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With the Compliments of

EDWARD BENNETT MATHEWS

Johns Hopkins University

Baltimore, Md.

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LETTER OF TRANSMITTAL

To His Excellency ALBERT C. RITCHIE,

Governor of Maryland and President of the Geological Survey Commission.

Sir: I have the honor to present herewith the eleventh of the general reports of the Maryland Geological Survey containing the results of extensive studies of two subjects of wide interest and great importance to the people of the State. Part I presents the results of a very detailed restudy of the Coals of Maryland and Part II presents the results of an exhaustive study of the Fire Clays of the State. I am,

Yours very respectfully,

EDWARD BENNETT MATHEWS,

State Geologist.

JOHNS HOPKINS UNIVERSITY,
BALTIMORE, *May 31, 1922.*

ILLUSTRATIONS

PART I

PART II

PREFACE

The present report consists of two parts. The first is the result of detailed field and office studies in the coal measures of Maryland and adjacent areas in Pennsylvania and West Virginia during the fifteen years that have elapsed since the Maryland Geological Survey's report on the Coals of Maryland, published in 1905.

Much development work and the precise methods of Dr. Swartz and his assistants have resulted in a more comprehensive knowledge of the region and a more exact correlation of the coal seams and the associated sandstones, limestones, and shales.

The Survey is indebted to the analytical chemists, Penniman and Browne, for the valuable analyses accompanying this part. The intelligent and helpful coöperation of the various mining companies is gratefully recorded. As in the past, the Survey has had the benefit arising from the coöperation of the U. S. Geological Survey.

The second part is devoted to a study of the fire clays of western Maryland. These clays are the basis of a growing industry in the manufacture of refractory wares which under proper stimulation supplements the decrease in output of the adjacent coals. The present report represents a careful study of a large number of typical samples taken from various parts of the field. The results of the tests on individual samples show actual behavior during the burning and indicate the uses for which these particular clays are especially adapted. The information secured and presented in the report adds greatly to the available knowledge of these clays. The chapter on the technology of the fire clays by Arthur S. Watts and that on the testing of the clays by H. G. Schurecht are by well known authorities in the ceramic field. The introductory chapter on the origin, distribution, and uses of clay presents a summary of recent advances in the rapidly growing subject of clays and their properties.

The investigation and the report are the result of a coöperative agreement between the Maryland Geological Survey and the U. S. Bureau of Mines.

PART I

THE COAL FORMATIONS AND MINES OF MARYLAND

BY

CHARLES K. SWARTZ AND WM. A. BAKER, JR.

WITH INTRODUCTION

BY

EDWARD BENNETT MATHEWS

INTRODUCTION

BY

EDWARD B. MATHEWS

The amount of information available regarding the coal fields of Maryland has increased greatly during the decades since the appearance of the report on the Physical Features of Allegany County. As the work has progressed the State Survey has published reports on the Physical Features of Garrett County (1902), the Coals of Maryland (1905), the Mineral Industries (1909), and the Physical Features of Maryland (1906). In each of these volumes the increasing knowledge of the region has been shown by additional details or changes in correlation of the coal seams worked at different localities. In no one previous publication have there been modifications of the generally accepted views comparable with those introduced in the present volume.

The changes that are now proposed represent conclusions based upon years of detailed, pains-taking investigations carried out for the Maryland Survey by Dr. Swartz and his assistants. The modifications in names and usage proposed are due to more correct views regarding the manner in which the coal beds were originally formed, a more accurate knowledge of the structure of the region, increase in opportunities for study resulting from the industrial development of the coal fields, and the discovery of errors of judgment made when the geology of the region was little known. The corrections introduced in the present report are an evidence of increased knowledge and understanding of the geology rather than a criticism of the judgment of earlier workers which was based upon the facts and development then available.

One of the important influences in modifying older views of correlation has been a better understanding on the part of geologists of the manner in which the coal beds were formed. Formerly, as is even yet the case in a popular way, coal swamps were pictured as covering thousands of square miles over which conditions were continuously favorable for the accumulation of coal material. The conditions changed abruptly over these vast areas in a way to stop the growth of coal-producing plants and to inaugurate a period of deposition of sand or mud. With equal suddenness, it was loosely thought, a new period of luxuriant vegetation again spread over continental areas, resulting in the formation of additional deposits of coal. Such conceptions are the basis of the widely held belief that individual coal seams are physically continuous over wide areas, and that the intervals of barren measures between adjacent coal beds are practically constant. This belief in turn led to the correlation of coal beds by the intervening intervals, their characteristic thicknesses, or physical peculiarities. This method of correlating coal beds because they lay a certain distance above or below some other coal thought to be the equivalent of a well-known coal in an adjoining area was early employed in the Georges Creek basin and led to errors in correlation and in the interpretation of the structure of the region. These errors were long unrecognized and false conclusions became the accepted rules of correlation among the workers in the area until coals were regarded as equivalents which really were at quite different horizons.

As geologists generally came to recognize that coal beds are not strictly continuous but lenses thickening and thinning at only approximately similar horizons it became evident that proper correlations could only be made by adequate studies of the structure and sequence based upon deposits, formed contemporaneously over wide areas, which contained characteristic fossils. When the facts presented by the rocks of the Georges Creek basin were studied with reference to such continuous guide-members it was found that current correlations based on intervals were sometimes incorrect and that inconsistencies previously noted in the region were removed when the correlations were based on such members traced over wide areas. Errors many and significant have crept in where correlations were based upon lithology and the method has been generally criticised. It is very easy to *assume* the equivalence of two nearby ledges of sandstone and to overlook the physical continuity of deposits changing their character from shale to sandstone or limestone. Errors of this kind underlie the older correlations of the Georges Creek coals with those of western Pennsylvania, since the guide members such as the Vanport or Ferruginous and Crinoidal limestones vanished or changed in character eastward and were lost sight of and the increasing thickness of intervening formations was overlooked.

When, however, the guide members are followed at close intervals with appreciation of their changing lithology, thickness, and fossil content, as has been done in the detailed work of Dr. Swartz and his assistants, the errors of the method as used in general studies may be avoided.

A second factor influencing the correlation of coal deposits has been our increase in knowledge of the coal fields of Maryland. This has been due to activities of State and Federal Surveys and the development of local workings since the inauguration of work by the Maryland Geological Survey. When the earlier work was done in the Maryland coal fields the time was not ripe for especially detailed investigations. The only topographic maps available when the State Survey inaugurated its work were the inaccurate "half-inch" sheets of the U. S. Geological Survey covering small areas in Allegany and Garrett counties. The locations of mines and outcrops were inaccurately represented or based on faulty property maps of different scales and it was impossible, with the material available, to make comparative studies of the geological positions of the various commercial coals with an accuracy sufficient to eliminate errors. The later work of the Survey was done, however, on the present topographic base.

Since the inception of geologic work the Consolidation Coal Co. has driven its Hoffman drainage tunnel two miles in length, giving a complete section from the Pumping Shaft to near Clarysville. This, combined with the shaft, has exposed a continuous section extending from above the Uniontown coal to below the Barton coal, permitting exact measurements of intervals. Other companies have made extensive explorations in the Upper Potomac basin by drilling and a small amount of drilling has been done recently in other basins. These records have been generously placed at the disposal of the Survey. Countless observations have been made, dips and strikes determined, and sections carefully measured by mining engineers and members of the State Survey, during the last two decades through which the investigations have continued. All of these sources of information have increased the records in possession of the Survey. Such records by careful study and comparisons have brought out much additional information regarding the character, position, and correlation of coals and accompanying strata.

The third factor in revising the correlation has been a review of the work of previous investigators in the light of our increased knowledge. Some of the earlier conclusions were naturally found to be incorrect. The errors of judgment shown have often been more apparent than real and were the result of the manner in which work outside of the state had been conducted. On account of the extensive work of the Second Pennsylvania Geological Survey and the overpowering predominance of Pennsylvania in the production of coal, that state has been accepted as typical and the names applying to the several coal seams and intervening strata as worked out by the Pennsylvania Survey have been more or less widely adopted throughout the entire Appalachian district. With increasing development these names were applied to wider and wider areas to indicate that the coal seams found in these outlying districts were correlated with the typical exposures of the Pittsburgh district. Thus many of the names still in use in Maryland and West Virginia show their Pennsylvania origin. As geological surveys progressed and the names were applied more and more widely in the direction of Maryland they followed two general lines; one trended east and south to the northern limits of the Georges Creek basin, the other southwest and east to the southern end of the Potomac basin. These two lines of progression and correlation uniting at the boundary of the Georges Creek and Upper Potomac basins where formerly there was little commercial development, each stratigraphic sequence was accepted at its face value as correct on the statement of men who had proved their authority by widespread careful geological work. When the more detailed investigations of recent years were carried out by the Maryland and West Virginia Surveys it became apparent that somewhere during the earlier work the old assumption of the continuity of coal beds and their correlation by characteristic thicknesses had introduced appreciable errors in the geological horizons assigned to the commercial coals of the Upper Potomac basin. The "Davis" coal of earlier reports which was correlated with the Middle and Lower Kittanning coals of Pennsylvania is now known to occupy the same geological position as that of the Upper Freeport of Pennsylvania. Similar significant changes have been recognized at other localities and in other parts of the column as may be seen by a careful reading of this report. The fundamental basis of the changes here proposed is the introduction of new methods of investigation by Dr. Swartz and his associates with increased refinement of work.

The introduction of new formational names and the change in correlation of geological strata, even of coal beds, would confuse the thinking of few but interested geologists if it were not for the pernicious practice on the part of operators and coal merchants of using geologic terms and geologic correlation as indications of the character and quality of their coal. Such usage might perhaps be justified under the old conception that individual coal beds were physically continuous and therefore probably of the same character over thousands of square miles. No questions at that time were asked as to how such a uniformity with conditions of catastrophic change before and after deposition of the coal could have taken place. Now, however, the circumstances are very different. With a knowledge of the facts that individual coals occur in lenses representing more or less limited swamps, characterized by individual conditions of deposition, and that given coal deposits thicken or thin and change in character according to minor conditions present at the time of their formation, there are no just grounds for using the geologic terms in the trade as unqualified indicators of the character of the coal. The product of two adjacent mines worked on beds of the same geological horizon may differ widely in character and it is only to the interest of the poorer to suggest that any similarity with the better deposit exists. Thus an operator in the Pittsburgh or Big Vein seam, if the term were not used as a trade term, would have only casual interest in the fact that his coal is at the same horizon as some other coal nearby. But when, as is now the case, the establishment of the fact that two deposits are at the same geologic horizon may be used by the producer as a means of selling an inferior coal on the reputation and at the price of a high-grade coal well known to the market, the geologic equivalency is a matter of first importance. The prevailing practice of selling coal on geologic horizons and the designation of quality by the use of geologic terms should be stopped since it brings benefit only to the producer of a lower-grade coal and may occasion injury to the careful producer working high-grade deposits. The coals from individual localities should be classified on their cleanliness, heat-producing, and other characteristic qualities and not by their geologic horizon.

It is recognized that under present conditions the introduction of new geologic terms and the adjustment of geologic correlations must occasion some confusion to the operators, but the price will be small if such confusion produces an abandonment of geologic terms from the trade and the establishment of a practice of marketing coals on their physical and chemical properties.

When this is done it will be possible to make such changes in geologic correlation as may become necessary with the advance of our knowledge of a given region without upsetting trade practices. It is hoped, however, that the refined measurement and careful investigations represented by the present report will have established an accuracy of correlation so high that subsequent important changes, in the Georges Creek basin at least, will no longer be necessary.

DISTRIBUTION AND STRATIGRAPHY OF THE COAL MEASURES OF MARYLAND

BY

CHARLES K. SWARTZ[1]

DISTRIBUTION OF THE STRATA

Coal-bearing rocks form a large part of the surface of Garrett County and outcrop in smaller areas in Allegany County in the western part of the State. The rocks were originally deposited in horizonal beds that were probably continuous over this region. They were folded after their formation into a series of subparallel arches and troughs. The summits of the arches were subsequently eroded so that the coal deposits are now found chiefly in the intervening basins.

The Upper Carboniferous beds lie to-day in three chief structural troughs, an eastern, a central, and a western, the axes of which trend in a northeast-southwesterly direction. The eastern and central troughs are separated by the long Oakland anticline.

The eastern trough is divided by the Potomac River into two parts, a northern and a southern. The northern part is called the Georges Creek basin, while the southern has received the name of the Upper

[1] Professor W. A. Price, Jr., of the University of West Virginia, has studied the marine faunas of the coal measures of Maryland, and Dr. Harvey Bassler has investigated the coal floras. Both of these workers have aided in the measurement and study of many sections and have been in frequent conference with the writer. The work of Dr. Price has been invaluable and has contributed largely to our knowledge of the stratigraphy of the coal measures of Maryland. The correlations here proposed rest in no small measure upon his studies of the faunas. Dr. Bassler's investigation of the floras has also been of great value. The writer wishes to express his indebtedness to these workers for their helpful cooperation in the investigations of the stratigraphy and correlation of the coal measures of Maryland. He also wishes to express his appreciation of the helpful and generous cooperation of Dr. George B. Richardson of the U. S. Geological Survey, upon whose work is based the interpretation of the section in Somerset County, Pennsylvania, presented in the following discussion.

Potomac basin. These two divisions, however, are purely artificial and together constitute a single structural unit. The central trough is cut into two parts by a slight transverse arching of the strata north of Oakland. The part lying south of the arch is known as the Upper Youghiogheny basin while the northern portion is called the Castleman basin. The western trough, in which Friendsville is situated, has been called the Lower Youghiogheny basin. It extends into Preston County, West Virginia, on the southwest and into Somerset County, Pennsylvania, on the northeast.

Coal-bearing Pocono strata are found in two parallel ridges, Town Hill and Sideling Hill, in eastern Allegany and western Washington counties. The positions of the various coal basins are indicated on the accompanying map, Plate I, Fig. 1, showing the distribution of the coal measures of Maryland.

STRATIGRAPHY

The coal measures of Maryland comprise two systems of rocks, the Carboniferous below and the Permian above. These systems are further subdivided into a number of formations whose names and relations are indicated in the following table:

- Permian
    - Greene formation
    - Washington formation
- Carboniferous
    - Upper or Pennsylvanian Series
        - Monongahela formation
        - Conemaugh formation
        - Allegheny formation
        - Pottsville formation
    - Lower or Mississippian Series
        - Mauch Chunk red shale
        - Greenbrier limestone and shale
        - Pocono Group
            - Pinkerton sandstone [1]
            - Meyers red shale [1]
            - Hedges black shale [1]
            - Purselane sandstone [1]
            - Rockwell shale [1]

[1] These divisions of the Pocono are recognizable only in the eastern exposures. The Pocono constitutes a single formation in the western part of the state.

The present chapter gives a brief discussion of the sequence and characteristics of the more persistent units recognizable in the coal measures of Maryland. A subsequent chapter will be devoted to the consideration of the special features observed in the various coal basins. The strata will be discussed in ascending order.

CARBONIFEROUS SYSTEM

The rocks constituting the Carboniferous of Maryland are divisible into two series of formations—the Lower Carboniferous or Mississippian series and the Upper Carboniferous or Pennsylvanian series. The strata of the lower division are chiefly marine and contain but little coal. Those forming the upper series were deposited chiefly upon the land and include the important coal deposits of the eastern United States. These divisions differ not only in the character of the rocks and the conditions under which they were accumulated, but are also separated over wide areas by a pronounced unconformity. The latter feature shows that a considerable period of time elapsed between the deposition of the lower and upper series during which there was widespread emergence of the continent and prolonged erosion of the land.

The facts cited above, coupled with the considerable thickness of the beds have led many students, including the writer, to consider these divisions to be independent systems. To the lower the name Mississippian has been applied from the excellent exposures of its strata in the bluffs along the Mississippi River. The upper division has received the name Pennsylvanian from the State of Pennsylvania where its beds were early studied and where they contain important deposits of coal.

LOWER CARBONIFEROUS—MISSISSIPPIAN SERIES

No coal is found in the Mississippian rocks of the western part of Maryland. The Pocono strata constitute a single division in the western exposures. They thicken greatly eastward and are divisible in eastern Allegany and western Washington counties into five formations, the Rockwell shale, Purselane sandstone, Hedges shale, Meyers red shale, and Pinkerton sandstone, all of which, except the Meyers red shale, contain thin seams of coal. These deposits in Maryland do not promise to have commercial value at the present time and are not further discussed in the present report.

UPPER CARBONIFEROUS—PENNSYLVANIAN SERIES

The Pennsylvanian strata contain the valuable coal deposits of Maryland. They comprise four formations, which will be discussed in the order of their deposition.

Pottsville Formation

CHARACTER AND THICKNESS.—The Pottsville formation was named from Pottsville, Pennsylvania, where its strata are well exposed. It consists of interbedded sandstones and shales. Some of the beds of sandstone are gray, coarse-grained and locally conglomeratic. Such strata are very resistant to weathering, so that the beds of this formation tend to form rugged mountains upon or near the crest of which the more resistant rocks outcrop in bold ledges. The coal seams of the Pottsville of Maryland are few in number, restricted in extent, variable in character and at most places possess little or no commercial value. The Pottsville formation of Maryland varies in thickness from 150 to 280 feet, its usual thickness being little over 200 feet.

POTTSVILLE-MAUCH CHUNK BOUNDARY.[1]—The Pottsville overlies the Mauch Chunk formation unconformably. This relation is shown more clearly in adjoining states where the Mauch Chunk formation is much thinner and where the Pottsville formation may lie, at neighboring points, in contact with the Mauch Chunk, Greenbrier, or even the Pocono formation. The existence of an unconformity at this horizon in Maryland is best seen in the variations in the thickness of the Pottsville, due to the

[1] The base of the Pottsville formation was drawn by O'Harra in his report upon the geology of Allegany County (Md. Geol. Survey, Allegany County, 1900, pp. 112, 113) above a limestone conglomerate found, at many localities, at the bottom of a very massive ledge of sandstone. This horizon is in the Mauch Chunk formation as is shown by the occurrence of a thick bed of red shale above it. The latter may be seen in the cut of the Western Maryland Railway at Barrelville and at many other localities.

presence or absence of some of its lower beds which were manifestly deposited upon an irregular land surface.

MEMBERS.—Because of their great commercial importance, the coal-bearing strata of the Appalachian province have been divided into a much larger number of units than are usually recognized in rocks that have less economic value. These divisions are known over wide areas and have received names from localities where they are well exposed. The stratigraphic sequence of the members of the Pottsville formation of Maryland is shown in the following table:

Top
Homewood sandstone
Upper Mercer shale and fauna
Upper Mercer coal
Lower Mercer coal
Upper Connoquenessing sandstone
Quakertown shale and fauna
Quakertown coal
Lower Connoquenessing sandstone
Sharon shale and fauna
Sharon coal
Sharon sandstone
Bottom

The characteristics of the various members are summarized in the following paragraphs:

Sharon Sandstone.—A sandstone is reported beneath the Sharon coal in a drill well near Grantsville which may be the Sharon sandstone.

Sharon Coal.—A thin seam of coal is found at a number of points at or near the base of the Pottsville formation. This bed is subject to great changes and may thin or disappear within short distances. It contains much bone and ash and does not promise to be of commercial importance. It attains a thickness of 20 inches in the cut of the Western Maryland Railway east of Westernport where it is well exposed. This coal may be correlated tentatively with the Sharon coal of Pennsylvania.

Sharon Shale and Fauna.—The Sharon coal is overlain by shale in which a number of specimens of *Lingula carbonaria* were found in the section on the Western Maryland Railway ¾ mile east of Westernport.

This deposit is here named the Sharon shale and its contained fauna the Sharon fauna.

Lower Connoquenessing Sandstone.—A thick bed of sandstone is usually found at or near the base of the Pottsville formation. At many places it is rather soft, somewhat argillaceous, micaceous, and is transitional to the sandstones of the underlying Mauch Chunk. Locally, it may be white, coarse-grained, and even conglomeratic. When found in the latter phase it is very resistant to weathering and outcrops in heavy ledges. Its thickness is very variable. At some places it attains a thickness of 20 to 30 feet, while at neighboring points it may be replaced by shale. It appears to occupy the position of the Lower Connoquenessing sandstone of Pennsylvania.

Quakertown Coal.—A thin and commercially unimportant seam of coal is found above the Lower Connoquenessing sandstone at a few localities. It generally consists largely of bone and is then without commercial value. It is 8 inches thick in the cut of the Western Maryland Railway east of Westernport. Like the other coals of the Pottsville formation of Maryland, it is very lenticular and may vanish within a few feet. It appears to occupy the position of the Quakertown coal of western Pennsylvania.

Quakertown Shale and Fauna.—The Quakertown coal is overlain by black shales in which a meager fauna was found in the section on the Western Maryland Railway $\frac{3}{4}$ mile east of Westernport. The species are probably brackish-water forms among which specimens of *Lingula carbonaria* are most common. It is interesting to note that fossil shells are reported at the same horizon in a drill hole in Mineral County, West Virginia. A Lingula fauna is reported by Reger and Teets in a dark shale, named by them the Quakertown Black shale, which appears to occupy the same horizon in Barbour and Randolph counties, West Virginia.[1]

Upper Connoquenessing Sandstone.—The interval above the Quakertown shale is occupied by lenticular beds of sandstone and shale. At some

[1] Rept. on the Geology of Barbour and Upshur counties and the western portion of Randolph County, West Virginia Geol. Survey, 1918, p. 273.

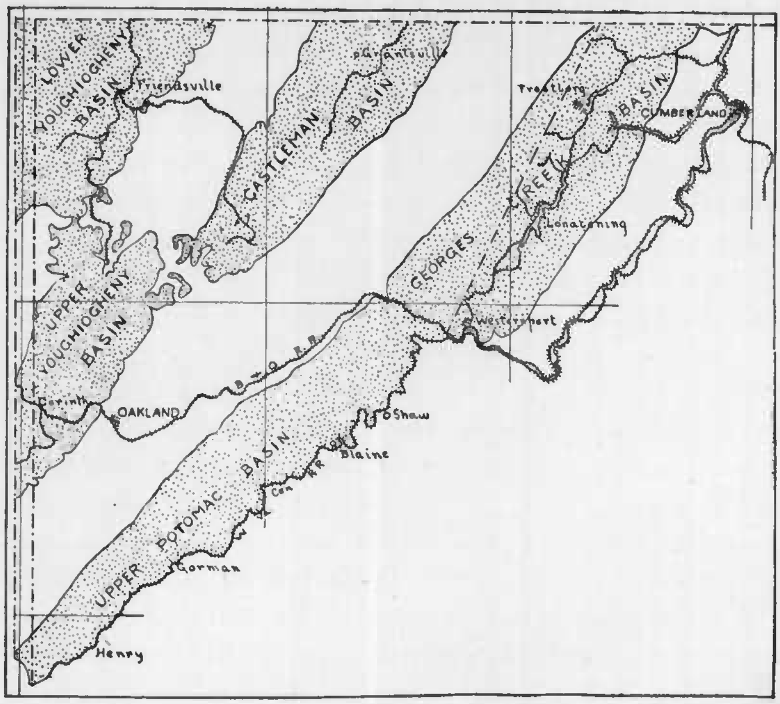

FIG. I.—MAP SHOWING LOCATION OF COAL BASINS OF MARYLAND.

FIG. 2.—VIEW OF CONNOQUENESSING SANDSTONE, SWALLOW FALLS, GARRETT COUNTY.

localities the sandstone is massive and forms thick ledges which may unite with the Lower Connoquenessing sandstone to make bold cliffs.

Lower Mercer Coal.—Two thin seams of coal are found 100 to 140 feet above the base of the Pottsville formation. The lower of these coals is generally thin, bony, without value, and is often absent. It varies in thickness from a few inches to 15 inches at most places. It is a valuable coal in the Upper Youghiogheny basin, 2½ miles northwest of Oakland, where it is 30 inches thick and is mined for local use. It was formerly called the Sharon coal at that locality. It may be correlated tentatively with the Lower Mercer coal of Mercer County, Pennsylvania.

Upper Mercer Coal.—This coal occurs from 10 to 30 feet above the Lower Mercer coal. It is very irregular in quality and thickness and is absent at many localities. It is without commercial value at most localities. Its thickness varies from a few inches to about 30 inches.

Upper Mercer Shale and Fauna.—A few species of shells, which probably inhabited brackish water, have been found in the shale immediately overlying the Upper Mercer coal in the section at the head of Warrior Run, east of Dans Mountain, and at Gladdens Run, Pennsylvania. They may represent the fauna of the Upper Mercer limestone of Pennsylvania.

Homewood Sandstone.—A very massive sandstone is found at the top of the Pottsville formation to which the name Homewood sandstone has been applied from its exposure at Homewood, Pennsylvania. Its character varies greatly from place to place. On Dans Mountain it is usually rather fine grained, while on Big Savage Mountain it is a very coarse, conglomeratic, and forms bold and conspicuous ledges of great thickness. The latter phase is well exposed at Sampsons Rock, west of Mount Savage. It is replaced locally by beds of shale. This sandstone is usually a conspicuous topographic feature throughout the region under discussion. It attains a thickness of 50 to 70 feet.

Allegheny Formation

CHARACTER AND THICKNESS.—The Allegheny formation consists of interbedded shale and sandstone and contains a number of coal seams, some of which have large commercial value. Its strata are, on the whole, more shaly than those of the underlying Pottsville and overlying Conemaugh formations and hence tend to disintegrate more readily upon exposure to the weather, though these features are not constant. The lower part of the Allegheny formation, comprising the beds lying beneath the Hardman ("Furnace") fire-clay, contains at many places massive sandstones, often crossbedded, that closely resemble those of the underlying Pottsville, while at a few localities nearly the entire formation is made of sandstone. The formation could fittingly be divided into two parts in Maryland, the lower characterized by massive, often crossbedded sandstones, the upper by more argillaceous sediments.

The formation receives its name from the Allegheny River along whose banks its strata are finely exposed, particularly in the vicinity of Freeport and Kittanning, Armstrong County, Pennsylvania. It was formerly called the Lower Productive Coal Measures. The thickness varies from 250 to 275 feet, its usual thickness being about 260 feet.

ALLEGHENY-POTTSVILLE BOUNDARY.—It has been thought that the Pottsville sandstones differ from those of the Allegheny formation in being coarser grained, harder, whiter, more compact, and much more resistant to weathering. The lower beds of the Allegheny formation of Maryland, however, consist, at many places, of sandstones which so closely resemble those of the underlying Pottsville that they cannot be separated from the latter lithologically. Indeed, at some localities the basal sandstones of the Allegheny formation are more massive and more resistant to weathering than those of the Pottsville formation. The discrimination of the formations is hence artificial rather than natural in Maryland, its chief value being for purposes of correlation. These facts, coupled with the inconstant character of the strata have led various workers to draw the Allegheny-Pottsville boundary in Maryland at different horizons in the past.

In the chapter on correlation it is shown that the Mount Savage coals are probably of Allegheny age, so that the Pottsville-Allegheny boundary is placed, in the present work, at the top of the massive sandstone lying beneath the Mount Savage coals.

MEMBERS.—The stratigraphic sequence of the members of the Allegheny formation of Maryland is shown in the following table:

Top

Davis rider coal—Upper Freeport rider coal
Davis coal—Upper Freeport coal
Bolivar clay
Upper Freeport limestone
Upper Freeport sandstone
Barrelville coal—Lower Freeport coal ("Parker coal")
Lower Freeport limestone
Montell sandstone
Montell rider coal
Montell coal—Upper Kittanning coal ("Bluebaugh coal")
Little Montell coal
Mount Savage iron ore—Johnstown iron ore
Hardman fire-clay ("Furnace clay")
Piney Mountain coal
Westernport sandstone
Luke coal—Middle Kittanning coal
Luke clay—Middle Kittanning clay
Ellerslie sandstone
Ellerslie coal—Lower Kittanning coal
Ellerslie fire-clay—Lower Kittanning fire-clay
Mount Savage sandstone—Kittanning sandstone—Clarion sandstone
Mount Savage rider coal—Scrubgrass coal ?
Upper Mount Savage coal—Clarion coal ?
Mount Savage fire-clay—Clarion fire-clay ?
Lower Mount Savage coal—Brookville coal ?

Bottom

The characteristics of these members are summarized in the following paragraphs:

Lower Mount Savage Coal.—Immediately overlying the Homewood sandstone is a bed of coal, which is subject to great variation in character and thickness. When present it is poor in quality and contains much shale and bone, so that it does not promise to have commercial value at most places. Its thickness varies from a few inches to 4 feet. This bed occupies the position of the Brookville coal which occurs at the base of the Allegany formation of western Pennsylvania.[1] It receives its name from Mount Savage in the Georges Creek Valley.

[1] The Brookville coal appears to be the same as the bed named the Craigsville coal by Butts in his report on the Kittanning-Rural Valley area (Bull. No. 279, U. S. Geol. Survey, 1906, p. 32).

Mount Savage Fire-Clay.—A valuable and important bed of fire-clay, which has long been worked on Big Savage Mountain in the Georges Creek basin, occurs between the Lower and Upper Mount Savage coals. It consists of both plastic and flint fire-clay. The former is soft and easily molded, while the latter is hard, lustrous and breaks with a conchoidal fracture. The flint clay occurs in lenses and irregular masses in the soft clay which it entirely replaces at some points. The Mount Savage clay attains a thickness of 5 to 12 feet in the Georges Creek Valley where it forms the basis of a large and flourishing industry.

Upper Mount Savage Coal.—Overlying the Mount Savage clay is a thick bed of coal which has long been known as the Upper Mount Savage coal because of its occurrence in association with the fire-clay in the mines at Mount Savage. The seam of coal is multiple-bedded, having a number of partings which vary greatly in thickness and which may increase in size until the deposit is split up into different seams. The coal contains a high percentage of ash and a considerable amount of sulphur so that it is not usually mined as a source of fuel although it has considerable fuel value. The following are typical sections of the coal:

Section of Upper Mount Savage coal in Mine No. 6, Union Mining Company, near Mount Savage.

	Inches
Roof shale.	
Coal	3¼
Shale	¼
Coal	5
Shale	1
Coal	3¾
Shale	¼
Coal	2½
Shale	½
Coal	1½
Shale	⅛
Coal	3
Shale	⅛
Coal	1
Bone	2
Coal	1
Floor shale.	
Total	22¼

Section of Upper Mount Savage coal in mine of Andrew Ramsay near Ellerslie, Pennsylvania.

	Inches
Roof shale.	
Coal	13½
Shale	3
Coal	8
Floor fire clay.	
Total	24½

Analyses of these coals are given in the table of analyses, numbers 29 and 32. The thickness of the seam varies greatly. On Big Savage Mountain, where it has its maximum development, it is 2 to 5 feet thick. The clays associated with this coal contain a profuse flora which indicates that the coal is probably of Allegheny age, occupying the position of the Clarion coal of western Pennsylvania.[1]

Upper Mount Savage Rider Coal.—The Mount Savage coal is overlain, at places, by a bed of fire-clay above which a thin seam of coal may occur. This bed appears to be a split from the main body of coal. It occupies the position of a similar bed known in western Pennsylvania as the Upper Clarion or Scrubgrass coal.

Mount Savage Sandstone.—A persistent and very massive bed of sandstone occurs above the Mount Savage coal which, when characteristically developed, is white, hard, and locally conglomeratic. It may contain numerous hackle teeth, formed by carbonaceous films, which, when well developed, give a singular pitted appearance to the broken slabs of rock. It contains numerous impressions of fossil foliage and stems, especially Sigillaria. This bed forms bold and conspicuous cliffs on Dans Mountain and in the vicinity of Swallow Falls on the Youghiogheny River, where its conglomeratic phase is well developed. When it presents this phase it so closely resembles Pottsville sediments that it has usually been assumed to be of Pottsville age.

This member has frequently been called the Upper Connoquenessing sandstone. On Big Savage Mountain it has been called the Homewood sandstone. It occupies the position of the Kittanning sandstone of western Pennsylvania.

[1] This flora will be described by Harvey Bassler in the Maryland Geological Survey Monograph of the Carboniferous.

Ellerslie Fire-Clay—Lower Kittanning Fire-Clay.—A bed of fire-clay is found above the Mount Savage sandstone at many localities. It is well shown in the fire-clay mines on the summit of Little Allegheny Mountain, west of Ellerslie, Pennsylvania, where it has a thickness of 8 to 9 feet and has been mined commercially, being the upper of the two seams of clay worked at that locality. The same seam is found in the mines near Mount Savage where it lies above the Mount Savage sandstone, although it has not been worked there. It appears to be the clay worked in the mines of the Maryland Coal Company near Lonaconing, where it is of good quality. It is also exposed at a small coal prospect at Swallow Falls. This clay appears to be a persistent bed and occupies the position of an important fire-clay worked in eastern Ohio and western Pennsylvania.

Ellerslie Coal—Lower Kittanning Coal.—This coal occurs 75 to 100 feet above the base of the Allegheny formation. It is very persistent, though subject to considerable variation in thickness. It is usually multiple-bedded, containing several partings which split it into a variable number of subdivisions. It may consist of two beds, the lower of which attains a thickness of 3 feet at the clay mine of Andrew Ramsay, west of Ellerslie, where it exhibits the following section:

Section of Ellerslie Fire Clay in Ramsay Mine, West of Ellerslie, Pennsylvania

	Inches
Sandstone or shale roof.	
Coal	14
Fire clay	51
Coal	15½
Shale	5
Coal	16
Floor shale.	
Total	101½

This bed displays the following section at the mine of John Sines, 8 miles north of Oakland:

	Inches
Shale roof.	
Bone	1½
Coal	15
Shale floor.	
Total	16½

Analyses of these coals are given in the table of analyses, numbers 30 and 52. The same seam has been prospected at Swallow Falls and near Friendsville in the Lower Youghiogheny basin. The character of the seam varies greatly in short distances. It contains much bone and ash so that it does not promise to be of commercial importance in spite of its considerable thickness. It has been identified in the past with various coals ranging from the Quakertown to the Montell (Bluebaugh) coal. *It is not the Davis seam* which has commonly been called the Lower Kittanning in Maryland, but lies about 190 feet below the latter. It occupies the position of the Lower Kittanning coal of western Pennsylvania.

Ellerslie Sandstone.—A sandstone is found locally over the Ellerslie coal to which the name Ellerslie sandstone is here applied because of its position.

Luke Clay—Middle Kittanning Clay.—An impure bed of clay overlies the Lower Kittanning coal at various localities. It is very lenticular in character and appears to be inferior in quality so that it does not promise to be of commercial value. It is exposed in the cut of the Baltimore and Ohio Railroad opposite Luke from which locality it may be called the Luke clay. This clay occupies the position of a fire-clay found at some localities beneath the Middle Kittanning coal in western Pennsylvania.

Luke Coal—Middle Kittanning Coal.—An irregular seam of coal overlies the clay last-mentioned. It is inconstant in character and is usually broken up into several divisions by partings which vary greatly in thickness within short distance. The coal attains a thickness of 2 feet, but is poor in quality and without present commercial value. This bed is the upper of two seams of coal exposed along the tracks of the Baltimore and Ohio Railroad opposite Luke, from which locality it receives its name. At places the interval separating this coal from the Ellerslie coal is so small that they might be viewed as one seam. Its position corresponds to that of the Middle Kittanning coal of western Pennsylvania.

Westernport Sandstone.—A thick and very massive sandstone is found above the Luke coal. It is gray, coarse-grained, and cross-bedded at many places, being similar in its lithological character to the sandstones of the

Pottsville formation. Interbedded with the sandstone are layers and lenses of shale. This sandstone is subject to great changes in thickness and lithological character from place to place. It forms bold cliffs along the Potomac west of Westernport, Maryland, where it attains a thickness of 40 feet. It receives its name from this locality.

Piney Mountain Coal.—A seam of coal is found at a number of localities in the northern part of the Georges Creek Valley and in the Upper Potomac and Castleman basins 20 to 50 feet beneath the Montell ("Bluebaugh") coal. It is chiefly known in drill holes in some of which it is reported to consist of two or three thin benches separated by thick shale partings, the whole being 5 to 15 feet thick. It is inconstant and has not been worked. It is exposed as a smut in the cut of the Western Maryland Railway through the north end of Piney Mountain, east of Barrelville, from which locality it is named.

The Piney Mountain coal is overlain locally by a thick sandstone to which no name has been given.

Hardman Fire-Clay—("Furnace Clay").—A valuable bed of fire-clay is found 125 to 150 feet above the base of the Allegheny formation in the Georges Creek Valley. It has been called the "Furnace clay" at the mines of the Union Mining Company, west of Mount Savage, where it is associated with the Mount Savage iron ore, and attains a thickness of 5 to 15 feet. This clay consists of both plastic and flint clay. It is not as pure as the Mount Savage clay, worked in the same region, although it has a very high fusion point. It appears to be replaced by a fusible plastic clay in the vicinity of Westernport, where it has been burned experimentally into tile, for the manufacture of which it seems well adapted.

Mount Savage Iron Ore.—A considerable body of limonite ("brown hematite") is found above the Hardman fire-clay at Mount Savage, where it was formerly worked as a source of iron. The ore was found in a tunnel, known as the "ore tunnel," or Tunnel No. 1, of the Union Mining Company, situated near the bottom of the incline leading to the fire-clay mines of that company. The tunnel was opened in 1846[1] and

[1] Singewald, J. T., Jr., Md. Geol. Survey, Vol. IX, Rept. on the Iron Ores, 1911, p. 244.

the iron ore was smelted at a furnace located at Mount Savage. It is interesting to note that the iron produced at Mount Savage was used in making iron rails for the Baltimore and Ohio Railroad Company where the first iron rails used in the United States were made. This deposit appears to be the same as the ore worked at Johnstown, Pennsylvania, from which place it has been named the Johnstown iron ore.

Little Montell Coal.—A thin coal or carbonaceous clay is found in drill holes and in the fire-clay tunnels west of the Union Mining Company of Mount Savage, immediately above the Mount Savage iron ore. It is here named the Little Montell coal from its position beneath the Montell coal.

Montell Coal—Upper Kittanning Coal ("Bluebaugh coal," Westernport coal, Brookville coal of earlier reports).—This important seam of coal is found 160 to 180 feet above the base of the Allegheny formation. It has its most important development in the Georges Creek Valley where it attains a thickness of 4 to 5 feet and is mined at a number of localities. It is multiple bedded at many places in this area, being split into two parts by a thick parting near the top. It is also mined at several places in the Upper Youghiogheny basin, although it is less valuable there. Sections of the coal are given on pages 191, 207, 211, 212, 219, 228, 277, 279. The following section is seen in the mine formerly operated by W. T. Sines, 6½ miles northwest of Oakland near Swallow Falls in the Upper Youghiogheny basin:

	Inches
Sandstone roof.	
Coal, bone and shale	12
Shale	6
Coal	37
Total	55

Analyses of this coal are given in the table of analyses numbers 11, 17, 19, 23, 31, and 53.

This coal has been called the Bluebaugh coal and also the "Brookville" coal in the Georges Creek Valley where it has commonly been believed to be at the base of the Allegheny formation. It is also probably the same as the Westernport coal, known locally as the "Two-foot" coal in the vicinity of Westernport. It occupies the position of the coal called the

Upper Kittanning at Kittanning and the Lower Freeport at Freeport, Pennsylvania. (See discussion on page 105.)

Montell Rider Coal.—A thin and unimportant coal is found at several places in the Georges Creek Valley, about 15 feet above the Montell coal, which is here called the Montell rider coal.

Montell Sandstone.—A thick bed of sandstone which is persistent over large areas and frequently forms cliffs is found above the Montell coal ("Bluebaugh coal"). It is finer grained and more argillaceous than the lower sandstones of the Allegheny formation are at most localities though it is conglomeratic west of Piedmont, W. Va. It attains a thickness of nearly 50 feet. Its conglomeratic phase is well exposed on the Baltimore and Ohio Railroad east of Bond Station. It is named the Montell sandstone from its position above the Montell coal.

Lower Freeport Limestone.—Limestone is found as a thin bed or in limestone nodules at a few localities beneath the Montell coal in the Upper Youghiogheny basin, in the position of the Lower Freeport limestone of western Pennsylvania.

Barrelville Coal—Lower Freeport Coal ("Parker" Coal, "Clarion" Coal of Earlier Reports).—A valuable seam of coal is found 30 to 40 feet above the Montell coal ("Bluebaugh" coal) and approximately 50 feet below the Davis or Upper Freeport coal. It is usually called the Clarion or Parker coal in the Georges Creek Valley where it frequently forms two divisions, separated by a thick parting. It is generally worth less in this basin than the Davis and Montell seams, but furnishes coal of unusual excellence and purity in the vicinity of Barrelville. This coal attains a thickness of 4 feet in the Upper Youghiogheny basin where it is mined at a number of points. Its structure is displayed in the section given on page 191 and its analysis in the table of analyses, numbers 12, 48, and 51. This bed occupies the position of the Lower Freeport coal of western Pennsylvania.

Upper Freeport Sandstone.—A sandstone is found in the interval between the Barrelville and Davis coals which occupies the position of the Upper Freeport sandstone of western Pennsylvania. It is very massive and forms bold cliffs at some localities, a feature well seen along the Savage River west of Piedmont where it occupies nearly the entire interval between the Barrelville (Lower Freeport) and the Davis (Upper Freeport) coals.

Upper Freeport Limestone.—Limestone has not been observed beneath the Davis coal in the Georges Creek Valley. It forms a thick ledge beneath the Davis coal at several localities in the Castleman and Upper Youghiogheny basins. This bed occupies the position of the Upper Freeport limestone of western Pennsylvania.

Bolivar Clay.—The Davis or Upper Freeport coal is underlain locally by an impure fire-clay. This clay is irregularly distributed, being absent at many places while at others it attains a considerable thickness. It appears to be without commercial value. It occupies the position of the Bolivar fire-clay of western Pennsylvania and eastern Ohio.

Davis Coal—Upper Freeport Coal (Grantsville Coal, Beachy Coal), "Split-Six" Coal, Corinth Coal, Lower Kittanning Coal of Earlier Reports.—This is one of the most valuable coal seams of Maryland and is persistent over wide areas. It has long been worked in the vicinity of Davis, West Virginia, from which locality it is known as the Davis coal. The seam is characteristically divided into two parts by a clay or rock parting which varies in thickness from a few inches to several feet. This coal attains its greatest importance in the Upper Potomac basin where it is extensively worked. The upper bench is of superior value in this basin, but the lower bench is commonly impure in the Upper Potomac basin, where it contains numerous binders, so that it is not mined at many places. It displays the same features in the Upper Youghiogheny basin where it is known as the Corinth coal. It is less valuable at Piedmont where it is called the "Split-six" coal. It is thinner in the northern part of the Georges Creek basin where it is less generally worked, though it attains a thickness of 6 feet locally and bears the clay binder so characteristic of the seam. This is a valuable coal in the Castleman basin where it is known as the Grantsville or Beachey seam. Sections of this coal are given on pages 219-286. Analyses are given in the table of analyses, numbers 24, 25, 35, 36, 38, 40, 43, 49, 55, and 56. The following section of this coal is seen in the mine of the Wills Coal Company, ½ mile south of

Corinth, West Virginia, a short distance west of the Maryland-West Virginia state line:

Section of Davis Coal ½ M. S. Corinth, W. Va.

