.969
Magnesium carbonate ($MgCO_3$)	18.494	10.222	1.854	2.908	4.244
Ferrous carbonate ($FeCO_3$)	11.600	3.693	1.798	2.972	4.393
Alumina (Al_2O_3)			.340		
Sulphur	.153	.168	.357	.166	.385
Phosphorus	.120	.034	.023	.137	.142

[a] Vol. H3, p. 231; analysis by A. S. McCreath.
[b] Loc. cit.; analysis by D. McCreath.
[c] Op. cit., p. 146.
[d] Vol. M2, p. 295; analysis by D. McCreath.
[e] Vol. H3, p. 134; analysis by D. McCreath
[f] Op. cit., p. 232; analysis by D. McCreath.
[g] Op. cit., p. 128; analysis by A. S. McCreath.
[h] Op. cit., p. 155; analysis by D. McCreath.

No. 97.—J. W. Beam's quarry at Jenner Crossroads (upper bench): Compact; brittle; fine grained; bluish gray.

No. 98.—J. W. Beam's quarry at Jenner Crossroads (middle bench): Hard; brittle; bluish gray.

No. 99.—J. W. Beam's quarry at Jenner Crossroads (lower bench); Compact; brittle; bluish gray.



A. LOYALHANNA LIMESTONE RESTING ON SANDSTONE OF THE POCONO FORMATION, ALLEGRIPPUS, BLAIR COUNTY, PA.

(Photograph by Charles Batts.)

B. WEATHERED SURFACE OF THE LOYALHANNA LIMESTONE AT THE "VIADUCT," 1 MILE EAST OF MINERAL POINT, CAMBRIA COUNTY, PA.

(Photograph by M. R. Campbell.)

No. 100.—D. Rodger's quarry on Huskins Run, Shade Township: Hard; rather sandy; bluish gray.

No. 101.—Trevorrow's quarry, near Davidsville: Very brittle; fine grained; bluish gray.

No. 102.—J. Weaver's quarry, about three-fourths mile west of Scalp Level: Compact; bluish gray; much coated with iron oxide.

No. 103.—J. J. Pile's quarry, near Spiesville, on Quemahoning Creek: Compact; brittle; bluish gray.

No. 104.—Wilt's quarry, near Stoystown: Compact; fine grained; bluish gray.

No. 105.—Reitz's quarry, 1¼ miles south-southeast of Friedenburg: Hard; compact; bluish gray.

No. 106.—Zimmerman's quarry, 3½ miles southeast of Somerset: Compact; sandy; bluish gray; thickness over 6 feet.

Of these analyses it will be noticed that the first three are from different benches in the same quarry. The marked difference in composition illustrates the statement already made that several analyses from different portions of the bed should be made in order to obtain a correct idea of its quality.

FREEPORT LIMESTONES.

Neither of the Freeport beds is of importance in the region, although they are known to be frequently present, and at a few points have been opened by farmers. The greatest known thickness is at the east end of the west-bound tunnel of the Pennsylvania Railroad at Gallitzin, where the following section of the Upper Freeport limestone has been measured.

Section of Upper Freeport limestone at Gallitzin, Pa.

	Ft.	In.
Limestone	2	9
Shale	0	9
Limestone	2	4
Shale	0	3
Limestone	2	0
Shale	0	7
Limestone with shale partings	5	6
Shale	1	10
Limestone	2	8
Total	18	8

At a small opening 2 miles east of Ashville, in Cambria County, a bed supposed to be one of the Freeport limestones has been observed to be over 6 feet. An entire thickness of over 15 feet is reported at this point, but the truth of the statement can not be vouched for. On the land of Dan Caldwell, 1 mile northwest of Glen Hope, in Clearfield County, the Upper Freeport limestone has been burned in the past, and a sample from this locality showed the following composition:

Analysis of Upper Freeport limestone from near Glen Hope, Pa.[a]

	No. 107.
Insoluble residue	2.070
Calcium carbonate ($CaCO_3$)	93.810
Magnesium carbonate ($MgCO_3$)	1.710
Sulphur	.053
Phosphorus	.008

[a] Vol. H, p. 105.

At a few other points the beds have been burned locally for agricultural purposes.

LIMESTONES OF THE CONEMAUGH AND MONONGAHELA FORMATIONS.