	Inches
Shale roof.	
Coal	15½
Shale	1½
Coal	14
Bone and slate	6
Coal	6
Shale floor.	
Total	43

For analyses see table of analyses, numbers 1, 33, 34, 39, 47, 50, 54.

The Davis seam has been called the Lower and Middle Kittanning coal in the former publications of the Maryland Geological Survey, and has long been known by that name by coal operators. It will be shown, however, in the chapter upon the correlation of the coals, that the horizon of the Davis seam is far above that of the Lower and Middle Kittanning coals of western Pennsylvania and that it occupies the position of the Upper Freeport coal of that region.

Davis Rider Coal—Upper Freeport Rider Coal.—This is a thin split separated from the main Davis coal by a shale parting in the Castleman and Lower Youghiogheny basins. The interval between the seams varies from 20 feet to a few inches or the rider may unite with the main seam, the thickness of the shale parting being subject to great variation within short distances. The thickness of this coal is usually not over 12 inches.

The relations of the Piedmont coal are such as to suggest that it is merely a thicker representative of this seam separated from the Davis coal by a somewhat greater interval. According to this view the Davis rider coal would belong to the Conemaugh formation to which it is referred in the section in the Castleman and Lower Youghiogheny basins.

CONEMAUGH FORMATION

CHARACTER AND THICKNESS.—The Conemaugh formation of Maryland consists of interbedded shales and sandstones and contains a number of seams of coal. The formation is further characterized by the presence of red beds, a feature which distinguishes it[1] from the underlying Allegheny formation. The red beds thin eastward being inconspicuous in the Georges Creek Valley, but increase in thickness westward, until they form a considerable part of the section in West Virginia and Ohio. Coincident with the increase in the volume of red deposit is a diminution in the quantity of coal so that the strata become increasingly barren westward and productive eastward.

The most important key rocks of the Conemaugh formation are beds of marine limestone and their associated shales, which bear remains of marine organisms. These strata have been traced over wide areas and furnish the most valuable known means of correlating the coal beds of this formation. The most important of these beds are the Ames or crinoidal limestone and the Brush Creek limestone, both of which have been traced with little interruption from southern Ohio through West Virginia into the Georges Creek basin. The formation also contains several less persistent beds of non-marine limestone. The coal beds tend to be more lenticular and variable in character than those of the Allegheny and Monongahela formations and many are merely local developments.

The Conemaugh formation receives its name from the Conemaugh River of western Pennsylvania where it is well exposed. It contains but little commercial coal in that region and hence was early called the Lower Barren Coal Measures. Numerous coal beds are, however, present in it in Maryland, so that it cannot justly be termed barren measures here. The thickness of the Conemaugh formation is known in Maryland only in the Georges Creek, Upper Potomac and Castleman basins, where it varies from about 825 feet to a little over 900 feet.

CONEMAUGH-ALLEGHENY BOUNDARY.—The base of the Conemaugh formation is placed at the top of the Davis (Upper Freeport) seam. This horizon is usually well defined topographically by the heavy Mahoning sandstone that overlies the latter coal. It is also the base of the strata containing red beds.

[1] I. C. White has called attention to the importance of these red beds as a diagnostic feature of the Conemaugh formation. W. Va. Geol. Survey, vol. ii, 1903, pp. 225-227; vol. iiA, 1908, pp. 622, 624; and Rept. on Braxton and Clay counties, 1917, pp. 822-829.

MEMBERS.—The stratigraphic sequence of the members of the Conemaugh formation of Maryland is shown in the following table:

Top

Morantown coal
Upper Pittsburgh limestone
Lower Pittsburgh sandstone
Little Pittsburgh coal
Lower Pittsburgh limestone
Second Little Pittsburgh coal
Connellsville sandstone
Third Little Pittsburgh coal (Franklin rider coal)
Franklin coal
Lonaconing sandstone
Lonaconing coal (upper bench)
Lonaconing coal (lower bench)
Hoffman sandstone
Upper Hoffman coal
Middle Hoffman coal
Hoffman limestone
Lower Hoffman coal
Clarysville sandstone
Upper Clarysville coal
Clarksburg limestone (upper bench)
Clarksburg red shale (upper bench)
Niverton shale and fauna
Lower Clarysville coal
Clarksburg limestone (lower bench)
Clarksburg red shale (lower bench)
Morgantown sandstone
Wellersburg rider coal
Wellersburg coal ("Twin" coal)
Wellersburg limestone
Barton red shale
Barton sandstone
Barton rider coal
Barton coal ("Four-foot" coal)
Upper Grafton sandstone
Federal Hill coal
Birmingham red shale
Lower Grafton sandstone
Ames limestone and shale
Harlem coal
Ewing limestone
Pittsburgh red shale
Unnamed coal
Saltsburg sandstone

Upper Bakerstown coal—Maynadier coal
Albright limestone
Cambridge red shale
Cambridge black shale and fauna—Friendsville shale and fauna
Thomas sandstone
Lower Bakerstown coal—Thomas coal (upper bench)
Lower Bakerstown coal—Thomas coal (lower bench)
Thomas limestone
Meyersdale red shale (upper bench)
Meyersdale limestone and fauna
Meyersdale red shale (lower bench)
Buffalo sandstone
Brush Creek rider coal
Brush Creek limestone, shale and fauna
Brush Creek coal
Irondale limestone
Corinth sandstone
Thornton clay
Mahoning red shale (upper bench)
Gallitzin coal
Mahoning red shale (lower bench)
Mahoning limestone
Upper Mahoning sandstone
Piedmont coal ("Six-foot" coal)
Lower Mahoning sandstone.
Bottom

The characteristics of these members are summarized in the following paragraphs:

Lower Mahoning Sandstone.—The Davis (Upper Freeport) coal is overlain at many localities by a few feet of dark arenaceous shale above which is a persistent sandstone known as the Lower Mahoning sandstone. This sandstone is generally somewhat argillaceous and often contains a large amount of mica. At some places it is coarse and hard. More rarely the interval is formed of shale with subordinate amounts of sandstone, as at Piedmont, West Virginia. This bed lies in the midst of rather soft strata and hence tends to weather into a well-defined ledge or cliff which forms a marked topographic feature in the region.

Piedmont Coal (Six-Foot Coal)—Lower Kittanning Coal of Earlier Reports.—This seam is found about 40 feet above the Davis (Upper Freeport) coal. It is subject to rapid changes in thickness. It is generally thin and unimportant and is cut out at many places. In the vicinity of

Piedmont, however, where it is known as the "six-foot" coal, it is mined extensively and attains a thickness of approximately 6 feet. It is also a valuable coal locally in the Upper Youghiogheny basin. It displays the following section in the Devon mine of the West Virginia Pulp and Paper Company at Luke.

Section of Piedmont Coal Seam, Devon Mine, Luke, Md.

	Inches
Shale roof.	
Coal	$11\frac{3}{4}$
Bone	$6\frac{3}{4}$
Coal	$18\frac{1}{2}$
Bone	$1\frac{1}{2}$
Coal	$26\frac{1}{4}$
Shale bottom.	
Total	$64\frac{3}{4}$

Its thickness and structure are further shown in the sections given on pages 160, 235, 248, 256, 276, 279, 280. Its composition is given in the table of analyses, numbers 1, 33, 34, 39, 47, 50, 54.

Although this coal has usually been considered to be the same bed as the Davis coal, it is distinct from the latter. The name Piedmont coal is suggested from its occurrence at Piedmont, West Virginia. The relation of this seam to the Davis coal is peculiar. Where the Piedmont coal is good the Davis seam is poor and they are separated by a shale interval. Where the Davis seam is good the Piedmont coal is poor or lacking, while the Davis seam may be overlain by sandstone. Attention has already been called to a rider above the Davis coal. It is possible that the Piedmont seam is this rider being a split from the more valuable upper bench of the Davis coal or even represents the latter bench. The relations northwest of Oakland in the Upper Youghiogheny basin are instructive. Here the coal at the horizon of the Davis seam, though thick, is valueless, while the coal 25 feet above it is pure and valuable.

Upper Mahoning Sandstone.—A thick bed of sandstone lies above the Piedmont coal to which the name Upper Mahoning sandstone is here applied. It is similar to the Lower Mahoning sandstone and, in the absence of the Piedmont coal, coalesces with the underlying sandstone to form a single unit.

Mahoning Limestone.—A limestone has been observed at a few localities above the Upper Mahoning sandstone to which the name Mahoning limestone is here applied. It occurs in nodules or may form a thin bed.

Mahoning Red Shale.—A bed of red shale has been observed at several localities in the Upper Potomac basin beneath the Brush Creek coal, for which the name Mahoning red shale is here proposed. Red shale appears at this horizon in the Conemaugh formation at widely separated points, having been observed in the well at Glenova, West Virginia [1]; in various wells in the vicinity of Pittsburgh, Pennsylvania, and more recently by Dr. Harvey Bassler and the writer at Freeport, Pennsylvania. This bed may be divided into two benches between which the Gallitzin coal may lie.

Gallitzin Coal.—A thin bed of coal is found about 40 feet above the Piedmont coal in the Upper Youghiogheny basin. This appears to occupy the position of the Gallitzin coal of Pennsylvania. It attains a thickness of 18 inches and is without commercial value.

Thornton Clay.—The Mahoning red shale occurs in the midst of a thick deposit of clay which is well exhibited in the cut of the Baltimore and Ohio Railroad, west of the station at Corinth, West Virginia, in the Upper Youghiogheny basin. It has long been burned into bricks in the vicinity. A similar deposit is found at this horizon at many places in Maryland. It is known as the Thornton clay in West Virginia.

Corinth Sandstone.—A bed of sandstone is found a short distance beneath the Brush Creek coal at many localities. It is well exhibited at the eastern end of the railroad cut on the Baltimore and Ohio Railroad at Corinth, West Virginia, from which place the name Corinth sandstone is here proposed.

The term Mahoning sandstone was proposed by Rogers for the sandstone overlying the Brush Creek coal [2] (White's Buffalo sandstone), but he appears to have used it for all the sandstones between this horizon and the Upper Freeport coal. White subsequently proposed to restrict the term to the sandstone between the Brush Creek coal and the Upper Free-

[1] White, I. C. Rept. on the Geology of Ohio, Brooke, and Hancock counties. Geol. Survey of W. Va., 1906, p. xiii.

[2] Geol. Survey Penn., vol. ii, pt. i, 1858, p. 477.

port coal[1] and called the sandstone above the Brush Creek coal the Buffalo sandstone. He later divided his Mahoning sandstone into an upper and lower division.[2] White's Lower Mahoning sandstone is itself double, being divided in Maryland and adjacent parts of Pennsylvania into two beds by a seam of coal. Over large areas it is very distinct from his Upper Mahoning sandstone from which it is separated by a thick shale interval. Again, the name Mahoning sandstone is best known to coal operators for the bed immediately over the Upper Freeport coal. These facts seem to the writer to render it desirable to recognize two units, separated by shale, a local coal, and red beds. To the upper he would apply the name Corinth sandstone and to the lower, more or less continuous mass, the name Mahoning sandstone. The latter is divided into an Upper and Lower Mahoning sandstone by the Piedmont coal.

Irondale Limestone.—A thin bed of limestone is found at some localities beneath the Brush Creek coal. This occupies the position of the Irondale limestone of Pennsylvania.

Brush Creek Coal.—This coal occurs 100 to 120 feet above the base of the Conemaugh formation. It rarely exceeds 16 inches in thickness and usually contains a considerable amount of bone. It is thicker and purer at some places, being 2 feet thick at Friendsville where it has been worked in a small way and exhibits the following section:

	Inches
Shale roof.	
Shale with streaks of coal	9
Coal	20

This coal has usually been called the Upper Kittanning in the Georges Creek Valley and the Lower Freeport in the Upper Potomac basin. The abundant marine fauna found above it shows that it is the Brush Creek coal. Though thin and commercially unimportant at most places, it is a very persistent and valuable key stratum.

Brush Creek Limestone and Shale.—The interval between the Brush Creek coal and the Buffalo sandstone consists of shale and limestone, both of which contains numerous marine organisms. The lower beds of shale

[1] 2d Geol. Survey Penn., vol. Q, 1878, p. 36.
[2] Bull. U. S. Geol. Survey No. 65, 1891, p. 95.

are dark, somewhat carbonaceous, and richly fossiliferous, and bear at many places small ferruginous concretions. Toward the top the beds become lighter colored, more arenaceous, and sparingly fossiliferous. Interbedded in the lower shale are some layers which contain such a profusion of organisms that they form lenticular beds of dark argillaceous limestone. These fossils show that this is the same horizon as the Brush Creek limestone of eastern Ohio, Pennsylvania, and West Virginia, one of the most important key rocks of the Conemaugh formation.

Brush Creek Rider Coal.—A thin seam of coal has been observed at a number of localities about 25 feet above the Brush Creek coal to which the name Brush Creek rider coal is here given. It is without commercial value.

Buffalo Sandstone.—This sandstone occurs above the Brush Creek limestone and shale. It is commonly very massive and forms bold ledges at its outcrop. It attains a maximum thickness of nearly 50 feet, but, like all of the sandstones of the coal measures, may be replaced locally by shale, the changes occurring within short distances.

Meyersdale Red Shale.—A bed of red shale occurs a short distance above the top of the Buffalo sandstone at many places. It is deep-red, soft, and breaks into small fragments. It may form two benches, one above and one below the Meyersdale limestone. This is a very persistent bed, being found at many localities in Maryland. It is also the most conspicuous bed of red shale found in the Lower Youghiogheny and Castleman basins in this state. A similar red shale occurs at apparently the same horizon, at many localities in the northern Appalachian basin, having been observed in Ohio, Pennsylvania, and West Virginia. This bed is finely exhibited in the cut of the Western Maryland Railway, east of Meyersdale, Pennsylvania, from which locality the name of Meyersdale red shale is proposed.

Meyersdale Limestone.—A thin and impure limestone containing marine organisms is associated with the Meyersdale red shale in the Lower Youghiogheny basin. It may lie above, below, or within the Meyersdale red shale. Its relation to the Pine Creek limestone of western Pennsylvania and the Cambridge limestone of eastern Ohio will be discussed in a later chapter.

Thomas Limestone.—A thin bed of fresh-water limestone is found in the fire-clay beneath the Thomas coal at a few places in the Upper Potomac basin. It is named the Thomas limestone from its position beneath the Thomas coal.

Lower Bakerstown Coal—Thomas Coal ("Three-Foot" Coal, "Honeycomb" Coal).—Two, and in some cases three, beds of coal lie between the Meyersdale red shale and the Saltsburg sandstone in Maryland, to which the collective name Bakerstown coals is here applied. The lower seam lies about 200 feet above the Davis (Upper Freeport) coal. It is a valuable coal in the Upper Potomac basin where it is known as the Thomas seam and is extensively mined. It is known locally as the "Three-foot" coal, but reaches a thickness of nearly 7 feet at Thomas. It is split into two beds in the Georges Creek and Upper Youghiogheny basins, separated by a variable shale interval, the lower division being thin and unimportant. The upper division is mined at various places in the Georges Creek basin, especially in the southern part of the valley where it is nearly 4 feet thick and is known locally as the "Ginseng seam." It is a single seam in the Lower Youghiogheny and Castleman basins where it is 18 inches to 3 feet thick and is an important coal.

The thickness and structure of this coal are shown in the sections on pages 161, 195, 213, 253, 264, 268, 271. Its composition is given in the table of analyses, numbers 13, 20, 37, 45, 46.

The Thomas coal is commonly known as the Upper Freeport in the Upper Potomac basin and as the Lower Freeport in the Georges Creek basin. That its true position is far above these coals is shown by the occurrence of the Brush Creek limestone with its distinctive marine fauna beneath it, its true horizon being near that of the Bakerstown coal of western Pennsylvania. It is known as the Honeycomb or Bakerstown coal in the Castleman basin and as the Bakerstown coal in the Lower Youghiogheny basin.

Thomas Sandstone.—A sandstone of variable thickness is found above the Thomas coal at places in the Upper Potomac basin replacing the Friendsville shale. It is called the Thomas sandstone from its position above the coal of the same name.

Cambridge Shale and Fauna.—The Thomas coal is overlain by a persistent bed of black shales that contain numerous marine organisms in the Lower Youghiogheny basin. In the Georges Creek basin this bed bears a few species of fossils that probably lived in brackish water. It appears to occupy the horizon of the marine Cambridge limestone of Ohio and of the Pine Creek limestone of western Pennsylvania and West Virginia. The name, Friendsville shale, is from Friendsville, Garrett County, where the beds are well exposed. The age of the fauna is discussed in the chapter upon the correlation of the coals.

Cambridge Red Shale.—A bed of red shale for which the name Cambridge red shale is here proposed is found above the horizon of the Cambridge limestone. It occurs at many localities from Ohio to Maryland.

Albright Limestone.—A bed of impure argillaceous limestone is found beneath the Upper Bakerstown (Maynadier) coal, which occupies the position of the Albright limestone of West Virginia. It is without marine organisms and was probably a fresh-water deposit.

Upper Bakerstown Coal—Maynadier Coal ("Upper Freeport" Coal of Earlier Reports).—A thick bed of coal is found beneath the Saltsburg sandstone to which the name Maynadier coal was given in the Castleman basin. It lies about 290 feet above the Davis seam and about 175 feet above the Brush Creek seam. It attains a thickness of 3 to 4 feet and is quite persistent. It usually bears a number of partings and is high in ash so that it has not been mined upon a large scale in the past. Its structure and thickness are shown in the section given on page 282. Its composition is given in the table of analyses, number 14. This seam has been called the Upper Freeport coal in the Georges Creek Valley.

Saltsburg Sandstone.—A heavy bed of sandstone is found about 300 feet above the base of the Conemaugh formation. It is coarse-grained, locally conglomeratic, and attains a thickness of nearly 50 feet. It outcrops in bold ledges. This sandstone has been called the Mahoning sandstone in the Georges Creek Valley, where the Upper Bakerstown (Maynadier) coal was considered to be the Upper Freeport.

Unnamed Coal.—A thin seam of coal has been observed at two places 45 to 50 feet above the Upper Bakerstown (Maynadier) coal to which no name has been given.

Pittsburgh Red Shale.—A very persistent bed of red or variegated shale, known as the Pittsburgh red shale, lies between the Harlem coal and the Saltsburg sandstone. In the Georges Creek Valley the red color usually appears as a mottling or in irregular patches in the shale, the remainder of the material being greenish. The volume of the red material increases both southward and westward, so that the entire unit is bright red at many places in West Virginia and Ohio. This bed weathers into characteristic soft, crumbling, granular fragments and clay.

Ewing Limestone.—The Harlem coal is underlain by an impure, argillaceous limestone known as the Ewing limestone, from its occurrence at Ewing, Ohio. The limestone forms nodular beds that break into yellowish lumps upon exposure to the weather. It contains numerous minute, rounded particles, some of which may be poorly-preserved ostracods. It attains a thickness of 4 feet.

Harlem Coal ("Brush Creek" Coal in Part of Earlier Reports).—This seam lies 200 to 250 feet above the Brush Creek coal. Though thin its quality is good so that it is mined at many points for local use. The prevailing thickness of the coal is 18 inches to 2 feet. It displays the following sections at the mine of J. Pratt, ¾ miles east of Mount Savage village.

Sections of Harlem Coal in Pratt Mine, near Mt. Savage, Md.

I

	Inches
Gray shale roof.	
Bone	5
Coal	28
Thin sale parting	..
Bony coal	6
Black shale floor.	
Total	39

II

	Inches
Slate roof.	
Coal	20
Bone	5¾
Slate floor.	
Total	25¾

The composition of this coal is given in the table of analyses, number 28. This seam has usually been known as the Brush Creek coal in the Upper Potomac and in the Georges Creek basins, though near Mount Savage, it was called the Crinoidal coal in the report on the Coals of Maryland. It is one of the most persistent coals of the Conemaugh formation and is a valuable key stratum.

Harlem Rider Coal.—This coal was found in a drill hole near Lord in the Georges Creek Valley, 20 feet above the Harlem coal. It is thin and without commercial value.

Ames Limestone and Shale ("Crinoidal Limestone").—The Harlem coal is overlain, at most places, by dark, fine-grained, somewhat carbonaceous shales, that weather into small, soft, irregularly-shaped fragments. Numerous small, elongated, ferruginous concretions are commonly present. The shale becomes increasingly lighter colored and arenaceous above, where it grades into the overlying sandstone. The lower dark shales contain marine organisms, which are so abundant in some beds that they form lenticular layers of dark argillaceous limestone. The limestone may be present at two horizons, a lower, a short distance above the Harlem coal, and an upper, 15 to 20 feet higher. The limestone, called the Ames limestone, is probably even better known as the "Crinoidal limestone" in western Pennsylvania and Ohio. It has been traced over wide areas in the northern part of the Appalachian coal basin. Both shale and limestone carry diagnostic species of fossil shells that render this one of the most important key rocks of the Conemaugh formation.

Lower Grafton Sandstone.—A very persistent sandstone, that has been named the Grafton sandstone from its occurrence at Grafton, West Virginia, lies above the Ames shale and limestone. This sandstone is divided into two parts, in the Georges Creek Valley, by a thin but persistent coal. The lower division is here termed the Lower Grafton sandstone. In the Georges Creek Valley, where this bed is best displayed, it consists characteristically of micaceous, thin-bedded, greenish sandstone, that breaks into smooth, thin, flat plates. It attains a thickness of 25 to 30 feet.

Birmingham Red Shale.—A bed of red shale has been observed at a few localities in the Upper Potomac basin about 75 feet above the Harlem coal. It occupies the position of the Birmingham red shale at Pittsburgh. Its precise relation to the Federal Hill coal is not known.

Federal Hill Coal.—A thin but persistent seam of coal is found about 75 feet above the Harlem coal at many localities which is here named the Federal Hill coal from its exposure in the cut of the Western Maryland

Railway through the north end of the Federal Hill, near Barrelville.[1] This coal attains a thickness of 15 inches, but is without economic value in Maryland. A seam has also been recognized at what appears to be the same horizon in the Castleman basin west of Meyersdale, Pennsylvania, and at other localities. It lies near the horizon of the West Milford coal of West Virginia, though it is probably a different seam.

Upper Grafton Sandstone.—A very persistent and massive bed of sandstone, which is here called the Upper Grafton sandstone, is found about 100 feet above the Harlem coal. It is very resistant to weathering and forms thick ledges and cliffs at many places, where it is a marked feature of the topography. In the absence of the Federal Hill coal it unites with the Lower Grafton sandstone to make a single unit.

Barton Coal ("Four-Foot" Coal—"Bakerstown Coal," in part, of Earlier Reports).—A thick seam of coal occurs 100 to 120 feet above the Harlem coal, which is called the Barton coal from its occurrence near Barton in the Georges Creek Valley, where it is also known as the "Four-foot" seam. This coal has its best development in the Georges Creek Valley where it has a thickness of nearly 4 feet and is extensively mined. Its structure and thickness are shown in the sections on pages 166, 197, 209, 226, 243, 265. Its composition is given in the table of analyses, numbers 2, 18, 27, 44. This is the most important coal in the Conemaugh formation of Maryland.

This coal was named the Barton coal by Stevenson.[2] It was subsequently called the Bakerstown coal in the Georges Creek Valley. It appears to be the seam commonly known as the Elklick coal in West Virginia and western Pennsylvania, although, as shown elsewhere, it is probably not the coal originally so named in Somerset County, Pennsylvania.

Barton Rider Coal.—A thin seam of coal is found at places a few feet above the Barton coal. It is without commercial value.

[1] This cut is situated west of Trotters Run and 1½ miles southwest of Barrelville, in the Georges Creek basin.

[2] Stevenson, J. J. 2d Geol. Survey, Pa., vol. KK, pp. 67-68, 1877. Stevenson named this coal from Barton Maryland (private communication to author).

Barton Sandstone.—A thick sandstone is found locally over the Barton coal at Barton and elsewhere which is named the Barton sandstone from its position.

Barton Red Shale.—Red shale was found above the Barton coal in drill holes in the Potomac basin which is here named the Barton red shale.

Wellersburg Limestone.—A limestone is found locally beneath the horizon of the Wellersburg coal to which the name Wellersburg limestone is here applied.

Wellersburg Coal—" Twin " Seam.—A thick seam of coal, to which the name Wellersburg coal was applied by Lesley,[1] is found at Wellersburg, Pennsylvania, about 60 feet above the horizon of the Barton coal. This seam is divided into two parts by a thick binder and hence is locally called the " twin seam." The binder varies in thickness from 2 to 5 feet. The upper bed attains a thickness of about 3 feet, but contains much bone and ash. The lower bed is of good quality and is mined for local use in the vicinity of Wellersburg where it is 2 to 3 feet thick. This coal exhibits the following structure on Cooks Hill near Wellersburg.

Section of Wellersburg Coal near Wellersburg, Pa.

	Feet	Inches
Coal and bone	3	
Shale	2 to 5	
Coal with sulphur	1	
Shale	..	3
Coal	1	2
Bone	..	4

It is possible that this coal is the northern extension of the Barton coal. It seems, however, more probable that it is a higher seam.

Wellersburg Rider Coal.—A thin seam of coal is found 25 feet above the Wellersburg (" Twin ") coal at Wellersburg, Pennsylvania, where it is about 12 inches thick. This coal occurs in shale which replaces the Morgantown sandstone at this locality.

Morgantown Sandstone.—A bed of sandstone is found about 200 feet above the Harlem coal which, when typically developed, is very massive and locally conglomeratic. At some places it bears many hackle teeth, similar to those found in the Mount Savage (Kittanning) sandstone. It is subject to considerable variation in character, however, and may be

[1] Lesley, J. P. 2d Geol. Survey, Pa., Ann. Rept., 1885, p. 237, 1886.

replaced by shale. It attains a thickness of 20 to 40 feet. The overlying rocks tend to weather more rapidly than those beneath this bed so that it often forms the top of a well-marked bench above which the slopes are gentle over wide areas. This sandstone occupies the position of the Morgantown sandstone of West Virginia with which it is here correlated.

Clarksburg Red Shale (lower bench).—Red shale has been observed above the Morgantown sandstone at a number of places in the Upper Potomac basin, where it occupies the position of the Clarksburg red shale of West Virginia. It occurs in two benches, the lower being below the lower bench of the Clarksburg limestone and the upper probably below the upper bench of the Clarksburg limestone.

Clarksburg Limestone (lower bench).—Limestone is found a short distance above the horizon of the Morgantown sandstone at many places. At places it is represented by calcareous nodules, elsewhere it may form a thick bed. At Wellersburg, Pennsylvania, in the northern part of the Georges Creek basin, it is a compact limestone which is reported to attain a thickness of 30 feet and was formerly quarried for local use. This limestone appears to occupy the position of the Clarksburg limestone of West Virginia. It occurs in two benches below the Clarysville coals.[1]

Lower Clarysville Coal.—Three beds of coal are found in the Georges Creek Valley between the Morgantown and Wellersburg sandstones to which the collective name Clarysville coals is here applied from the occurrence of two of the seams in the Hoffman Drainage Tunnel near Clarysville. All are local and without commercial value.

The Lower Clarysville coal is well exposed near the base of the third cut of the Western Maryland Railway east of Mount Savage village where it exhibits the following section:

	Inches
Roof. Calcareous shale with limestone nodules.	
Coal and bone	15
Shale	36
Bone	3
Lower Clarksburg limestone.	

This coal has been seen at a few other localities.

[1] Two limestones are found in analogous positions in the vicinity of Morgantown, West Virginia, where the lower has been called the Mona limestone and the upper the Clarksburg limestone.

Niverton Shale and Fauna.—A bed of dark to olive shales found at various places in the Castleman basin above the lower bench of the Clarksburg limestone where it contains a great profusion of a new species of *Pleurophorous* and a few *Estheria ortoni.* It is well exposed on the west bank of the Castleman River 1.3 miles south of Niverton, Pennsylvania, from which locality it receives its name.

Upper Clarysville Coal.—This seam lies 277 feet below the Pittsburgh seam in the Hoffman Drainage Tunnel where it is 15 inches thick.

Clarksburg Limestone (upper bench).—A bed of limestone lies below the horizon of the Upper Clarysville coals at a few localities which is here called the upper bench of the Clarksburg limestone. It attains a thickness of 5 to 6 feet.

Clarysville Sandstone.—A thick sandstone about 250 feet beneath the Pittsburgh coal is found at various localities in the Georges Creek Valley. It is usually thin-bedded and somewhat argillaceous and is locally replaced by shale. It is well exposed on the hilltop southwest of Wellersburg in the northern part of the Georges Creek basin. It is also seen above the Clarysville coals in the Hoffman Drainage Tunnel at Clarysville from which locality it receives its name.

Lower Hoffman Coal.—Two, and in a few cases three, beds of coal are found in the Georges Creek Valley between the Wellersburg and Hoffman sandstones. The upper and lower beds are found in the Hoffman Drainage Tunnel near Clarysville from which locality the collective name of Hoffman coals is here proposed for this group. The lower bed lies 237 feet beneath the Pittsburgh seam in the Hoffman Tunnel where it is 14 inches thick. It is also exposed in the cuts of the Western Maryland Railway east of Mount Savage village.

Hoffman Limestone.—A limestone of variable thickness is found at a number of localities in the Georges Creek Valley beneath the Middle Hoffman coal. It is named the Hoffman limestone because of its relation to that bed.

Middle Hoffman Coal.—This bed has been observed at a few localities in the Georges Creek Valley. It is seen overlying the Hoffman limestone in the first cut of the Western Maryland Railway east of Mount Savage village where it is 15 inches thick.

Upper Hoffman Coal.—This is a thick but impure seam of coal which is found 200 to 220 feet beneath the Pittsburgh seam. It is 52 inches thick in the Hoffman Drainage Tunnel where it exhibits the following section:

	Inches
Coal	7
Rock with coal streaks	9
Coal with rock streaks	7
Rock	2
Coal with rock streaks	27

It is also well exposed on Cooks Hills, north of Wellersburg, Pennsylvania, where it shows the following section:

	Inches
Coal	8
Rock parting	23
Coal	23

Hoffman Sandstone.—A thick sandstone is found at various localities in the Georges Creek Valley above the upper Hoffman coal for which the name Hoffman sandstone is here proposed, from its occurrence in the Hoffman Drainage Tunnel. It attains a thickness of 20 to 30 feet.

Lonaconing Coal.—Two seams of coal are found 150 to 180 feet beneath the Pittsburgh coal in the Georges Creek Valley where they have been known as the Lonaconing coal. The lower bench lies 177 feet beneath the Pittsburgh coal in the Hoffman Drainage Tunnel where it is 12 inches thick. This is a thin and unimportant coal.

The upper bench of this coal lies about 150 feet beneath the Pittsburgh coal in the Georges Creek Valley where it is reported to attain a thickness of nearly 30 inches and has been mined for local use. It exhibits the following section in the Hoffman Drainage Tunnel:

	Inches
Roof sandstone.	
Coal	8
Black shale	½
Coal	11½
Total	20

Lonaconing Sandstone.—A thin-bedded sandstone is found locally between the Lonaconing and Franklin coals to which the name Lonaconing sandstone is here applied. It is seen at various places along Georges Creek south of Lonaconing.

Franklin ("Dirty Nine-Foot") Coal.—A thick seam of coal is found in the Georges Creek Valley 125 feet to 140 feet beneath the Pittsburgh seam which has been called the Franklin coal from its occurrence at the village of Franklin, near Westernport. It consists of several beds of coal separated by carbonaceous shale and bone and attains a thickness of nearly 9 feet in the southern part of the Georges Creek Valley where it is popularly known as the "Dirty Nine-Foot" seam. It is 32 inches thick in the Hoffman Drainage Tunnel. Its composition is given in the table of analyses, number 9. This seam was called the Little Clarksburg coal in the earlier reports of the Maryland Geological Survey.

Third Little Pittsburgh Coal or Franklin Rider Coal.—A seam of coal has been observed 25 feet above the Franklin coal in the Hoffman Drainage Tunnel near Clarysville, where it is 14 inches thick. It may be regarded as a rider of the Franklin coal or as a Third Little Pittsburgh coal.

Connellsville Sandstone.—A massive sandstone is found 100 to 125 feet below the Pittsburgh coal which occupied the position of the Connellsville sandstone of Pennsylvania. It may be replaced more or less completely by shale, in which event one or two coals, the Franklin Rider coal and Second Little Pittsburgh coal, may be found within it. This sandstone is a conspicuous feature in the southern part of the Georges Creek Valley where it attains a great thickness and outcrops in prominent ledges.

Second Little Pittsburgh Coal.—Two seams of coal are found in the Georges Creek Valley 60 to 100 feet beneath the Pittsburgh coal which are known as the Little Pittsburgh coals. The lower seam, known as the Second Little Pittsburgh coal, is found in the Hoffman Drainage Tunnel near Clarysville where it is 17 inches thick.

Lower Pittsburgh Limestone.—A thin bed of limestone is found locally beneath the Little Pittsburgh coal which occupies the position of the Lower Pittsburgh limestone of western Pennsylvania.

Little Pittsburgh Coal.—This coal is found at a number of places in the Georges Creek Valley where it attains a thickness of 3 to 4 feet and is mined locally. Its thickness and structure are shown in the section on page 167. Its composition is given in the table of analyses, number 3.

Lower Pittsburgh Sandstone.—A thick and prominent sandstone is found 25 to 50 feet beneath the Pittsburgh seam at many localities to which White has applied the name of Lower Pittsburgh sandstone.[1]

Upper Pittsburgh Limestone.—A thin bed of limestone has been observed in a drill hole near Carlos in the Georges Creek basin beneath the Pittsburgh seam which occupies the position of the Upper Pittsburgh limestone.

Morantown Coal.—An impure coal, usually double-bedded, is found beneath the Pittsburgh seam at various places in the Georges Creek Valley which is here called the Morantown coal from its occurrence near Morantown, north of Frostburg. This coal attains a thickness of 4 feet on the property of the Trimble heirs, near Morantown, south of Mount Savage, where it lies 5 to 7 feet beneath the Pittsburgh coal and exhibits the following section:

	Inches
Coal	24
Shale	12
Coal	8

In the Hoffman Drainage Tunnel near Clarysville where the upper bench lies 4.3 feet beneath the Pittsburgh seam, it exhibits the following structure:

	Inches
Coal	14
Shale	18
Coal	8

Monongahela Formation

CHARACTER AND THICKNESS.—The Monongahela formation consists chiefly of interbedded shales and sandstones, with a few beds of limestone. The proportion of shale in it is larger than in the Conemaugh formation. It bears coal beds of great importance, the Pittsburgh coal at its base being the most valuable deposit of the region. The formation has long been known as the Upper Productive Coal Measures because of its rich content of coal. The Monongahela formation receives its name from the

[1] White, I. C., W. Va. Geol. Survey, vol. ii, 1903, p. 204.

exposures on the Monongahela River near Pittsburgh, Pennsylvania. Its thickness varies from 240 to 270 feet in Maryland.

MONONGAHELA-CONEMAUGH BOUNDARY.—The base of the Monongahela formation is placed at the base of the Pittsburgh coal.

MEMBERS.—The stratigraphic sequence of the members of the Monongahela formation in Maryland is shown in the following table:

Top

Waynesburg coal—Koontz coal
Waynesburg limestone
Uniontown sandstone
Benwood limestone
Upper Sewickley sandstone
Upper Sewickley coal
Lower Sewickley sandstone
Lower Sewickley coal—Tyson coal (upper and lower benches)
Cedarville sandstone
Redstone coal (upper bench)
Redstone sandstone
Redstone coal (lower bench)
Upper Pittsburgh sandstone
Pittsburgh coal

Bottom

Clark and Martin published a description of the Coal Measures of Maryland in 1902 in which they correlated the various members recognized by them in the Monongahela and overlying formations with the divisions of the coal measures of Pennsylvania and West Virginia.[1] I. C. White subsequently suggested a different correlation, basing his suggestions largely upon the thickness of the sections in Maryland and West Virginia.[2]

The relation of the two correlations is shown in the following table:

Clark and Martin 1902	*I. C. White 1903*
Washington coal	Waynesburg coal
Waynesburg (Koontz) coal	Uniontown coal
Upper Sewickley coal	Sewickley coal
Lower Sewickley coal	Redstone coal
Redstone coal	Pittsburgh roof coal
Pittsburgh coal	Pittsburgh coal

[1] Clark, Wm. Bullock and Martin, G. C. Bull. Geol. Soc. Amer., 1902, vol. xiii, pp. 226-232; Rept. on the Coals of Maryland, Md. Geol. Survey, 1905, vol. v, pp. 312-314.

[2] White, I. C. Coal Report. West Virginia Geol. Survey, 1903, vol. ii. pp. 145. 146.

The correlation of the beds above the Upper Sewickley has not been investigated critically since the publication of the report of Clark and Martin. The writer believes, with White, however, that the Monongahela formation of Maryland is probably much thicker than was supposed by former workers and that the Koontz coal is probably not the Waynesburg coal of Pennsylvania. The area in which the beds above the Koontz coal are preserved in Maryland is small and affords no good exposures. Until a critical study of the fossil flora of the higher strata is made no confident conclusions can be reached as to their true relations with the deposits of Pennsylvania and West Virginia. It has seemed better therefore to retain the correlations of Clark and Martin in this report pending further investigation of the strata above the Sewickley, rather than to introduce new names which further study might compel us to change.

The description of the Pittsburgh coal and of the members above the Tyson coals are based largely on the report of Clark and Martin.[1]

Pittsburgh ("Big Vein," "Fourteen-Foot," Elk Garden) Coal.—At the base of the Monongahela formation is the seam of coal known locally as the "Big Vein" or "Fourteen-foot" coal. This seam in its stratigraphic relations to the overlying and underlying beds corresponds exactly to the Pittsburgh coal. The flora of the roof shales, as far as our present knowledge goes, is the same; and Dr. I. C. White has pointed out the identity of structure within the bed.

The various elements composing the seam are constant and characteristic in number and relative position. The relative thickness of these individual elements varies from place to place. From the Pittsburgh region toward the southeast there is a gradual increase in the thickness of the "breast" coal, which reaches a maximum in the southern end of the Georges Creek basin, where the entire bed has been found in a single locality to reach 22 feet in thickness. There is greater change within the limits of the Georges Creek basin than there is between the central part of the Georges Creek basin and the Pittsburgh region. This change consists chiefly in an increase in the number and thickness of the shales at the expense of the "breast" coal. This seam was called the Elk Garden coal in the Piedmont folio of the U. S. Geological Survey and in the

[1] Clark, Wm. Bullock, and Martin, G. C., Md. Geol. Survey, vol. v, 1905, pp. 310-312.

Report on the Geology of Allegany County. The name Pittsburgh coal was applied to this seam by J. P. Lesley in 1856.

The structure of this seam is displayed in sections given on pages 162-245. Its composition is given in the table of analyses, numbers 4, 5, 6, 7, 21.

Upper Pittsburgh Sandstone.—The Pittsburgh coal is overlain at many localities by a thick sandstone which occupies the position of the Upper Pittsburgh sandstone of western Pennsylvania.

Redstone Coal.—The Redstone coal is found in the Georges Creek basin 20 to 50 feet above the base of the Pittsburgh coal. It consists of two distinct benches separated by a lenticular deposit of shale and sandstone. The interval between them is subject to marked changes in short distances. When occupied by sandstone it may be as much as 40 feet. At places the beds appear to unite to form a single seam consisting of several benches separated by shale or thin sandstone partings and attaining a thickness of 6 to 10 feet. The thickness of the separate coals varies from 1 to 3 feet. The upper has usually been called the Lower Sewickley in the Georges Creek Valley, but is distinct from that coal, being separated from it by the Sewickley limestone.[1]

The Redstone coal contains a large amount of ash and, where thick, usually bears numerous partings so that it has not been mined extensively in the past. It exhibits the following section in the Bowery Furnace mine of the Brophy and Hitchens Coal Company at Midlothian:

Section of Redstone Coal at Midlothian

	Inches
Roof shale.	
Coal	6
Bone and shale	1
Coal	10
Slate and bone	7
Coal	19
Slate and coal streaks	11
Coal	14
Slate	1
Coal	17
Total	86

[1] I. C. White has suggested that the lower of these seams is to be identified with the Pittsburgh roof coal of Western Pennsylvania. (Coal Report, West Virginia Geol. Surv., 1903, vol. ii, pp. 145-146.) The author is much inclined to agree with this suggestion. In this event the upper bed only would be the Redstone coal.

Redstone Sandstone.—The sandstone separating the upper and lower benches of the Redstone coal is here named the Redstone sandstone. Its maximum thickness is about 40 feet.

Cedarville Sandstone.—The Redstone coal is overlain by a sandstone which has been named the Cedarville sandstone in West Virginia. It attains a thickness of 20 to 30 feet at some places.

Sewickley Limestone.—An impure limestone is found between the Redstone and Sewickley coals which occupies the position of the Sewickley limestone of western Pennsylvania. It attains a thickness of 6 to 8 feet. It was quarried at Midlothian and near Mount Savage for use in the iron furnaces formerly situated at these points. It is a persistent bed in the Georges Creek Valley and is an important guide to the position of the Lower Sewickley coal.

Lower Sewickley Coal—Tyson Coal.—Three seams of coal are found in the interval from 60 to 180 feet above the Pittsburgh coal to which the collective name Sewickley coals is here applied. The lowest of these coals is known as the Tyson coal in the Georges Creek basin where it is extensively mined. The interval between the Lower Sewickley and Pittsburgh coals is subject to remarkable variation, being about 70 feet at Midlothian, 80 feet in the Pumping Shaft south of Frostburg, and increasing to 160 feet in Mine No. 10 of the Consolidation Coal Company, near Eckhart. This variation led to the belief that there are two Sewickley coals, a lower and an upper, which were thought to be situated about 80 feet and 120 feet respectively above the Pittsburgh seam, the Tyson being believed to be the upper of these two coals. The identity of the Tyson and the lower of these seams is fully established by continuous workings in the same bed at varying elevations, as seen in Mines 10 and 11 of the Consolidation Coal Company near Frostburg. This condition led also to the confusion of the Upper Redstone with the Lower Sewickley coal. The Upper Redstone lies at many places about 80 feet above the Pittsburgh coal and was hence identified with the Lower Sewickley. That it is distinct from the latter coal is shown by the occurrence of a limestone between them which can be followed throughout the field. The Lower Sewickley is double bedded, consisting of a main lower bed with a split (rider) at many places. It would thus appear that there are five coals lying within the interval under discussion—two Redstone and three Sewickley coals. The two Redstone coals appear to consolidate locally to make one seam. It is possible that the Sewickley coals may unite in a similar manner to make a single coal in the southern part of the Georges Creek Valley.

The variation in intervals between the Pittsburgh and Lower Sewickley coals appears to be related to the thickness of the sediments separating the two divisions of the Redstone coal. When the deposits are thin the Redstone may form a single thick seam as at the Pumping Shaft and at Midlothian and the interval between the Pittsburgh and Lower Sewickley coals is small. When the deposits between the divisions of the Redstone are thick, the Redstone coals appear to be thin and the interval between the Pittsburgh and Lower Sewickley large. In other words, an increase in the interval between the Pittsburgh and upper bench of Redstone is associated with an increase in the interval between the Pittsburgh and Lower Sewickley coals.

The relative positions of the beds is shown in the following table:

Sewickley coals	Upper Sewickley or Borden	
	Lower Sewickley or Tyson coal	upper bench
		lower bench
	Sewickley limestone	
Redstone coal	Upper bench of Redstone	
	Redstone sandstone	
	Lower bench of Redstone	

Pittsburgh Coal

The Lower Sewickley coal, though of small areal extent, is one of the most valuable of the smaller coals of the Georges Creek basin. Its thickness is commonly 2½ and 3½ feet. Typical sections are given on pages 165-222, and analyses are given in the table of analyses, numbers 8, 10, 16, 22, 26.

Lower Sewickley Sandstone.—This is a thin sandstone of variable thickness found locally above the Lower Sewickley coal.

Upper Sewickley Coal (Borden).—This coal is found at a few localities in the Georges Creek Valley about 120 feet above the Pittsburg seam. It is not the Tyson coal which was called the Upper Sewickley in the former report of the Maryland Geological Survey, but is a higher coal, as is seen at the Pumping Shaft, south of Frostburg, where the mineable Tyson lies 46 feet beneath it. But little is known of the extent of this coal. It displays the following section in the Borden Pumping Shaft:

	Inches
Coal	10
Shale	36
Coal	20
Total	66

Upper Sewickley Sandstone.—A sandstone is found at places between the Sewickley and Uniontown coals which occupies the position of the Sewickley sandstone of western Pennsylvania and which is here called the Upper Sewickley sandstone. It attains a thickness of 15 feet.

Benwood Limestone.—A limestone is found at a few places in the Georges Creek Valley replacing the Upper Sewickley sandstone. It occupies the position of the Benwood limestone of West Virginia. It is 6 feet thick near Borden Shaft.

Uniontown Coal.—A thin coal is found in the Pumping Shaft section near Frostburg, about 60 feet above the Upper Sewickley coal and close to the top of the Sewickley sandstone. It was thought by Clark and Martin to correspond in position and character to the Uniontown coal of Pennsylvania.

Uniontown Sandstone.—A short distance above the Uniontown coal, in the Pumping Shaft section, there is a thin sandstone which is probably the Uniontown sandstone.

Waynesburg Limestone.—A limestone occurs a short distance above the Uniontown limestone and from 20 to 30 feet below the top of the formation which corresponds in its stratigraphic position to the Waynesburg limestone of Pennsylvania and West Virginia.

Waynesburg Coal (*Koontz Coal*).—There is a very persistent coal seam, of considerable economic importance, that may occur anywhere in the interval up to 20 feet above the top of the Waynesburg limestone. From its position, 230 to 250 feet above the base of the Monongahela formation, and in its regular stratigraphic sequence, it was regarded by Clark and Martin as the Waynesburg coal. In the Report on the Geology of Allegany County it was named the Koontz coal, from its occurrence at the mining village of that name near Lonaconing. The roof of the Waynesburg coal is the top of the Monongahela formation.

The analysis is given in the table of analyses, number 15.

PERMIAN SYSTEM

The Permian rocks of Maryland do not differ in any essential respect from those of the underlying Carboniferous system, so that it is not possible to draw any well-defined lithological line of division between them in this region. The discrimination of this system in the Appalachian region is based upon the differences in the character of the fossil plants which show that the strata are of the age of the Permian deposits in Europe.

I. C. White[1] named the Permian rocks of southwestern Pennsylvania the Dunkard Creek series. They have since been divided into two formations. The upper of these, consisting largely of shale and sandstone and containing but little coal has been called the Greene formation from Greene County, Pennsylvania. The lower division containing a number of beds of limestone and several coal seams has been called the Washington formation, from Washington County, Pennsylvania. The Permian rocks of Maryland were called the Dunkard formation in the more recent reports of the Maryland Geological Survey. They were earlier named the Frostburg formation.

The Permian rocks of Maryland are less than 400 feet thick, while those of southwestern Pennsylvania are nearly 1500 feet thick. It is hence manifest that but a small portion of the Permian strata of the Appalachian province is represented in Maryland, the upper beds having probably been removed by erosion.

Washington Formation

CHARACTER AND THICKNESS.—The Washington formation consists of interbedded shale, sandstone, thin beds of limestone, and several seams of coal. This formation has a maximum thickness of 300 feet in Maryland.

[1] Bull. U. S. Geol. Survey, No. 65, 1891, p. 20.

The most important section is exposed near the Borden Shaft in the Georges Creek Valley.

WASHINGTON-MONONGAHELA BOUNDARY.—The base of the Washington formation is placed at the top of the Waynesburg coal (Koontz coal).

MEMBERS.—The stratigraphic sequence of the members of the Washington formation in Maryland is shown in the following table:

Upper Washington limestone
Unnamed limestone
Unnamed limestone
Washington coal
Waynesburg A coal
Waynesburg sandstone

The stratigraphy of the Permian rocks of Maryland has not been investigated in detail since the publication of the report on the Coals of Maryland in 1905, in which various divisions were described by Wm. Bullock Clark and G. C. Martin. The following description of the members is quoted, in part, from that report[1]:

Waynesburg Sandstone.—A sandstone of no very great prominence occurs a short distance above the Waynesburg coal. It probably represents the Waynesburg sandstone, since its stratigraphic position is the same.

Waynesburg "A" Coal.—A thin coal which corresponds in position to the Waynesburg "A" coal of Pennsylvania and West Virginia is found on top of the Waynesburg sandstone, and about 45 feet above the Waynesburg coal.

Washington Coal.—About 75 feet above the Waynesburg "A" coal, and separated from it by an interval consisting in Maryland apparently of shales and limestones, is a seam of coal whose character is not well known. The thickness of this coal is about 3½ feet and its quality is not known. This coal corresponds in position to the Washington coal of Pennsylvania.

Unnamed Limestone.—Two thin beds of limestone have been observed 1 foot and 120 feet respectively above the Washington coal to which no names have been given.

[1] Clark, Wm. Bullock, and Martin, G. C. Md. Geol. Survey, vol. 5, 1905, p. 314.

Upper Washington Limestone.—A bed of limestone approximately 4 feet in thickness occurs about 170 feet above the Washington coal. It is approximately in the position of the Upper Washington limestone of Pennsylvania.

Greene Formation

CHARACTER AND THICKNESS.—The Greene formation of Maryland does not differ essentially from the underlying Washington formation, consisting, like it, of interbeded shale and sandstone with a single bed of limestone and coal. The lower strata of this division only are found in Maryland where its thickness is only 90 feet. The beds are restricted to a single locality near Borden Shaft.

GREENE-WASHINGTON BOUNDARY.—This boundary is placed at the upper surface of the Upper Washington limestone in harmony with the horizon selected in Pennsylvania.

MEMBERS.—The stratigraphic sequence of the members in this formation in Maryland is shown in the following table:

Unnamed sandstone
Jollytown limestone
Jollytown coal

The following description of these members is given by Wm. Bullock Clark and G. C. Martin.[1]

Jollytown Coal.—A thin seam of coal is found about 25 feet above the outcrop of the Upper Washington limestone. It is apparently in the stratigraphic position of the Jollytown coal of Greene County, Pennsylvania.

Jollytown Limestone.—A limestone of 10 to 15 feet in thickness is found about 15 feet above the Jollytown coal. It is in the position of the Jollytown limestone of Pennsylvania.

Unnamed Sandstone.—Above this limestone there are no good exposures, and not more than 50 feet of strata are preserved in Maryland. The highest bed is a sandstone which caps the hill east of Borden Shaft.

[1] Clark, Wm. Bullock, and Martin, G. C. Md. Geol. Survey, vol. v, 1905, p. 314.

CORRELATION OF THE COAL MEASURES OF MARYLAND

BY

CHARLES K. SWARTZ

The coal measures of the northern Appalachian province have been divided into formations and these in turn into numerous members, each of which has received a name from some locality where it is well exposed. Many of the divisions were established by the geologists of the Pennsylvania Geological Survey, so that the names employed are derived in many cases from localities in that State.

In tracing the beds from the regions in which they were early studied into other areas, it is necessary to determine the relative ages of the strata of various places, a process known as the correlation of the beds.

The extreme variability of the beds of the coal measures renders such correlation very difficult. Most of the strata were laid down upon land surfaces in swamps, streams, and lagoons. The character of the deposits may change within short distances, sandstone passing into shale, and shale into other types of sediments so that it is difficult to find persistent features in beds so variable. Again, the Carboniferous strata have been subdivided, because of their commercial importance, into a much larger number of units than is usual, even in the more persistent and less variable marine deposits. Indeed, the extent of the subdivision has, in many cases, exceeded the accuracy with which the work has been attempted and the precision of the criteria used, thereby rendering the correlations insecure.

It will, therefore, be helpful to precede the consideration of the age of these strata in Maryland by a brief discussion of the criteria employed in the correlation of coal measures.

CRITERIA OF CORRELATION

The following afford the most valuable means of correlating Carboniferous strata of the types found in Maryland: fossil organisms; the lithology of the beds; the intervals between the strata; the sequence of deposits and organisms; systematic variations in the character and thickness of the strata; unconformities and other evidences of earth movements; certain other criteria. Each of these will be briefly considered.

FOSSIL ORGANISMS

Fossil organisms afford the best known means of recognizing a given stratum and tracing it from place to place. The organisms may be of two kinds—animals and plants, the animal forms living together being known collectively as faunas, while plants so associated are termed floras.

FAUNAS.—Large numbers of marine organisms are found in certain Carboniferous strata, some of which are restricted to particular beds, so that the strata containing them are readily recognizable. Such faunas have afforded the best known means of correlating the coal measures in the past. The fossils are found chiefly in limestone though they occur less abundantly in shales associated with the limestones. The most important strata containing marine organisms are the Ames or Crinoidal limestone, the Cambridge or Pine Creek limestone, the Brush Creek limestone, and the Vanport or Ferriferous limestone. All of these beds, save the last, have been traced from Ohio, through western Pennsylvania and West Virginia, into Maryland. There are in addition several other less important though significant zones.

FLORAS.—Numerous and often beautifully preserved plant fossils are found in the rocks. These organisms, however, have not been as well known in the Appalachian coal fields as the marine forms and hence have not been used as extensively as the latter in correlation of the beds of this area. Increasing knowledge of the fossil plants is rendering them a most valuable means of correlation.

LITHOLOGIC CRITERIA

The character of the rocks affords a second means of correlation; the most valuable lithological features for this purpose being those displayed by coal seams, sandstones, red beds, and limestones.

LITHOLOGY OF COAL SEAMS.—It has often been assumed that coal seams exist in continuous sheets over great areas, so that it has been thought possible to recognize even thin beds in many states. The writer believes that the coal seams are, in general, lenticular and limited. While a few beds, such as the Pittsburgh coal, may have originally covered great areas it is believed that many are local and were laid down in swamps of limited extent. There may, however, have been periods when the swamps flourished at numerous places in a large region, alternating with times when conditions were less favorable for the growth of vegetation. The coal beds were laid down on comparatively flat surfaces, and hence possess a rude synchronism. The assumption, however, that they are continuous sheets laid down over great areas cannot but lead to error in many cases.

In a similar manner it has been assumed by some that the structure and composition of the seams remain nearly constant and hence may be employed in correlating seams at widely separated points. It is believed that, although these features may be traced over considerable areas in some beds, they are on the whole local and must be used with great caution. Reliance upon these features alone in correlating beds at distant points cannot but lead to grave error.

LITHOLOGY OF SANDSTONES.—The same remarks apply with much greater force to sandstones and their associated shales. They were probably deposited by the action of streams or by local agencies and hence are subject to rapid variation in thickness and character within short distances. When employed with proper reserve they are a valuable means of correlation, but to rest conclusions upon their occurrence and character at widely separated points is unsafe. It is remarkable that sediments so variable should possess even the measure of constancy they do display.

LITHOLOGY OF RED BEDS.—The occurrence of red beds in certain parts of the section is significant. While observation shows that they are lenticular and variable, they nevertheless possess a very considerable stratigraphic value, being probably significant of climatic conditions. It is believed that they can be used for correlation much more extensively than they have been in the past.

LITHOLOGY OF LIMESTONES.—Limestones containing marine organisms have the greatest value in correlating the strata, as has been shown above. Non-marine limestones are also very important. They are, however, subject to much more variation than those containing marine organisms and hence are much less significant than the latter.

INTERVALS

It has long been recognized that many coal beds are approximately parallel over considerable areas, throughout which they are separated by rather constant distances. The intervals between the seams is a valuable aid in the recognition of the beds, provided that due caution is employed in their use. They are, however, subject to considerable local variation as shown in the discussion of the Redstone and Sewickley coals in this report. Recent work has shown that the number of coal seams is much larger in some regions [1] than has been formerly supposed, so that distinctions based upon the intervals must be employed with caution in correlating the beds. The assumption of constant intervals between the seams throughout a very large region is manifestly unsafe.

SEQUENCE OF DEPOSITS AND ORGANISMS

The occurrence of similar strata in the same sequence at different points is one of the most valuable means of correlation known. This is especially true where some of the series of the strata are characterized by

[1] Recent work of the author shows that there are nine seams above the Vanport limestone, instead of six as usually supposed, in the type section of the Allegheny formation in the vicinity of Freeport and Kittanning, Pennsylvania. Four of these are Freeport coals and five Kittanning coals.

fossil organisms and by well-defined lithological features. A correlation based upon the definite sequence of a considerable number of beds containing characteristic organisms and having a definite lithology is of the greatest value.

Systematic Variations in the Character and Thickness of the Strata

In some cases the strata varies systematically in a region. Such, for instance, is a constant increase in distance between two beds in passing in one direction across a given region. Thus the distance between the Pittsburgh coal and the Ames limestone increases constantly in passing from Ohio to Pennsylvania and thence into Maryland. Again, there may be progressive changes in the lithological character of the rocks in passing through a region as seen, for instance, in the increasing percentage of red beds in going westward from Maryland. Such systematic variations of the strata possess much significance.

Earth Movements

Unconformities and other features, such as the occurrence of marine limestones, that may indicate oscillation of the earth's crust are of much significance for correlation.

Other Criteria

Finally, certain general and philosophical considerations may be made the basis of correlation, but they should be used with great reserve and rest upon many facts.

CORRELATION OF THE COAL MEASURES OF MARYLAND WITH THOSE OF OTHER STATES

Having considered briefly the criteria upon which the correlation of the coal measures may be based we may proceed to apply them to the correlation of the Carboniferous strata of Maryland with those of other parts of the northern Appalachian coal basin. The discussion of the problem will be facilitated by treating the formations in descending order, considering first the correlation of the Monongahela formation and afterward the relations of the Conemaugh, Allegheny, and Pottsville formations in the order named.

MONONGAHELA FORMATION

The most important coal in the Monongahela formation is the Pittsburgh seam. This bed has been traced over an area extending from eastern Ohio to western Maryland. Throughout most of this region it is recognizable by its superior thickness and purity as well as by its relation to the other beds. It also possesses a rather persistent structure. A large flora is associated with this seam which has been studied by Dr. Harvey Basler, who will describe the Carboniferous plants of Maryland in a forthcoming publication of the Maryland Geological Survey. These features render the Pittsburgh seam a valuable datum plane of wide extent for the correlation of the coal measures of the northern Appalachian coal basin.

The identification of the remaining members of the Monongahela formation is based largely upon their lithological features and their intervals above the Pittsburgh coal. The correlation of the uppermost beds is insecure. It is hoped that further study of the fossil plants will give decisive evidence upon these questions.

CONEMAUGH FORMATION

The Conemaugh formation may be divided for purposes of correlation rather sharply into two parts, a lower and an upper. The lower part of the Conemaugh formation comprises a series of strata that have great significance for the correlation of the coal measures of the northern Appalachian province. Certain of the beds bear distinctive marine faunas, while the entire series possesses a well-defined lithology, both faunas and lithology occurring in a recognizable sequence. This combination of faunas and lithology in definite sequence furnishes probably the best means available for the correlation of the coal measures of the region under discussion. The strata under consideration include the following significant members:

Top

Ames (Crinoidal) limestone with marine fauna
Harlem coal
Pittsburgh red beds
Saltsburg sandstone—massive at many places
Coal (local)
Portersville limestone and shale with marine faunas
Coal (local)
Cambridge red beds
Cambridge (Pine Creek limestone) with marine faunas
Coal (local)
Meyersdale red beds
Buffalo sandstone.
Brush Creek limestone and shale with marine fauna
Brush Creek coal
Mahoning red beds
Mahoning sandstones
Upper Freeport coal, forming top of Allegheny formation.

Bottom

Four of the above beds contain marine fossils. Two of them, the Ames (Crinoidal) limestone and the Brush Creek limestone are of great extent and contain diagnostic fossils by which they have been traced from southern Ohio through Pennsylvania and West Virginia to western Maryland. They are probably the most valuable strata for the correlation of the measures in the region under consideration. Two or, in some cases, three coals of somewhat irregular distribution are found between the Saltsburg and Buffalo sandstones. They appear to have been called collectively the Bakerstown coal in western Pennsylvania.

A comparison of a number of sections will enable us to trace this series of beds from southern Ohio through Pennsylvania and West Virginia to Maryland.

SECTIONS OF THE LOWER CONEMAUGH IN OHIO, PENNSYLVANIA, AND WEST VIRGINIA

Gallia County, Ohio.—The Conemaugh formation of Ohio has been studied by Condit, the following section being based upon one which he gives for Gallia County.[1] (See plate of columnar sections, fig. 1.)

	Thickness Feet	Thickness Inches	Total Feet	Total Inches
Ames limestone, very impure, ferruginous and sandy. Marine fossils are abundant..........	1		1	
[*Pittsburgh*] *red beds*. Shale and red clay with nodular limestone	40		40	
Portersville limestone with marine fossils, a thin ferruginous layer	..	8	40	8
Anderson coal, thin, missing in many localities ...	..		..	
Shale	38		78	8
Cambridge limestone with marine fossils. A dark-gray rock with flinty layers, missing in many localities	3		81	8
Shale, sandy	20		101	8
Brush Creek shale and limestone, with marine fossils. Limestone in two or more layers........	38		139	8
Mason [Brush Creek] *coal*, thin.................	..	4	140	
Sandstone, shale	25		165	
Mahoning coal, thin or wanting in most localities.	..		...	
[*Mahoning red beds*], clay, pale red color, having nodules of ferruginous limestone. [*Mahoning limestone*]	3		168	
Mahoning sandstone, massive, coarse-grained.....	31		199	
Upper Freeport or No. 7 coal. Missing in many localities. Top members of the Allegheny formation.				

The interval from the Ames limestone to the base of the Brush Creek limestone is 140 feet in this section.

Muskingum County, Ohio.—Passing toward the northeast the following section is observed in Muskingum County, Ohio.[2] (See plate of columnar sections, fig. 2.)

[1] Condit, D. D. Conemaugh Formation in Ohio. Ohio Geol. Survey, 4th ser., Bull. 17, 1912, p. 77, names in [ ] are introduced by the author.

[2] Condit, D. D. Conemaugh Formation in Ohio. Ohio Geol. Survey, 4th ser., Bull. 17, 1912, p. 146. Somewhat modified. Names in [ ] are introduced by the author.

	Thickness Feet	Total Feet
Ames limestone. A gray rock with marine fossils. In some localities it is impure, sandy, and conglomeratic......	2	...
Shale, sandy, thin-bedded sandstone in some localities......	13	13
Harlem coal, thickness variable..........................	1	14
Clay	2	16
Shale, sandy; sandstone in some localities................	21	37
Ewing limestone, either nodular or in beds. Fish teeth and minute fossils are plentiful. Locally the limestone is replaced by sandstone..............................	3	40
[*Cow Run*] *sandstone.* Shale, sandy; coarse sandstone at places in the southern part of the county..............	28	68
Portersville limestone and shale. Shale dark, calcareous, with marine fossils, the shells of which are pyritized...	7	75
Anderson coal, worked at many localities.................	2	77
Clay shale with nodules of non-fossiliferous limestone......	12	89
Cambridge limestone with marine fossils; a massive bed in the eastern part of the county, thin or missing at many localities in southern portion.......................	2	91
Buffalo sandstone, massive in northern part of county, flaggy to southward...............................	34	125
Brush Creek shale and limestone. Comprising:		
Black shale in northern part of county, cherty beds in southern part; containing marine fossils............	6	131
Shale, sandy	16	147
Nodular limestone in a number of thin layers, interlain with shale (not noticed in northern part of county) with marine fossils..............................	5	152
[*Upper Mahoning*] *sandstone.* Sandstone and shale......	14	166
Mahoning coal, thin......................................	..	...
[*Mahoning limestone.*] Clay with buff limestone in nodules or layers; missing in some localities.................	3	169
[*Lower*] *Mahoning sandstone*, thin-bedded................	35	204
Upper Freeport or No. 7 coal, top member of Allegheny formation.		

The same sequence is observable here as in the preceding section, but the interval between the Ames and Brush Creek limestones has increased from 140 to 152 feet.

Wheeling, West Virginia.—Dr. I. C. White has described an admirable section from a diamond drill hole bored at Glenova near Wheeling, West

Virginia. The faunas and lithological features were well shown in the core as follows[1]: (See plate of columnar sections, fig. 3.)

	Thickness Feet	Thickness Inches	Total Feet	Total Inches
Ames limestone with fossil crinoids and *Productus nebrascensis*	0	3	...	
Pittsburgh red shale. Clays and shales, much of which is red and variegated	47	0	47	0
[*Saltsburg*] *sandstone.* Sandy shales interstratified with micaceous, shaly sandstone	57	6	104	6
Shales dark, sandy with fossil plant fragments	8	3	112	9
[*Portersville*] *limestone and shale.* Above are shales, dark, with fossil shells, crinoids, etc.; below is impure fossiliferous limestone	2	4	115	1
Shale, dark, sandy	2	..	117	1
Bakerstown coal	0	8	117	9
Fire clay sandy, impure, variegated at base	4	0	121	9
[*Cambridge*] *red beds.* Shales red and variegated.	10	2	131	11
Cambridge limestone and shale. Above are shales, limy, very fossiliferous with *Chonetes granulifer, C. mesolobus, Productus nebrascensis, P. semireticulatus, Fenestella,* etc.; below is limestone with fossil crinoids, etc	3	0	134	11
Fire-clay, impure, sandy	6	4	141	3
Shales, light-gray, sandy	40	4	181	7
Brush Creek limestone and shale. Comprising:				
Shales, dark-gray, fossiliferous. *Aviculopecten* numerous	11	10	193	5
Shales, light-gray, sandy	27	0	220	5
Limy shale, dark, with marine fossils	1	4	221	9
Shales, sandy, micaceous, gray	4	6	226	3
Shales, dark-gray with marine fossils including many *Avieulopectens*	11	0	237	3
Bituminous slate	1	4	238	7
Brush Creek coal. Hard, semi-cannel	0	6	239	1
[*Mahoning*] *red beds.* Fire-clay, impure, sandy, stained red at base	11	0	250	1
Shale, gray, sandy with streaks of impure fire-clay	19	11	270	0
[*Mahoning*] *limestone* and fire-clay	13	3	283	3
[*Mahoning*] *red beds.* Fire-clay, limy and sandy, stained red in middle for 3 feet	13	0	196	3
[*Mahoning*] *sandstone.* Shale and sandstone	16	6	312	9
Fire-clay marking position of Upper Freeport coal	...		...	

[1] White, I. C. Preface to the Rept. on the Geology of Ohio, Brooke and Hancock counties; West Virginia Geol. Survey, 1906, p. xii. The names of the horizons in [ ] are added by the writer. The position of the Upper Freeport coal is questionable. White places it 270 beneath Ames limestone.

An interesting feature in the occurrence of red beds below the Brush Creek coal. The great increase in thickness is to be noted, the interval between the Ames limestone and the Upper Freeport coal being 206 feet near Zanesville, Muskingum County, Ohio, while here it is 313 feet if the position assigned to the Upper Freeport by the author is correct. The distance from the top of the Ames to the base of the Brush Creek faunas has also increased from 152 feet to 238 feet.

Pittsburgh, Pennsylvania.—Raymond has studied the strata under discussion in the vicinity of Pittsburgh where he has described the following section[1]: (See plate of columnar sections, fig. 4.)

	Thickness Feet	Thickness Inches	Total Feet	Total Inches
Ames limestone and shale, containing many *Ambocoelia planoconvexa, Chonetes granulifer, Derbya crassa*, and other fossils	6	0		
Harlem coal	1	2	1	2
[*Pittsburgh*] *red beds.* Red and variegated clay with limestone nodules	59	8	60	10
Cow Run sandstone [Saltsburg]	45	0	105	10
Thin coal near base of sandstone	0	2	106	0
Black shale	5	0	111	0
[*Cambridge*] (*Pine Creek*) *limestone* with marine fossils	0	6	111	6
[*Meyersdale*] *red shale* (recorded in drill holes only)	..		...	
Buffalo sandstone shaly above, compact and conglomeratic below	77	0	188	6
Brush Creek limestone and shales. Middle beds containing many marine fossils	39	6	228	0
[*Brush Creek*] *Mason coal*	0	6	228	6
Clay-shale passing to heavy-bedded sandstone	27	6	256	0
Black shales	16	0	272	0
Gallitzin coal	2	0	274	0
[*Mahoning red beds*], gray clay in Raymond's section, red clay in drill records	12	0	256	0
Mahoning sandstone, partially concealed	43	0	299	0
Upper Freeport coal	..		...	

[1] Raymond, P. E., Ann. Carnegie Museum, vol. v, 1908-1909, p. 167. The occurrence of the Meyersdale and Mahoning red beds is from drill records near Pittsburgh and not from Raymond's section. Form of section modified by writer who has introduced names in [ ].

This section shows the persistence of the same series of beds and their eastward thickening. It is interesting to note the occurrence of red beds below the Brush Creek coal, as near Wheeling, West Virginia.

Freeport and Kittanning, Pennsylvania.—The following generalized section was observed near Freeport and Kittanning, Armstrong County, Pennsylvania.[1] (See plate of columnar sections, fig. 5.)

The section is based upon numerous drill records and upon surface sections measured by the writer and Harvey Bassler.

	Thickness Feet	Total Feet
Ames limestone containing numerous *Ambocoelia planoconvexa* and *Chonetes granulifer*	1	
Pittsburgh red beds. Red shale with some lighter colored beds	35	35
Concealed	50	85
Saltsburg sandstone consisting of thin-bedded sandstone and shale	50	135
Shale and clay	5	140
Upper Bakerstown coal	1	141
Clay	2	143
Cambridge red beds, local	6	149
Shale and sandstone. At base is the *Cambridge* (Pine Creek) *limestone* with marine fauna	20	169
Lower Bakerstown coal. Bone and shale	1	170
Clay	11	181
Meycrsdale red beds. Red shale	7	188
Buffalo sandstone, massive, locally conglomeratic	34	222
Shale arenaceous above, darker below, replaced in part, locally, by the *Brush Creek red beds*	11	233
Brush Creek limestone and shale containing numerous *Chonetes verneuilanus*	3	236
Brush Creek coal	1	237
Shale arenaceous above	22	259
Mahoning red beds, upper bench	3	262
Shale	2	264
Gallitzin coal, local	1	265
Shale	12	277
Mahoning red beds, lower bench	8	285
Upper Mahoning sandstone replaced locally near top by the *Mahoning limestone*	26	311
Mahoning coal, local	1	312
Lower Mahoning sandstone	29	341
Dark shale	4	345
Upper Freeport coal	..	...

[1] The Pine Creek fauna is supplied from observations of I. C. White.

Morgantown, West Virginia.—The following section is observed at Morgantown, West Virginia, according to the work of I. C. White and his associates[1]: (See plate of columnar sections, fig. 6.)

	Thickness Feet	Total Feet
Ames limestone, shaly, silicious, marine fossils prolific	9	...
Harlem coal	1	1
Pittsburgh red shale, concealed above	72	73
Saltsburg sandstone, massive, greenish, micaceous	12	85
Shale, sandy	5	90
Bakerstown coal and fire clay	5	95
[*Cambridge*] *red beds*, shale weathering reddish, sandy	10	105
[*Cambridge*] (*Pine Creek*) *limestone*, silicious, hard, with marine fossils	1	106
Shale, brown	2	108
Buffalo sandstone	81	189
Brush Creek limestone and shale, with marine fauna	8	197
Brush Creek coal	1	198
Sandstone and shale	16	214
Mahoning sandstone, containing *Mahoning* coal locally	50	264
Shale and thin coal	5	269
Upper Freeport coal	..	...

Preston County, West Virginia, lies east of Monongalia County and adjoins Maryland on the west. The following section is displayed at Newburg in this county, according to Hennen and Reger[2]: (See plate of columnar sections, fig. 7.)

	Thickness Feet	Total Feet
Ames limestone and dark shale, containing marine fossils	15	...
Harlem coal	1.5	1
Fire-clay and shale	5	6
Pittsburgh red beds	25	31
Saltsburg sandstone. Massive sandstone. The lower beds are replaced locally by red shale	35	66
Bakerstown coal	2	68
Concealed. Holding elsewhere at base the [*Cambridge*] (*Pine Creek*) *limestone* with marine fossils, and the [*Meyersdale*] *red shale*	79	147
Buffalo sandstone, massive, gray, sometimes pebbly	35	182

[1] White, I. C. W. Va. Geol. Survey, Rept. on Marion, Monongalia, and Taylor counties, 1913, p. 116. The Brush Creek limestone and fauna are recorded on p. 315.

[2] Hennen, Ray V., and Reger, David R. W. Va. Geol. Survey, Rep. of Geol. of Preston County, 1914, p. 90. Several details are added from the generalized section of the Conemaugh formation in this county, given on pp. 113, 114, of the report named.

	Thickness Feet	Total Feet
Brush Creek limestone and shale with marine fossils......	25	207
Brush Creek coal..	2	209
[*Irondale*] *limestone*, fire-clay and shale with nodules of limestone. (This unit is replaced by sandstone at Newburg)	4	213
Upper Mahoning sandstone, massive.........................	20	233
Mahoning coal, not persistent.............................	1	234
Thornton fire-clay, good, not persistent..................	5	239
Lower Mahoning sandstone, gray............................	40	279
Uffington shale, dark, sandy, with plant fossils..........	10	289
Upper Freeport coal.......................................	..	...

The interval from the Ames limestone to the Brush Creek limestone and shale inclusive varies from Ohio eastward as shown in the following table, the average distance in Pennsylvania and West Virginia being about 225 feet:

Ames-Brush Creek Interval

	Feet
Gallia County, Ohio..................................	140
Muskingum County, Ohio.............................	152
Wheeling, West Virginia.............................	238
Pittsburgh, Pennsylvania	228
Freeport-Kittanning, Pennsylvania..................	237
Morgantown, West Virginia	197
Preston County, West Virginia......................	207

We have now traced this series of beds from southern Ohio through Pennsylvania and West Virginia to the Maryland-West Virginia state line, and find that all the sections contain limestones with marine fossils, each bed carrying its own diagnostic species. Thus the Ames limestone is characterized throughout the region by numerous *Ambocoelia planoconvexa* and *Chonetes granulifer,* the Brush Creek by *Chonetes verneuilanus,* etc., while the strata display similar lithology in like sequence. This combination confirms the correctness of the correlation of these beds, a result which has been established by the labor of many workers.

SECTIONS OF THE LOWER CONEMAUGH IN MARYLAND

The relations of the sections already described to those observed in Maryland will now be considered. The strata of the various basins will be treated in order from those of the Lower Youghiogheny basin on the west to those of the Georges Creek basin on the east.

Lower Youghiogheny Basin

This basin is situated in the northwestern angle of the state and extends into Preston County, West Virginia, on the southwest, and into Somerset County, Pennsylvania, on the northeast. The section exposed in this region was described by G. C. Martin.[1] It was subsequently studied by W. A. Price, Jr., the writer, and their associates. The faunas were studied by Price, who measured the following section at Friendsville[2]:

	Thickness		Total	
	Feet	Inches	Feet	Inches
Ames limestone and shale, containing numerous *Ambocoelia planoconvexa, Chonetes granulifer, Derbya crassa*	10	0		
Harlem coal	1	3	1	3
Pittsburgh red beds, variegated red shale	10	0	11	3
Saltsburg sandstone, fine-grained and cross-bedded; replaced by clays and shales on the strike	32	0	43	3
Yellowish clay and sandy shale with ferruginous and calcareous nodules	22	0	65	3
Cambridge (Friendsville) shale and fauna. Yellow sandy shale containing marine fauna	4	0	69	3
Yellow sandy shale above, black shale below	20	6	89	9
Lower Bakerstown coal (Thomas coal)	1	6	91	3
Clay	2	0	93	3
Sandstone, variable, argillaceous	12	0	105	3
Dark shales	14	0	119	3
Meyersdale red shale containing a band of gray limestone with marine fossils. Some marine fossils are also found in the red shale	28	0	147	3
Meyersdale limestone containing *Spirifer cameratus ?* and other marine fossils	1	0	148	3
Buffalo sandstone. Interbedded shale and sandstone	9	0	157	3
Brush Creek shale and limestone. Dark shale bearing calcareous nodules with a band of limestone near base; containing *Chonetes verneuilanus* and many other fossils	26	0	183	3
Brush Creek coal	2	0	185	3
Concealed	12	0	197	3

[1] Martin, G. C. Md. Geol. Survey, Rept. on Geol. of Garrett County, 1902, p. 130; *Ibid.*, Rept. on Coals of Md., 1905, p. 254; U. S. Geol. Survey, Grantsville-Accident Folio, No. 160, 1908, p. 6.

[2] Price, W. A., Jr. Dissertation MSS., Johns Hopkins Univ., 1913, p. 80. With later modifications by Dr. Price and the author.

	Thickness Feet	Thickness Inches	Total Feet	Total Inches
Corinth sandstone	15	2	212	3
Calcareous clay above, concealed below	15	0	227	3
Gallitzin coal blossom	..	..	...	..
Concealed	38	0	265	3
Piedmont coal with shale parting 6 feet thick	7	10	273	1
Black shale	10	0	283	1
Lower Mahoning sandstone. Sandstone and shale, partially concealed	33	0	316	1
Upper Freeport coal	..		...	

The thickness of this section is somewhat greater than indicated here as no correction was made for dip in measuring up the steep face of a cliff.

The section shows four beds containing marine faunas with diagnostic species. The entire section is in harmony with that observed in Preston County, West Virginia, with which this basin is continuous, being part of the same structural trough.[1]

Upper Youghiogheny Basin

This basin forms part of the Corinth coal basin of Preston County, West Virginia. It lies a few miles south of the Lower Youghiogheny basin from which it is separated by a low arch. The following section was observed here by W. A. Price, Jr., and the author[2]: (See plate of columnar sections, fig. 8.)

	Thickness Feet	Total Feet
Ames limestone and shale with marine fauna	5	...
Harlem coal	1	1
Fire-clay	4	5
Pittsburgh red shale	23	28
Saltsburg sandstone. Massive sandstone	40	68
Dark shale	20	88
Upper Bakerstown coal (Maynadier coal)	4	92
Clay	13	105
Albright limestone	1	106
Shale	4	110
Lower Bakerstown coal (Thomas coal, upper bench)	2	112
Clay	11	123
Lower Bakerstown coal (Thomas coal, lower bench)	2	125

[1] The relations of the Cambridge (Friendsville) and Meyersdale faunas will be considered in a separate article in the *Bulletin of the Geological Society of America* of 1919.

[2] The writer is responsible for the measurements and descriptions of beds.

	Thickness Feet	Total Feet
Fire-clay	10	135
Shale	6	141
Meyersdale red shale locally replaced by sandstone	22	163
Buffalo sandstone locally conglomeratic above, shale below	38	201
Brush Creek limestone with marine fauna	2	203
Argillaceous sandstone above, dark shale with marine fauna below	19	222
Brush Creek coal	1	223
Fire-clay, impure	10	233
Corinth sandstone and shale	37	270
Gallitzin coal	1	271
Thornton clay and *Mahoning red shale*	12	283
Upper Mahoning sandstone	27	310
Piedmont coal	3	313
Lower Mahoning sandstone replaced locally by shale	17	330
Upper Freeport coal (Davis coal)	..	...

The coal named the Upper Freeport (Davis) coal was called the Lower Kittanning in this basin by I. C. White and his associates in their report upon the Geology of Preston County, West Virginia.[1] The same workers also called the Harlem coal of the above section the Brush Creek coal. The Ames and Brush Creek horizons were subsequently found carrying their diagnostic fossils by Price and the writer. The occurrence of these faunas and the characteristic lithology of the rocks in their usual sequence, establishes the correlation given above and shows the essential harmony of the section in this basin with those already described in Preston County, West Virginia, and in the Lower Youghiogheny basin. These facts show that the Corinth (Davis) coal is of Freeport age.[2]

Castleman Basin

This basin lies northeast of the Upper Youghiogheny basin from which it is separated by a low arch. Both these basins lie west of the Oakland

[1] W. Va. Geol. Survey, Geol. of Preston County, 1914, pp. 343-345.

[2] Mr. Ray V. Hennen of the West Virginia Geological Survey was led by earlier work to think it probable that the Corinth coal is the Upper Freeport.

anticline and would be continuous were it not for the feature named. The following section is exhibited in this basin: (See plate of columnar sections, fig. 9.)

	Thickness Feet	Total Feet
Ames limestone and shale with marine fauna	23	...
Harlem coal	1.5	1.5
Ewing limestone	3.5	5
Pittsburgh red beds; light-colored shale above, variegated red below	55	60
Saltsburg sandstone, massive, locally conglomeratic	26	86
Black shale	2	88
Upper Bakerstown coal (Maynadier coal "slaty vein")	3	91
Albright limestone	4	95
Shale	8	103
Albright limestone	1	104
Cambridge (*Friendsville*) *black shale* containing marine fossils	25	129
Lower Bakerstown coal (Thomas coal, Honeycomb coal)	2	131
Shale	28	159
Meyersdale red beds	5	164
Buffalo sandstone	16	180
Meyersdale red beds	26	206
Buffalo sandstone	41	247
Brush Creek limestone and shale with marine fossils	14	261
Brush Creek coal	1	262
Fire-clay	3	265
Irondale limestone	2	267
Shale	35	302
Mahoning sandstone	52	354
Shale	5	359
Upper Freeport rider coal (Piedmont coal ?)	1	360
Dark shale	11	371
Upper Freeport Coal (Davis coal)	..	...

The *Meyersdale red beds* occur at the horizon of the upper part of the Buffalo sandstone, which they replace locally. The occurrence of the marine limestones, with their characteristic faunas, the similarity of the lithology, and the sequence of beds and faunas, show the essential identity of this section with those already described.

Upper Potomac Basin

This basin lies a few miles east of the Oakland anticline which separates it from the Upper Youghiogheny basin. The following section is observed here: (See plate of columnar sections, fig. 10.)

	Thickness Feet	Total Feet
Ames limestone and shale with marine fauna. Dark shale with 1 foot of limestone at base of unit	10	...
Harlem coal	1.5	1.5
Ewing limestone. Limestone nodules in fire-clay	13.5	15
Pittsburgh red shale	5	20
Saltsburg sandstone partially replaced by Pittsburgh red shale	65	85
Shale	2	87
Upper Bakerstown coal (Maynadier coal)	2	89
Fire-clay	2	91
Albright limestone	4	95
Cambridge red shale	5	100
Shale	10	110
Thomas sandstone	25	135
Lower Bakerstown coal (Thomas coal)	5	140
Thomas limestone. Thin limestone in fire-clay	10	150
Buffalo sandstone, replaced locally by the *Meyersdale red shale* 15 to 25 feet below top	50	200
Brush Creek shale and fauna. Dark shale containing marine fauna	9	209
Brush Creek coal	1	210
Fire-clay	2	212
Irondale limestone	1	213
Corinth sandstone	12	225
Shale	10	235
Thornton clay, upper bench	10	245
Mahoning red shale, upper bench	14	259
Gallitzin coal	1	260
Thornton clay, lower bench	5	265
Mahoning red shale, lower bench	5	270
Mahoning limestone. Thin limestone in shale	5	275
Upper Mahoning sandstone. Micaceous sandstone	10	285
Shale	2	287
Piedmont coal ("Six-foot coal")	5	292
Fire-clay	2	294
Lower Mahoning sandstone. Micaceous sandstone	28	322
Dark shale	5	327
Upper Freeport coal (Davis coal). Consisting usually of two benches separated by a clay parting of variable thickness.		

This section harmonizes fully with those already described and also with that in the Georges Creek basin.

Georges Creek Basin

The Upper Potomac and Georges Creek basins constitute a single structural trough which lies east of the Oakland anticline. This trough is traversed by the Potomac River at Piedmont which divides it into two parts, the southwestern division being known as the Upper Potomac basin and the northeastern as the Georges Creek basin. The division is, however, purely artificial and has been made for convenience in discussing the region.

The following section is exhibited here: (See plate of columnar sections, fig. 11.)

	Thickness Feet	Total Feet
Ames limestone and shale with marine fauna. A bed of limestone occurs near the base of this unit and another is found locally about 20 feet above the base	28.5	...
Harlem coal	2	2
Ewing limestone	4	6
Pittsburgh red beds, variegated red and light-colored shale.	26	32
Saltsburg sandstone. Massive, conglomeratic. A thin, unnamed coal occurs locally about 475 feet beneath the Pittsburgh seam	45	77
Shale	7	84
Upper Bakerstown coal (Maynadier coal)	3	87
Albright limestone	2	89
Fire-clay	15	104
Cambridge (Friendsville) *shale and fauna.* Dark shale with marine fauna	20	124
Lower Bakerstown coal (Thomas coal, upper bench)	3	127
Shale	15	142
Lower Bakerstown coal (Thomas coal, lower bench)	1	143
Clay and shale	47	190
Meyersdale red beds. Red and variegated clay	5	195
Shale	9	204
Buffalo sandstone. The *Brush Creek rider coal* occurs locally about 765 feet beneath the Pittsburgh seam	48	252
Brush Creek shale and limestone. Black shale and argillaceous limestone with marine fauna	4	256
Brush Creek coal	1	257
Irondale limestone. Clay and shale bearing at some places nodules of limestone	4	261
Corinth sandstone	6	267
Thornton clay, upper bench	20	287
Mahoning red beds. Red and variegated shale	5	292
Thornton clay, lower bench	15	307
Mahoning limestone. Shale with lenses of limestone locally	5	312

	Thickness Feet	Total Feet
Upper Mahoning sandstone	15	327
Shale	3	330
Piedmont coal	6	336
Fire-clay	3	339
Lower Mahoning sandstone, often micaceous	28	367
Shale	3	370
Upper Freeport coal (Davis coal). Top of Allegheny formation.		