Throughout the Conemaugh formation limestone beds are numerous, but are always thin, and can never be traced for long distances. In Cambria County the best-known exposures occur along the Pennsylvania Railroad cuts in the Wilmore basin between Summerhill and Munster, in which region beds up to 6 and 10 feet in thickness have been observed, but are never known to be persistent. The majority of these beds occur in an interval about 300 to 400 feet above the Upper Freeport coal.

Elk Lick limestone.—This bed of limestone attains considerable prominence in Somerset County. It occurs from 200 to 240 feet below the Pittsburg coal, and in its best development reaches a thickness of 12 feet. This limestone has not been studied by the present survey, but the Second Survey reports it as of a light-gray color, often tinged with buff. At a quarry three-fourths of a mile north of Ursina the bed is said to be 10 feet thick and to yield lime of superior quality. Several analyses have been made, which show the following compositions:

Analyses of Elk Lick limestone from Somerset County, Pa.

	No. 108.[a]	No. 109.[b]	No. 110.[b]
Insoluble residue	3.740	19.800	2.500
Calcium carbonate ($CaCO_3$)	90.803	55.589	89.522
Magnesium carbonate ($MgCO_3$)	2.738	14.224	5.327
Ferrous carbonate ($FeCO_3$)	1.986	6.835	1.812
Alumina		2.886	.224
Sulphur	.084	.185	.245
Phosphorus	.048	.032	.016

[a] Vol. H3, p. 259; analysis by D. McCreath.

[b] Vol. M2, p. 291 (D. McCreath).

No. 108.—Pittsburg Coal, Coke, and Iron Company's quarry, three-fourths of a mile north of Ursina: Exceedingly compact and fine grained; bluish gray; conchoidal fracture; thickness, 10 feet.

No. 109.—Elias Yoder's quarry, 1 mile west of Meyersdale: Hard; compact; bluish gray.

No. 110.—Peter G. Berkey's quarry, near Jenner Crossroads: Compact; bluish gray; conchoidal fracture.

Pittsburg, Redstone, and Sewickley limestones.—Of the Little Pittsburg, Redstone, and Sewickley limestones, which occur in a small area in southern Somerset County, little is known except from the following analyses:

Analyses of limestones from Somerset County, Pa.

	No. 111.[a]	No. 112.[b]	No. 113.[c]	No. 114.[d]
Insoluble residue	20.660	4.040	11.510	9.730
Calcium carbonate ($CaCO_3$)	64.706	86.625	74.803	69.160
Magnesium carbonate ($MgCO_3$)	2.156	6.152	6.734	15.555
Ferrous carbonate ($FeCO_3$)	4.274	1.825	5.282	3.935
Alumina (Al_2O_3)	1.700		1.548	1.366
Sulphur	2.431	.093	.052	.046
Phosphorus	.751	.023	.070	.017
Carbonaceous matter	2.602	-------	-------	-------

[a] Vol. H3, p. 75; analysis by A. S. McCreath.
[b] Vol. M2, p. 289.
[c] Vol. H3, p. 92; analysis by D. McCreath.
[d] Vol. M2, p. 287; analysis by D. McCreath.

No. 111.—Little Pittsburg limestone, from S. S. Flickinger's quarry, 2½ miles north of Salisbury: Compact, very brittle; structure somewhat slaty; color, dark bluish gray; carries considerable coaly matter and much pyrite.

No. 112.—Redstone limestone, from M. J. Beechy's quarry, 2½ miles southwest of Salisbury: Minutely crystalline; pearl gray; conchoidal fracture.

No. 113.—Sewickley limestone, J. M. Hayes's quarry, 1 mile north of Salisbury: Hard; brittle; bluish gray.

No. 114.—Sewickley limestone, from Saylor Hill quarry, three-fourths of a mile west of Meyersdale: Compact; brittle; yellowish gray.

PAST AND PRESENT USES.