The base of the Conemaugh formation in this basin has been drawn in the past at the top of a coal which lies approximately 600 feet below the Pittsburgh seam. That this is not the Upper Freeport coal is shown by the occurrence of the Brush Creek limestone and shale with their diagnostic marine fossils approximately 170 feet *below* this coal as well as by the presence of the Ames (Crinoidal) limestone with its fauna about 75 feet *above it.* The Upper Freeport coal of western Pennsylvania and West Virginia lies, instead, nearly 100 feet below the Brush Creek limestone and 300 to 350 feet beneath the Ames limestone. These facts show that the seam in question cannot be the Upper Freeport, but is, on the contrary, a much higher coal. Moreover, the Davis coal, known at Piedmont as the "Split-six" seam and farther north as the "Six-foot" seam, occupies the position of the true Upper Freeport of western Pennsylvania. Additional and fuller evidence bearing upon this conclusion will be presented in a subsequent publication of the Maryland Geological Survey. The section thus interpreted, harmonizes fully with that observed in the Upper Potomac basin and in the other areas.

An examination of the above sections shows the following intervals between the Ames and Brush Creek limestones in Maryland.

	Interval
Lower Youghiogheny basin	185
Upper Youghiogheny basin	222
Upper Potomac basin	209
Castleman basin	262
Georges Creek basin	256

The average interval in Maryland is thus about 230 feet, which agrees closely with that observed in western Pennsylvania and West Virginia, which is about 225 feet, the greater interval eastward corresponding with the observed general thickening of the sediments towards the northeast.

The lower members of the Conemaugh formation, which lie between the Ames limestone and the Upper Freeport coal, have now been traced across the northern Appalachian coal basin from Ohio to the Georges Creek Valley in Maryland. We find that they everywhere constitute a clearly defined and recognizable series of strata which are characterized by their faunas, their lithology, and the sequence in which they occur. In this manner a series of datum planes has been secured to which the other beds of the coal measures may be referred.

It is not our purpose to discuss the correlation of the upper members of the Conemaugh formation in detail in this place. The most persistent member of the upper series appears to be the Clarksburg limestone which has a wide extent as shown on the plate of columnar sections. The most important coal of the Upper Conemaugh is the Barton coal which appears to be the "Elklick" coal of West Virginia and western Pennsylvania. It does not appear, however, to be the Elklick coal of Lesley, named from its exposure on Elklick Creek near Salisbury, Pennsylvania, which lies much higher in the section.[1]

An interesting feature of the Conemaugh formation is the systematic increase in the thickness of the beds from Ohio eastward. The Pittsburgh-Brush Creek interval is 300 feet in Gallia County, Ohio, about 475 feet at Pittsburgh, Pennsylvania, 575 feet in Preston County, West Virginia, about 725 feet in the vicinity of Somerset, Pennsylvania,[2] 740 feet in the Castleman Basin, and nearly 800 feet in the Georges Creek Valley. This persistent increase is well shown in the plate of columnar sections accompanying this report. These facts preclude the possibility of considering the Maynadier coal, situated about 600 feet beneath the Pittsburgh seam, to be the Upper Freeport seam as has been done in the past. Coincident with the change in thickness is a marked increase in the number of coal beds so that the Conemaugh formation of the Georges Creek

[1] The Elklick coal of Lesley lies 200 feet beneath the Pittsburgh coal at the type locality, according to Platt (2d Geol. Survey of Pa., vol. HHH, p. 60). The Conemaugh formation is known to be much thicker at this place than it is farther west, so that an interval of 200 feet here would correspond to a smaller interval in western Pennsylvania.

[2] According to measurements and drill records furnished the author by G. B. Richardson of the U. S. Geological Survey, who has surveyed that region. The author is responsible for the interpretation of the details of the drill records.

Valley contains many coal seams and is no longer to be considered a barren formation.

ALLEGHENY FORMATION

The most valuable aid in correlating the strata of the Allegheny formation of western Pennsylvania and Ohio is the Vanport or Ferriferous limestone. This bed is well marked both lithologically and faunally, being usually a thick and pure limestone which has not been observed very far east of Pittsburgh, so that the correlation of the seams east of the latter region must rest largely upon the intervals and lithological features of the beds and the structure and character of the coal beds. These are much more variable than the faunas and hence introduce uncertainties into the correlation. It is hoped, however, that a fuller study of the floras will remove this difficulty.

The preceding discussion shows that the interval between the Pittsburgh and Brush Creek coals increases constantly from Ohio eastward. It is interesting to note, in contrast with this, that the distance between the Brush Creek coal and the base of the coal measures remains nearly constant over much of the region between the Ohio-Pennsylvania state line and western Maryland, being generally about 600 feet. This is well see in numerous drill holes and in many sections throughout the area under discussion.

The Upper Freeport coal is the first persistent and widely extended coal beneath the Brush Creek limestone, the interval between them being 115 feet in the type region near Freeport, Pennsylvania, and about the same distance at Pittsburgh, Pennsylvania.[1] I. C. White and his associates correlate with the Upper Freeport a coal found about 110 feet below the Brush Creek limestone in Preston County, West Virginia,[2] while Richardson[3] identifies a coal lying 130 feet beneath the Brush Creek limestone near Somerset, Pennsylvania, with that seam.

The Davis coal lies about 120 feet beneath the Brush Creek coal and limestone in Maryland. It is the first persistent seam beneath the latter

[1] Raymond, P. Ann. Carnegie Mus., Pittsburgh, vol. v, 1908-1909, pp. 167-168.

[2] White, I. C. W. Va. Geol. Survey, Rept. on the Geol. of Preston Co., 1914, p. 114.

[3] Richardson, G. B. Private communication to author.

coal and its position clearly corresponds to that of the Upper Freeport of western Pennsylvania. Limestone has not been observed beneath this seam in the Georges Creek Valley, but it has been reported in this position in the Upper Potomac basin, while a thick bed of limestone underlies it in the Castleman and Upper Youghiogheny basins. Again, the Davis seam resembles the typical Upper Freeport coal in being overlain by a massive, often micaceous sandstone which is very similar lithologically to the Mahoning sandstone of Freeport, Pennsylvania. Red beds associated with beds or nodules of limestone are also found locally above this sandstone in Maryland, as at Freeport, Pennsylvania. The Davis seam is well marked topographically by the bench that develops at its position. Finally, it is an important seam which is mined extensively. The preceding discussion has shown that the Upper Freeport coal must be sought for approximately in the position of the Davis seam. All of these facts show that the Davis coal is the Upper Freeport seam of Maryland.[1] The associated fossil plants are also in harmony with this interpretation.

A coal seam known as the Upper Kittanning coal lies about 100 feet beneath the Upper Freeport coal in Somerset County, Pennsylvania,[2] where it is underlain by the Johnstown cement rock and iron ore. The Mount Savage iron ore underlies the Montell coal (Bluebaugh coal) locally in the Georges Creek Valley, its distance beneath the Davis coal being about 100 feet. The Montell (Bluebaugh) coal is also an important commercial seam in this region and appears to occupy the position of the Upper Kittanning coal of Somerset County, Pennsylvania.

The Mount Savage fire-clay lies 250 to 260 feet beneath the Davis coal, and is associated with a profuse flora which is of Lower Allegheny age, according to Dr. Harvey Bassler. The Upper and Lower Mount Savage

[1] The Piedmont "Six-foot" coal which lies 75 to 80 feet beneath the Brush Creek coal could be regarded as the Upper Freeport seam. It is, however, a local and inconstant coal, frequently vanishing in short distances and subject to "cut-outs." No limestone is beneath it. When present it is often found between two beds of sandstone and hence appears to resemble more closely a higher coal. It is also much less perfectly adapted for purposes of mapping than the Davis seam. These considerations render it more desirable to consider this seam as a coal in the Conemaugh.

[2] Personal communication of G. B. Richardson of the U. S. Geological Survey who has surveyed this region.

coals thus apparently correspond with the Clarion and Brookville coals of western Pennsylvania and the Mount Savage fire-clay with the Clarion fire-clay which is a valuable fire-clay at many places in Pennsylvania and Ohio. These horizons being fixed, the thick Ellerslie coal occupies the position of the Lower Kittanning coal of Somerset County, Pennsylvania, and the Ellerslie fire-clay corresponds with the Lower Kittanning fire-clay of western Pennsylvania and Ohio. The section of the Allegheny formation of Maryland is thus seen to correspond in its essentials with the section of this formation seen in Somerset County, Pennsylvania.[1]

The general relations of the coals as thus interpreted are shown on the plate of columnar sections.

[1] The relations between the various coals called Lower Freeport and Upper Kittanning in Pennsylvania are obscure and need further investigation. The Lower Freeport coal lies 80 to 100 feet beneath the Upper Freeport coal in the vicinity of Freeport, Pennsylvania, the interval being 89 feet in the cliff opposite Freeport. A coal found the same distance beneath the Upper Freeport at Kittanning is called the Upper Kittanning by Butts in the Kittanning folio of the U. S. Geological Survey, its position corresponding to that of the coal called the Upper Kittanning in Somerset County, Pennsylvania. The interval between the Upper Freeport and the Montell coals of Maryland is the same. These coals hence occupy like positions and are probably the same seam. In other words, the Montell coal (Bluebaugh coal) of Maryland, is the Upper Kittanning of Somerset County and Kittanning, Pennsylvania, and probably the Lower Freeport of Freeport. The Barrelville (Parker) coal would thus be White's Middle Freeport coal which occupies a corresponding horizon at Freeport, while the Piney Mountain corresponds closely in position to the Upper Kittanning of Freeport which is 135 feet beneath the Upper Freeport at that place and like the latter coal is often double bedded.

These relations are indicated in the following table:

Freeport Intervals		*Maryland Intervals*	
Upper Freeport	0	Upper Freeport (Davis)	0
Middle Freeport	40	Barrelville (Parker)	50
Lower Freeport rider.		Montell rider.	
Lower Freeport	80-100	Montell (Bluebaugh)	80-110
Upper Kittanning	135	Piney Mountain	130-150
Middle Kittanning	variable	Luke	variable
Lower Kittanning	220	Ellerslie	200

Although the above relations appear probable the name Upper Kittanning is applied to the Montell coal in Maryland in harmony with current usage in Somerset County, Pennsylvania, pending further investigation of the region between the latter place and Freeport.

POTTSVILLE FORMATION

The Pottsville formation of Maryland has hitherto been made to embrace all of the strata between the Montell Upper Kittanning coal of this work ("Bluebaugh coal") and the Mauch Chunk red shale.[1] The Allegheny-Pottsville boundary was drawn at different horizons at different localities by various workers in the past. Thus, at Mount Savage it was placed above the Mount Savage sandstone of this work,[2] at Westernport it was drawn at the top of the Lower Freeport sandstone,[2] while in the vicinity of Barrelville it was placed beneath the Upper Kittanning (Montell or Bluebaugh) coal. This was due in large measure to the local variation in the character of the sandstones and shows that lithology affords an insecure basis for the separation of the Pottsville and Allegheny formations in Maryland.

A large flora has been found in beds associated with the Mount Savage fire-clay. The plants have been studied critically by Dr. Harvey Bassler. They show, in his opinion, that these deposits are probably of Allegheny age. The Pottsville-Allegheny boundary has hence been placed in the present report at the top of the sandstone underlying the Lower Mount Savage coal. This horizon is about 380 feet beneath the Brush Creek limestone and shale in Maryland, a position that corresponds approximately with that observed by the writer near Freeport, Pennsylvania, where the interval is 415 feet. If this horizon is accepted then the Pottsville formation is 150 to 280 feet thick in Maryland, its usual thickness being a little over 200 feet, which is in close agreement with the prevailing thickness of the formation observed in numerous sections and drill holes in western Pennsylvania and adjacent parts of West Virginia.

The correlation of the divisions of the formation, as thus defined, rests largely upon a comparison of the lithology and intervals of these beds with those of the Pottsville of other regions, fortified by comparisons of

[1] O'Harra in his report on the Geology of Allegheny County, Md. (Md. Geol. Survey, 1900, p. 113), included the upper part of the Mauch Chunk formation in his Pottsville. For further discussion of this horizon see p. 38.

[2] Md. Geol. Survey, Rept. on Coals of Md., 1905, pp. 225 and 298.

the fossil floras[1] which have been studied by Harvey Bassler and O. B. Hopkins.

The Pottsville formation of Maryland consists generally of two zones of sandstone separated by a shale interval. The upper sandstone holds the position of the Homewood sandstone of Pennsylvania and the lower that of the Connoquenessing. Two coals are found in the intervening shale interval which correspond, in position, to the Mercer coals of western Pennsylvania. A third coal is found at some places within the lower sandstone which has the position of the Quakertown coal which divides the Connoquenessing sandstone into two parts, an upper and a lower. A fourth coal is found beneath the lower sandstone in the position of the Sharon coal of western Pennsylvania.

Meager brackish-water faunas are found above the Quakertown coal, the significance of which is not fully known. It is interesting to note that a more abundant fauna is found in the same position in the Kanawha formation of Randolph and Barbour counties, West Virginia. A similar fauna is found above the Upper Mercer coal in Maryland and corresponds in position to the marine fauna in the Kanawha black flint of West Virginia which appears to be of Mercer age.

The close analogy of the section of the Pottsville formation of Maryland with that of western Pennsylvania is shown in the following comparative generalized sections:

Section of Pottsville in the Georges Creek basin, Maryland	Section of Pottsville near Freeport Pa.[2]
Homewood sandstone, massive sandstone, locally conglomeratic.	Homewood sandstone. Massive coarse sandstone. ("60-foot" sandstone).
Shale zone with Upper and Lower Mercer coals (coals local).	Shale zone with Upper and Lower Mercer coals (coals local).
Connoquenessing sandstone, massive sandstones divided into two parts locally by the Quakertown coal.	Connoquenessing sandstone ("70-foot sandstone). Divided into upper and lower divisions by the Quakertown coal.
Sharon coal.	Sharon coal.
Thickness, 150-280 feet.	Thickness, 150-200 feet.

The general relations of the sections of Maryland to each other and to those of other regions is shown in the plate of columnar sections.

[1] The results of this study will be given in detail in a forthcoming monograph on the Carboniferous of Maryland to be published by the Maryland Geological Survey.

[2] Based upon numerous drill records.

THE COAL BASINS OF MARYLAND

BY

CHARLES K. SWARTZ

The stratigraphy and correlation of the coal measures of Maryland as a whole have been considered in the preceding chapters. In the following discussion the characteristics of the individual coal basins will be described briefly, beginning on the west with the Lower Youghiogheny basin.

Lower Youghiogheny Basin

This basin lies in the northwestern angle of the State of Maryland, extending thence into Preston County, West Virginia, on the west and into Somerset County, Pennsylvania, on the north. The area occupied by it in Maryland is small, its major extent being in the adjoining states. It embraces strata extending from the Upper Conemaugh to the base of the coal measures, the overlying beds having been eroded. It contains less valuable coal than the other basins.

The following is a generalized section of the coal measures in this basin, the beds being named in descending order:

CARBONIFEROUS SYSTEM

Pennsylvanian Series

Conemaugh Formation

	Thickness Feet	Total Feet
Shale and sandstone, partially concealed	62	62
Little Clarksburg coal	3.7	65.7
Fire-clay	1.3	67
Clarksburg limestone	5	72
Morgantown sandstone	26	98
Shale	47	145
Barton sandstone	12	157
Shale	3	160

	Thickness Feet	Total Feet
Barton limestone	6	166
Shale	36	202
Grafton sandstone, massive conglomeratic sandstone	88	290
Ames limestone and shale with marine fauna in upper beds.	9	299
Harlem coal	1	300
Pittsburgh red beds. Red and light-colored shale	10	310
Saltsburg sandstone, massive sandstone	30	340
Shale	25	365
Cambridge (Friendsville) shale containing marine fauna in upper beds	25	390
Lower Bakerstown coal (Thomas coal)	3	393
Fire-clay	2	395
Shale	25	420
Meyersdale red beds. Red clay shale	25	445
Meyersdale limestone containing marine fauna. The limestone is found within or at the base of the Meyersdale red beds	1	446
Buffalo sandstone	11	457
Brush Creek limestone and shale containing marine fauna. The limestone is found about 3 feet above the base of this unit	26	483
Brush Creek coal	2	485
Shale	15	500
Upper Mahoning sandstone	15	515
Shale	13	528
Piedmont coal	1	529
Shale	36	565
Total thickness of Conemaugh formation exposed		565

Allegheny Formation

Upper Freeport coal (Davis coal) consisting locally of: Coal, 1 foot; Shale, 4 feet; Coal, 2 feet	7	7
Shale and sandstone	45	52
Lower Freeport coal (Barrelville coal)	2	54
Shale, sandstone, and concealed	104	158
Middle Kittanning coal (Luke coal)	2	160
Shale	23	183
Lower Kittanning coal (Ellerslie coal) containing thick clay partings	5	188
Shale	54	242
Mount Savage sandstone	25	267
Total thickness of Allegheny formation		267

Pottsville Formation

	Thickness Feet	Total Feet
Homewood sandstone, massive conglomeratic sandstone...	91	91
Shale	77	168
Upper Connoquenessing sandstone	40	208
Shale	20	228
Lower Connoquenessing sandstone	25	253
Total thickness of the Pottsville formation		253

MISSISSIPPIAN SERIES

Mauch Chunk Formation

Red shale.

UPPER YOUGHIOGHENY BASIN

This basin is situated in the western part of Garrett County, Maryland, and in the eastern part of Preston County, West Virginia, being known in the latter area as the Corinth or Mt. Carmel basin. It lies immediately south of the Lower Youghiogheny basin.

All of the coal measures which formerly occurred above the middle of the Conemaugh have been eroded from the region. The most valuable seams of coal in this basin are the Piedmont, the Davis or Upper Freeport (Corinth), and the Barrelville or Lower Freeport coals.

The following is a generalized section of the coal measures of this basin:

Conemaugh Formation

	Thickness Feet	Total Feet
Morgantown sandstone, locally massive and conglomeratic.	45	45
Shale	4	49
Barton coal	1	50
Upper Grafton sandstone, locally replaced by shale	25	75
Shale	24	99
Federal Hill coal	1	100
Shale	27	127
Lower Grafton sandstone	20	147
Ames limestone and shale with marine fauna	5	152
Harlem coal	1	153
Fire-clay	4	157
Pittsburgh red shale	23	180
Saltsburg sandstone	40	220
Dark shale	20	240
Upper Bakerstown coal (Maynadier coal)	4	244
Clay	13	257
Albright limestone	1	258

	Thickness Feet	Total Feet
Shale	4	262
Lower Bakerstown coal (Thomas coal, upper bench)	2	264
Clay or dark shale	11	275
Lower Bakerstown coal (Thomas coal, lower bench)	2	277
Fire-clay	10	287
Shale	6	293
Meyersdale red shale. Red clay shale locally replaced by sandstone	22	315
Buffalo sandstone, locally conglomeratic	20	335
Shale	18	353
Brush Creek limestone with marine fauna	2	355
Argillaceous sandstone above, dark shale with marine fauna below	19	374
Brush Creek coal	1	375
Fire-clay, impure	10	385
Corinth sandstone and shale	27	412
Gallitzin coal	1	413
Thornton clay and *Mahoning red shale*	12	425
Upper Mahoning sandstone	37	462
Piedmont coal	3	465
Lower Mahoning sandstone, locally shale	17	482
Thickness of Conemaugh Formation described		482

Allegheny Formation

	Thickness Feet	Total Feet
Upper Freeport (Davis) *coal* consisting of: Coal, 3 feet; Clay, 1 foot; Coal, 2 feet	6	6
Bolivar fire-clay	7	13
Upper Freeport limestone, in beds or nodules	5	18
Shale and fire-clay	22	40
Upper Freeport sandstone and shale	24	64
Lower Freeport (Barrelville) *coal*	4	68
Fire-Clay and shale containing locally the *Lower Freeport limestone*	10	78
Montell sandstone containing locally the thin *Montell rider coal*	24	102
Upper Kittanning (Montell) *coal*	4	106
Clay and shale	19	125
Westernport sandstone, massive, locally conglomeratic	60	185
Fire-clay	12	197
Lower Kittanning (Ellerslie) *coal*	3	200
Lower Kittanning fire-clay	2	202
Mount Savage sandstone, gray, very massive, locally conglomeratic	50	252

	Thickness Feet	Total Feet
Upper Mount Savage coal	1	253
Shale	22	275
Total thickness of Allegheny Formation		275

Pottsville Formation

Homewood sandstone	35	35
Shale	23	58
Upper Mercer coal	2	60
Sandstone	23	83
Lower Mercer coal	4	87
Upper Connoquenessing sandstone and shale	80	167
Quakertown coal	2	169
Lower Connoquenessing sandstone	50	219
Total thickness of Pottsville Formation		219

MISSISSIPPIAN SERIES

Mauch Chunk Formation

Red shale.

CASTLEMAN BASIN

This basin occupies a considerable area in the northeastern part of Garrett County. It lies a few miles northeast of the Upper Youghiogheny basin, from which it is separated by a low anticlinal arch, both basins being situated west of the Oakland anticline.

The upper strata of the Conemaugh and all of the overlying formations have been eroded from most of this area. The Pittsburgh seam and the lower part of the Monongahela formation are exposed, however, on the hilltops north of the Maryland state line.

The most important coal seams worked in the past in this region are the Lower Bakerstown (Thomas or "Honeycomb") coal and the Davis (Upper Freeport) coal, known locally as the Beachy or Grantsville coal. The Harlem ("Fossil") coal, though thin, is opened for local use.

The following is a generalized section of the coal measures of this basin[1]:

Monongahela Formation

Pittsburgh coal. Exposed north of the Maryland state line.

[1] The intervals are based largely upon drill records. The names applied to the upper coals of the Conemaugh formation are tentative only. Much work must be done in the adjoining part of Pennsylvania before final names can be given to them.

Conemaugh Formation

	Thickness Feet	Total Feet
Shale	8	8
Morantown coal (reported)	1	9
Upper Pittsburgh limestone (reported)	1	10
Shale	17.5	27.5
Stray coal	0.5	28
Shale	28	56
Little Pittsburgh coal	1	57
Lower Pittsburgh limestone	5	62
Connellsville sandstone (locally massive)	18	80
Clay with limestone and iron ore	9.5	89.5
Franklin rider coal	0.5	90
Clay with limestone lenses and iron ore	10	100
Franklin coal	1.5	101.5
Clay with calcareous nodules and ore, stray coal 1 inch thick at base	7.5	109
Clay and shale	16	125
Lonaconing sandstone. Sandstone and shale	17	142
Lonaconing coal (Elklick coal of Rogers)		
Coal 0.25; Shale 2.50; Coal and bone 3.25	6	148
Fire clay	10	158
Bluelick limestone	2	160
Shale	13	173
Upper Hoffman coal	1.5	174.5
Shale	3.5	178
Hoffman limestone	2	180
Shale	14.5	194.5
Lower Hoffman coal	0.5	195
Clarysville sandstone and shale	25	220
Upper Clarysville coal	1	221
Clay	6	227
Clarksburg limestone (upper bench) with many fossil ostracoda	7	234
Sandstone and shale	6	240
Niverton shale and fauna	8	248
Lower Clarysville coal	0 to 2.5	250
Fire clay	3	253
Clarksburg limestone (lower bench) with many fossil ostracoda	5	258
Shale	9	267
Morgantown sandstone, locally very massive	35	302
Wellersburg coal	1	303
Wellersburg limestone and fire-clay	7	310
Barton sandstone and shale	30	340
Barton rider coal	1	341

	Thickness Feet	Total Feet
Shale and sandstone	17.5	358.5
Barton coal	1.5	360
Fire-clay	2	362
Barton limestone	5	367
Upper Grafton sandstone	23	390
Shale	25	415
Federal Hill coal	1	416
Shale	7	423
Lower Grafton sandstone. Massive sandstone	32	455
Ames limestone and shale with marine fauna	23	478
Harlem coal ("Fossil" coal)	1.5	479.5
Ewing limestone	3.5	483
Pittsburgh red beds. Light-colored shale above, variegated red below	55	538
Saltsburg sandstone, massive, locally conglomeratic	26	564
Black shale	2	566
Upper Bakerstown coal (Maynadier coal, "Slaty vein")	3	569
Albright limestone	4	573
Shale	8	581
Albright limestone	1	582
Cambridge (Friendsville) *black shale*, containing marine fossils	25	607
Lower Bakerstown coal (Thomas coal, "Honeycomb" coal)	2	609
Shale	28	637
Meyersdale red beds	5	642
Buffalo sandstone	16	658
Meyersdale red beds. Red and variegated clay shale, containing the *Meyersdale limestone* with marine fauna	26	684
Buffalo sandstone	41	725
Brush Creek limestone and shale with marine fossils	14	739
Brush Creek coal	1	740
Fire-clay	3	743
Irondale limestone	2	745
Shale	35	780
Mahoning sandstone	52	832
Shale	5	837
Upper Freeport rider coal (Piedmont coal ?)	1	838
Dark shale	11	849
Total thickness of Conemaugh formation		849

Allegheny Formation

Upper Freeport (Davis coal, Beachey coal, Grantsville coal)	3	3
Bolivar fire-clay containing thick bed of *Upper Freeport limestone* locally	5	8
Upper Freeport sandstone	33	41

	Foot	Thickness Feet	Total Feet
Shale		10	51
Lower Freeport (Barrelville) *coal*		1.5	52.5
Fire-clay and shale		24	76.5
Upper Kittanning coal (Montell coal)		2.5	79
Shale		18	97
Sandy shale		14	111
Sandstone		17	128
Dark shale		8	136
Piney Mountain coal consisting of			
Coal and bone	1		
Shale	6		
Coal and bone	1.5	10	150
Clay and shale	3.5		
Coal and bone	2		
Shale		9	159
Westernport sandstone. Massive, gray, sandstone		39	198
Shale, light-colored above, dark beneath		3	201
Lower Kittanning coal (Ellerslie coal)		2	203
Mount Savage sandstone and shale		21	224
Shale		7	231
Upper Mount Savage coal		1	232
Shale and clay		14	246
Lower Mount Savage coal		1	247
Shale, arenaceous below		19	266
Total thickness of Allegheny formation			266

Pottsville Formation

	Thickness Feet	Total Feet
Homewood sandstone, massive conglomeratic sandstone	25	25
Dark shale	10	35
Mercer coal	1	36
Dark shale	14	50
Fire-clay	6	56
Upper Connoquenessing sandstone	57	113
Shale	5	118
Quakertown coal	1	119
Shale	6	125
Lower Connoquenessing sandstone	60	185
Shale	14	199
Sandstone and shale	22	221
Sharon coal, upper bench	3	224
Fire-clay	7	231
Sharon coal, lower bench	2	233
Fire-clay and shale	4	237
Sharon sandstone	43	280
Total thickness of Pottsville formation		280

MISSISSIPPIAN SERIES

Mauch Chunk Formation

Red shale.

UPPER POTOMAC BASIN

This basin extends from the head waters of the Potomac River to Piedmont, West Virginia. The Potomac River flows through it, dividing it into parts, the western being situated in Maryland while the eastern is in West Virginia. The uppermost strata of the Conemaugh formation and all the formerly overlying beds have been eroded from the Maryland portion of the basin, save in a small area near Shaw where the Pittsburgh seam is exposed on the hill tops.

The Pittsburgh seam attains a thickness of over 20 feet near Elk Garden, West Virginia, where it is known as the Elk Garden seam. The most important coals in the Maryland portion of this basin are the Barton coal (often called the "Four-foot" or "Bakerstown" coal), the Thomas coal (Lower Bakerstown coal of this work, "Upper Freeport" of earlier reports), and Davis coal (Upper Freeport coal of this work, Lower Kittanning of earlier reports).

The following is a generalized section of the coal measures of this basin [1]:

Monongahela Formation [2]

		Thickness Feet	Total Feet
Upper Pittsburgh sandstone		35	35
Pittsburgh coal			
Roof coal and shale	2		
Shale	6	20	55
Coal	12		
Total thickness of Monongahela formation described			55

[1] The author is greatly indebted to the Davis Coal and Coke Company for the privilege of examing the records of a large number of diamond-drill holes drilled in this area. The information concerning the coal intervals obtained in this manner has been of great value in the preparation of this report.

[2] The upper 175 feet of the section is based upon a section made by Mr. David B. Reger of the West Virginia Geological Survey to whom the author is greatly indebted for the privilege of incorporating it in this article.

Conemaugh Formation

	Thickness Feet	Total Feet
Shale	6	6
Limestone and shale	4	10
Morantown coal	4	14
Shale	46	60
Lower Pittsburgh sandstone and shale	12	72
Little Pittsburgh coal including thick shale parting near top and bottom	6	78
Shale	19	97
Connellsville sandstone, shaly sandstone and shale	20	117
Franklin coal	1	118
Shale	34	152
Lonaconing sandstone	18	170
Fire-clay	17	187
Shale, sandy below	18	205
Black shale	9	214
Hoffman sandstone and shale	11	225
Black shale	5	230
Hoffman coal	1	231
Fire-clay and shale	9	240
Shale	15	265
Clarysville sandstone and shale	12	277
Upper Clarksburg red shale	10	287
Shale	28	315
Black shale	5	320
Lower Clarksburg sandstone	5	325
Lower Clarksburg red beds. Red shale	15	340
Morgantown sandstone and shale	37	377
Morgantown red beds and shale	5	382
Shale	17	399
Barton rider coal	1	400
Barton sandstone and shale	16.5	416.5
Barton coal	3.5	420
Upper Grafton sandstone and shale	35	455
Birmingham red beds. Red shale	5	460
Shale	22	482
Lower Grafton sandstone	25	507
Ames limestone and shale with marine faunas. One foot of limestone is found at the base of this unit	10	517
Harlem coal	1.5	518.5
Ewing limestone	12.5	531
Pittsburgh red beds. Red and variegated clay shale	5	536
Saltsburg sandstone. Massive sandstone partially replaced locally by red beds	65	601
Shale	2	603

	Thickness Feet	Total Feet
Upper Bakerstown coal (Maynadier coal)	2	605
Fire-clay	2	607
Albright limestone	4	611
Cambridge red shale	5	616
Shale	10	626
Thomas sandstone	25	651
Lower Bakerstown coal (Thomas coal)	5	656
Thomas limestone. Thin limestone in fire-clay	10	666
Buffalo sandstone. Replaced locally by *Meyersdale red beds* 15 to 25 feet beneath top	50	716
Brush Creek shale and fauna. Black shale containing marine fauna	9	725
Brush Creek coal	1	726
Fire-clay	2	728
Irondale limestone	1	729
Corinth sandstone	12	741
Shale	10	751
Thornton clay, upper bench	10	761
Mahoning red shale, upper bench	14	775
Gallitzin coal	1	776
Thornton clay, lower bench	5	781
Mahoning red shale, lower bench	5	786
Mahoning limestone. Thin limestone in shale	5	791
Upper Mahoning limestone	10	801
Shale	2	803
Piedmont coal ("Six-foot" coal)	5	808
Fire-clay	2	810
Lower Mahoning sandstone—micaceous sandstone	28	838
Dark shale	5	843
Upper Freeport coal (Davis coal)		
Total thickness of Conemaugh formation		843

Allegheny Formation

Upper Freeport coal (Davis coal, "Lower Kittanning coal" of earlier reports), usually consisting of two benches separated by a variable clay parting	7	7
Shale	90	47
Upper Freeport sandstone and shale	13	60
Lower Freeport coal (Barrelville coal)	1.5	61.5
Fire-clay and shale	16.5	78
Montell sandstone, massive locally conglomeratic	20	98
Upper Kittanning coal (Montell coal)	2.5	100.5
Shale	11.5	112

		Thickness Feet	Total Feet
Sandstone. Massive above, thinner bedded and shaly below.		16	128
Piney Mountain coal. Variable—locally consisting of:	Feet		
Coal and bone	2		
Shale and sandstone	7	12	140
Coal and bone	3		
Fire-clay		8	148
Westernport sandstone. Massive, cross-bedded...........		60	208
Lower Kittanning coal..............................		2	210
Shale		18	228
Mt. Savage sandstone..............................		11	239
Upper Mount Savage coal............................		1	240
Shale		8	248
Lower Mount Savage coal............................		1	249
Shale		3	252
Total thickness of Allegheny formation..............			252

Pottsville Formation

	Thickness Feet	Total Feet
Homewood sandstone. Massive, locally conglomeratic.....	70	70
Shale	17	87
Fire-clay	2	89
Lower Mercer coal..................................	1	90
Fire-clay	2	92
Upper Connoquenessing sandstone......................	70	162
Shale	28	190
Lower Connoquenessing sandstone and shale.............	25	215
Sharon coal	1	216
Shale	19	235
Total thickness of Pottsville formation..............		235

MISSISSIPPIAN SERIES

Mauch Chunk Formation

Red shale.

GEORGES CREEK BASIN

This basin is the northeastern extension of the Upper Potomac basin with which it unites to form a single structural trough. This trough is divided into two parts by the Potomac River whose waters turn eastward at Piedmont.

The Georges Creek basin contains the thickest section of coal measures found in Maryland, embracing strata extending from the Permian to the base of the Carboniferous. Many more coal seams are found here than occur in corresponding beds in other areas, especially in the Conemaugh formation, making this the most important coal basin of Maryland.

The following is a generalized section of the coal measures of the Georges Creek basin:

PERMIAN SYSTEM

Greene Formation

	Thickness Feet	Total Feet
Unnamed sandstone	10	10
Concealed	25	35
Shale, limestone, and concealed	37	72
Jollytown coal	2	74
Concealed	20	94
Thickness of Greene formation exposed		94

Washington Formation

Upper Washington limestone	4	4
Concealed	80	84
Unnamed limestone	2	86
Concealed	110	196
Shale	1	197
Unnamed limestone	1	198
Black shale	0.5	198.5
Washington coal	3.5	202
Concealed	10	212
Limestone	2	214
Concealed	40	254
Waynesburg "A" coal	2	256
Waynesburg sandstone and shale	39	295
Total thickness of Washington formation		295

CARBONIFEROUS SYSTEM

PENNSYLVANIA SERIES

Monongahela Formation

Waynesburg coal (Koontz coal)	4	4
Fire-clay	5	9
Waynesboro limestone	9	18
Shale and silicious fire-clay	12	30

	Inches	Thickness Feet	Total Feet
Uniontown sandstone and shale		22.5	52.5
Uniontown coal		0.5	53
Shale and sandstone		13	66
Benwood limestone, replaced locally by the *Upper Sewickley sandstone*		8	74
Fire-clay		7	81
Upper Sewickley sandstone		14	95
Upper Sewickley coal. Variable, consisting locally of:			
Coal	10		
Shale	30	5	100
Coal	20		
Fire-clay and shale		5	105
Lower Sewickley sandstone and shale		20	125
Lower Sewickley coal, local (Tyson coal) upper bench		2	127
Sandstone and shale		15.5	142.5
Lower Sewickley coal (Tyson coal) lower bench		2.5	145
Fire-clay and shale		10	155
Sewickley limestone		5	160
Cedarville sandstone and shale		20	180
Redstone coal (upper bench)		3	183
Redstone sandstone and shale		0.40	203
Redstone coal (lower bench)		4	207
Fire-clay and shale		13	220
Upper Pittsburgh sandstone		15	235
Pittsburgh coal (Big Vein coal)		10	245
Total thickness Monongahela formation			245

Conemaugh Formation

	Thickness Feet	Total Feet
Shale	3	3
Morantown coal in two benches, including parting	5	8
Shale	3	11
Upper Pittsburgh limestone	1	12
Shale	18	30
Lower Pittsburgh sandstone	25	55
Shale	9	64
Little Pittsburgh coal	3.5	67.5
Shale	4	71.5
Lower Pittsburgh limestone	0.5	72
Connellsville sandstone containing locally about its middle the *Second Little Pittsburgh coal* (about 12 inches thick)	40	112
Third Little Pittsburgh coal (Franklin rider coal)	1	113
Shale	12	125

	Thickness Feet	Total Feet
Franklin coal ("Dirty nine-foot coal") consisting of coal and bone in several beds separated by shale partings....	9	134
Lonaconing sandstone or shale..........	26	160
Lonaconing coal (upper bench), local consisting of		
Coal and bone..........	2	162
Shale	11	173
Lonaconing coal (lower bench)..........	1	174
Shale and fire-clay..........	4	178
Hoffman sandstone	20	198
Upper Hoffman coal..........	3	201
Fire-clay and shale..........	16	217
Middle Hoffman coal, local..........	1	218
Hoffman limestone and fire-clay..........	10	228
Shale	88	236
Lower Hoffman coal, local..........	1	237
Fire-clay and shale..........	3	240
Clarysville sandstone	20	260
Shale	5	265
Shale	10	275
Upper Clarysville coal..........	2	277
Clarksburg limestone (upper bench)..........	5	282
Shale	16	298
Lower Clarysville coal (upper bench)..........	1	299
Shale	10	309
Lower Clarysville coal (lower bench)..........	1	310
Clarksburg limestone (lower bench)..........	5	315
Morgantown sandstone, conglomeratic, containing locally about middle the thin *Wellersburg rider coal*..........	35	350
Wellersburg coal ("Twin coal"). Two beds of coal separated by thick shale..........	8	358
Shale and sandstone..........	31	389
Barton rider coal..........	1	390
Shale	14	404
Barton sandstone (local)..........	10	414
Barton coal ("Four-foot" coal) "Bakerstown coal" of earlier reports	4	418
Fire-clay and shale..........	7	425
Upper Grafton sandstone..........	25	450
Shale	8	458
Federal Hill coal..........	1.5	459.5
Shale	15.5	475
Lower Grafton sandstone..........	30	505
Ames limestone and shale with marine fauna. A bed of limestone occurs near the base, another occurs locally about 20 feet above the base of this unit..........	28.5	533.5
Harlem coal ("Brush Creek" coal of earlier reports)....	1.5	535

	Thickness Feet	Total Feet
Ewing limestone	4	539
Pittsburgh red beds, variegated red and light-colored shale.	26	565
Saltsburg sandstone. Massive, conglomeratic. An unnamed coal is reported locally about 575 feet beneath the Pittsburgh seam	45	610
Shale	7	617
Upper Bakerstown (Maynadier) *coal.* Upper Freeport coal of earlier reports	3	620
Albright limestone	2	622
Fire-clay	15	637
Cambridge (Friendsville) *shale.* Dark shale with marine fauna	20	657
Lower Bakerstown (Thomas) *coal*, upper bench. Lower Freeport coal of earlier reports	3	660
Shale	15	675
Lower Bakerstown (Thomas) *coal*, lower bench	1	676
Clay and shale	47	723
Meyersdale red beds. Red clay and shale	5	728
Shale	9	737
Buffalo sandstone containing locally the thin *Brush Creek rider coal* about 765 feet beneath the Pittsburgh seam.	48	785
Brush Creek shale and limestone. Black shale and argillaceous limestone with marine fauna	4	789
Brush Creek coal (Upper Kittanning coal of earlier reports)	1	790
Irondale limestone. Clay and shale with nodules of limestone locally	4	794
Corinth sandstone	6	800
Thornton clay, upper bench	20	820
Mahoning red beds	5	825
Thornton clay, lower bench	15	840
Mahoning limestone. Shale with lenses of limestone locally	5	845
Upper Mahoning sandstone	15	860
Shale	3	863
Piedmont coal (Six-foot coal, Lower Kittanning coal in part of earlier reports)	6	869
Fire-clay	3	872
Lower Mahoning sandstone or shale	28	900
Shale	3	903
Total thickness of Conemaugh formation		903

Allegheny Formation

Upper Freeport coal (Davis coal) "Split-six" coal, "Lower Kittanning" coal in part of earlier reports)	5	5
Bolivar clay	24	29
Upper Freeport sandstone	6	35

	Thickness Feet	Total Feet
Shale	14	49
Lower Freeport coal (Barrelville coal) ("Parker" coal, "Clarion" coal of earlier reports)	2.5	51.5
Shale	13.5	65
Montell sandstone containing locally the thin *Montell rider coal*	30	95
Upper Kittanning coal (Montell coal). ("Bluebaugh coal," "Brookville" coal of earlier reports)	5	100
Shale	10	110
Little Montell coal (local)	0.5	110.5
Mount Savage iron ore (Johnstown iron ore)	0.5	111
Hardman fire-clay ("Furnace clay")	8	119
Shale	10	129
Pincy Mountain coal. Locally having several benches separated by shale partings	1	130
Shale	5	135
Westernport sandstone. Massive, cross bedded, interbedded with shale	35	170
Middle Kittanning coal (Luke coal). Irregular. May be in several benches	5	175
Middle Kittanning (Luke) *fire-clay* and shale	7	182
Ellerslie rider coal (local)	1	183
Shale	4	187
Lower Kittanning coal (Ellerslie coal). Impure with clay partings	5	192
Lower Kittanning fire-clay (Ellerslie fire-clay)	8	200
Mount Savage sandstone, massive, locally conglomeratic with numerous plant impressions and hackle teeth	38	238
Upper Mount Savage rider coal (Scrubgrass coal)	1	239
Fire-clay	6	245
Upper Mount Savage coal	5	250
Mount Savage fire-clay	8	258
Lower Mount Savage coal	2	260
Total thickness of Allegheny formation		260

Pottsville Formation

	Thickness Feet	Total Feet
Homewood sandstone. Massive, locally conglomeratic	65	65
Upper Mercer shale and fauna	9	74
Upper Mercer coal	1	75
Shale	32	107
Lower Mercer coal	1	108
Shale	12	120
Upper Connoquenessing sandstone and shale	30	150
Quakertown shale and fauna	2	152
Quakertown coal	1	153

	Thickness Feet	Total Feet
Fire-clay	2	155
Shale	25	180
Lower Connoquenessing sandstone	20	200
Sharon coal	1	201
Shale, locally present	19	220
Total thickness of Pottsville formation		220

MISSISSIPPIAN SERIES

Mauch Chunk Formation

Red shale.

The section given above is that found in the center of the basin. The thickness of the Conemaugh formation displays marked differences in different parts of the basin, being little more than 825 feet near Westernport, about 900 feet in the center of the basin and over 900 feet near Wellersburg, Pennsylvania, although no opportunity for precise measurement has been found in the latter region. This change is in harmony with the general increase in thickness of the Conemaugh toward the northeast in the northern Appalachian province.

The chief coals of the region are the Waynesburg, Lower Sewickley (Tyson), Pittsburgh, Barton ("Four-foot"), Thomas, Piedmont ("Six-foot"), Davis ("Split-six"), Barrelville (Parker) and Montell (Bluebaugh). The Harlem coal, though thin, is of good quality and is mined at numerous localities for local use. Some of the other coals of the Conemaugh formation are thick locally, but all are lenticular and inconstant, being subject to great changes in short distances, while most are impure. The Little Pittsburgh, Franklin, Maynadier (Upper Freeport of earlier reports), Ellerslie and Upper Mount Savage are thick coals at some places, but are less pure and little worked.

The thickness of the formations of the Pennsylvanian series in the various basins of Maryland is shown in the following table:

	Pottsville	Allegheny	Conemaugh
Lower Youghiogheny basin	253	267	565[1]
Upper Youghiogheny basin	219	275	482[1]
Castleman basin	280	266	849
Upper Potomac basin	235	252	842
Georges Creek basin	220	260	903

[1] Formation is not completely shown.

COMPOSITION AND FUEL VALUE OF THE COALS OF MARYLAND

BY

CHARLES K. SWARTZ

Introduction

Method of Analysis.—Analyses of coals are of two kinds, proximate and ultimate. In proximate analyses the relative amounts of moisture, volatile matter, fixed carbon, and ash contained in the coal are usually determined, while in ultimate analyses the relative amounts of the elementary bodies composing the coal are ascertained. Ultimate analyses are of two degrees of refinement. In the first the relative amounts of the elementary bodies occurring in the combustible constituents of the coal only are considered, while in more elaborate analyses all of the elementary constituents of the coal, including those in the ash, are determined. The ultimate analyses of the coals of Maryland given in this report are of the first type, showing the proportions of hydrogen, carbon, nitrogen, oxygen, and sulphur present in the coal, together with the per cent of ash.

Fuel Value.—The fuel value expresses the number of heat units a given amount of coal yields upon combustion and is manifestly of great importance. Two systems of units are in use, calories employed in the metric system and British thermal units used in the English system. These terms may be defined as follows:

A calorie is the amount of heat required to raise the temperature of one gram of water one degree Centigrade.

A British thermal unit is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

The fuel value, expressed in the metric system, states the number of calories of heat produced by the combustion of one gram of coal. In the

English system the value expresses the number of British thermal units emitted by the combustion of one pound of coal. Thus the fuel value 7590 calories means that the combustion of one gram of coal will heat 7590 grams of water one degree Centigrade, while the value 13,662 B. T. U. means that the combustion of one pound of coal will heat 13,662 pounds of water one degree Fahrenheit.

These values can be determined both by experiment and by calculations based upon the ultimate analyses of the coal. They have been found in both ways in the appended tables which give the thermal values of the coals analyzed.

Methods of Sampling.—Samples for analyses have been collected uniformly in the following manner: A place was sought where the coal appears to present the average thickness and quality of the seam in the mine. The face of the coal was first cut and afterwards further cleaned by brushing it with a stiff wire brush. A sample was then obtained by cutting a groove across the face of the seam not less than 3 inches deep and 6 inches wide, all partings and other portions of the bed discarded in mining being rejected from the coal cut. The material so secured was then finely pulverized and quartered two or more times until the desired amount was secured. The samples were shipped in air-tight jars so as to retain the moisture and other volatile constituents of the coal, as it occurs in the mines. The location of each sample in the mine is given.

The analyses have been made by the Chemical Department of the U. S. Bureau of Mines, affording a guarantee of their excellence and accuracy, the analyst being A. C. Fieldner.

THE COAL MINES OF MARYLAND

BY

WILLIAM A. BAKER, JR.

Introduction

Location.—The coal mines of Maryland are confined to five basins, which occupy parts of Allegany and Garrett counties. The most important of these, the Georges Creek basin, is situated partly in Allegany and partly in Garrett County, occupying a narrow strip of land between Dans and Savage mountains. The Maryland portions of the other four coal basins lie wholly in Garrett County. Of these the most important is the Upper Potomac basin, which from a structural point of view, is the southwestern continuation of the Georges Creek basin. The Potomac River flows near the axis of the basin, so only about one-half of it is within Maryland. The remaining three synclinal troughs of Garrett County are the Upper Youghiogheny or Oakland basin, the Lower Youghiogheny or Friendsville basin, and the Castleman or Grantsville basin. The location of these five basins are shown on the accompanying map.

The following table shows the relative importance of these five coal basins, based upon the number of shipping and local, or fuel, mines now in operation at the time of writing of this report:

Name of coal basins	Number of shipping mines[1]	Number of local mines
Georges Creek	36	16
Upper Potomac	16	1
Castleman	...	13
Upper Youghiogheny	3	7
Lower Youghiogheny	...	2

Seams Mined.—Until recent years the coal mining industry of Maryland was confined almost exclusively to the mining of the Pittsburgh or

[1] Based on number of mines reporting production in 1918 or known to be in operation.

"Big Vein" seam. During the past few years the operators of the region realized that their resources of "Big Vein" were limited. It is estimated that available tonnage of "Big Vein" coal will be practically exhausted within the next ten years. The daily output to-day of coal from this seam is only one-half that mined two years ago. For this reason the interest of all operators is now being centered upon the smaller coal seams, and experiments are being carried on to determine the most economical methods of mining these beds.

The following "small seams" are being mined in Maryland at the present time:

Names used in this report	Names used in earlier reports
Waynesburg	Waynesburg
Upper Sewickley or Borden	Upper Sewickley
Lower Sewickley or Tyson	Lower or Upper Sewickley or Tyson
Barton	Barton, Bakerstown
Harlem	Masontown, Brush Creek
Upper Bakerstown or Maynadier	Maynadier, Upper Freeport
Lower Bakerstown or Thomas	Thomas, Upper Freeport, Lower Freeport
Brush Creek	Upper Kittanning
Piedmont	Lower Kittanning
Upper Freeport or Davis	Lower Kittanning, Split-six
Lower Freeport or Barrelville	Parker, Clarion
Montell or Upper Kittanning	Bluebaugh, Brookville

In addition to these coals prospects have been opened in a number of other seams for local use.

CLASSIFICATION OF MINES.—The mines of Maryland are classified under two heads in the following discussion: First, those in which the coal is being mined for shipment or shipping mines, and second, those in which the coal is mined for local use or fuel mines. All mines of the first class are described in full, while only the more important of the latter class are considered.

The mines of each coal basin are brought together, shipping mines being described first and then the more important fuel mines. The arrangement of the properties is alphabetical in each class, according to the names of the operators.

A constant outline is used in describing the properties, the following being the order of treatment:

Name of the present operator.
History of the coal operators of property to date.
Property: ownership, location, etc.
List of mines worked, coal seams, and location.
Name of individual mine.
- Location.
- Local name of the seam mined.
- Section of the coal where sampled.
- Description of the coal.
- Type of opening.
- Method of mining.
- Ventilation.
- Drainage.
- Haulage.
- Size and type of mine car.
- Gauge and kind of mine tracks.
- Scales.
- Loading coal: tipple, dump, treatment of coal, loading railroad cars.
- Power.
- Shipping point, name of the railroad.
- Number of employees.
- Output for 1918

MINES OF THE GEORGES CREEK BASIN

The mines of this basin include both shipping and fuel mines. The shipping mines will be described first and afterwards the fuel mines. The following is a list of the operators whose mines are described in this report:

Shipping mines	Postoffice address of mine office
Allegany Coal Company	Westernport, Md.
Brailer Mining Company	Mount Savage, Md.
Brophy-Hitchens Coal Co	Midlothian, Md.
Caledonia Coal Company	Barton, Md.
Chapman Coal Mining Company	Barton, Md.
Clair Coal Company	Westernport, Md.
Consolidation Coal Company	Frostburg, Md.
Cumberland Big Vein Coal Company	Cumberland, Md.
Fitzpatrick Coal Company	Pekin, Md.
Frostburg Big Vein Coal Company	Frostburg, Md.

Georges Creek Coal Company, Inc.	Lonaconing, Md.
Georges Creek Coal Mining Company	Lonaconing and Barton, Md.
Georges Creek-Parker Coal Company	Frostburg, Md.
Green Coal Mining Company	Meyersdale, Pa.
Hampshire Big Vein Coal Company	Piedmont, W. Va.
Hoffa Bros. Coal Company	Barton, Md.
Maryland Coal Company	Lonaconing, Md.
McKee Coal Company	Frostburg, Md.
McNitt Big Vein Coal Company	Frostburg, Md.
Midland Mining Company	Cumberland, Md.
Midlothian Coal Company	Frostburg, Md.
Miller and Greene Coal Company	Westernport, Md.
Moscow-Georges Creek Coal Mining Company	Cumberland, Md.
Mount Savage-Georges Creek Coal Company	Frostburg, Md.
Mullaney Coal Company	Mount Savage, Md.
New Central Coal Company	Lonaconing, Md.
New York Mining Company	Mount Savage, Md.
North Maryland Coal Mining Company	Johnstown, Pa.
Phoenix and Georges Creek Mining Company	Phoenix, Md.
Piedmont and Georges Creek Coal Company	Frostburg, Md.
Pine Hill Coal Company	Lonaconing, Md.
Stanton-Georges Creek Coal Company	Frostburg, Md.
Sullivan Bros. Coal Company	Frostburg, Md.
United Big Vein Coal Company	Baltimore, Md.
Westernport Coal Company	Westernport, Md.
West Virginia Pulp and Paper Company	Luke, Md.

Fuel mines

Abbot mine
Allegany Big Vein Coal Company
Brode's mine
Big Savage Fire Brick Company
Borden Fuel Company
Clifton Big Vein Coal Company
Eagan mine
Evans and Kemp Coal Company
Hitchins Fuel mine
Meese mine
Metz mine
Moore mine
Smith's mine
Reynolds mine
Williams mine
Workman mine

MINES OF THE UPPER POTOMAC BASIN

Shipping mines

Aberdeen Coal Company	Steyer, Md.
Blaine Mining Company	Potomac Manor, W. Va.
Bloomington Coal Company	Bloomington, Md.
Chaffee Coal Company	Vindex, Md.
Cover Coal Company	Piedmont, W. Va.
Davis Coal and Coke Company	Thomas, W. Va.
Garrett County Coal and Mining Company	Harrison, W. Va.
Hamill Coal and Coke Company	Blaine, W. Va.
Hubbard Coal Mining Company	Gleason, W. Va.
McKanwig Coal Company	Bayard, W. Va.
Monroe Coal Mining Company	Barnum, W. Va.
Pattison Coal Company	Bloomington, Md.
Potomac Valley Coal Company	Blaine, W. Va.
Standard Coal Company	Cumberland, Md.
Strathmore Coal Mining Company	Garmania, W. Va.
Wolf Den Coal Company	Kitsmiller, Md.

Fuel mine

Gilbert's mine

MINES OF THE UPPER YOUGHIOGHENY BASIN

Shipping mines

The Pendergast and Ashby Coal Company	Hutton, Md.
Snowy Creek Coal Company	Crellin, Md.
Turner and Douglas Coal Company	Crellin, Md.

Fuel mines

Ashby's mine
Beeghley mine
Browning mine
Chisholm mine
Lance Bros. mine
Leighton mine
Shaeffer mine
Tower mine

MINES OF THE CASTLEMAN BASIN

Fuel mines

Beachey mine
Beitzel mine
Bittinger mine
Butter's mine
Clatters mine
Hackman mine
Jennings Bros. mine
Kinsinger mine
Lĕgeer's mine
McKenzie mine
Shaw mine
E. Stanton mine
U. M. Stanton mine
Wisseman mine
Yoder mine

MINES OF THE LOWER YOUGHIOGHENY BASIN

Fuel mines

Fike mine
Steele mine

METHODS OF MINING EMPLOYED IN THE COAL MINES OF MARYLAND

BY

WILLIAM A. BAKER, JR.

Introduction

A brief account of the various methods of mining coal now employed in Maryland will be given in this chapter. The peculiar mining conditions encountered by each operator necessitate the adoption of methods best suited to his particular mines. No attempt will therefore be made to present a complete account of processes of mining carried on in all the operating mines, but a more general discussion of the coal mining industry of Maryland will be given.

Surveys.—The presence of coal being known in a region, preliminary surveys are undertaken in order to locate the property lines and to aid in the determination of the horizontal and vertical position and outcrops of the seams. A careful investigation of the geology of the region is undertaken, great aid being derived in this work from federal and state geological surveys.

Test holes are drilled and openings driven into the outcrops of the coals in order to secure sections of the seams and samples for analyses. Levels are then run and more detailed surveys made to tie up the various outcrops, ascertain the available tonnage of coal, and to find more accurately the strike and dip of the seams. The final results of the field work supply data for the exploitation of the coal; *i. e.,* the location of railroad sidings, mine openings, tramroads, gravity plane, tipple, mine houses, power plant, shops, stables, reservoir for water supply, etc. Further surveys keep pace with the progress of the work both within and without the mines.

MAPS.—Accurate maps are an important factor in the coal mining industry. The types of maps used may be classified as surface and underground maps or combinations of the same. The former include property, insurance and outside workings; the latter, often called mine maps, show the state of development underground. A property map should show the boundary lines of the property, location of outcrop of coal seams, mine entries, test openings, drill holes, the location of the outside mine plant company town, etc., together with such physical features as streams, swamps, lakes, etc. Such maps are made on varying scales of from 100 feet to the inch to one mile to the inch. Insurance maps are occasionally kept showing relative position of all buildings and structures of all kinds at mining plant and company town. The mine maps must show in detail all mine workings to date and the plans for future development. The mine workings include all headings, air courses, cross-cuts, rooms, underground shops, stables, shaft bottoms, mine entries, pillared out-workings, together with their elevations and station numbers. The mine maps are usually made on a scale of 100 feet to the inch.

OPENINGS

There are three types of mine openings: drifts, slopes, and shafts. The Georges Creek and its tributaries have, during the past ages, eroded their courses deeper and deeper into the valley floor, exposing most of the coal seams. For this reason most of the mine openings in the Georges Creek basin are by drift entries. There are only a few slope entries and but one shaft in this entire basin. In the Upper Potomac basin there are two shafts and two slopes, the rest of the mine openings being drift entries. In the other three coal basins of Maryland the entries to all the mines are by drift openings into the outcrops of the coal seams.

The standard single-drift entry is 9 feet wide by 7 feet high. In most of the fuel mines of the Castleman and the Youghiogheny basins, the drift entries are much smaller, varying from 4 feet by 3 feet and 5 feet by 4 feet to the standard size entry. Many of the shipping mines use the double-drift entry systems, *i. e.,* a drift opening wide enough for two tracks, one for the returning empty cars and another for the loads. In such cases the size of the openings vary according to the particular arrangement of the tracks, etc., at the mouth of the mine. A second drift entry is made, usually close to the first, which is used for the air course, and in many instances for the drainage as well. The fan to ventilate the mine is located at the mouth of the second drift opening. The slope entries are usually made on the double entry system, as are also the compartments of the shafts. The slopes and shafts vary in size, length or depth, etc., and will be described separately in the following chapter.

At some of the more modernly equipped mines, such as those of the Maryland Coal Company, the West Virginia Pulp and Paper Company, the Consolidation Coal Company, etc., the openings are lined by concrete walls and arches until the solid strata are reached. The majority of the Maryland mine openings are, however, only timbered or lagged.

SYSTEMS OF MINING

ROOM AND PILLAR SYSTEM.—The Room and Pillar system of mining has been used in the mines of Maryland ever since the earliest days of the coal mining industry. This system, however, has been greatly changed from the original form. The various modifications of this system used throughout the coal regions will not be described in this report, as they have already been treated in detail by many authorities upon the subject. The latest development of this system, however, which is now being used by most operators in this region, may be called the Room and Panel system, or simply the Panel system. This system will be briefly discussed.

THE ROOM AND PANEL SYSTEM.—Two or three main headings, or entries, are driven into the coal seam to be mined. These headings are parallel to each other, but are separated by a barrier pillar of coal which may vary from 50 to 100 feet wide, depending upon the thickness of the coal seam and the overlying strata. One of these headings is used for a haulage way, the second for an air course, and the third, if present, serves as a "manway" or "traveling way" for the miners. At intervals of from 200 to 700 feet, depending upon the thickness of the coal seam and the thickness and character of the overlying strata, a pair of side entries, or panel headings, are driven at right angles, if possible, to the main heading. These panel headings are seldom less than 1000 feet long, and usually are 10 feet wide or over. By this method a territory under development is divided into rectangular panels, each of which has 10 or more rooms. These panel headings or room headings are driven on easy grades which are favorable to haulage and ventilation. The panels are worked in pairs. When the upper panel heading has been driven to its end, the rooms are turned off on 30- to 100-foot centers. The standard rooms for "Big Vein" workings are 400 feet long and 13 feet wide, leaving barrier pillars of 87 feet in width. The length and width of the rooms are varied to suit the conditions involved by the pitch and thickness of the seam, the weight of the overlying strata, and the character of the roof above the coal seam. For example, the panel headings are turned off the main headings at 200- to 250-foot intervals in the Tyson mines of the Consolidation Coal Company. Also their 30-foot rooms are broken off the panel headings on 60-foot centers. The rooms in the upper panel are limited by a barrier pillar which separates and protects them from the panel heading above, but those in the lower panel heading are driven through to the "gob" of the upper panel. Both the retreating and advancing methods of drawing pillars are employed, though most operators favor the former. The line of pillar work extending over the two panels should have an angle of about 45° to the direction of the panels. The following sketch (fig. 1) illustrates this Room and Panel system as used by several operators. The Davis Coal and Coke Company use this system at their Kempton mine, only there they have 20 and 25 rooms to each panel heading. The Georges Creek Coal Company, Incorporated, use a different modification of this same system. Their rooms are driven forward and pillared back in batteries of 12, before others are started. In a similar manner, each operator uses some variation or modification of the Room and Panel system, or of the old Room and Pillar System, which he considers best adapted to the mining of his particular coal seam.

LONGWALL SYSTEM.—The Longwall system of mining coal has never been successfully used in Maryland as it has not been tried under favorable conditions. This system can only be economically installed in coal

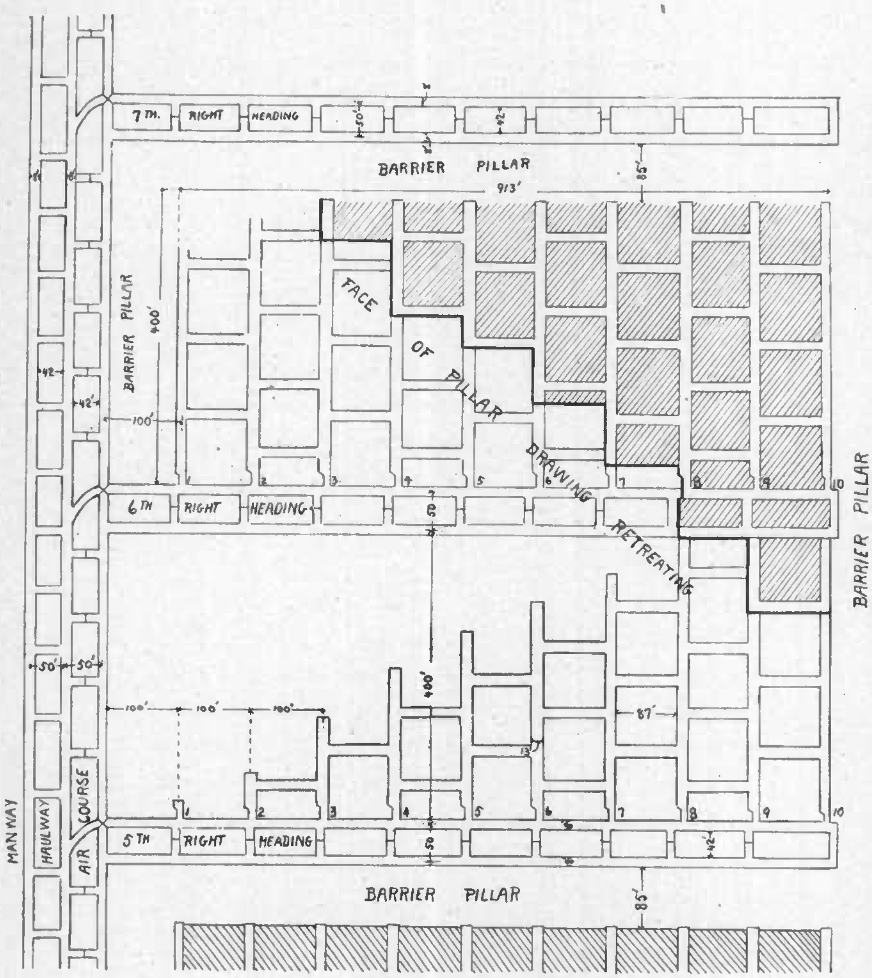

FIG. 1.—ROOM AND PANEL IN PANEL SYSTEM.

seams having thick sandstone roof which will permit drawing the long wall faces from 70 to 1000 feet in width with the use of little or no timbering. The system calls for the use of elaborate mining machines—cutting machines and conveyors.

RECOVERING THE GOAL

DRIVING HEADINGS.—In the headings the working face is at least 4 to 8 feet in advance of the point to which the rock has last been removed. This must be done in order to keep the coal free from the rock when it is shot. Rock drills of various types are used, such as Power Twist Drills, Ingersol-Sargeant Compressed Air Drills, Temple-Ingersol Electric Drills, and various types of Jack Hammer Rock Drills. Of these various types of Jack Hammer Drills the Sullivan Jack Hammer Rock Drill is considered by the majority of operators to be the most efficient and economical. The holes drilled are usually from 2 to 6 feet long and up to 2 inches in diameter. Dynamite or powder is used for the charge, depending upon the kind of rock to be shot.

TIMBERING.—Usually when the coal is removed in the rooms and headings the overlying strata must be supported. The nature of the roof determines whether the props are to be placed close together or far apart. For example, immediately overlying the "Big Vein" is a brittle shale interstratified with thin seams of coal known as the "Wild Coal" or "Rashings." Upon exposure to air the wild coal crumbles and falls. Also this roof coal contains many "horsebacks" inverted wedge-shaped masses, and "slips," formed by the cleavage planes of the coal bed. Therefore, from the character of the roof, it can readily be seen that all workings in the "Big Vein" must be more or less closely timbered. On the other hand, the roof above the Parker coal seam at Barrelville is a heavy sandstone some 30 feet thick, which requires little or no timbering. Also, to a limited extent, the width of the headings and rooms determine the amount of timbering necessary to hold up the roof; but then the width of the headings and rooms are determined primarily by the character of the roof itself.

METHODS OF TIMBERING

TIMBERING ALONG THE HEADINGS.—The roof in the headings is usually supported by "sets of timber" (fig. 2). A set of timbers consists of a wooden cross-bar supported by two wooden props, one near each end. The nature of the roof determines the distance between sets of timber.

In some places a number of sets of timber are placed side by side forming what is called a "crib" or "cog." In some mines the headings are driven twice as wide as necessary, and in such cases half of the roof is supported

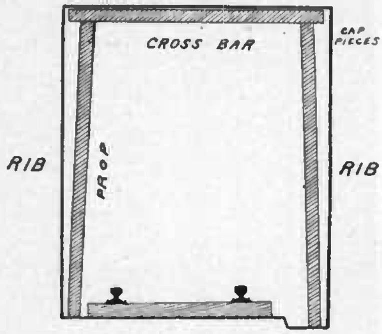

FIG. 2.—SET OF TIMBER.

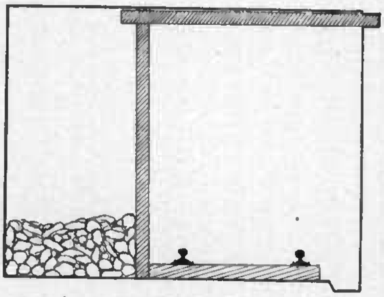

FIG. 3.—PROP WITH CROSS-BAR SET IN RIB.

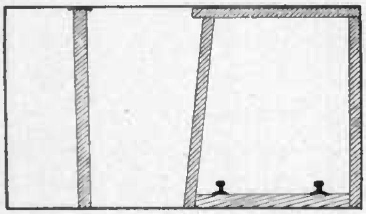

FIG. 4.—PROP AND SET-OF-TIMBER.

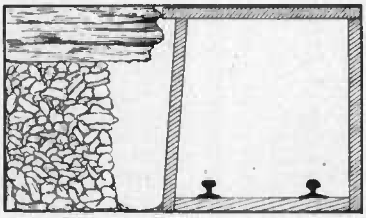

FIG. 5.—GOB AND SET-OF-TIMBER.

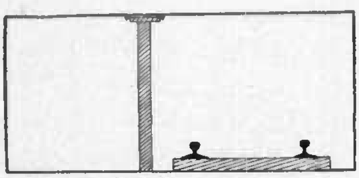

FIG. 6.—PROP AND CAP PIECE.

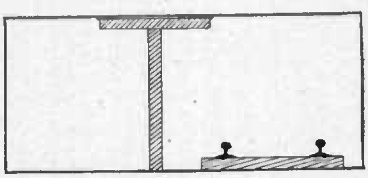

FIG. 7.—PROP WITH CROSS-BAR WIDE CAP PIECE.

by sets of timber, and the other half is "gobbed," *i. e.*, part of the heading filled from payment to roof with rock (fig. 5). The expense of hauling this rock out of the mine is thus saved by gobbing it along the headings.

TIMBERING IN THE ROOMS.—The roof in the rooms may be supported by several ways of timbering. Sets of timber may be used there as along the headings (fig. 4). Usually but one side of the room is gobbed so that it may not interfere with drawing the pillars. In most instances wooden props are placed in lines near the center of the room about 2 to 8 feet apart. These props are a little shorter than the height of the room and a wooden wedge is driven between the top of the prop and the roof (fig. 6). Frequently the prop supports a wooden cap placed at right angles to the course of the room, and the prop and cap piece are wedged securely between the floor and roof by wedges (fig. 7). Until recently the rooms, and sometimes the headings, were timbered with a cross-bar supported at one end by a prop, the other end being let into the coal of the rib (fig. 3). This last method of timbering is, however, very dangerous and unsatisfactory and is not being used at any of the larger mines.

By agreement the operator supplies the miner with all the necessary timber free of cost. The miner, however, is compelled to keep his room or heading timbered as the working face is advanced without receiving extra pay for the same.

METHODS OF MINING

In a few mines the coal is mined entirely by pick. Unless the coal is very soft, mining entirely by pick increases the cost of operation and lowers the capacity of the mine—to say nothing of the increased labor to the miner. Usually the miner will first "mine" the coal by pick, *i. e.,* he will undercut, or cut at the top, or along the rib or ribs—depending upon the nature, thickness, and section of the coal seam, and also upon the character of the roof and floor. For instance, in the Consolidation Tyson Mine No. 9, a cut is made by pick at the top of the seam. This cut is 18 inches high at the face, and is made 5 feet back into the seam, the cut thinning down gradually until it is only 6 inches high. Having thus "mined" the coal by pick, the miner can shoot it out.

Instead of mining the coal by pick, electric mining machines are used in many mines, especially in those operating the smaller seams. There are machines which cut the coal at the top of the seam, at the bottom, or at any place in between. The section of the seam determines the position of the cut. These machines make a cut from rib to rib (side to side) across the entire working face of the room or heading. The cuts are made

3 to $5\frac{1}{2}$ feet back into the coal and from 5 to $8\frac{3}{4}$ inches high. The machines are carried on special cars. When in operation they are generally removed from the cars and pulled up to the working face. Two men operate one of the mining machines and go from room to room to cut the coal for the miners. The miner then has only to shoot the coal and load it into the mine cars.

In some mines the coal is not mined at all, but is "shot off the solid." This procedure is the cause of large quantities of shale becoming mixed with the coal, producing what is termed "dirty" coal.

To shoot the coal the miner drills a hole $1\frac{1}{2}$ inches in diameter and about 4 feet deep into the seam, at a varying angle to the seam at the

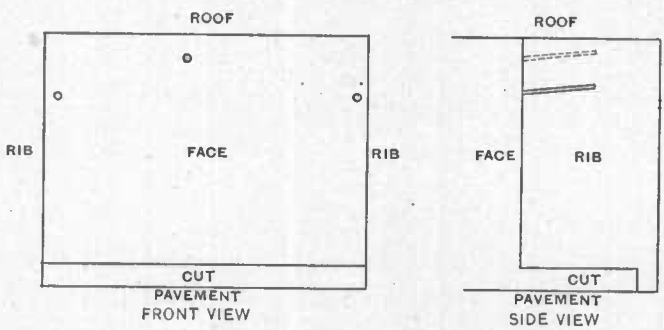

FIG. 8.—DIAGRAM SHOWING METHOD OF DRILLING.

working face. This hole is drilled by hand, using a 6-foot breast auger. If the coal has been undercut at the bottom, for instance, then a hole is placed in about the center of the face near the top, and another at each rib a little below the first (fig. 8). The hole is cleaned out by means of a small scraper, and from 6 to 14 inches of black powder inserted in a paper cartridge. The hole is then filled and tamped with wet coal dust, a most dangerous and reprehensible practice. A small rod, called a "needle," some $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter, is left in the hole while it is being tamped. After this operation the needle is pulled out leaving a small tube-like space for the squib to reach and explode the powder.

The number of tons of coal shot per can of powder varies with the size and character of the coal seam. At a few mines 80 to 90 tons of coal are shot per 25 pounds of black powder. These figures are higher than the average, which is placed by numerous operators as between 50 and 80 tons per can.

In most of the mines some top rock has to be "shot down," or bottom rock "shot up," in the headings to provide sufficient clearance for mules and haulage motors. At least 4½ feet of clearance above the top of the rails is necessary for the best results in the haulage headings. As a general rule, however, neither top nor bottom rock is removed in the rooms. There are a few rare exceptions to this rule, as for example in the mine of the Miller and Greene Coal Company, where one foot of bastard fireclay bottom is removed to provide sufficient clearance for mine cars to be used in the rooms.

DRAWING PILLARS.—Drawing pillars, *i. e.*, mining the coal from the pillars left standing when the rooms are broken off, is one of the most important steps in the mining of coal, for it depends upon the pillar work whether the most complete recovery of coal is obtained. It is the general policy of some coal operators to draw their pillars as the work advances, while other operators draw their pillars as return work. That is to say, some companies wait until the headings have been driven to the boundary lines of their property and the panel headings and rooms all driven, before any of the coal is taken from the pillars. Other companies will, after the panel headings and rooms have been made, immediately start to draw their pillars. In either case a sufficient number of barrier pillars are left standing to protect the headings.

There is much to be said for and against either system of pillar drawing. By the retreating method, the rooms and panel headings must be kept timbered during the intervening period of cutting them and drawing the pillars. Also, unless the tracks are relaid, this method calls for an excessive supply of mine rails lying idle during this interval of time. On the other hand, if the pillars are drawn by advance work there is the possibility of squeezes and creeps being started, and large quantities of coal being lost beyond recovery. The latter method, however, has the advantage of producing a larger tonnage during the early development of the mine. Some operators believe that the recovery from certain coal seams is best achieved by one method, while other operators favor the reverse. Both methods are in use now throughout the five coal basins of the State.

The following is considered by all operators to be the most up-to-date and economical method of drawing pillars in thick seams. This method, often called the "Rectangular Method of Pillar Drawing," is so planned as to avoid all sharp angles, as the coal crumbles and squeezes if the

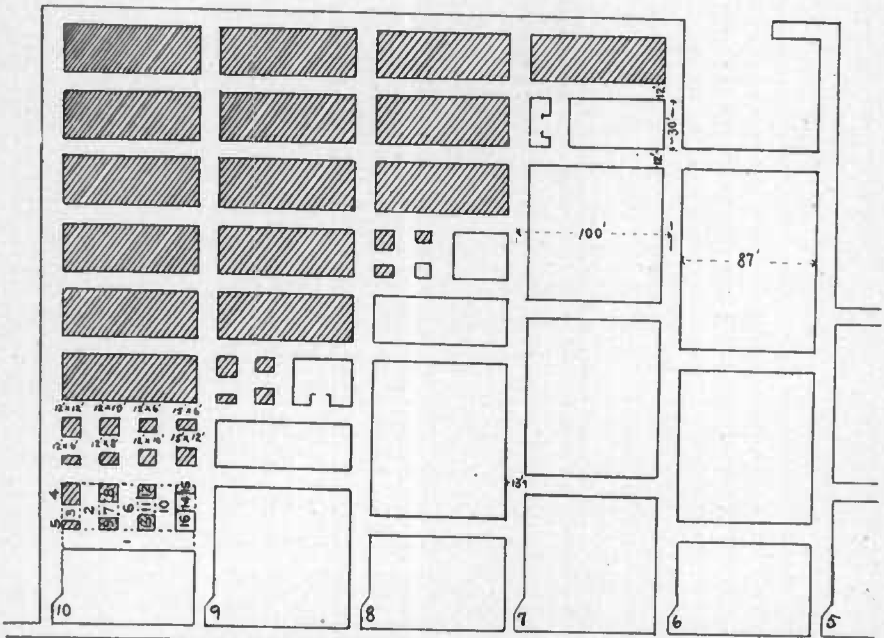

FIG. 9.—DIAGRAM SHOWING METHOD EMPLOYED IN RECOVERING COAL FROM THE PILLARS.

pillar ends in sharp angles. To illustrate this method a typical example is given in the following sketch (fig. 9). To simplify the explanation we will describe the method by applying it to a mine where the pillars of coal left standing measure 72 feet long by 87 feet wide. The work on such a pillar is first started by making a 12-foot cut through the last pillar of the last cut room (*i. e.*, in this case Room No. 10), separating a block of coal 30 feet wide by 87 feet long. This block of coal is then subdivided into smaller blocks varying in size from 6 feet by 12 feet to

15 feet by 12 feet, in the order shown by the numbers in the illustration. The smallest blocks are removed first and the largest blocks are cut last, because it is on these that the greatest pressure is manifested in the removal of the original block cut from the pillar. When this block has been removed, another cut is made into the same pillar and the process repeated. The pillar line is kept approximately on an angle of 45° to the rooms. It is sometimes found impossible to take the small blocks out clean because the gob from the preceding work runs in on the new cut. Under such circumstance a line of props is set on the upper side of the large block to keep this gob from running in when the small blocks below are removed. This method of drawing pillars should result (theoretically) in an average recovery of about 95 per cent of the coal, and also protect the workings against creeps and squeezes.

Much of the coal from the Georges Creek region is recovered from the abandoned workings of previous operations. This being the case the above method of drawing pillars cannot always be applied. In many instances the recovery is not as complete as the method described above would imply. As much coal as possible with safety of the mines is "hogged" from the ribs of pillars before the roof falls. Recovery of coal from abandoned workings requires the handling of much rock and use of many props. This feature in itself would account for the fact that the average production cost per ton in the Georges Creek region is higher than that in the Upper Potomac region where the development in the main is in virgin beds of coal.

VENTILATION

MEANS OF VENTILATION.—The ventilation of most of the fuel mines of the state is by natural means. That is to say, no attention at all is given to the ventilation of the workings. It is only when ten or more men are employed in a mine that the mining laws of the state can be enforced. According to these laws not less than 100 cubic feet of fresh air per minute must be supplied to each person employed in the mine. A modification of this law permits the Mine Inspector to allow the supply of air to be reduced from 100 cubic feet to 80 cubic feet per minute per man in old workings. Therefore, the methods of ventilation described below apply only to those mines in which ten men, or over, are employed.

In early days the mines were ventilated by an air shaft driven through the overlying strata to the surface. Where this shaft pierced the surface a wooden stack or chimney, about 50 to 70 feet high, was built to assist in producing a current of air. At the bottom of the air shaft a fire was kept burning all the time. In many cases a stone or brick furnace was built to protect the surrounding coal from catching on fire. Iron pipes or rails were used as grating for this crude furnace. The object in having a fire was to heat the surrounding air, causing it to rise up the shaft and pass out of the mine. The ascending air was replaced by foul air from the surrounding workings, and a corresponding amount of fresh air was drawn into the mine at the entry. This system of ventilation is still used in a number of mines.

With an increase in the size of the mines, it was found that the required amount of air could not be obtained by this method. Therefore fans were used which either force fresh air into the mine (so-called force fans) or which drawn the foul air out of the mines (so-called exhaust fans). The same fan may be used for either purpose, depending upon the direction in which it is caused to revolve. The majority of the operators in Maryland prefer to run their fans compressively, forcing fresh air into the mine through the air course. At the present time only five mines are ventilated by exhaust fans. The chief objection to exhaust fans is that they draw out black damp from the old workings and then circulate this gas through the mine before it finally reaches the surface. The force fans, on the other hand, maintain a pressure of air in the mine sufficient to drive all black damp back into the old workings where its presence does not affect the air in the live workings.

Of course the circulating air must be directed in a determined path through the workings of the mine. The air enters the mine by the air course which has been driven parallel with the main haulage way. When the panel headings are reached part of this current of air is split off and forced into headings and rooms of that panel. In like manner all the headings and rooms receive their allotment of fresh air. The air having passed through the rooms of one panel is returned directly towards the mouth of the mine, and not towards the next panel. Each series of rooms off a panel heading receives fresh air (fig. 2). The return air passes out of the mine through the main haulage way.

To direct the air current doors, brattices, overcasts, and regulators are used. The wooden doors used are constructed so as to close in the direction in which the air current travels. They are usually hung with the lower hinge driven farther into the post that supports them than the upper one, so that they close automatically. The automatically opening and closing doors used at the Washington Mine No. 2 of the Piedmont and Georges Creek Coal Company warrant special mention. In the main entry of this mine are two sets of doors, one set of steel and the second of wood. The pressure of the trip of cars on a tripper rail regulates the opening of these doors to allow the trip to pass through; and upon release of the pressure upon the rail, the doors swing shut again. Brattices are built across headings or cross-cut to prevent the air current from taking a short cut to the return air-ways before circulating through the workings. They are constructed of wood, closely packed gob, brick, or concrete. A regulator is a brattice having an opening covered with a slide. Adjustment of this slide controls the amount of air passing through the regulator. Overcasts are used to carry the air over the top of a heading. They are built of wood, brick, or concrete. Sometimes temporary doors and brattices are made by stretching a strip of canvas across the heading. At times a long strip of canvas is stretched parallel to one rib of a heading dividing it into two parts. The air is driven back of the canvas to the working face, securing a temporary circulation of air.

GASES.—There is very little fire-damp in the coal mines of Maryland. The gas has been found occasionally in mines operating the Waynesburg and "Big Vein" coal seams. Although they are practically free from fire-damp, large quantities of black damp, or carbon dioxide, are present in many mines of the region, particularly in those mines that have much "worked-out" territory adjoining them. From these old workings, especially at times of a change from high to low barometer, the black damp pours into the mine. If the mine is properly ventilated no serious trouble will be experienced by this gas.

The miners use either small oil or carbide lamps (fig. 10) which they wear on their caps. No safety lamps are used in any mine in the State. While an electric light is generally placed at all switches along the main haulage headings, the underground pump rooms and workshops are also illuminated by electricity.

DRAINAGE

Many mines of the State are drained by natural means. In such mines the lowest workings are above the water level of the streams. The drift entry is made into the lowest part of the seam and the workings advanced

FIG. 10.—MINERS CARBIDE LAMP.

in the direction of the rise. Under such ideal conditions the mine water is drained in ditches by gravity from the inside workings out through the drift entry to the surface.

Although a large percentage of the mines of the region are naturally drained, yet there are many others in which artificial methods of drainage must be used. In the latter case, a "sump" is generally made by excavating the strata beneath the coal bed at the lowest part of the mine, so that all the mine water can be drained into it through ditches dug along the headings leading toward the sump or pumped into it by small pumps. The water thus collected in the sump is pumped to the surface by steam, compressed air, or electric pumps of various designs and capacities. This method of drainage is used in drift, slope, and shaft mines. In all mines, however, there are local depressions or swamps of various sizes which are drained temporarily by hand pumps, siphons, steam pumps or by small portable electric pumps.

The drainage system of the mines of the Consolidation Coal Company is the most elaborate employed in the state. The Hoffman Drainage Tunnel, together with its two auxiliary tunnels, the Midland Drainage Tunnel and the Allegany Water Ditch, will be described in some detail under the Consolidation Coal Company's mines. Several other ingenious schemes to drain mines will be mentioned in the next chapter under the description of various mines.

HAULAGE

MINE CARS.—Various types of mine cars are used throughout the coal region of the state. Many standard makes are used, such as the Watt, Barnesville, Hockensmith, Fairmont, Punxsutawney, etc. In addition are some designed and made by the carpenters at the various mines. Even a few of the Old Potomac "Big Vein" mine cars are still being used by some operators. It is therefore undesirable to give a detailed description of all the types of mine cars now in use in the region, so that only those general features which are common to most of them will be discussed here.

The cars are generally constructed so that they are wider at the top than at the bottom, the sides having a flare or batter, the top of the car projecting as far as the outside of the wheels, or beyond. The body of the car is usually made of wood, oak being preferred, and has wooden or iron ribs to re-enforce the sides. A front board is usually built above the gate end of the car to keep the coal in place when the car is run down the gravity planes. Some types of mine cars have the body made entirely of steel. The roller bearing trucks are always made of iron or steel. The wheels revolve on their axle and not with the axle as do the wheels of a railroad car. Each car is provided with an end gate hinged at the top and kept closed by various devices which must be released before the car is dumped. Each car is also furnished with a brake to control it on grades. Various types are used. A form frequently employed in the past consisted of a 3 by 12-inch block wheel which was placed between the wheels and pressed down by a lever at the side of the car. This brake had not sufficient power to control the cars on heavy grades where the brakeman would insert a piece of wood or iron, called a "sprag," between the spokes of the wheels. This prevents the wheel from revolving and stops the car. What is known as the double brake is now used on most of the mine cars. An iron bar passes under the car and operates a pair of wooden blocks between the wheels on each side of the car. On some types of cars the brake lever is placed at the end of the car rather than on the side.

The capacity of the cars varies from 4 to 8 bushels (cars used in fuel mines) to 2½ tons. The majority of the cars average 1 ton 8 cwt. In loading the fine coal is first shovelled into the bed of the car and the lumps are used to build up, or "top" the car with a cap of coal 12 to 18 inches above the level of the body.

TRACKS.—Various types of mine tracks are used. In the larger mines the gauge of the tracks range from 36 to 48 inches. Steel T-rails weighing from 15 to 45 pounds per yard are laid in the headings, while 12- to 30-pound rails are employed in the rooms. The tracks are laid upon hewn or sawed cross-ties which are placed 18 to 30 inches apart. Some of the shipping mines of the Georges Creek and Upper Potomac basins use wooden tracks in the rooms, but in such cases strap-iron is generally nailed upon these rails to prevent wear and to lessen friction. In most mines where the grade in the headings or rooms is rather steep, sand rails are used. The latter are made by nailing wooden strips some 4 inches wide along the outside of the tracks upon which sand is thrown to increase the friction and keep the haulage motors or mine cars from slipping. The wooden rails are made of sawed lumber, varying in size from 4 inches by 4 inches to 3 inches wide and 2 inches thick. They are laid upon iron angle ties to which the rails are attached by clamps. The angle ties are then laid on the pavement.