As a rule the Carboniferous limestones of Pennsylvania are not suited for building stone, but many of them, when burned, form lime of excellent quality for agricultural, building, and fluxing purposes. The most widespread use in the past has been as fertilizer, for which most of the beds are well adapted. The farmers have long since learned this, and the use of lime for this purpose is probably more prevalent in Pennsylvania than in any other State.[1] The pro-

[1] The use of lime on Pennsylvania soils is discussed at length by William Frear in Bull. Pa. Dept. Agric. No. 61, 1900, 170 pages.

portion of farmers using lime on their land varies greatly in different counties, being generally, though not always, dependent on the amount of limestone available. The most extensive use is in Greene, Somerset, and Westmoreland counties, where over 75 per cent of the farmers use it to a greater or less extent. In Fayette, Cambria, Clarion, and Jefferson it is used by 50 to 75 per cent, in Indiana by 25 to 50 per cent, in Armstrong by a few farmers only, and on the soils of Washington, Beaver, Lawrence, Butler, Allegheny, and Clearfield counties it is rarely used.

A number of beds of limestone are worked for railroad ballast, especially the Loyalhanna and Vanport. For this and other purposes the Vanport limestone is extensively quarried at West Winfield, in eastern Butler County. At this place it is mined by A. G. Morris and "used for ballast, concrete work, artificial stone, fluxing, and chemical purposes, and is burned into lime." The Loyalhanna limestone is used for paving blocks and is crushed for ballast on Youghiogheny River above Connellsville, on Loyalhanna Creek above Latrobe, and on Conemaugh River below Johnstown.

In the past a number of the beds, notably the Vanport, Johnstown, and Benwood, have been used in making natural cement, which, among other purposes, was used in the construction of locks on the Erie and Pittsburg Canal and on Monongahela River.

Perhaps the most important use of limestone at present is in the manufacture of Portland cement. For this cement a limestone of high grade is necessary. The percentage of magnesium carbonate, especially, must be less than 5 per cent, the amount of calcium carbonate should be at least 75 per cent, and the ratio of silica to alumina plus iron should be as 5 is to 2. However, as this ratio can usually be obtained by mixing with other raw materials, it is not necessary that the stone should possess a composition strictly within these limits. Suitable limestones are not abundant in western Pennsylvania, but the Vanport is almost universally low enough in magnesia, and the Upper Freeport usually so. The majority of the beds show in some places a suitable composition, but at other localities, and often in the same quarry, are entirely unsuitable. On account of the extensive outcrop of the Vanport limestone there is in this region a wide field for the founding of new Portland-cement factories. At present the only plant in this region is that of the Crescent Portland Cement Company at Wampum. In eastern Ohio there are a few plants.

SUMMARY.

The foregoing pages give, in brief, the extent of present knowledge of the limestones of western Pennsylvania. The economic importance of the beds may be summarized as follows:

The limestones of the Pocono formation are probably of no value except for railroad ballast and paving blocks.

The Greenbrier makes an excellent lime for fertilizer, and it has been used to some extent as a flux.

The Mercer limestones are usually too thin to be of any value.

The Vanport limestone is the purest bed known in western Pennsylvania. Almost without exception it contains a fairly high percentage of lime, low percentages of magnesia, phosphorus, and silica, and probably may be depended upon as an excellent source of supply in Portland-cement manufacture. It also furnishes the best stone for nearly all purposes for which limestone is used.

The Johnstown limestone is of some value for burning into natural cement, but is wholly unsuited for Portland cement, containing as it does high percentages of magnesia.

The Lower Freeport limestone is a thin bed, variable both in occurrence and in amount of impurities, and generally can not be depended upon for economic purposes.

The Upper Freeport limestone is occasionally of workable thickness and usually of considerable purity. The majority of the analyses show a small percentage of magnesia, with about the right proportions of iron, alumina, and silica for cement-making limestone, for which purpose it is available in certain regions.

The Ames limestone is of no economic importance.

The Elk Lick limestone may be of some value in Somerset County, but little is known of it.

The Pittsburg limestone seems to be of a moderate degree of purity, but is usually thin and can probably be worked only locally.

The Redstone limestone has in the past been considerably used for fluxing purposes, but it appears to contain too much magnesia to be of value for Portland cement.

The Sewickley limestone is shown by the only known analysis to be of considerable purity and probably suitable for cement manufacture.

The Benwood limestone can be used for various purposes, but its analyses show that its quality is extremely variable.

The Waynesburg limestone is a bed of good quality, which makes a strong lime. Its suitability for cement has not as yet been tested.

The Upper Washington limestone is reported to make lime of good quality, and if it maintains the approximate composition shown by the only known analysis, may be expected to be available for cement.

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