As the room advances the tracks are laid so that the mine cars can always stand on the track near the working face. The tracks are turned into the cross-cuts where pillars are being drawn; and as the pillars are removed the tracks are taken up again so that they may not be lost under the fall. Practically no attempt, save only the crudest, is made to grade the tracks in the rooms. The grading of the tracks along the haulage ways is an important factor in increasing the efficiency of the primary haulage motors.

In the small fuel mines of the Castleman, Friendsville, and Oakland basins wooden tracks are commonly placed in the headings while no tracks are used in the rooms. The gauge of the tracks ranges from 24 inches to 36 inches in the small mines.

The turn-outs, or switches, are generally manufactured at the mine. Sometimes the frogs are cut and riveted to steel plates. The latches (switch points) are from 18 inches to 8 feet long, well connected with tie rods. Frequently they have a ground throw-lever, or switch ball, for throwing them. These switches are laid according to a fixed method, so that each frog has the same relative position with reference to the room, and the curvature of the switch and the turn inside of the switch are the same except in a few instances. The most satisfactory results have been obtained from laying the curves on 63-foot centers, in which case the cars can take the curves safely.

In mines having rope haulage, sheaves or rollers are fastened to the cross-ties to guide the rope and reduce the friction. On straight roads these rollers are of wood, revolving on an iron or wooden spindle. They are kept in position by two wooden supports, each of which has a horizontal hole of slightly larger diameter than the axle of the roller which revolves in it. The roller supports are nailed across two adjoining cross-ties in the middle of the mine track. On curves the ropes are kept in position by iron sheaves revolving on a vertical axle. Where electric haulage systems are used in a mine the tracks are bonded with channel pins and 2/0 copper wire or with standard 2/0 and 4/0 compressed terminal bonds.

Methods of Haulage.—The haulage inside the mine depends entirely upon the location of the mine, the size of the workings, and the thickness of the coal seam. Many of the shipping mines in the Georges Creek basin use electric haulage, the power for which is either purchased or is made in the company's power house at the mines. In the Upper Potomac basin a much smaller percentage of the mines employ electric haulage; the majority using horses or mules. The haulage in the mines of the other three basins is chiefly by hand, though some use horses or mules.

In all the small fuel mines the inside haulage is by hand. That is to say, the miner, after loading his car, pushes it himself from the working face to the mouth of the mine. Indeed, in many instances, the coal seams worked in these fuel mines are too thin to permit even the smallest mules to be used for haulage. Also, in most cases, the output of the mines does not justify the added expense of shooting enough rock to obtain sufficient clearance for the use of mules or horses.

Several types of haulage are used at most mines. For convenience of discussion, they may be divided into two general classes which will be designated as primary and secondary. The latter will be considered first in order to follow the haulage of the coal from the inside working face to the tipple.

Secondary haulage, or gathering, consists in the placing of empty mine cars at the working faces and the gathering of the loaded cars. The loaded cars are hauled to the inside "lye," or switch, where they are made up into "trips" (trains of cars) of varying numbers, depending upon the system of primary haulage used at the mine. Horses, ponies, or mules are used chiefly for secondary haulage in most of the mines. Some, however, use electric motors, compressed-air locomotives or wire-rope haulage. Of the electric motors used for this purpose two types are prevalent in Maryland. One is of the storage battery type and the other the overhead trolley system. Locomotives of the second type are especially designed for gathering as they are equipped with an automatic reel attachment for carrying 300 to 500 feet of insulated cable conductor to be used in rooms and headings where there is no overhead wire. In such cases, when the gathering motor reaches that point in the heading where the overhead wire stops, the end of the cable is attached to the end of the trolley wire and automatically "paid out" as the motor advances and also automatically rewound in even layers and with uniform tension as the motor returns to this point. Motors of the latter type are used in the Washington Mines Nos. 1, 2, and 5 of the Piedmont and Georges Creek Coal Company. The Consolidation Coal Company uses small compressed-air locomotives in one or two of their mines for secondary haulage. In a few mines where the pitch of the coal seam is heavy or at a high angle, *i. e.,* to the horizontal toward the sides of the basins, part of the secondary haulage is performed by various systems of wire-rope haulage. This wire-rope haulage may be either gravity planes or a system of winding rope around the drums of a stationary steam or electric-hoisting engine. Gravity planes will be described later in detail. Suffice it to say that the loads passing down one heading pull the empties up a parallel heading or up a parallel track on the same heading. Haulage by inside gravity planes is used in several mines of the Georges Creek Coal Company, Inc.

Primary haulage in the mine embraces the haulage of mine cars from the inside "lye" to the tipple. The inside "lye" is a switch laid some distance in from the entry along the main haulage way. The distance from the entry varies from 800 to 7500 feet, depending upon the size and plan of development of the mine. The empty mine cars are pulled into the mine to this "lye," from which they are distributed to the working faces by secondary haulage. The loaded mine cars, gathered from the working faces, are all brought together to the "lyes" where a sufficient number are coupled together to make up a "trip." The number of empty and loaded cars hauled in a "trip" depends upon the system of primary haulage. In many mines horses and mules are used for primary haulage, and in such cases they are generally used in string-teams of two or three, and are able to haul probably six to ten mine cars. Electric motors, gasoline motors, steam and compressed-air locomotives are also used for primary haulage. These primary haulage motors are always larger than those used for secondary haulage. The usual "trips" consist of from 10 to 30 mine cars.

In some mines stationary hoisting engines, either steam or electric, are used for the primary haulage, especially if the entrance to the mine is by means of a slope. In a tail-rope system, the rope for pulling the empty cars into the mine (called the tail-rope) is carried along the side of the track and is guided and kept in position by iron sheaves. At the inside end of the haulage entry the tail-rope passes around a large iron sheave placed horizontally, called a "bull wheel." The tail rope then returns toward the mouth of the mine down the center of the haulage track. The end of this tail-rope is fastened to the inside end of a trip of empty cars, and by it the trip is pulled into the mine. Another rope is attached to the other end of the trip, and as the tail rope pulls the trip in, the pulling rope is unwound from its drum and taken in with it. The pulling rope is fastened to the front end and the tail-rope to the last car of the trip of "loads" standing at the inside "lye." This trip of loaded cars is then pulled out of the mine by the pulling rope, and the tail-rope is pulled out at the same time. Each rope is wound on a separate drum, working independently of each other. Each drum has a clutch so that the engineer can cause it either to revolve on its shaft or to turn with its shaft as required. Both drums are operated by one stationary engine, which is usually placed outside the mine.

GRAVITY PLANES.—In many instances the mine openings are situated at a considerable elevation above the railroads. In such cases the coal is brought down to the railroads by a gravity plane or series of gravity planes. The three or four rails used on these planes are laid on wooded cross-ties which are set on a graded bed. When three rails only are used, a "turn-out" is made at a point midway between the termini which is large enough to allow the two trips to pass each other. A rope, attached to the hind end of the trip of loaded cars, passes around a series of sheave wheels or drums in the wheel house at the top of the plane and stretches down to the bottom of the plane where the end is attached to the front of the "trip" of empties. Wooden rollers are set at intervals along the tracks to lessen the wear and friction on the rope. The loaded cars pull up a corresponding number of empties. The "trip" consists of 1 to 8 cars. The speed of the cars is regulated by brake-bands acting on the wheels or drums at the head of the plane, and are controlled by a lever operated by the man who "runs the plane." In place of a gravity plane a Roebling Twin Bucket Aerial Tramway is used at the mines of the Hamill Coal and Coke Company to convey the coal from the mouth of the mines to the tipple.

SIGNALS.—When wire-rope haulage is used inside the mine, signals are employed to notify the engineer in the power house when to move and when to stop the "trip." For this purpose two parallel wires, which are about 6 inches apart, are attached to insulated supports on the rib of the haulage entries or on posts, and are connected with an electric battery which operates an electric gong in the engine house. The brakeman who accompanies the trip carries a small metal bar with which he makes a connection between the two wires, completing the circuit and ringing the bell in the engine house to indicate his desire to stop, or move the trip in or out of the mine.

It is necessary for the man who connects and disconnects the rope at the foot of the plane, to signal to the man at the top, who controls the brakes and "runs the plane," when to let down the trip. Telephones are generally used for this purpose, although sometimes the signal is given by waving the arm.

Where the entrance to a mine is by shaft the system of signaling used is either by telephone, electric bells, compressed air, or speaking tubes. In the Tyson mine of the Maryland Coal Company quite an elaborate system of colored electric lights is used as block signals for the haulage motors.

RECEIVING AND SHIPPING THE COAL

WEIGHING THE COAL.—Each loaded mine car bears the check of the miner (or miners) who has loaded it. The man who weighs the coal—the "weight boss"—takes this check off the car and credits the weight of the coal to the miner whose name appears on the daily weight sheet opposite the number of the check. The tare weight of all the cars is known and the scales are set to allow for that weight. With the exception of two or three mines, the miners are paid by the ton, so that the mine scales must be continually tested and examined by the State Mine Inspector.

As a rule the scales for weighing the mine cars are located on the tipple structure from 20 to 25 feet in front of the tipple proper, and a small building encloses the weighing beams and also affords shelter to the man who weighs the coal. At a very few mines the scales are situated at the top of the gravity plane or at the mouth of the mine. Fairbanks Standard Scales are used by most of the operators, and a few of the larger shipping mines have automatic scales of the same make.

At a few mines there is a weight office, sometimes called a manifest office, located a short distance below the tipple where each railroad car is weighed after it has been loaded.

CLEANING THE COAL.—The coal is usually loaded directly into the railroad car from the mine cars. The miner is instructed to pick out as much slate, bone, and rock as possible when loading the mine car, but conditions under which he works do not permit him to clean the coal very thoroughly. Several men, called "slate pickers," are hence employed to pick shale, etc., from the coal as it is being loaded into the railroad cars at the tipple. At a few mines the coal is further systematically cleaned at the tipple by passing it over screens and picking tables in order that all of the shale, bone, and rock may be removed before loading it upon the railroad cars. No attempt is made to clean the fine coal (the so-called "slack") which passed through the screens. After passing over the picking tables, the coal may be further screened to classify it by size into nut, lump, etc., or the slack may be remixed with the lump and the whole sold on the market as "run of mine." The various types of screens and picking tables used for this purpose may be illustrated by those in use at the mines of the Georges Creek-Parker Coal Company, the Piedmont and Georges Creek Coal Company, the Monroe Coal Mining Company, the New York Mining Company, etc.

TIPPLES.—When tipples are located at the foot of gravity planes they are, wherever possible, built out of line with the plane so that "run-away" cars will jump the track at the foot of the plane and not wreck the tipple. As a further precaution safety latches or switches are used on most planes. The tipple structure is always built of wood. Since the advent of the high 100,000-pound capacity steel railroad cars, these structures have been built so that the mine car tracks are at least 22 feet above the railroad tracks. The track returning from the tipple has a down grade to allow the empty mine cars to run off the tipple by gravity.

Automatic pin-pulling devices for the purpose of saving labor in dumping the cars are used at most tipples. These applications are of different patterns, some of which are quite ingenious. Where end-dumps are used the loaded mine car is tilted forward over the end of the tipple—its weight being counterbalanced by weights of various types. Cross-over dumps are used on some tipples which "break" in the middle, throwing the loaded car forward to empty its contents; then rising again to its original horizontal position. The next approaching loaded mine car then bumps the empty forward and over the cross-over dump to the returning side track for the empty cars.

STORAGE BINS.—At the tipples of some mines, storage bins have been constructed into which the coal may be dumped when there is a shortage of railroad cars for shipment, so that the operations at the mines do not need to be interrupted on account of car shortages. Different types of such bins may be seen at the mines of the Davis Coal and Coke Company, the Piedmont and Georges Creek Coal Company, the Hamill Coal and Coke Company, and others.

SIDINGS.—The railroad sidings are constructed with slight grades passing the tipples so that the empty and loaded cars will run easily and at the same time be controlled while running towards or away from the tipple. From 1½ to 2 per cent grades are given to these sidings. The railroad cars are controlled by their brakes and by blocks of wood which the car runner places on the rails in front of the wheels. Some few mines use a mechanical railroad car retarder while loading the car at the tipple.

LABOR

CONDITIONS OF WORK.—The ideal working condition, from the miner's point of view, is for two men to mine coal in each room. This condition grew out of the old custom of the miner and his assistant working together (usually father and son in the early days) when the methods of mining were entirely different from those in use to-day. At many mines this condition is still adhered to. The one noticeable exception, however, is the "Big Vein" workings of the Consolidation Coal Company, where as many as 16 men are employed in the same room.

The miner's picks are sharpened and his tools kept in order by the blacksmith employed by the operator. One cent per ton is usually deducted from the miner's earnings to cover this expense. The company also sells the miner small cans of black powder at the wholesale market price. All necessary timber is furnished to the miner by the operator free of charge and in return the miner does not receive extra pay for keeping his room or heading timbered.

UNIONS.—The Georges Creek and Upper Potomac regions are classified at the present time as non-union; that is to say, the union is not officially recognized by the coal operators, although all mine committees (elected by miners to represent their interests) receive prompt recognition and courteous treatment by the operators. During the history of the coal-mining industry of Maryland there have been several attempts to form labor unions among the miners, but up to the summer of 1917 they did not meet with much success. During the summer of 1917 a new effort was made by the United Mine Workers of America to organize the miners into a union. At the present time (May 6, 1918) there exists an agreement between the operators and miners of the Maryland coal fields setting forth definite working principles, wage scale, etc., this agreement to be in effect "during the continuance of the war, and in any event for at least two years, and thereafter subject to revision upon 90 days' notice by either of the parties."

WELFARE OF EMPLOYEES.—Many of the larger companies build houses which they rent to their employees. Practically all the companies operating in the Upper Potomac basin, and also a few in the Georges Creek basin, own their own mining towns. The town of Kempton, belonging to the Davis Coal and Coke Company, may be cited as an ideal mining town. This town is laid out after the most improved method, the sidewalks being all of cement and the town lighted by electricity. Each house is built on a separate lot of land, which is large enough for a lawn in front and a small garden in the rear. The houses have tile foundations, wooden structure, asbestos shingled roof, and all painted the same shade of gray. The town consists of 76 single houses of 4 and 6 rooms and 10 double houses of 10 rooms each. The company has a store there so that the people may be supplied with meat, vegetables, fruit, furniture, clothes, etc. A modern school and play grounds have recently been added for the children. For amusement and entertainment the company built an arcade building which contains a lunch room, barber shop, bowling alleys, pool tables, dancing floor, and an auditorium for plays, lectures, and moving pictures. A Mining Institute has been established at Kempton for the benefit of the employees of the company. At the meetings of this Institute lectures are given on the practical methods of mining, etc.

ALLEGANY COAL COMPANY

The Tacoma mines of the Allegany Coal Company are located at Franklin Hill between the mines of the Piedmont and Georges Creek Coal Company and the town of Westernport.

TACOMA MINE No. 1 (C, D-11).—Tacoma Mine No. 1 consists of two drift openings into the Piedmont (Six-foot) coal seam. The mine was originally opened in 1872 and until November 15, 1912, was operated as a fuel mine. Since that time, however, coal has been shipped. The coal in this mine averages about 5 feet 6 inches. Where sampled, Room No. 8 off First Right Heading, the coal measured as follows:

		Inches
Roof....	Rock.	
	Shale	3-6
	Coal	10
	Bone	6
	Coal	18
	Shale	1
Bottom..	Coal	26½
	Shale floor.	

The results of the analysis of this coal are shown in table of analyses, No. 1.

This mine has been developed on the Room and Pillar system. The mining is done by pick. The mine is ventilated by a furnace which produces some 6000 cubic feet of air per minute. The intake at the opening averages 18,900 cubic feet of air per minute. The drainage is natural. Haulage in the mine is by 5 mules. There are no scales at the tipple, the coal being weighed in the railroad cars by the Cumberland and Pennsylvania Railroad. Thirty-six one-ton Watt mine cars are used. The gauge of the mine tracks is 42 inches. At the tipple an end dump unloads the coal from the mine cars into a chute 70 feet long by 4 feet wide and 3 feet high, lined with sheet iron, from which the railroad cars are loaded sideways.

During 1918 an average of 38 miners and 7 laborers were employed at this mine. The output for the year was 49,542 tons.

TACOMA MINE No. 2, Thomas (C, D-11).—The drift opening to Tacoma Mine No. 2 is located on the same property about 600 feet northwest of the Tacoma Mine No. 1. The work of opening this mine was started in February of 1917, and although the first shipment was made in June of the same year, the mine has not been operating continuously since that time.

The average section of the coal bed at this time is:

Soapstone roof.	Inches
Bone coal (containing pyrite)	3
Coal	5
Bone	5
Coal	21
Brown shale floor.	

The mine workings are being developed on the Room and Pillar system. Both ventilation and drainage are by natural means. The haulage in the mine is by 1 mule. Fifteen one-ton mine cars are in use. Sixteen-pound T-rails are laid throughout the mine for 42-inch gauge tracks. The coal from this mine is hauled over an 800-foot tramroad to a tipple. There the coal unloaded from the mine cars over an end dump, passed down a 350-foot timber chute, lined with sheet iron, into railroad cars standing sidewise. No scales are used, the coal being weighed in railroad cars by the Cumberland and Pennsylvania Railroad.

TACOMA MINE No. 3, Thomas (C, D-11).—Tacoma Mine No. 3 is a double-drift opening into the same seam of coal as No. 2 and on the same property. This mine was opened on August 15, 1917, and the first shipment was made on October 29 of the same year.

The average section of the seam in this mine shows:

Shale roof.	Inches
Coal	20
Rock	9
Coal	28
Brown shale floor.	

This mine is developed on the Room and Pillar system and the mining is by pick. The ventilation and drainage are natural. One mule is used for haulage. The capacity of the mine cars used is $1\frac{1}{4}$ tons. The 42-inch gauge mine track is laid with 25-pound T-rail. This mine, similar to Tacoma Mine No. 2, has never been operated continuously since it was opened.

BRAILER MINING COMPANY

The Brailer Mining Company, formerly the Georges Creek and Bald Knob Coal Company, operates the Bald Knob mines which are situated in a detached area of the "Big Vein" coal seam at the extreme northern end of the Georges Creek coal basin, 1.5 miles north of the town of Mount Savage. The mines were originally opened in 1903-4 by the Georges Creek and Bald Knob Coal Company and were operated for several years as shipping mines. During the period from 1906 to 1916 they were operated as local fuel mines, but resumed shipments in October, 1916, under the management of the Brailer Mining Company.

The Bald Knob mine (B-3; B, C-2, 3) consists of four double-drift openings into the "Big Vein" coal seam and one drift opening into the Redstone coal seam. The operations in the Redstone seam are not being worked at present. An average section of the "Big Vein" coal seam shows:

Shale roof.	Inches
Bone	½
Coal	6
Bone	½
Coal	4
Black Jack	1
Coal	23
Slate	1½
Coal	24

The old workings in the mine were developed on the Room and Pillar system while the new development has been by the Panel system. Both ventilation and drainage are by natural means. The secondary haulage is by 6 mules and 1 horse. The primary haulage, from the inside lye (600 feet from mouth of entry), out and along the outside tramroad (375 feet long) to head of plane is by a string team of 2 mules. Forty-seven 2-ton Belt mine cars (home made) with a tare weight of 1700 pounds are used. The gauge of the mine tracks is 42 inches. Thirty-pound T-rails are used inside and 40-pound T-rails along outside tram-road. The coal is lowered in 5-car trips down an incline plane 4700 feet long (with a grade of 13 to 22 degrees) by means of a 75 h. p. double-cylinder Exeter steam hoist. Steam for this hoist is supplied by a 60 h. p. Erie City boiler. The mine cars, after being weighed on Fairbanks scales, are unloaded over an end dump at the tipple into railroad cars, loading same sidewise. The tipple is located at Mount Savage on a spur of the Cumberland and Pennsylvania Railroad, passing through the property of the Union Mining Company.

During 1918 an average of 45 miners and 9 laborers were employed. The output for the year was 61,773 tons.

THE BROPHY-HITCHINS COAL COMPANY

The Brophy-Hitchens Coal Company is opening both the Tyson and Redstone coal seams on the Bowery Furnace and Borden Shaft properties near the town of Midlothian.

REDSTONE MINE (C-5, 6).—Two drift openings have been driven into the Redstone coal seam at this mine. The first shipments were made during April, 1918. An average section of the coal seam in this mine shows:

	Inches
Shale grading to bastard fire-clay	12-15
Coal	3
Bone	15-20
Shale	8-18
Coal	25-30
Shale bottom.	

The mine workings are being developed on the Room and Panel system. The workings are ventilated by a 6-foot Jeffrey disc fan which is driven by a 15 h. p. electric motor of the same manufacture. The drainage is by natural means. Two Jeffrey Arc Wall mining machines are used to mine the coal. The haulage is by two 6-ton Jeffrey electric gathering locomotives, having reel attachments. Twenty 2-ton mine cars are in use. These cars have Sanford Day roller-bearing trucks with steel and wood sides reinforced with iron ribs. At the tipple the coal is weighed on Fairbanks scales and loaded into railroad cars over a cross-over dump.

The shipping point is Midlothian on the Midlothian branch of the Cumberland and Pennsylvania Railroad.

TYSON MINE (C-6).—A slope entry was started during September, 1918, into the Tyson coal seam. At the present time both ventilation and drainage are by natural means. The haulage is performed by the same electric locomotives mentioned above. The method of mining will be the Room and Pillar system and mining machines will not be used. At present 15 one-ton Watt mine cars are used. The Tyson slope is connected with the above-mentioned tipple by a 2000-foot tramroad.

The gauge of the mine tracks in both mines is 42 inches. Thirty 5-pound steel T-rails are used outside and along main haulage headings inside. Sixteen- and 20-pound steel T-rails are used in the rooms.

A brick substation has been built at the mines. Here the 6600-volt A. C. power purchased from the Hagerstown and Frederick Railway Company is stepped down to 2200-volt A. C. by transformers. A 2200-volt A. C. Westinghouse induction motor is direct-connected to a generator of same manufacture which produces 250-volt D. C. used for haulage and mining machines. The 2200-volt A. C. is stepped down to 440- and 220-volt A. C. used to operate fan, shop motors, lights, etc.

During 1918 an average of 5 miners and 25 laborers were employed at these mines, producing 5550 tons of coal.

CALEDONIA COAL COMPANY

The Caledonia Coal Company is operating at present three mines: the Caledonia mines where both the Tyson and "Big Vein" coals are worked, and the Moscow Mine No. 1 in the Barton coal. The Caledonia mine is owned in fee, having been purchased from the American Coal Company on June 1, 1915. The mineral rights for Moscow Mine No. 1 were leased from Mr. A. B. Shaw on November 15, 1915. These mining rights were formerly held by W. A. Somerville and Brotzmarkle (from May to October, 1902); by the Askey Brothers (W. and D. Askey from January to April, 1908); and by J. F. Scott and W. Brownell (from June to December, 1910).

CALEDONIAN "BIG VEIN" MINE (C-10).—This mine is located on the west side of the Georges Creek Valley, three-fourths of a mile west of

Barton. Four drift openings have been made into the "Big Vein" seam at different places along the hillside. The coal seam here varies from 9 to 14 feet. The method of mining is all pillar and crop work, and accordingly the mining is by hand. The mine has natural ventilation and drainage. Twenty 2-ton (bedded) mine cars of 1820-pound tare weight are used for these workings. The gauge of track is 36 inches. The haulage in the mine is accomplished by 2 mules. There are three miles of tramroad from the openings to the top of the gravity plane, the haulage along this tramroad being by means of an 18-ton Vulcan dinkey engine. The gravity plane, which is 2700 feet long, connects the mine with the tipple located on the Cumberland and Pennsylvania Railroad. Coal is weighed at the tipple on Fairbanks Standard scales and loaded into the railroad cars over an end dump, loading the railroad car sidewise.

During the year 1918 an average of 25 miners and 3 laborers were employed at this mine. The total output of coal of the Caledonia Coal Company for the year was 101,529 tons.

THE CALEDONIA TYSON MINE (C-10).—The Tyson seam at this place is 110 feet above the "Big Vein." The coal at this mine varies from 6 to 7 feet thick. This coal requires much picking by the miners.

The following section is the average of several measurements:

	Inches
Shale roof.	
Coal	18-30
Shale	3
Coal	10-18
Shale	8-12
Coal	4-8
Shale	3-7
Coal	24-30
Shale bottom.	

The mining is all by pick and is confined to crop and pillar coal. The mine is ventilated and drained naturally. Forty mine cars are used here which have a capacity of 1½ tons (bedded). The tare weight of these cars is 1780 pounds. Gauge of the mine tracks is 36 inches. The haulage inside the mine is by 4 mules. One horse is used at the top of the plane to pull the cars off the head. There is a tramroad of some 600 feet between the mine openings and the top of the gravity plane. This plane is 400 feet long and has an average grade of 20 degrees. From the bottom of this plane, the cars are let down the plane of the "Big Vein" mine and the coal is shipped over the same tipple. Three loaded cars going down to plane pull up 3 empties and also pull 2 loaded cars along the tramroad from the mine openings to the head of the plane.

The company employed an average of 40 miners and 5 laborers at this mine.

MOSCOW MINE NO. 1 (C, D-9, 10).—This mine is located on the east side of the Georges Creek Valley about 1 mile northeast of the town of Barton. The coal seam was opened originally in 1902. The coal being mined here is the Barton seam which averages about 28 to 34 inches thick. The development of the workings is by the Room and Pillar system and the mining is all by pick work. The mine is artificially ventilated by a 6-foot Stine force fan which is directly connected to 20 h. p. Imperial electric motor. Two siphons, one placed inside the mine and the other outside, are used to drain the mine. Two mules are used for the haulage inside the mine. At this mine are 31 one-ton Barnesville mine cars. The gauge of the mine tracks is 42 inches. The coal is weighed on Fairbanks Standard scales at the tipple and loaded into railroad cars over an end dump.

During 1918 an average of 10 miners and 6 laborers were employed.

CHAPMAN COAL MINING COMPANY

The Chapman Coal Mining Company operates the Swanton mine at Barton, Maryland. The Swanton mine is developing the Barton coal seam.

SWANTON MINE (C-10).—This mine is a double-drift opening into the Barton coal seam, which here averages from 26 to 38 inches, although in places as high as 42 inches. The section of the seam where samples from the right rib at the face of the Sixth Right Heading was:

	Inches
Shale roof.	
Bone	18
Coal	28
Shale floor.	

The analysis of this coal is shown in table of analyses, No. 2.

The mine is developed on the Room and Pillar system and the mining is all by pick work. A 3-foot Crawford and McCrimmon force fan, belt-driven by a 10 h. p. Bessemer gas engine ventilates the mine. At 72 r. p. m. this fan produces 24,480 cubic feet of air per minute. The drainage is natural. The haulage in the mine is by 16 mules. One hundred and thirty 1-ton mine cars are used, which are remodeled after the Watt and Barnesville types. Gauge of the mine tracks is 42 inches. The mine cars are let down a gravity plane 500 feet long in 3-car trips to the tipple, which is located on a siding of the Cumberland and Pennsylvania Railroad at Barton. The cars are weighed on Fairbanks Standard scales and coal loaded into 2 railroad cars over 2 end dumps. Seventy-five miners and 28 laborers were employed on an average at this mine during 1918, producing 83,899 tons of coal.

During 1918 neither "Big Vein" nor Tyson coals were mined at the Swanton mines. The Tyson mine was abandoned during 1917, the coal being all extracted by that time. The workings in the "Big Vein" were also abandoned during 1917 for similar reason. However, quite a large reserve of "Big Vein" coal was discovered in the same hill several miles west of the old abandoned "Big Vein" workings and on February 1, 1919, the company started to construct a tramroad around the hillside to these new openings.

LITTLE PITTSBURGH MINE.—Years ago an opening was made into the Little Pittsburgh coal seam by the company, but the venture proved a commercial failure at that time. All the equipment for this mine has been removed. A sample of this coal was obtained and, at the place where it was sampled, it showed the following section:

Shale roof.	Inches
Coal	3
Shale	1
Coal	22¾
Shale bottom.	

The analysis of this coal is shown in table of analyses, No. 3.

CLAIR COAL COMPANY

The Clair Coal Company is operating the Penn Mine No. 1 (B, C-11) which is located on the west side of Georges Creek Valley about one-half mile north of Franklin Station on the Cumberland and Pennsylvania Railroad. Two drift entries have been made into the Barton coal seam. The coal in this mine varies from 24 to 42 inches thick. The mine has been developed on the Room and Pillar system and the mining is all done by pick work. The mine is ventilated by an 8-foot Stine exhaust fan which is belt-connected to a 10 h. p. Stine steam engine. (For economic reasons a 12 h. p. gasoline engine is at present used to operate fan instead of the steam engine.) At 54 r. p. m. this fan produces 72,000 cubic feet of air per minute. The drainage is natural. The haulage in the mine was by 8 mules. The company has 57 one-ton mine cars, having a tare weight of 1200 pounds. The gauge of the mine track is 42 inches. The mine is connected with the tipple by a 1300-foot gravity plane, having a grade of from 10 to 35 degrees. The coal is let down the plane in 3-car trips. The coal is weighed at the tipple on Fairbanks scales. The tipple is built of frame work covered with corrugated galvanized iron. It is provided with two end dumps, over which the coal is loaded into the railroad cars endwise; and two end dumps into wagon chutes. During 1918 the mine employed an average of 30 miners and 20 laborers and produced 49,209 tons of coal.

The Clair Coal Company opened the Six-foot seam on their property. The headings were stopped because of a rock fault or roll which was encountered. During November, 1918, arrangements were made between the Clair Coal Company and the Piedmont-Georges Creek Coal Company whereby the former company could use the mine workings of the latter's Washington Mine No. 3 and its equipment to advance headings to points behind the rock fault encountered when opening the seam from the former's property. Upon determination of nature of coal behind the fault and the position and dimensions of the latter, the Clair Coal Company may or may not develop this seam and drive a rock tunnel through the fault from their original opening.

Consolidation Coal Company

The mines of the Consolidation Coal Company extend from one mile north of the town of Frostburg south to Midland, occupying a greater part of the northern half of the Georges Creek coal basin. Within this territory are located the following mines:

Consolidation No. 1 mine at Ocean
Consolidation No. 2 mine at Carlos Junction
Consolidation No. 3 mine at Hoffman
Consolidation No. 4 mine at Eckhart
Consolidation No. 5 mine at Midland
Consolidation No. 6 mine at Woodland
Consolidation No. 7 mine at Lord
Consolidation No. 8 mine at Midland
Consolidation No. 9 mine at Frostburg
Consolidation No. 10 mine at Eckhart
Consolidation No. 11 mine at Pumping Shaft
Consolidation No. 12 mine at Borden Shaft
Consolidation No. 13 mine at Consolidation Village
Consolidation No. 14 mine at Allegany
Consolidation No. 15 mine at Vale Summit
Consolidation No. 16 mine near Vale Summit.

Consolidation Mines Nos. 1, 3, 4, 7, 8, 12, 13, 14, 15, and 16 are operating the "Big Vein" seam, while Nos. 2, 5, 6, 9, 10, and Tyson Nos. 7 and 13 are working in the Tyson seam. Of these latter mines, Nos. 2, 5, and Tyson No. 7 have been temporarily abandoned.

PITTSBURGH (BIG VEIN) MINES

The Pittsburgh or "Big Vein" seam operated by this company shows a workable section over 9 feet in thickness and is of uniformly excellent quality throughout. The method of mining adopted for all new work in this seam is the Room and Pillar system. This system is widely modified to conform with local conditions, but the general plan is to drive pairs of parallel side entries at intervals of from 400 to 500 feet. Rooms 13 feet wide are broken off these entries, preferably at right angles, on 100-foot centers, thus leaving an 87-foot pillar between the rooms. Cross-cuts and break-throughs are driven through the pillar at such distances as will conform with the state mining laws. Whenever possible this development is divided into sections or panels, each section or panel being pillared back separately. Every effort is made to have headings, rooms, and cross-cuts at right angles to each other, thus avoiding the poor recovery incidental to sharp angles. Pillar lines are carried at angles of about 45° to the rooms. All places, both advancing and retreating, are driven as pick work.

All of these mines are inclined toward, or are located in, the lowest point of the Georges Creek basin. Water filters through the overlying strata at the average of six gallons per acre per minute, thus necessitating the drainage of these mines—a very serious question. In 1903 the management decided to drive a tunnel two miles long on a grade of .3551 per cent from the lowest point of the basin (near the bottom of the No. 3 or Hoffman Slope) northeasterly to a point near Clarysville on Preston Run. This tunnel, known as the Hoffman Drainage Tunnel, was completed in 1906 and has satisfactorily handled the mine drainage ever since. Many local swamps or basins were encountered, and to drain these it was necessary to excavate 13 miles of ditch through the intervening "hills." An auxiliary tunnel, one-half mile long, was driven to connect the drainage system of the southern portion of the property with that of the northern. The Midland Drainage Tunnel (.10 mile long), together with a ditch .6 mile in length drains a local basin at the extreme end of the property; and the Allegany Water Ditch (.8 mile long) which is in part actually a tunnel, drains the extreme northern end.

These tunnels and ditches drain the entire property. There are, however, many small local depressions which cannot be economically ditched and the water accumulating therein is pumped into the drainage ditch by compressed air or electric pumps. The compressed air pumps are being gradually supplanted by electric pumps of the Aldridge Triplex and the De Laval Centrifugal types.

The fans ventilating the "Big Vein" mines are operated as force fans. A large percentage of brattices and overcasts were originally constructed of wood, but these are being replaced by brick and concrete structures.

The standard track gauge in all of this company's "Big Vein" mines is 36 inches. The standard mine car weighs approximately 1900 pounds and has a capacity of 5000 pounds of coal.

The construction of the tipples is very simple, provision being made only at Consolidation Mines Nos. 1, 3, and 7 for the dumping of more than one class of coal. The tipple at Consolidation Mine No. 7 is the only one of all 16 mines where provision has been made to load coal into box cars. All the coal before being unloaded from mine cars passes over and is weighed on Fairbanks Standard scales.

CONSOLIDATION MINE No. 1.—This slope mine is located near Ocean Station on the main line of the Cumberland and Pennsylvania Railroad. The slope entry is 2700 feet long. The following constituted an average section of the seam in this mine:

	Feet	Inches
Coal	5	11
Shale	0	¾ to 2
Coal	0	6
Shale	0	1
Coal	1	0
Shale	0	¼
Coal	1	5
	9	

An analysis of this coal is given in table of analyses, No. 4.

Twenty-five horses haul the coal from the working face to the motor side tracks. Two large compressed-air locomotives take it from these tracks to the bottom of the slope, from which point it is hoisted to the surface in 23-car trips by a Dixon Second Motion 18 by 36-inch hoisting engine. The slate is handled outside by a 5-ton electric lorry made by the Connellsville Manufacturing and Mine Supply Company, over same coal tipple.

The mine is ventilated by a Crawford and McCrimmon fan, 25 feet in diameter and 8 feet wide, running at a normal speed of 49 r. p. m. At this speed it produces 60,000 cubic feet of air per minute.

The power-house contains 11 boilers, having a total of 940 boiler horsepower, which furnish steam at an average pressure of 95 pounds for the fan, two high-stage and one low-stage air compressors, one A. C. and one D. C. generator, and the hoisting engine. One of the high-stage compressors is an Ingersol-Sargeant Duplex with a Cooper-Corliss engine, the other an Ingersol-Sargeant Air Compressor. The low-stage compressor is a 175 Ingersol-Rand. The A. C. Allis-Chalmers generator is direct-connected to a 16 by 14-inch Flemming engine and generates current for lighting purposes at 2200 volts. The direct current is produced by a 250-volt 150 k. w. Westinghouse generator which is belt-connected to an 18 by 18¾-inch Buckeye engine.

During 1918 there were employed at this mine 232 men who produced 231,752 net tons of coal.

CONSOLIDATION MINE NO. 3 (C, D-5).—This mine has a slope entry 7100 feet long. The outside plant is located at Hoffman Village on the Cumberland and Pennsylvania Railroad.

The following is a section of the coal in this mine:

	Feet	Inches
Shale roof.		
Coal	5	9
Shale	0	½
Coal	0	7
Shale	0	1
Coal	1	1½
Shale	0	½
Coal	1	4
Shale floor.		
	8	11½

An analysis of this coal is given in table of analyses, No. 5.

The coal is gathered at the working face by 19 horses and hauled to the bottom of the slope. From this point the coal is hoisted to the surface by a 26 by 48-inch first-motion hoist made by the Connellsville Manufacturing and Mine Supply Company. A 5-ton Connellsville Manufacturing and Mine Supply Company electric lorry is used to handle refuse slate outside the mine over a separate rock tipple.

Four boilers totaling 600 boiler horsepower are located at this plant and furnish steam at 110-pound pressure for the hoisting engine and for a Vulcan fan. This fan is 20 feet in diameter and 5 feet 10½ inches wide, and produces about 30,000 cubic feet of air per minute at 64 r. p. m.

There is a further power installation located at this mine which supplies power also for Mines Nos. 11 and 12, in which are located 10 boilers of a total of 780 boiler horsepower. These boilers furnish steam at 110 pounds pressure for one high-stage Norwalk 300 h. p. air compressor and one low-stage 200 h. p. Ingersol-Sargeant Duplex air compressor, one 18 by 18¾-inch Cooper-Corliss engine, one Buckeye engine belt-connected with a Westinghouse 250-volt 150 k. w. direct-current generator, a 6 h. p. generating engine for signals and lights, a second motion 12 by 20-inch 125 h. p. Franklin hoisting engine, and an 80 h. p. 16 by 30-inch Crawford and McCrimmon engine direct-connected to a Lepley steel fan 7 feet in diameter and 5 feet 10 inches wide. The fan and engine are housed in a fireproof building having a safety explosion chamber and produces 129,000 cubic feet of air at 68 r. p. m.

During 1918 there were employed at this mine 195 men and produced 155,436 net tons of coal.

CONSOLIDATION MINE No. 4 (C, D-4).—This mine, having a slope 21,000 feet long, is located on the Cumberland and Pennsylvania Railroad at Eckhart. Nine horses are used to haul the coal from the working face to the motor lye. A 10-ton Heffrey electric locomotive then hauls it to the bottom of the slope, from which point it is hoisted to the surface by a 16 by 24-inch second-motion 140 h. p. hoisting engine.

The returning empty mine cars for this mine are hauled to the outside "knockel" by an 8 by 12-inch Copeland and Bacon slow-rope haulage engine. From this point they drop to the bottom of the slope by gravity.

There are located at this mine three boilers with a total of 290 boiler horsepower, supplying steam at 95-pound pressure to the hoisting engine, the slow-rope haulage engine, the fan engine, and a 238 h. p. 19 by 18-inch Ridgeway engine direct-connected to a Thompson-Ryan 250-volt 150 k. w. generator.

Eighty-one men were employed and 84,273 net tons of coal were produced at this mine during 1918.

CONSOLIDATION MINE No. 7 (C-7).—This mine is located about one-half mile west of Lord Village and ships over the Cumberland and Pennsylvania Railroad. The following is a section of the seam at this locality:

	Feet	Inches
Shale roof.		
Coal	6	3
Shale	0	¾
Coal	0	3
Shale	0	¾
Coal	1	½
Shale	0	½
Coal	0	11
Shale floor.		
	8	7½

An analysis of this coal is given in table of analyses, No. 6.

The entry to the mine is by a slope 4000 feet long. The coal is gathered entirely by horses, 9 being used for this purpose. These horses haul the coal to the inside lye, which is located at the bottom of the slope entry. The mine cars are then hoisted to the surface by a 386 h. p. 26 by 48-inch first-motion hoisting engine made by the Connellsville Manufacturing and Mine Supply Company.

The mine workings are ventilated by a Crawford and McCrimmon force fan 25 feet in diameter and 6½ feet wide, driven by a direct-connected 14 by 26-inch steam engine of the same manufacture. At 70 r. p. m. this fan produces 92,000 cubic feet of air.

The boiler house contains 8 boilers aggregating 1100 boiler horsepower, which furnish steam at a pressure of 105 pounds to the hoisting engine, fan engine, two low-stage compressors (one a 45 h. p. Rand Straight Line, the other a 50 h. p. Ingersol-Sargeant Straight Line), two Ottumwa box-car loaders, and two small generators for signals and lights.

The mine, during 1918, employed 86 men and produced 96,127 net tons of coal.

CONSOLIDATION MINE No. 8 (C-7).—This is a drift mine near Midland and is situated on the Cumberland and Pennsylvania Railroad. Coal is gathered at the working face and hauled to the outside tipple by 5 horses.

The mine is ventilated by a Crawford and McCrimmon fan 14 feet in diameter and 4 feet wide, belt-driven by a 10 h. p. General Electric motor. This fan produces 95,700 cubic feet of air, operating at 44 r. p. m. The power used in operating this mine is generated at the power plant of Consolidation Mine No. 1.

During 1918 47 miners were employed who produced 45,125 net tons of coal.

CONSOLIDATION MINE No. 12 (C-6).—Consolidation Mine No. 12 is located just south of the village of Borden Shaft on the main line of the Cumberland and Pennsylvania Railroad. The mine is two miles south of Frostburg.

The mine was originally opened in 1859 by the Borden Mining Company and operated until 1872 when the outside plant was destroyed by fire. This was reconstructed in 1873 and the mine operated until 1889.

During this time the workings were drained by means of two large Cornish pumps. The volume of water became so great that these pumps could no longer control it and in 1889 the mine was allowed to fill up with water. The Consolidation Coal Company in 1911 drained the water in the mine by means of their present drainage system, rebuilt the plant, and started shipping coal in 1912.

The shaft at this mine is 150 feet deep. There are two compartments of the shaft which are wood lined. The mine cars are pushed onto the shaft cage at the bottom by hand, but at the top the cars automatically dump the coal into a chute from which the railroad cars are loaded.

The mine workings are ventilated from the fan at Consolidation Mine No. 11. The haulage in the mine is by 18 horses and one large compressed-air locomotive. Two boilers generating 140 boiler horsepower are located at this mine and furnish steam for the hoisting engine and a small generator for lighting purposes. Compressed air for the locomotive is supplied at the power plant of Consolidation Mine No. 11.

During 1918 this mine employed 130 men who produced 158,905 net tons of coal.

Consolidation Mine No. 13 (B, C-5).—This mine is located on a branch of the Cumberland and Pennsylvania Railroad, about one-half mile west of the town of Frostburg and operates in both the "Big Vein" and Tyson seams. The "Big Vein" is opened by both slope and drift entries. There are three openings in the Tyson seam, two of which are connected with the tipple by a tramway and the other with an engine plane. The slope and engine plane are operated by a 50 h. p. 10 by 12-inch Flory double-drum engine and the remainder of the haulage is accomplished by the use of 10 horses and mules.

There is no mechanical ventilating equipment at the Tyson seam opening, the natural ventilation being quite satisfactory. The "Big Vein" workings are ventilated by two Crawford and McCrimmon fans, 12 feet in diameter; one being 3.7 feet wide and the other 3.5 feet wide. Both fans are operated by a 10 by 12-inch direct-connected Crawford and McCrimmon steam engine at 52 and 65 r. p. m. and deliver 13,000 and

16,000 cubic feet of air respectively. Steam at 100 pounds pressure is supplied for the operation of the hoist and fan engines by a 100 h. p boiler.

This mine, during 1918, produced 40,234 net tons of coal and employed 73 men.

CONSOLIDATION MINE No. 14 (C-4).—This mine is located just east of the town of Allegany. It was formerly known as the Old Allegany mine and was operated and owned by the Georges Creek Coal and Iron Company. The Consolidation Coal Company purchased this property some 30 years ago. At that time the mine was called the Consolidation Mine No. 5. The mine has been abandoned since 1896. It was reopened early in 1917 and the first shipments made during July of the same year.

An average section of the "Big Vein" coal seam at this locality shows:

	Inches
Shale roof.	
Coal	17
Slate	7
Coal	33
Slate	1
Coal	6
Slate	1
Coal	26
Shale floor.	

A drift opening has been made into the seam for the purpose of recovering bottom coal, pillars and stumps of the old workings, as also the crop coal. The haulage is by 4 mules. The workings are ventilated by a 5-foot Stine disc force fan, belt-connected to a 8 h. p. General Electric motor. At 320 r. p. m. this fan produces 15,246 cubic feet of air. The mine cars are let down a 700-foot gravity plane having an average grade of 8°. Coal is shipped over the Cumberland and Pennsylvania Railroad. The power necessary for operating this mine is supplied by power plant at Consolidation Mine No. 9.

During 1918 an average of 25 men were employed who produced 10,238 net tons of coal.

CONSOLIDATION MINE No. 15(D-5, 6).—This mine is located at Vale Summit. The historical facts surrounding this locality, although most unusually interesting, will not be covered in this report. The property originally was purchased by the Astor Coal Mining Company which was

FIG. 1.—VIEW OF LOWER SHARON COAL AND SANDSTONE, NEAR WESTERNPORT, ALLEGANY COUNTY.

FIG. 2.—VIEW OF CONSOLIDATION COAL COMPANY, OCEAN NO. 1.

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then called Pompey Smash, the name of Vale Summit following at a much later date. In 1873 a stove used to ventilate the old Spruce Hill mine became overheated and set fire to the surrounding coal. This fire has been burning ever since, but has been confined to the "rashings" coal above the Pittsburgh seam proper and therefore has not greatly damaged the marketable coal. Since 1906 the Consolidation Coal Company has been combating the fire and, although they have not succeeded in extinguishing it yet, they have mined coal from this territory.

The new Astor slope driven during 1906 was reopened in 1915 and has been advanced to a distance of 1500 feet. Another opening was made during 1917-18 through which most of the coal from this mine is brought to the surface.

The mine workings are ventilated by a Crawford and McCrimmon force fan, 12 feet in diameter by 3 feet 7 inches wide. At 70 r. p. m. this fan produces 17,568 cubic feet of air against a 2-inch water gauge.

The haulage inside the mine is by means of 4 horses. The coal is pulled up the slope to the surface by a 35 h. p. J. A. French stationery steam hoisting engine.

CONSOLIDATION MINE No. 16 (D-5) is located near Vale Summit between Consolidation No. 15 and Brown's Shaft. Four openings have been made in the crop. Nos. 1, 2, and 3 are slope entries and No. 4 a drift entry. Nos. 2 and 3 have been temporarily abandoned.

There are 3.4 miles of tramroad with 6076 feet of side track from No. 1 opening passing the other three openings and connecting with the old Hoffman and Astor tramroad near Consolidation No. 15 at Vale Summit. This tramroad is laid with 67-pound T-rail. Seven horses are used inside openings Nos. 1 and 4 to haul coal. A Vulcan hoisting engine driven by a 50 h. p. 250-volt General Electric motor is used to pull the mine cars up the slope at No. 1 opening. The workings of this opening are ventilated by a 7½-foot Stine disc force fan, belt-driven by a 25 h. p. Crocker-Wheeler electric motor. At 349 r. p. m. this fan produces 27,000 cubic feet of air. The fan is stationed at the top of an 8-foot by 8-foot air shaft.

No. 2 opening is ventilated by an 8-foot Stine disc force fan belt-driven from a 15 h. p. Westinghouse electric motor and equipped with

Cutler-Hammer automatic motor starter. This fan is located at the top of an 8- by 8-foot shaft as is the case at No. 1 opening.

The workings at No. 3 opening are ventilated by a 5-foot Buffalo Force Company's fan, belt-driven by steam engine. This fan is situated over the top of an air shaft 6 feet by 7 feet by 20 feet deep. Over the top of another air shaft 10 feet by 10 feet by 16 feet deep a 5½-foot Stine disc force fan, belt-driven by electric motor, ventilates the workings of No. 4 opening. At 270 r. p. m. this fan supplies 11,650 cubic feet of air.

The power plant for Consolidation No. 16 is located by No. 2 opening. It consists of two 150 h. p. Erie boilers, a Houston, Stanwood, and Camble Company stationery steam engine, and a 100 k. w. 250-volt Morgan-Gardner Electric Company generator.

The coal is hauled in mine cars by two dinkey engines (a 15 and 18-ton American Locomotive Works) from mine openings along a tramroad to the tipple at Consolidation Mine No. 3.

TYSON SEAM MINES

The Tyson seam operated by the Consolidation Coal Company varies in thickness from 30 to 48 inches, the average being 40 inches. Main entries or headings have been projected on easy grades over the entire field. Side entries or room headings are driven off these main entries—preferably at right angles—at 200 to 250-foot intervals. Rooms 30 feet wide are broken off these room headings on 60-foot centers. Cross-cuts in rooms and headings are driven in compliance with the state mining laws. All working places are driven parallel, or at right angles to each other as far as practicable to secure the best recovery in pillaring. The workings are divided into sections or panels, each being pillared back separately. Clearance in excess of the requirements of the mining laws is provided on the "brake side" of all mine tracks, and sufficient roof or bottom rock is removed to provide at least 4½ feet vertical clearance over the rail. No roof is taken down in the rooms.

Power twist drills, Ingersol-Sargeant air drills, Temple-Ingersol electric drills, and the Sullivan jack hammer drills have been used to drill the holes for this rock work.

Two air courses are provided for those main headings from which extensive development is expected, the shorter or less important headings having only one air course. Fans are used to ventilate these mines. The brattices and overcasts in all main air courses are constructed of brick or concrete. A very ingenious device has been resorted to in order to provide drainage for these mines. Bore holes, 6 inches in diameter, are drilled from the surface through the low spots and local basins in the Tyson seam to the workings in the "Big Vein" underneath. The water flows, or is pumped to these local sumps, drops down the bore hole and then runs into the nearest ditch of the elaborate drainage system provided for the "Big Vein" workings. This scheme makes possible the use of a minimum number of pumps. The pumps employed operate against a very low head and require little power for their operation. The pumps are of the Aldridge Triplex and Fairmont types.

A 42-inch gauge mine car of about 1600 pounds tare weight and 2800 pounds capacity has been adopted as a standard for the Tyson mines. The tipples and dumps, while efficient, are of very simple construction. All the coal is weighed on Fairbank's Standard track scales.

CONSOLIDATION NOS. 2, 5, AND TYSON NO. 7 (C-6, 7).—These mines, located near Carlos Junction, Midland, and Lord, respectively, are not being operated at present. The pillaring of the "Big Vein" has caused breaks in the overlying strata that extend up to and through the Tyson seam to the surface, thus temporarily hampering the mining of the Tyson seam. After this work in the "Big Vein" shall have been completed and due time allowed for the subsidence or settling of the over and underlying stratas, these mines will again be reopened and operations resumed.

CONSOLIDATION MINE NO. 6 (C-6).—This drift mine is located at the end of the Carlos Junction yard of the Cumberland and Pennsylvania Railroad. The area of coal to be recovered overlies the "Big Vein" workings of Consolidation No. 1. This mine was opened in September, 1917, and the first shipment made during October of the same year.

The average section of coal in this locality measures:

	Inches
Sandstone roof.	
Coal	34
Shale floor.	

The workings are ventilated by a 4-foot Buffalo Forge exhaust fan belt-driven by an electric motor. This is operated at 490 r. p. m., producing 4600 cubic feet of air.

The haulage is by 6 mules.

During 1918 17 miners were employed who produced 9752 net tons of coal.

CONSOLIDATION MINE No. 9 (C-4).—This mine, one and one-half miles northeast of Frostburg is located on the Cumberland and Pennsylvania Railroad. The following is a section of the coal in this mine:

	Feet	Inches
Shale roof.		
Coal	3	7
Shale floor.		

Two drift openings are used as haulways and two additional openings have been provided for manways and air courses. About 22 per cent of the coal is being mined by two Sullivan Short Wall machines, the balance of the output being pick work.

The primary haulage in this mine is performed by two 10-ton General Electric locomotives and the secondary haulage by two 7-ton Jeffrey Electric locomotives and two horses. The mine workings are ventilated by a 15-foot by 4-foot Crawford and McCrimmon fan, direct-connected to a 25 h. p. 8 by 14-inch steam engine of same manufacture. This fan at 62 r. p. m. produces about 14,000 cubic feet of air. In addition to this a second fan, 12½-foot Cole force fan direct-driven by a General Electric motor, has been installed during 1918. A 6-inch bore hole has been drilled for transmission and telephone wires from surface to point in manway of this mine, 92½ feet.

The power house contains two 150 h. p. Erie boilers, supplying steam at 110 pounds pressure to a 125 h. p. Erie City engine and a 150 h. p. Russel engine, both of which are belt-connected to two 250-volt 100 k. w. Westinghouse generators. These boilers also supply steam for the fan engine. In addition to generating power at this mine the Consolidation Coal Company purchases power from the Hagerstown and Frederick Electric Railway Company.

One hundred and fifty-five men were employed and 121,475 gross tons of coal were produced in 1918.

CONSOLIDATION MINE No. 10 (C-4, 5).—This drift mine, opened in 1908, is located at Eckhart Village and ships over the Cumberland and Pennsylvania Railroad. It is a pick mine. A 7-ton Jeffrey electric gathering locomotive and 7 mules gather the coal, placing it on the main lyes, and two 10-ton Jeffrey electric haulage locomotives haul it to the surface to the tipple at Consolidation Mine No. 4. This tipple is equipped with two coal chutes, one for loading "Big Vein" coal and the other for loading Tyson Coal. The empty mine cars are hauled back into the mine by electric motors.

The workings of this mine are connected with those of Consolidation No. 11 and are ventilated by fan located at latter mine. Power for the operation of the haulage locomotives and pumps is obtained from the power plants at Consolidation Mine No. 4 and at Pumping Shaft.

During 1918 this mine employed 82 men and produced 75,959 gross tons of coal.

CONSOLIDATION MINE No. 11 (C-5).—This mine lies between Consolidation Mine No. 10 and the Borden Shaft, access being obtained to it through the Pumping Shaft (sometimes called New Shaft) of the Consolidation Coal Company which is situated about two miles west of Frostburg on the main road between Frostburg and Lonaconing. The coal is obtained by pick mining exclusively and is gathered by a 7-ton Jeffrey haulage locomotive, supplemented by 4 mules. The coal is hauled through workings of Consolidation Mine No. 10 by one of the 10-ton electric locomotives to the tipple outside Consolidation No. 4.

Air for ventilating purposes is drawn from the current produced by the Lepley fan at the power station, described under Consolidation No. 3. This fan ventilates Consolidation Nos. 10, 11, 12, and part of workings of No. 3. Power for the operation of the electric haulage locomotives is obtained from this same power station.

Twenty-nine men were employed and 24,141 net tons of coal produced at this mine during 1918.

Savage River Pumping Station

Droughts are of frequent occurrence in this region, making difficult the problem of water supply for the boiler plants at the various mines. Large tanks and reservoirs for the storage of boiler water have been erected in connection with every power plant. These are fed from wells, springs, and streams. During times of prolonged drought this supply has failed, and it has been necessary to bring water by rail in cars specially constructed for this purpose. To avoid dependence upon such an uncertain and uneconomical source of supply, the Consolidation Coal Company decided to construct an emergency water supply system. Surveys were accordingly made, and in 1906 a pumping station was erected on Savage River about 3 miles northwest of Consolidation Mine No. 7. A dam for impounding the water was built on the Savage River and two 100 h. p. portable boilers and a 240 h. p. Snow Compound Duplex pump with water cylinders 8 by 24 inches were installed. Four thousand feet of 8-inch and 4000 feet of 6-inch pipe were laid which extended from the pumping plant of the Savage River over Little Savage Mountain, across the valley of Little Savage River, and up the west slope of Big Savage Mountain to its summit. From this point an open trough 2500 feet long was constructed to the head waters of Wright's Run. With this arrangement, during times of drought, water is pumped from the Savage River to Wright's Run, where it flows down the stream toward Consolidation No. 7. Three storage reservoirs are located on the run between the point where the trough discharges and the No. 7 mine.

CUMBERLAND BIG VEIN COAL COMPANY

The Cumberland Big Vein Coal Company have an opening, the Conway Mine (C, D-3, 4), in the "Big Vein" seam about a mile southeast of Morantown. This company is operating under a 10-year lease of the "Big Vein" outcrops and pillars at this locality from the Union Mining Company. The work of opening this mine was started about May 1, 1917, and the first shipment was made June 10. 1917.

Average Section

	Inches
Shale roof.	
Top coal	8
Wild coal	7½
Shale	12
Coal	7½
Shale	1
Coal	8
Shale	1½
Coal	18
Shale	½
Coal	23

The opening is a timbered drift entry. The mine workings are developed on the Room and Pillar system. The ventilation and drainage are by natural means. One mule and one pony are used for the hauling in the mine. Thirty one-ton cars, weighing 1176 pounds empty, are used. The track, 36-inch gauge, is of 16-pound T-rail. The coal is hauled along a 1¼-mile tramroad by a 10-ton Porter dinkey engine to the tipple. The coal is weighed on Fairbanks scales at the tipple and loaded into railroad cars sideways over an end dump. The tipple is located at Eckhart, next to the tipple of the Sullivan Brothers Coal Co.

During 1918 18 miners and 9 laborers were employed, producing 12,560 tons of coal.

FITZPATRICK COAL COMPANY

The Fitzpatrick Coal Company is operating the old Pekin mine of the Piedmont Mining Company which they leased May, 1912.

THE PEKIN MINE (C, D-9) is situated in the hill west of the town of Pekin. The mine was originally developed on the Room and Pillar system in the "Big Vein" coal seam which here varies from 8 to 12 feet in thickness. The present operations consist of recovering "lost coal," pillars, and "crop" coal. The Fitzpatrick heirs operated the mine only during the winter months when the ventilation of the mine is fairly good as they do not have a fan. The mine was closed in May, 1916, but operations were resumed for the winter on October 1, 1916, and the mine has been worked steadily ever since. A 2 h. p. Eclipse gasoline pump (2-inch intake and 2-inch discharge), having a capacity of 1500 to 1800 gallons per hour, is used to drain the local sumps and also at places where the coal goes to the dip. There are 50 one-ton mine cars of 1800 pounds tare weight at the mine.

Several new openings have recently been made some 1350 feet from the head of the gravity plane. One horse is used for haulage along the tram-road. The coal is let down a 900-foot gravity plane to the tipple. The coal is weighed on Fairbanks Standard scales at the tipple, dumped over an end dump into a short chute from which the railroad cars are loaded sidewise. The shipments are made over the Cumberland and Pennsylvania Railroad.

FROSTBURG BIG VEIN COAL COMPANY

The Frostburg Big Vein Coal Company has leased from the Union Mining Company a portion of "Big Vein" and Tyson coal seams adjoining the town of Allegany on the west side of Jennings Run and reached by a short branch of the Cumberland and Pennsylvania Railroad.

"BIG VEIN" MINES (B, C-4).—Operations in this seam were started during February, 1917, and first shipments were made during July of the same year. At this locality the "Big Vein" coal seam has split into two distinct seams which are separated by a hard shaly sandstone which varies from 2 to 25 feet thick. The Frostburg Big Vein Coal Company is operating both these seams. Sections from them measured as follows:

Lower Seam

Sandy shale roof.	Inches
Coal	10
Bone	1
Coal	8
Bone	½
Coal	9
Bone	½
Coal	27
Shale floor.	
Total	56

Upper Seam

Shale roof.	nches
Coal	15
Bone	$\frac{1}{16}$
Coal	18
Bone	½
Coal	14
Bone	¼
Coal	12
Sandy shale bottom.	
Total	60

Ten timbered drift openings have been made along the outcrop of these seams. Four of these openings are at present in use. Where the openings have been driven into solid coal the method of mining has been by the

Room and Pillar system. The openings into the outcrop did not offer conditions for any particular system to be used. Both the ventilation and drainage are by natural means. Ten horses are used to haul the coal from the working places in the mine to the head of the plane outside. The gauge of the mine tracks is 48 inches. Sixteen-pound T-rails are used inside and 20-pound T-rails outside, on tramroad and plane. The openings are connected with the head of the plane by 5000 feet of tramroad. The plane is 796 feet long with grades of from 8 to 12 degrees. The coal is weighed by Fairbanks Standard scales at the tipple and loaded into railroad cars sideways over an end dump.

TYSON MINES.—The development of the Tyson mines was started during August, 1917. The section of the seam at this place measured:

Rock roof.	Inches
Coal	36-42
Rock floor.	

The mine has been developed on the double drift entry system and the mine workings on the Room and Pillar system. The ventilation and drainage are natural. Haulage inside the mine is by 3 mules. The gauge of the mine tracks is 48 inches. Sixteen-pound T-rails are used inside and 20-pound T-rails outside. About 30 one-ton mine cars of the Watt type are used in the Tyson. The coal is weighed at the mine entry on Standard scales and reloaded into 3-ton "Big Vein" mine cars over an end dump. These cars are then hauled over a 2500-foot tramroad to the head of the plane. The coal is sent down the plane and handled over the same tipple as coal from the "Big Vein" mine described above.

During 1918 the company employed an average of 42 miners and 29 laborers, producing 40,601 tons of coal during the year.

GEORGES CREEK COAL COMPANY, INC.

The Georges Creek Coal Company, Inc. (A, B-8, 9, 10, 11, 12) was formerly the Georges Creek Coal and Iron Company, the change having been made during 1910. This company is at present only operating in the Tyson coal, their mines in the "Big Vein" having all been worked out and abandoned. The operating mines at present are Mines Nos. 1, 2, 3, 4. The output for the year was 259,389 tons.

GEORGES CREEK MINE No. 1 (D-6).—This mine is located on the west side of the Georges Creek Valley about three-fourths of a mile north of Lonaconing. The "Big Vein" coal was worked out in June, 1915, but the Tyson coal has been mined here since 1904. The Tyson coal in this mine is usually free of shale or bone partings and averages 3 feet 4 inches in thickness. The method of mining is a modification of the Room and Panel system. Rooms are driven and pillared back in batteries of 12 before others are started. Mining is all by pick work.

The mine is ventilated by a 5-foot Robbison centrifugal steel exhaust fan which is driven by a 20 h. p. A. C. motor. This fan produces 40,000 cubic feet of air per minute against a $1\frac{1}{2}$-inch water gauge. The mine is self-draining through a tunnel driven from the low points in the mine to the surface on the side of the hill. In use at this mine are 100 one-ton Watt mine cars. The gauge of the track is 42 inches. The mine cars are gathered at the working face by 6 mules and are pulled from the inside lye to the tipple by a 13-ton Jeffrey electric haulage motor. The mine is connected with tipples on both the Cumberland and Pennsylvania Railroad and the Western Maryland Railway. The coal is weighed on Fairbanks Standard scales and dumped over a Phillips cross-over tipple into the railroad cars.

Starting June 1, 1916, power has been purchased from the Edison Electric Company of Cumberland and substations built at the mines to convert the 2200-volt A. C. into 250-volt D. C. for haulage purposes. The substation at No. 1 mine, however, furnishes power to Mine No. 3. One hundred miners and 25 laborers were employed at this mine during 1918.

GEORGES CREEK MINE No. 2 (D-6, 7, 8).—Georges Creek Mine No. 2 is situated on the east side of the Georges Creek Valley about one-half mile north of Lonaconing. This mine was opened in 1912 in a detached area of 80 acres of Tyson coal. The coal seam averages from 30 to 42 inches. This mine was developed on a modification of the Room and Panel system, as was Mine No. 1. The mining is all by pick work, no machines being used.

A 5-foot Robinson disc exhaust fan operated by a 15 h. p. A. C. motor ventilates the mine. The capacity of this fan is 20,000 cubic feet of air per minute, working against a ¾-inch water gauge. The drainage is natural, a tunnel leading from the lowest points in the mine to the surface. The haulage in this mine is by 2 mules. Forty one-ton mine cars of the Watt type are used. The gauge of the mine track is 42 inches. The coal from this mine is let down a 250-foot gravity plane to a tipple on the Western Maryland Railway. Coal is weighed on Fairbanks Standard scales and dumped over an end dump, loading railroad cars sidewise.

During 1918 34 miners and 5 laborers were employed.

GEORGES CREEK MINE No. 3 (D-6, 7, 8).—This mine is located on the west side of the Georges Creek Valley about ½ mile north of Lonaconing. This mine was opened by double drift entries during November, 1911, into the Tyson coal. The coal bed in this mine is free from shale and bone binders and averages 3 feet 6 inches in thickness. A sample was taken from Broadback's Room off the Third Right Heading where the sections of the coal measured:

	Feet	Inches
Shale roof.		
Coal	3	6½
Shale floor.		

For analysis of this sample see table of analyses, No. 10.

A modification of the Room and Panel system is used in this mine as in all the others belonging to this company. The mining also is by hand. The mine is ventilated by a 6-foot Stine exhaust fan direct-connected to a 20 h. p. self-starting Imperial electric motor. Against a 1½-inch water gauge this fan produces 40,000 cubic feet of air per minute. The drainage is natural, a tunnel being driven to the surface from the lowest points in the mine. One hundred 1-ton Watt cars are in use here. They are gathered from the rooms and hauled to the inside motor lye by 6 mules, after which a 10-ton Jeffrey electric locomotive hauls them to the tipple. Forty-two-inch gauge mine tracks, 16-pound steel T-rails in rooms and 35-pound steel T-rails in headings are used here as in the other Georges Creek Coal Company's mines. The coal is weighed on Fairbanks Standard scales and then dumped oven an end dump into a 3-inch bar screen used to separate lump from slack. A 90-foot chute is used to load two railroad cars on separate tracks at the same time. The coal from this mine is being shipped over the Western Maryland Railway.

During 1918 an average of 120 miners and 20 laborers were employed.

GEORGES CREEK MINE No. 4 (D-6, 7, 8).—Georges Creek Mine No. 4 is located along Koontz Run about 1 mile north of Lonaconing. This mine was opened during June, 1913, using a double entry system. The mine is developed along the same Room and Panel system as used in Mines Nos. 1, 2, 3. The main entry is driven along the strike line and all butt entries are turned off on the pitch, which at this mine averages 8 per cent.

A 6-foot Ventura disc exhaust fan, which is belt-connected to a 20 h. p. D. C. motor is used to ventilate the mine. This fan produces 40,000 cubic feet of air per minute against a 1¾-inch water gauge. The mine is self-draining. The main haulage is accomplished by one 8-ton Jeffrey electric locomotive. The haulage on the butt headings is by two 40 h. p. Lidgerwood stationary hoists. Inside gravity planes are used here as also in Mine No. 3. One hundred and ten 1-ton Watt mine cars, running on 42-inch gauge tracks, are used in this mine. The coal is weighed on a Fairbanks Standard scales at the tipple and then loaded into cars on the Western Maryland Railway tracks.

An average of 60 miners and 20 laborers being employed during the year.

GEORGES CREEK COAL MINING COMPANY

The Georges Creek Coal Mining Company is operating the Jackson mine of the American Coal Company. This property lies on the east side of the Georges Creek basin, extending from Lonaconing southward beyond Moscow Mills. The American Coal Company leased the property in August, 1916, to Hoffa and Sons Coal Company who, in 1917, sold their rights to the present operators. At present the company is mining the Tyson seam and stripping the "Big Vein" outcrop.

TYSON MINE (C, D-8, 9).—Two timbered drift openings have been made into the Tyson seam. The workings are developed on the Room and

Pillar system. The mining is by pick. The mine is ventilated by a 5-foot Stine force fan, capacity 40,000 cubic feet per minute, belt-driven by a 10 h. p. Phoenix Electric Company motor. The mine water is drained in ditches to the surface by gravity. Four ponies are used for hauling in this mine. Forty-eight 1-ton mine cars of the Hockensmith type, tare weight 1400 pounds, are used in the Tyson mine. The track is 36-inch gauge and laid with 16-pound T-rail. One hundred and fifty feet of tramroad leads from the mine opening to the upper or Tyson tipple. There the coal is weighed on Standard scales and unloaded from Tyson cars over an end dump into a covered chute 264 feet long. At the lower end of the chute, which is on the level of the "Big Vein" seam, the coal is loaded into "Big Vein" mine cars of capacity of 2 and 3 tons. These cars are hauled over a 200-foot tramroad in three-car trips by a horse to the top of the "Big Vein" incline plane. This plane is 980 feet long with a grade of from 9 to 26 degrees. The coal is weighed a second time on Fairbanks Standard 5-ton scales on the railway siding tipple in order to ascertain total shipments. The coal is loaded into the railroad cars sidewise over an end dump. The lower, or railway tipple, is located on a siding of the Cumberland and Pennsylvania Railroad about 2000 feet south of the Lonaconing depot.

Average Section

Sandstone roof.	Inches
Coal	33
Slate	6
Coal	10
Sandstone floor grading over to fire-clay.	

STRIPPING THE "BIG VEIN" (D-9).—The overburden of the outcrop of the "Big Vein"—10 to 40 feet—is being stripped and thrown over the bank. A 90-ton Marion steam shovel with 40-foot boom and 2½-yard dipper, built particularly for stripping, is used to remove the top soil. The surface of the stripped coal is cleaned by men with shovels. To date the area of stripped coal surface is several thousand feet long and 30 to 60 feet wide, following the outcrop around the sides of the hill. A 60-ton Marion steam shovel, with a 26-foot boom and a 2½-yard dipper was at first used to dig the coal and load same into the "Big Vein" mine cars.

This, however, was not proven as successful as allowing the miners to actually mine the exposed seam. Accordingly several "pits" have been made into the stripped coal where from 4 to 6 miners actually mine the coal. Each "pit" has its own horse to haul the cars. The various "pits" are connected by 3 miles of tramroad with the head of the "Big Vein" gravity plane. An 18-ton Porter dinkey engine is used for haulage along this tramroad. There are 48 "Big Vein" mine cars of 2- and 3-ton capacity used for this operation. The gauge of the mine tracks is 36 inches. The "Big Vein" coal passes down gravity plane to tipple where it is loaded into railroad cars (as stated above) mixed with Tyson coal.

Average Section

	Inches	Open cut
Roof coal	82	10 to 14 feet of coal all goes in the car.
Slate	2	
Coal	3	
Slate	1	
Coal	27	
Shale floor.		

During 1918 the company employed an average of 31 miners and 46 laborers, producing 57,728 tons of coal.

GEORGES CREEK-PARKER COAL COMPANY

The Georges Creek-Parker Coal Company is operating the Bond and Parker mines at Barrelville, Maryland. These were among the first mining operations of the State. Mines in these thin coal seams could not compete in the early days with the "Big Vein" mines because of the cost of operation, and therefore had to be abandoned. These mines were re-opened in 1903 by the Cumberland Basin Coal Company and operated intermittently during the following 9 years. No comprehensive plan was followed in the development of these mines, no adequate provision made for ventilation and drainage, nor yet for the ultimate extraction of the coal. The venture resulted at the time in failure. The property was idle for the next 5 years. In December, 1916, the present company re-opened the mines, making their first shipment on December 21, 1916.

The Bond and Parker mines (C, 4-1, 2) are located about 3000 feet north of the village of Barrelville, near the northern end of the Georges Creek Basin.

The Parker mine is in the Lower Freeport or Barrelville coal of this work, which is the Clarion or Parker coal of earlier reports. It varies in thickness from 22 to 39 inches. Where sampled the section measured:

	Inches
Sandstone.	
Shale	16½
Draw slate	2½
Coal	23
Sand shale.	

For analysis see table of analyses, No. 12.

The Bond mine is in the Upper Kittanning or Montell of this work, which is the Brookville or Bluebaugh coal of earlier reports. It varies from 36 to 42 inches in thickness. The seam showed the following section at the point where a sample was secured:

	Inches
Sandstone.	
Coal	8
Shale	20½
Coal	2¾
Shale	¾
Coal	22¾
Shale	1¾
Coal	5
Shale	1½
Coal	2½
Sand shale.	

The Parker seam lies about 40 to 60 feet above the Bond seam, but the two are separated by over 30 feet of massive sandstone. The opening of the Parker mine is by a drift entry. The present operators have driven a rock tunnel from the Parker seam to the Bond seam. Thus the two coal seams may be reached through one mine entry, minimizing the cost of hauling coal from the mine to the tipple. The Parker mine is ventilated by a 14 by 16-foot Crawford and McCrimmon seam-driven force fan, and the Bond workings by an 8-foot Stine electric force fan. The drainage in both workings is by natural means. Two Myers Bull Dosen electric pumps are used to drain local sumps. The method of mining is by the

Room and Panel system, the mining being entirely by pick work. The main haulage in the mine is by a 10-ton General Electric locomotive, and the secondary haulage is by 2 electric hoists and 8 mules. Sixty mine cars of ½-ton capacity are in use at the mine. These mine cars are modeled after the Watt type, having wooden bodies on Whitney trucks. Forty-pound steel T-rails are used in the main headings and 12, 15, and 20-pound steel T-rails in the rooms. The gauge of these tracks is 36 inches. Fairbanks Standard scales are used at the tipple.

The coal from these two seams is carefully prepared for the market. To clean the coal a 60-foot Link-Belt picking table is used at the tipple over which the coal must pass before being loaded into the railroad cars. The power-house is equipped with the following: Two 225 h. p. Keeler water-tube boilers of the marine type; a Webster steam vacuum feed-water heater and purifier; two Dean boiler feed pumps 7 inches by 5½ inches by 6 inches; two 250 h. p. Ball Side Crank steam engines belt-connected to two 150 k. w. General Electric motor generators.

During 1918 the company employed 42 miners and 4 laborers, producing 39,838 tons.

GREEN COAL MINING COMPANY

The Green Coal Mining Company's mine (C, D-9, 10) is located on the eastern side of Georges Creek one-half mile south of Moscow Mills. The mine was opened by the Piedmont Mining Company and worked by them until 1902. The property then came into the possession of A. B. Shaw, who leased it to the present operators who began work during February, 1917, and made their first shipment on May 23, 1917. Only the "Big Vein" is worked, although some little prospecting has been done for the Little Pittsburgh seam.

Average Section

	Inches
Roof coal.	
Coal	67
Slate	1
Coal	2
Slate	1
Coal	30
Shale floor.	

FIG. I.—DAVIS COAL AND COKE COMPANY, HENRY NO. I.

FIG. 2.—DAVIS COAL AND COKE COMPANY, TOWN OF KEMPTON.

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The "Big Vein" is worked by 4 drift openings with natural ventilation and drainage. The method of mining is to remove outcrop and pillars left in the workings of former operations. Two horses are used for haulage. Five hundred feet of tramroad has been laid. Gauge of track is 42 inches. Twenty-pound T-rails are used on the outside tramroad, 16-pound T-rails are used on headings, and 3 by 4-inch boards used in rooms. Twenty "Big Vein" cars of 1.75 tons capacity, tare weight 1400 to 1600 pounds, are in use. The coal is sent down a gravity plane 1100 feet long with a grade of 17 to 28 degrees to the tipple where it is weighed on Fairbanks scales. The mine cars are unloaded over an end dump, emptying the coal into a side chute that loads the railroad car endways. The coal is shipped over the Cumberland and Pennsylvania Railroad from Barton.

During 1918 the company employed 23 miners and 10 laborers. The output for 1918 was 17,330 tons.

HAMPSHIRE BIG VEIN COAL COMPANY

The Hampshire Big Vein Coal Company is operating Hampshire Mines Nos. 1 and 2 near Reynolds.

During 1918 an average of 63 miners and 48 laborers were employed. The tonnage for the year was 104,423.

HAMPSHIRE MINE NO. 1 (C, D-11).—The Hampshire Mine No. 1 is located on the east side of the Georges Creek Valley, just south of Reynolds. This property was opened about 40 years ago by the Baltimore and Hampshire Coal Company. Later the West Virginia Central and Pittsburgh Railway Company bought the property and continued to work it. This company afterwards leased the mines to Wm. E. Walsh and later to the White, Gannon and Gleason Company. In 1900 the Piedmont and Cumberland Coal Company bought the lease from White, Gannon and Gleason Company and worked the mine until 1905 when it was abandoned. At present the title of the property rests with the West Virginia Central and Pittsburgh Railway Company who has leased the same to the present operators. The Hampshire Big Vein Coal Company began work on August 20, 1916, and made their first shipments on December 4, 1916.

The mine is operating in the "Big Vein" coal seam. An average section of this seam shows:

	Inches
Roof coal.	
Coal	82
Slate	1¼
Coal	1
Slate	1
Coal	17
Slate	¼
Coal	14
Shale bottom.	

Nine timbered drift openings have been made into the seam. The present operators are recovering outcrop coal and pillars left by former operations. Both ventilation and drainage are by natural means. Eight horses are used for haulage inside the mine and a 10-ton Porter dinkey engine outside along tramroad. Fifty 2-ton Hockensmith "Big Vein" mine cars, tare weight 1675 pounds, are in use at the mine. The gauge of the mine tracks is 36 inches. The various mine openings are connected with the head of the top gravity plane by 6000 feet of tramroad. The coal is lowered down two gravity planes to the tipple. The upper plane is 1000 feet long, having a grade of 12 to 33 degrees; and the lower plane is 800 feet long, having a grade of 12 to 28 degrees. At the tipple the coal is weighed on standard scales and loaded into railroad cars sidewise over an end dump. The shipping point is Hampshire on the Cumberland and Pennsylvania Railroad.

HAMPSHIRE MINE No. 2 (D-10, 11).—The Hampshire Mine No. 2 is located at Reynolds on the Cumberland and Pennsylvania Railroad. The land belongs to the Morrison heirs who leased the mineral rights to the Barton Coal Mining Company. During 1917 the Hampshire Big Vein Coal Company purchased the lease from the Barton Coal Mining Company, renaming the latter's Moscow Mine No. 1 (also called "Ginsang") the Hampshire Mine No. 2.

The mine is opened into the Barton coal seam. A sample of the coal was taken from the main right heading where the section of the coal is about the average of the mine. The section at this point is as follows:

	Inches
Bastard fire-clay roof.	
Bone	19
Coal	8½
Bone	1½
Coal	24
Shale floor.	

The analysis of this coal is shown in table of analyses, No. 13.

Two new openings have been driven into the seam by the present operators. These openings were made into solid coal at both ends of the old workings, thus both shortening the inside haulage and also offering opportunities for quicker development. The workings are developed on the Room and Pillar system, the rooms being driven on 60-foot centers.

The mine is ventilated by a 12-foot Stine force fan driven by a Stine steam engine. A 20 h. p. boiler supplies steam to fan engine. At 60 r. p. m. this fan produces 54,500 cubic feet of air. The water in the mine is drained by gravity in ditches to a sump from which point it is brought to the surface by means of an Ejector steam suction pump. Haulage is performed by mules. About 40 one-ton mine cars are used. The gauge of the mine track is 42 inches. At the tipple the coal is weighed on Chapman scales and loaded into railway cars sideways over an end dump. The shipping point is Reynolds on the Cumberland and Pennsylvania Railroad.

HOFFA BROTHERS COAL COMPANY

The Hoffa Brothers Coal Company operates the mines of the Potomac Coal Company and the Moscow Mine No. 4.

THE POTOMAC MINES.—These mines, leased from the Union Mining Company, are operating both the "Big Vein" and Barton coal seams.

"BIG VEIN" MINES (D-9).—The Potomac Coal Company stopped their work in the "Big Vein" mine about 1900 when they opened a mine in the Barton coal. The Hoffa Brothers Coal Company began operations at the Old Potomac mine in October, 1915, and made their first shipment of coal on December 20, 1915. Their first operations were in the "Big Vein" seam. They have 12 drift openings into this seam, nine of which are being operated at present. These openings are situated about 1 mile southeast of the town of Barton. The method of mining is to recover abandoned coal, pillars and outcrop coal. All the mining is done by pick work. The thickness of the coal in this mine varies from 8 feet to 14 feet. The ventilation and drainage are by natural means. Eleven horses are used to haul the coal from the working faces in the mine to the head of the top plane. The coal from the "Big Vein" mines is lowered down a series of four planes to the tramroad. The top plane is 350 feet long, the second 650 feet, the third 1300 feet, and the lowest 600 feet. Sixty-five 2-ton mine cars of their own design and make are used in the "Big Vein" workings.

BARTON MINE (C, D-10).—The Hoffa Brothers Coal Company reopened this mine on August 1, 1916. The coal shows an average thickness of 30 inches of clean coal. The method of mining at present is by pick work on the Room and Pillar system by which this mine was originally developed. The present operators expect to change over to the Room and Panel system and use arc wall cutting machines to mine the coal. The mine is ventilated by a 20 feet by 7 feet Crawford and McCrimmon force fan which is belt-connected to a Whitney gas engine. At 80 r. p. m. this fan produces 52,000 cubic feet of air per minute. The drainage is by natural means. Haulage from the mine to the top of the 600-foot plane is by 3 mules. Forty one-ton Hockensmith wooden mine cars are used in this mine.

An 18-ton Porter dinkey engine hauls the cars over the half-mile of tramroad to the tipple which is situated just below the town of Barton on a switch of the Cumberland and Pennsylvania Railroad. The coal is weighed on Fairbanks Standard scales and loaded into railroad cars sidewise over an end dump.

During 1918 this mine employed 56 miners and 48 laborers and produced 98,871 tons of coal.

MOSCOW MINE NO. 4 (C, D-9).—The Moscow Mine No. 4 of the Hoffa Brothers Coal Company is located on the west side of Georges Creek just south of Moscow Mills. This is a solid piece of coal which has been leased from A. B. Shaw. However, a little coal had previously been removed by Shaw and also by Wyland and Meyers. The company started work March, 1917, and shipped coal during August, 1917. The mine is opened in the Barton or Four-Foot seam.

Average Section

	Inches
Sandstone roof.	
Shale	4½
Bone	4
Coal	30

This mine has a concrete double-entry drift. The workings are developed on the Room and Pillar system and are ventilated by a 6-foot steel force fan which is driven by a 6 h. p. Witte gasoline engine. The mine is drained by a siphon which is started with a hand pump. The haulage is by means of 3 mules inside and one outside. Four hundred feet of tram-road leads from the mouth of the mine to the tipple. Hockensmith 1-ton cars with a tare weight of 1365 pounds are used to haul the coal. The track gauge is 36 inches and the tracks are laid with T-rail, 12-pound in rooms and 16 to 20 pounds elsewhere. The coal is weighed on Howe scales, dumped over the end dump into an apron, and thence into railroad cars standing sidewise. Shipping point is Moscow Mills on the Cumberland and Pennsylvania Railroad.

Ten miners and 8 laborers were employed during 1918 who produced 11,524 tons of coal.

MARYLAND COAL COMPANY

The Maryland Coal Company is operating mines in the Tyson, "Big Vein," Waynesburg, and Upper Bakerstown (old "Upper Freeport" or Maynadier) coal seams. These mines are (A, B-5, 6, 7, 8; B, C, D-8, 9):

Tyson Mine No. 1—Tyson coal.

New Detmold Mine—"Big Vein."

Waynesburg Mine No. 1—Waynesburg coal.

New opening—Upper Bakerstown (old "Upper Freeport") coal.

The "Big Vein" workings of the Appleton and Kingsland mines were abandoned during 1912.

TYSON MINE NO. 1.—Tyson Mine No. 1 is located on the northwestern edge of the town of Lonaconing and on the west side of Koontz Run. This mine was opened for shipment in 1907. The seam averages from 28 to 45 inches in this section. There are several small binders in the seam which are picked out by the miners when loading the cars in the mine. The mine was opened on double-drift entries and the workings are developed on the Room and Pillar system. Howell Hand Ratchet coal drills are used to mine the coal. A Fort Wayne electric rock drill equipped with a 54 h. p. General Electric motor is used to drill rock in the headings.

The mine is ventilated by a 6-foot Jeffrey electric fan driven by a 2000-volt (20 h. p.) squirrel cage induction motor. The capacity of this fan is 125,000 cubic feet of air per minute, but at present it is being driven at 135 r. p. m., producing 80,000 cubic feet per minute.

There are many local dips in the coal bed at this mine which are drained by five 2-inch Fairmount pumps equipped with a 2 h. p. compound General Electric motors. The capacity of the pumps is 100 gallons of water per minute. The primary haulage in the mine is accomplished by one 10-ton Jeffrey electric haulage locomotive. Secondary haulage is performed by five 6 h. p. pneumoelectric stationary engines and three 5 h. p. Lidgerwood electric stationary engines. Ten mules are used for gathering the cars. On the outside a 25 h. p. stationary electric-driven hoist is used to haul supplies from the railroad to the mine. One hundred 1-ton cars of the Watt, Barnesville and Hockensmith steel-car types are used at this mine. Thirty-five-pound steel T-rails are used in the headings and 16-pound steel T-rails in the rooms. The gauge of the mine tracks is 42 inches. The coal is weighed at the tipple on Fairbanks Standard automatic scales.

The tipple is one of the most modern completely equipped coal tipples in the state and therefore deserves a fuller description. As the trip of mine cars approaches the tipple they are uncoupled by the brakeman and fed by gravity to a Jeffrey car haul, which is run by a 10 h. p. compound compensator Westinghouse electric motor. The car haul consists of an endless chain to which at intervals upright iron hooks are attached which take hold of the axle of the mine cars, pushing them toward the tipple.

The cars pass over automatic scales and on to a Phillips cross-over dump, unloading the coal into a chute. It is made of wood but the inside is lined with .3-inch sheet iron. The chute is 220 feet long, 4 feet wide, and 3 feet high and is inclined at an angle of 37 degrees. The coal drops down the chute to a railroad car, loading it endways, a funnel apron being used at the lower end to guide the stream of coal. The railroad siding has a grade sufficient to allow the railroad car to run past the tipple by gravity. A steel wire rope is attached to the front end of the car while a counter-balancing weight is attached to the other end of the rope. By this arrangement one man, stationed at the foot of the chute, can regulate the flow of coal by a trap door at the end of the chute, and can control the placing of the coal in the car by the adjustable deflecting apron.

The rock brought out of the mine is taken to a separate tipple where the mine cars unload the rock over an end dump into a rock chute, a 42/100 h. p. Westinghouse electric motor being used to operate the gate at the end of the chute. A 15 h. p. Westinghouse series electric haulage locomotive is used to haul the rock from the tipple to a rock dump, the motor itself holding rock and also pushing another rock car which is specially designed to dump the rock endwise over the pile. A third-rail system carrying 250-volt current is used on the rock track.

The coal from this mine is shipped over the Western Maryland Railway. During 1918 the mine employed an average of 175 miners and 48 laborers.

WAYNESBURG MINE NO. 1.—This mine is situated in the same hill above the Tyson Mine No. 1. The Waynesburg seam was originally opened as a prospect in 1912. A new drift opening was started on October 10, 1916.

The Waynesburg coal seam here consist of two benches totaling from 48 to 52 inches, separated by coal and bone partings which are removed by the miners when loading. The breaking into small cubes is characteristic of the coal, especially the top bench. A sample of the coal was taken from this mines from the right rib at the face of the main heading which at that time had only been driven some 600 feet inside from the entry. The analysis of this sample is shown in table of analyses, No. 15.

The old test opening was formerly ventilated by a furnace and air-stack, but during the early part of November, 1916, a 5-foot Stine disc electric fan was installed. The mine workings are self-draining. The Room and Panel system of mining is used, the rooms being broken off on 56-foot centers. Two Sullivan short-wall mining machines, with a 7½-foot cutting bar, and one Goodman breast machine are used in mining the coal. Five horses are used for secondary hauling. From the inside "lye" and down the switchback tramroad to the tipple an 8-ton Goodman electric locomotive is used for primary haulage. One hundred 2-ton Hockensmith mine cars are used in this mine. The gauge of the mine tracks is 42 inches.

The coal is hauled down to the top of coal chute at the Tyson Mine No. 1 where it is handled as before described.

NEW DETMOLD MINE.—The New Detmold mine of the Maryland Coal Company is situated on the west side of the Georges Creek Valley about three-fourths of a mile southeast of Lonaconing. The "Big Vein" mine was abandoned in 1911, but was re-opened during the late fall of 1915. The company is now mining pillars, crop, and some solid coal from the old workings abandoned during 1901-2.

During the former operations the rooms and headings were flooded where the coal went to the dip. A new opening has been made at a lower level in order to drain the water from these dip headings. An 8-foot Jeffrey electric force fan has been installed which is run by a 15 h. p. General Electric motor. Five horses are used for haulage inside the mine. Remodelled "Big Vein" cars are used on account of the comparatively low headings in the mine, for in many instances tunnels have had to be driven through old falls. Forty-two-inch gauge mine tracks of 35- and 16-pound steel T-rails are used.

The coal from this mine is hauled to a separate tippel located about 200 feet north of the Tyson-Waynesburg tipple. A 12-ton Porter dinkey engine is used for haulage over this 6000-foot tramroad. The coal is weighed on Fairbanks scales and loaded into railroad cars sideways over an end dump.

"FREEPORT MINE."—A new opening was driven into the Upper Bakerstown (old "Upper Freeport") coal seam about one mile southeast the McKee Mine No. 2 of the McKee Coal Company on the west side of Koontz Run. This mine was not operated during 1918 owing to scarcity of labor.

This mine was opened on the double-drift entry system and the workings will be developed on the Room and Pillar system. When last operated the haulage inside was by 2 mules. Fifteen 1-ton Watt mine cars were used. The coal was hauled by a 15-ton Jeffrey electric locomotive to a tipple some 800 feet from the entry. About 10 miners and 5 laborers were employed.

The substation to supply power for the mines of this company is located at Tyson Mine No. 1. This was the first substation of its kind installed in Allegany County, being built in November, 1915. 33,000-volt A. C. is purchased from the Edison Electric Company of Cumberland. This current is stepped down to 2200-volt A. C. by transformers and used to operate motor-generator set. The substation is equipped with type A Electrolytc lighting arresters. The entire equipment was made and installed by the Westinghouse Electric & Mfg. Company.

McKEE COAL COMPANY

The McKee Coal Company is operating McKee Mine No. 1 near Lord Village and McKee Mine No. 2, "Big Vein" and Tyson at Koontz. The company was incorporated September 1, 1916. At that time they leased from the New Central Coal Company a portion of the "Big Vein" coal which had been left in their Koontz property and on January 31, 1919, the McKee Coal Company purchased all mining rights in the Tyson and "Big Vein" seams of the entire Koontz property, together with all mine equipment and buildings at the Koontz mine. In addition to this property the company owns the coal under the McKee farm and has also leased some coal from the Consolidation Coal Company. The output for 1918 was 33,958 tons.

McKEE MINE No. 1 (B-7).—McKee Mine No. 1 is located west of Lord Village. Thus far the operations have been confined to the "Big

Vein" seam at this mine. An average section of this "Big Vein" coal here measures:

	Inches
Roof coal.	
Coal	84
Slate	1
Coal	3
Slate	1
Coal	12
Slate	¼
Coal	13
Hard shale floor.	

Five timbered drift openings have thus far been made into the seam. Four of these five openings have natural ventilation and drainage. The fifth opening is ventilated by a 5-foot Buffalo Forge Company force fan belt-driven by a 12 h. p. S. S. S. gasoline engine. Haulage is by 5 horses. Forty 2-ton Monongahela mine cars of 1800 pounds tare weight are used. Thirty-six-inch gauge tracks are laid with 20-pound T-rails. Three gravity planes are used to bring the coal down from mines to tipple. The upper plane is 1700 feet long with a grade of from 2 to 8 degrees, the middle plane is 1100 feet long with grade of 2 to 7 degrees, and the lower plane is 2300 feet long with grade of 3 to 20 degrees. The lower plane crosses the tramroad of Consolidation Mine No. 7 within 100 feet of the mouth of that mine. The tipple is located on the Carlos Branch of the Cumberland and Pennsylvania Railroad about one-half mile west of Lord Village. The coal is weighed on Fairbanks scales and dumped over a two-dump tipple into railroad cars, loading one endwise and the other sidewise.

During 1918 the company employed 35 miners and 10 laborers.

McKEE MINE NO. 2, TYSON (B, C-7, 8).—This mine is situated along Koontz Run about 2½ miles northwest of Lonaconing. The "Big Vein" coal was mined here by the New Central Coal Company until 1912. In 1896 that company opened the Tyson and Waynesburg seams experimentally at the same mine. The Tyson coal averages 3 feet 6 inches here and in most places appears to be free of shale or bone binders. A sample of the Tyson coal was taken from the face of the main heading where the seam had the following section:

	Feet	Inches
Shale roof.		
Coal	3	5
Shale bottom.		

For analysis of this coal see table of analyses, No. 22.

The opening into the mine is by the usual double-drift entry system. The usual system of Room and Pillar work used extensively throughout the region is employed here. No mining machinery is used, the coal being mined entirely by pick work. The mine is ventilated by a 20 by 5-foot Crawford and McCrimmon force fan direct-connected to a 20 h. p. Crawford and McCrimmon steam fan engine. The capacity of this fan is 80,000 cubic feet per minute at 65 r. p. m. of fan. A small shaft at the back of the mine is also used to aid in the ventilation. The mine is self-draining. Ten mules are used to gather the coal from the face of the workings and haul them to the inside "lye." A tail-rope haulage system operated by a J. J. Millholland 14 by 24-foot stationary steam engine, located outside the mine, brings the cars from the inside "lye" to the head of the gravity plane. This engine receives its power from two 80 h. p. return tubular boilers of the same make. The main haulage rope is $\frac{7}{8}$-inch diameter and the tail rope is $\frac{3}{4}$-inch diameter, both being steel wire cables. The gravity plane is 700 feet long from top to the tipple. One hundred and fifty 1-ton mine cars of 960- to 1000-pound tare weight are used at this mine. The cars were designed by the New Central Coal Company and made at the mine. The gauge of the track is 42 inches. Thirty-five-pound T-rails are used in the headings and 16-pound steel rails in the rooms. The coal is weighed on Fairbanks Standard scales at the tipple. On this frame tipple the coal is loaded into railroad cars endwise over an end dump. The coal is shipped over the Western Maryland Railway.

An average of 60 miners and 22 laborers were employed at this mine during 1918.

McNITT BIG VEIN COAL COMPANY

The McNitt Big Vein Coal Company operates a mine (B-6) about 1 mile north of Midlothian. This property was operated many years ago by the Blaen Avon Coal Company. It passed to A. B. Shaw and then to R. K. Shaw, of Baltimore, who leased it to the present operators. This company started work in February, 1917, and soon after began shipping.

Average Section

	Inches
Roof coal.	
Coal	71
Slate	1½
Coal	3
Slate	1
Coal	11
Slate	¼
Coal	11½
Hard shale floor.	

This company has four timbered drifts into the "Big Vein," all naturally ventilated and drained. The mine is developed on the Room and Pillar system, operating chiefly the outcrop and a few pillars. Five horses are used for hauling. Eighteen 1½-ton mine cars of various types are in use. The track is 36-inch gauge and laid with 16- to 30-pound T-rail. There are two gravity planes, an upper one 1700 feet long (running 4-car trips) on a 2 to 8 degree grade, and a lower one 1700 feet long (running 5-car trips) on a 3 to 10 degree grade. Both use a ¾-inch wire rope. The company proposes to build 1000 feet of tramroad above the upper plane in order to develop more territory. At the foot of the lower plane is 800 feet of tramroad leading to tipple. The coal is weighed on Fairbanks scales and dumped over an end-dump tipple into railroad cars, standing lengthwise. The shipping point is Midlothian on the Cumberland and Pennsylvania Railroad.

During 1918 an average of 28 miners and 8 laborers were employed. The output for 1918 was 29,607 tons.

MIDLAND MINING COMPANY

The Midland Mining Company is operating the Neff Run mine which is located about one-half mile northwest of the town of Midland. They are now operating in a small tract of the "Big Vein" seam which has been leased from the Georges Creek Coal Company, Inc. They formerly worked the New Enterprise mine which was abandoned in 1912.

The Neff Run mine (D-6) consists of six drift openings into the "Big Vein" coal which here averages from 10 to 12 feet thick. Opening No. 1 was first made by John Clise in 1901 for a fuel mine. This entry was reopened by the Midland Mining Company in 1912 as was also opening No. 2. Opening No. 3 was started on March 1, 1916, opening No. 4 on December 16, 1915, and opening No. 5 on June 1, 1916. These openings are ventilated and drained naturally. In places there is very little cover over the coal so that pillar-falls produce open holes to the surface which aid in the ventilation of the mine, although they also form inlets for quantities of surface water. The dip of the coal bed in some of the headings reaches, as a maximum, 12 to 14 degrees, so that little difficulty is experienced in draining the mine without artificial means.

The mine is developed on the Room and Pillar system and the mining is all by pick work. Eight horses are used for haulage inside the mine and along the tramroad from the mine openings to the top of the gravity plane. The main heading in Mine No. 5 has an average grade for half the distance of from 10 to 12 degrees. The empty cars are hauled in by horses, but the loads run out by gravity. None of the other openings have a grade exceeding 3 degrees. No. 4 is the main opening into the seam, having been driven back 1500 feet into the hill. The gravity plane is 520 feet long and has an average grade of 18 degrees for most of the distance. Two-car trips are run over this plane. Eighty mine cars are used in this mine, each having a capacity of 2 tons bedded. Tare weight of the mine cars is 1780 pounds. The gauge of the mine tracks is 36 inches. The mine cars are weighed on Fairbanks Standard scales at the tipple and then dumped over an iron T-rail back balance dump, which loads the coal sidewise into the railroad cars. The coal is shipped over the Cumberland and Pennsylvania Railroad, the Neff Run branch of this railroad connecting the tipple with the main line.

During 1918 70,325 tons of coal were mined, 56 men being employed on the average during the year.

MIDLOTHIAN COAL COMPANY

The Midlothian Coal Company is operating the old Bowery mine of the Borden Mining Company. This mine was abandoned by the owners in 1899. It was then leased from the Borden Mining Company by Robert Harvey who operated it for two years, taking out about 200 tons of coal per day. The Bowery Coal Company was formed in 1901 and leased this mine from the Borden Mining Company. This company operated the mine until 1911, taking out 150 tons of coal per day during that time. In 1911 the Bowery Coal Company subleased the mine to the Reed Coal and Coke Company. The mine was idle the first year of this lease, but during the second year the Reed Coal and Coke Company took out about 100 tons of coal per day. In 1913 the Bowery Coal Company took back their lease from the Reed Coal and Coke Company. The mine was idle until the Midlothian Coal Company bought the lease of the Bowery Coal Company in 1915. On January 1, 1916, the present operators reopened the Bowery mine. In addition to this property the Midlothian Coal Company also leased a tract of land from the Barton and Georges Creek Valley Coal Company, who held the lease from the Consolidation Coal Company; and a third tract of land from the New Central Coal Company (see accompanying property map).

The Bowery mines are situated on the south side of the valley of Winebrenner Run at Midlothian. There are four drift openings into the hill just south of the town, three of which are into the "Big Vein" and the fourth into the Tyson seam. Mining is directed to the recovery of abandoned coal from pillars and outcrop and the work is all by pick.

"BIG VEIN" MINE Nos. 1, 2 (B, C-6) AND 3 (C-6).—There are three openings into the same seam and constitute in reality but one mine. The mine has natural ventilation and drainage. The haulage in the "Big Vein" mine is by 2 horses and 1 mule. Sixteen "Big Vein" mine cars of the old Potomac type are in use which have a capacity of $2\frac{1}{2}$ tons and a tare weight of 1775 pounds.

TYSON MINE No. 1 (B, C-6).—This mine is ventilated by a furnace and air stack. The drainage is by natural means. Thirty-six mine cars are used in this mine; 11 of which are of the Whitney type and the rest are of the Watt type. The haulage is by 1 mule. The gauge of the mine tracks is 36 inches. The coal from the "Big Vein" is brought down to the tipple over an 800-foot gravity plane in 4-car trips. The grade of this plane is so slight that a single bull wheel serves the purpose of plane machinery at the head of the plane.

The coal from both seams is shipped over the same tipple. The coal is weighed on Fairbanks Standard scales and dumped into a short chute over an end dump. The railroad cars are loaded sidewise from the chute. The tipple is located on the Midlothian branch of the Cumberland and Pennsylvania Railroad. During 1918 an average of 30 miners and 10 laborers were employed at these mines. The production for the year 1918 was 23,886 tons.

MILLER AND GREENE COAL COMPANY

The Miller and Greene Coal Company are operating the No. 1 mine (D-11) which is situated on the northeastern outskirts of the town of Westernport at Franklin Station on the Cumberland and Pennsylvania Railroad. The mine originally belonged to J. O. J. Greene who leased it to the Franklin Coal Company in 1911. The latter company went into the hands of receivers in 1913. The present company began operations in December of 1915. The mine is a drift entry into the Montell (Upper Kittanning) coal seam.[1] The coal varies in thickness from 28 to 42 inches. A sample was taken from a butt heading off the main heading, where the section of the seam was:

Sandstone roof.	nches
Coal	14½
Clay binder	½-2
Coal	5¾
Shale binder	¼
Coal	6
Bastard fire-clay bottom.	

For analysis of the sample see table of analyses, No. 18.

[1] This was called the Clarion coal in the reports of the Maryland Geological Survey and was identified with the Parker (Barrelville or Lower Freeport) coal of Barrelville.

In the headings $1\frac{1}{2}$ to 3 feet of the underlying clay is taken up for clearance, while only 1 foot of clay is removed in the rooms. The mine is developed on the Room and Pillar system. All the mining is by pick work. The mine is ventilated by a 16-foot Crawford and McCrimmon force fan which is direct-connected to a 30 h. p. Crawford and McCrimmon steam engine. At 60 r. p. m. this fan produces 27,900 cubic feet of air per minute. The mine is self-draining. Haulage in the mine is by a $3\frac{1}{2}$-ton Jeffrey electric locomotive and 5 small mules. Forty-five one-ton Watt mine cars are in use. Thirty-pound steel rails are used in the main headings and 16-pound rails in the rooms. The gauge of the mine tracks is 42 inches. The coal is weighed on Fairbanks Standard scales at the tipple and then dumped over an end-tip into the railroad cars, loading them sidewise. The coal is shipped over the Cumberland and Pennsylvania Railroad. The power to operate the mine is purchased from the Cumberland and Westernport Electric Railway Company.

An average of 39 miners and 1 laborer were employed at this mine during 1918, producing 17,000 tons of coal.

MOSCOW-GEORGES CREEK COAL MINING COMPANY

The Moscow-Georges Creek Coal Mining Company operates two mines (B, C-9, 10), Moscow No. 2 in the "Big Vein," and Moscow No. 3 in the Barton coal.

MOSCOW MINE No. 2, formerly the old Pickell mine, is located near Barton on the west side of the Georges Creek Valley. The "Big Vein" averages 12 feet thick at this mine. There are several drift openings into the seam at places best suited to reach the "Big Vein" that had formerly been cut off by fire. The ventilation is by natural means, air holes having been driven to the surface. The mine is self-draining. Horses are used to haul the coal from the mine openings on a tramroad to the top of the plane—a distance of 6000 feet. There are three gravity planes used to reach the "Big Vein" from the tipple. The first plane is 2200 feet long, the second 1700 feet, and the third 400 feet long. At the bottom of this lowest plane the coal is hauled over a short tramroad to the tipple. The tipple is described under Moscow Mine No. 3.

FIG. 1.—DAVIS COAL AND COKE COMPANY, TIPPLE AT KEMPTON.

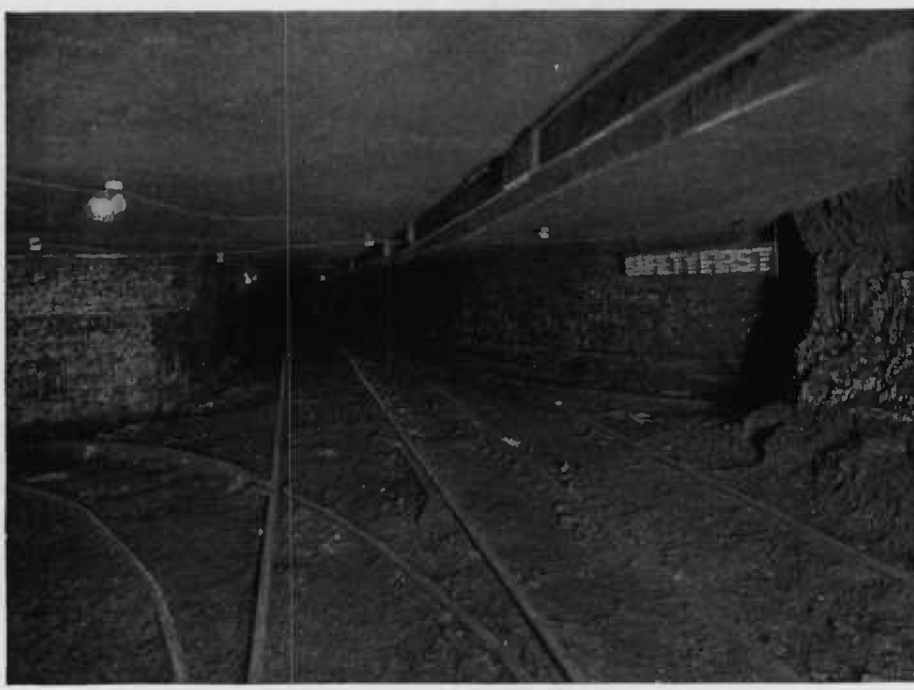


FIG. 2.—VIEW IN DAVIS COAL AND COKE COMPANY'S MINE AT KEMPTON.

MOSCOW MINE NO. 3.—Moscow Mine No. 3 is also located on the west side of the Georges Creek Valley near Barton, in the same hill beneath Moscow Mine No. 2. This mine is operating the Barton coal, which here varies in thickness from 26 to 44 inches. A sample was taken of the coal in this mine from a room of the Second Left Heading where the section measured:

	Inches
Shale roof.	
Bone	5¾
Coal	16½
Bone and shale	¼
Coal	8¾
Shale bottom.	

For analysis of this sample see table of analyses, No. 19.

This mine was opened 40 years ago by using the Long Wall system of mining. Headings were advanced about 1000 feet into the seam. The mine workings are now being developed on the Room and Pillar system. The mine is ventilated by a 6 by 4-foot Western Electric force fan direct-connected to a 15 h. p. Western Electric motor. At 350 r. p. m. this fan produces 19,999 cubic feet of air per minute. The drainage of the mine is natural. The haulage in the mine and along the short tramroad is by 6 mules. Eighty 1-ton mine cars, which are designed after the Barnesville type, are used in this mine. The gauge of the mine tracks is 42 inches. Coal is weighed on Fairbanks Standard scales at the tipple. The coal is then dumped over a Jones and Laughlin end dump into a bar screen which separates the run-of-mine into lumps and slack, so that the coal may be shipped as slack, lump, or run-of-mine. The tipple is located on a switch of the Cumberland and Pennsylvania Railroad, over which railroad the coal is shipped.

An average of 52 miners and 10 laborers were employed at this mine during 1918. The output for the year was 46,251 tons of coal.

MOUNT SAVAGE-GEORGES CREEK COAL COMPANY

The Mount Savage-Georges Creek Coal Company is operating the Mount Savage Mines Nos. 1 and 2 which are situated south of Jennings Run Valley about one-half mile southwest of Barrelville, Maryland.

The land was originally owned by the Chesapeake Steam Transportation Company, an English syndicate. John Sweet, in 1854, at the request of H. T. Welds, superintendent of that company, started to dig a tunnel into the hillside to reach the Bluebaugh coal seam. The company expected to sell the coal to the blast furnaces then situated at Mount Savage. The tunnel was driven 1000 feet into the hill, but did not reach the coal seam. The company subsequently sold their property, part to Fairweather and Ladue and part to J. A. Emrick. Ladue became sole owner of the Fairweather and Ladue portion. He subsequently leased part of his land to McMullen Brothers who made a new opening into the coal seam and operated the Partridge mine for a short time. In 1909 Emrick sold, and Ladue leased their land to the Maryland Coal and Iron Company. Emrick received part payment in cash and the rest as a mortgage for the land sold to his company, while Ladue leased his land on a royalty basis. The Maryland Coal and Iron Company completed the tunnel started by the Chesapeake Steam and Transportation Company, advancing it 600 feet to the Bluebaugh coal seam. This company operated the Trotters Run or Sunnyside mine for one and one-half years, taking out in that time about 80,000 tons of coal. In 1913 the Maryland Coal and Iron Company went into the hands of receivers. Mrs. C. J. Emrick then received title to J. A. Emrick's mortgage, giving her approximately 120 acres of coal. The portion owned by Ladue was also taken back by him, and is now owned by the Ladue heirs, *i. e.,* the estate of J. E. R. Ladue, E. H. Ladue, L. B. Ladue, and J. H. Ladue. This tract consists of about 3300 acres. Mrs. C. J. Emrick operated the mine from March 4, 1915, to November 1, 1916, selling the entire output to the Cumberland and Pennsylvania Railroad. George Stern, of Frostburg, in the meantime had bought the surface from the Ladue heirs and Mrs. Emrick. The Mount Savage-Georges Creek Coal Company has leased the minerals from the Ladue heirs and Mrs. Emrick and bought in fee a few acres from Mrs. Emrick for their mine plant. The present company, formed by Stern, began operations on November 8, 1916, using the same entry as the previous operators, calling it Mt. Savage Mine No. 1.

During the year 1918 the company began work at Mount Savage Mine No. 2, which is located approximately three-fourths of a mile east of their No. 1 mine and in the same seam of coal.

The Montell coal seam in these mines averages from 3 to 4 feet thick. A shale binder of from 1½ to 4 inches in thickness occurs from 8 to 16 inches above the floor. Where sampled in the mine the section of the seam measured:

	Inches
Shale roof.	
Coal	31
Shale	2
Coal	9
Shale bottom.	

For analysis of this sample see table of analyses, No. 20.

MOUNT SAVAGE MINE NO. 1 (C-2, 3; C, D-23; D, E-2, 3, 4).—This mine, as stated above, is the development of the original opening—a 9-foot drift tunnel 1600 feet long, driven on a slight grade in favor of the loaded mine cars. A shaft 10 feet in diameter at the top and 6 feet in diameter at the bottom has been sunk 204 feet from the surface down to the coal seam. (This shaft was completed in 1912 under the management of the Maryland Coal and Iron Company.) For the purpose of ventilating the workings a 6-foot Stine force fan has been placed at the top of this shaft. This fan is driven (with Morris belting) by a 20 h. p. Allis-Chambers induction motor, equipped with a potential starter of the same make. For purposes of rushing heading development a portable 2-foot American Blower force fan and several hundred feet of 18-inch prepared canvas tubing has been installed to supply adequate fresh air to the miners at the face of said heading. The mine water drains by gravity in ditches to two sumps from which it is pumped to the surface by two Stine electric pumps, 5 and 10 h. p., respectively.

The method of mining is a modification of the Room and Panel system. The headings are driven 10 to 15 feet wide and the rooms 30 feet wide. At the present time all mining is by pick, but arrangements have been made to install arc wall mining machines. The secondary haulage, or gathering, is performed by a 25 h. p. and a 35 h. p. Diamond stationary electric hoist and by 8 small ponies and mules. The primary haulage, *i. e.,* from the inside lye outside along the 400-foot tramroad to the tipple, is by a 6-ton Westinghouse-Baldwin trolly locomotive. For rock work a Sullivan rock drill and a Fort Wayne rock drill have been installed. One hundred and seventy-five 1½-ton Watt type mine cars are in use. Thirty-pound T-rails have been laid along the tramroad and headings and 16-pound T-rails in the rooms. The gauge of the mine tracks is 42 inches. Two end dumps are situated at the covered tipple for loading the railroad cars sideways. The coal from this mine is all shipped over the Cumberland and Pennsylvania Railroad.

MT. SAVAGE MINE NO. 2 (D-2).—The recent development of this mine offers little descriptive matter. The heading and air courses have been driven to date some 600 feet into the coal seam. The average section thus far encountered would measure:

	Feet
Shale roof.	
Coal	2.00
Slate	0.12
Coal	0.60
Shale bottom.	

The method of mining will be a modification of the Room and Panel system. To date the mining has been by pick. Ventilation is by natural means, assisted by use of an air shaft to surface. Drainage is natural. The haulage inside the mine is by one pony, while the outside haulage along the short tramroad is by one mule. Twenty-two 1-ton Watt cars are in use at the present time. Thirty-pound T-rails are used. The gauge of the mine tracks is 42 inches. The coal is weighed on standard scale at tipple and loaded into railroad cars sideways over an end dump. The tipple is located on a siding of the Western Maryland Railway.

Electric power for use at the mine is purchased from the Hagerstown and Frederick Railway Company. There the 6600-volt A. C. is stepped down to 2200-volt A. C. by transformers. This 2200 A. C. operates a Westinghouse synchronous motor which is direct-connected to a Westinghouse generator which generates 250 D. C. to operate haulage motor.

Also a series of transformers steps down the 2200-volt A. C. to 220-volt A. C. used to operate hoist, pumps, and rock drills.

At the present time the company employs 70 miners and 10 laborers. The output for 1918 was 49,679 tons.

MULLANEY COAL COMPANY

The Mullaney Coal Company is operating Mullaney Mine No. 1 (C-2, 3) which is situated about three-fourths of a mile east of the town of Mount Savage on the south side of Jennings Run Valley. This mine was opened as a fuel mine by Mr. Henry Mullaney on March 1, 1916. A tipple was constructed during October, 1918.

The mine consists of two drift openings, *i. e.*, air course, and heading, which to date have been advanced probably 1000 feet into the hill. The coal mined here is probably the Lower Bakerstown or Thomas coal of this work (the Lower Freeport of earlier reports). Several faults have been encountered thus far so that the section of the seam varied greatly as the workings developed. The last section measured at face of heading showed:

	Inches
Shale roof.	
Coal	17
Bone	2
Coal	18
Bone	2
Coal	10
Shale.	

The mine workings are to be developed on the Room and Pillar system. The mining is by pick. The mine is ventilated and drained by natural means. The haulage is by one mule. Six 1-ton mine cars are used, the same being made at the mine. The gauge of the mine tracks is 30 inches. Twelve-pound T-rails are used on the short tramroad and inside the mine. There are no scales at the mine. The coal is loaded into railroad cars sidewise over an end dump. The tipple is situated on a siding of the Cumberland and Pennsylvania Railroad over which the coal is shipped.

During 1918 15 miners were employed who produced 2100 tons of coal.

NEW CENTRAL COAL COMPANY

The New Central Coal Company is operating the "Big Vein" Mines Nos. 1 and 2 (D-8) and the Midlothian mine. Their Koontz mine was sold to the McKee Coal Company on January 31, 1919.

"BIG VEIN" MINE NO. 1.—This mine is located on the hill above and on the east side of the town of Lonaconing. Operations at this mine were started during September, 1917, and the first shipments made during November of the same year. Two openings have been made into the "Big Vein" coal seam at this mine. The mine workings consist chiefly of pillars and crops left by former operations, although there is much solid coal yet to be recovered. The "Big Vein" seam here averages 10 to 12 feet thick. The mining is all by pick. Ventilation and drainage thus far are both by natural means. Two mules are used for haulage inside and out the mine. Ten 1-ton Watt mine cars are in use. The gauge of the tracks is 36 inches. Twenty-pound T-rails are laid along the tramroad and 12- and 16-pound T-rails are used inside. The mine openings are connected with the tipple by 1000 feet of tramroad. This tipple is described below under "Big Vein" Mine No. 2.

Eight miners and 2 laborers are at present employed at this mine.

"BIG VEIN" MINE NO. 2.—This mine is located on the hill above and on the east side of the town of Lonaconing. It was opened by double-drift entries during the year 1912 into the Tyson seam.

The coal of this mine averages 42 inches. The development of the mine was on the Room and Pillar system, the mining being entirely by pick work. A 6-foot Sirroco disc fan belt-driven by a 10 h. p. Bessemer gas engine is used to ventilate the workings. The capacity of this fan is 20,000 cubic feet of air per minute. The mine is drained naturally. Three mules are used for haulage in the mine. Thirty-five 1-ton Watt mine cars are used here. The cars are let down a gravity plane 400 feet long to the tipple. Here the coal is weighed on Fairbanks Standard scales. The coal is loaded into the railroad cars sidewise over an end dump. Shipments are made over the Western Maryland Railway, the tipple being situated on the east branch of this railroad.

During 1918 an average of 25 miners and 2 laborers were employed at this mine. The output for that year was 29,727 tons of coal.

MIDLOTHIAN MINE.—The New Central Coal Company has opened up the old Midlothian mine which was abandoned in 1884. The work was started in June, 1917, and the first shipments made during January, 1918. The mine is located at Midlothian.

The following section of the "Big Vein" seam was measured, the same being about average for coal encountered in this mine:

	Inches
Roof coal.	
Coal	67
Slate	3
Coal	2
Slate	1
Coal	20
Hard shale floor.	

The mine workings consist chiefly of pillar and crop coal, although there is quite an amount of solid coal now accessible. The former operations were abandoned in 1884 owing to a fire in the mine. The present workings have been opened to recover the coal beyond the fire zone. The mining is all by pick. The development in the solid coal is by the Room and Pillar system. Three timbered drift openings have been made in the seam at this mine. Both ventilation and drainage are by natural means. The haulage is performed by two horses. Twelve 2-ton "Big Vein" mine cars are in use. The gauge of the mine tracks is 36 inches. Twenty-pound T-rail is used both inside and outside the mine. The coal from one opening is sent down a 600-foot plane, the grade of which varies from 5 to 15 degrees. The coal is weighed at the tipple on Fairbanks Standard scales. The coal is loaded into railroad cars sidewise over an end dump. The tipple is situated on a siding of the Cumberland and Pennsylvania Railroad.

During 1918 the company employed at this mine 20 miners and 3 laborers, producing 25,071 tons of coal.

NEW YORK MINING COMPANY

The New York Mining Company is at present operating Union Mines Nos. 1 and 2 and Tyson Mines Nos. 1, 2, and 3. The old Union mine was worked out during the spring of 1911, and is now abandoned. The New Hope mine and the Clifton mine were also abandoned in June, 1913.

UNION MINE NO. 1 (A, B-3).—The Union Mine No. 1 is located on the west side of Jennings Run Valley, about one-half mile northeast of the town of Allegany. This mine originally belonged to the Withers Mining Company, but was bought by the New York Mining Company in the spring of 1906. The first shipment from the mine was made by the present operators in December of the same year. The "Big Vein" coal mined here varies in thickness from 30 inches to 14 feet. A sample of coal taken in Room No. 5 off the Fourth Left Heading, which is in the northwestern section of the mine, showed the following section:

	Inches
Shale roof.	
Coal	9½
Bone	1¾
Coal	9½
Bone	½
Coal	7
Bone	½
Coal	28
Shale floor.	

For analysis of this sample see table of analyses, No. 23.

The opening into the mine is by a double-drift entry system, the grade being in favor of the loads. The mine is ventilated by an 8-foot Stine disc force fan, belt-driven by a 20 h. p. Goodman electric motor. At 55 r. p. m. this fan produces 56,100 cubic feet of air per minute. The drainage of the mine is by natural means. The mine is developed on the Room and Pillar system. Two Sullivan Short Wall mining machines are used to mine the coal, although some of the coal is mined by hand. The primary haulage in the mine is accomplished by a 13-ton Westinghouse-Baldwin electric locomotive. The secondary haulage and gathering is by one 3-ton Westinghouse electric locomotive with reel attachment. In this mine 65 mine cars of a capacity of 77 cubic feet and 30 mine cars of capacity of 47 cubic feet are used. Thirty-two-pound steel T-rails are used in the main headings and 16-pound steel T-rails in the rooms. The gauge of the mine tracks is 48 inches. The coal is weighed on Standard scales as the mine cars pass on the tipple. The tipple, designed by the Jeffrey Manufacturing Company, is quite elaborate, especial attention being given to the economic cleaning and handling of coal and refuse. The coal is dumped from the mine cars over a Sullivan cross-over dump into a feed conveyor. It then passes over a screening table where the coal is separated into four sizes. From the screening table the coal passes over picking tables where most of the slate and rock is removed. The coal then passes into the railroad cars, two cars being loaded at the same time. The picking table, screens, and conveyors are operated by electric motors. The electric power to operate the mine is purchased from the Hagerstown and Frederick Railway Company. The 2200-volt A. C. operates a Westinghouse synchronous motor which is direct-connected to a Westinghouse generator producing 250-volt D. C. The coal is shipped over the Cumberland and Pennsylvania Railroad, a switch being made to connect the tipple at the mine with the main line at Allegany.

During 1918 this mine employed on an average 123 miners and 33 laborers, and produced 116,370 tons of coal.

Tyson Mines Nos. 1, 2, and 3 (A, B-3).—At Union Mine No. 1 the Tyson coal is mined, three drift openings having been made into this coal, which here lies 120 feet above the "Big Vein." Although these openings are given different numbers they are practically one mine and will be described as such. Drift entry to Tyson No. 1 was driven during 1908, Tyson No. 2 in August, 1913, and Tyson No. 3 on August 17, 1914. The coal in the Tyson bed here averages 51 inches. A sample taken from Room No. 3 of the Second Right Heading of Tyson No. 3 showed the following:

	Inches
Shale roof.	
Coal	47½
Shale bottom.	

For analysis of this sample see table of analyses, No. 24.

The mine is ventilated and drained by natural means. The method of mining is the Room and Panel system, rooms being driven on 65-foot centers and panel headings being broken off main headings at 200-foot intervals. The mining is by pick work. The haulage is by 3 mules. The coal is hauled to the outside of the mine and along a 900-foot tramroad to a 300-foot gravity plane. At the bottom of this plane the coal is weighed and dumped into "Big Vein" cars and hauled through the Union No. 1 mine and dumped into railroad cars over the same tipple as described under Union No. 1. In the Tyson mine 60 mine cars of 34 cubic feet capacity are used. The gauge of the mine car tracks is 48 inches. Two 20 h. p. Sullivan electric portable air compressors and hammer drills are used at the mines of this company for rock work. Power to operate this mine is brought up from substation at Union No. 1.

During 1918 an average of 35 miners and 7 laborers were employed.

Union Mine No. 2 (B, C, D-3, 4).—This mine is situated on the east side of the Jennings Run Valley one-half mile east of the town of Allegany and directly opposite Union Mine No. 1. This mine has been operated since 1894. The thickness of the "Big Vein" coal in Union No. 2 averages 10 feet, although in places, due to faulting, the coal bed is 24 feet thick. The opening into the mine is by means of a drift entry of 1½ to 2 per cent grade in favor of the loads. The mine is ventilated by a 12-foot Crawford and McCrimmon electric fan. At 90 r. p. m. and against a ½-inch water gauge, this fan delivers 21,600 cubic feet of air per minute. The mine is naturally drained. At present the method of mining consists of robbing the pillars, the mine having been developed on the Room and Pillar system. All advance work in this mine was completed several years ago and now only the pillar work remains. The haulage in this mine is by 3 horses and 1 mule. There are about 200 mine cars of 77 cubic feet capacity in active use. The gauge of the mine tracks is 48 inches. The coal is weighed at the tipple on Standard scales. A Link-Belt picking table is used at the tipple to clean the coal. Power to operate fan and tipple at this mine is purchased from the Frederick and Hagerstown Railway Company. The 2200-volt A. C. is stepped down to 220 A. C. by transformers at the time. The coal is shipped over the Cumberland and Pennsylvania Railroad which reaches the tipple by a switchback off the main line. Thirty-five miners and 16 laborers were employed on the average during 1918, producing 35,962 tons of coal.

NORTH MARYLAND COAL MINING COMPANY

The North Maryland Coal Mining Company are operating the Montell mine (D, E-5, 6) which is located at Mertens Station (near Vale Summit) on the Western Maryland Railway. The company purchased this property on August 1, 1918, from the Maryland-Georges Creek Coal Company which went into the hands of receivers on January 8, 1917. The entrance to the mine is by the Montell Tunnel, which has been driven 2480 feet into the mountain. Several coal seams are cut in the tunnel but only two are worked, viz., the Upper Freeport (Davis) coal and the Montell (Upper Kittanning) coal. A sample of the Davis coal was taken from the Frederick Heading where the following section was measured:

	Inches
Shale roof.	
Coal	10½
Shale	4
Coal	13½
Shaly rock	11
Coal	19½
Shale	1
Coal	25
Shale floor.	

For analysis of this sample see table of analyses, No. 17.

A sample of the Montell coal was taken from the First Left Heading in the south side where the section measured gave:

	Inches
Shale roof.	
Coal	11
Shale	20
Coal	20
Shale	1½
Coal	8½
Wild coal	18
Rock.	

For the analysis of this sample see table of analyses, No. 16.

The mine has been developed on the Room and Pillar system and the mining is by pick. Both ventilation and drainage are by natural means. The secondary haulage is performed by two 5 h. p. Lidgerwood stationary room hoists, a 50 h. p. Thomas Elevator Company's stationary hoist, and 8 mules. The primary haulage is accomplished by a 6-ton General

Electric trolly locomotive. There are about 150 one-ton Watt mine cars in use. The gauge of the mine track is 42 inches.

Electric power to operate the mine is purchased from the Hagerstown and Frederick Railway Company. High-tension wires bring 33,000-volt A. C. to the mine substation. It is there stepped down to 2200-volt A. C. by transformers and used to operate Ridgeway Dynamo Engine Company synchronous motor which is direct-connected to a generator of the same make. The generator produces 250-volt D. C. which current is used to operate hoists and locomotive.

The tipple is located on a spur of the Western Maryland Railroad over which the coal is shipped. The coal is weighed on Fairbanks Standard scales and loaded into railroad cars over a cross-over dump.

During 1918 this company employed 68 miners and 8 laborers. During that year 56,366 tons of coal were mined.

PHOENIX AND GEORGES CREEK MINING COMPANY

The Phoenix and Georges Creek Mining Company operates the Elkhart mines (C, D-10, 11) which are situated on the west side of the Georges Creek Valley about one-fourth of a mile northwest of Phoenix. Both the Barton and Lower Freeport coal seams are being mined at the present time. The Phoenix mine of this company was worked out in March, 1911. The company has leased the Barton coal seam on two tracks of land belonging to the West Virginia Central and Pittsburgh Railway Company in connection with coal on land owned in fee by themselves.

BARTON MINE was opened on a double-drift entry system in the Barton coal seam in 1904. The mine was developed on the Room and Pillar system with mining by pick work. The present operators have changed from the Room and Pillar to the Panel system. Under this system the panel headings are driven on 250-foot centers and rooms then turned off the headings on 50-foot centers. Two Martin-Gardner electric top-cutting machines are used to mine the coal. The ventilation of the mine is by a 6-foot Stine centrifugal force fan direct-connected with a 20 h. p. General Electric motor. At 100 r. p. m. this fan produces 48,000 cubic feet of air per minute. The mine is self-draining. The secondary haulage is accomplished by two Martin-Gardner gathering locomotives with reel attachments. The primary haulage is performed by a 7-ton Martin-Gardner electric haulage locomotive. There is a tramroad 600 feet long from the mouth of the mine to the top of a gravity plane which is 900 feet long. One hundred and forty Hockensmith mine cars of 1-ton capacity are used here. The gauge of the mine tracks is 42 inches. At the tipple the coal is weighed on Standard automatic scales and dumped over an ordinary back-balance end dump, loading the railroad cars sidewise. Coal may be screened, separating it into lump and slack or may be shipped as run-of-mine. Power to operate the mines is purchased from the Cumberland and Westernport Electric Ry. Company, the 650-volt current being stepped down to 250 volts D. C. for use at the mines.

During 1918 an average of 60 miners and 24 laborers were employed, producing 59,666 tons of coal which was shipped over the Cumberland and Pennsylvania Railroad.

"LOWER FREEPORT MINE."—The company opened this mine during 1913, but abandoned operations until May, 1917. The first shipment was made during the latter part of July, 1917. This coal is the Thomas seam.

The workings are developed on the Room and Pillar system. The coal is mined by a Martin-Gardner top-cutting machine. The mine is ventilated by a 6-foot Stone force fan, belt-driven by a 15 h. p. General Electric motor. The mine workings are drained by natural means. Two mules are used to gather the coal and haul same to inside lye. The primary haulage inside and outside along tramroad is performed by a 3½-ton Jeffrey electric locomotive. The coal is hauled over a 1700-foot tramroad to the tipple, mentioned under the Barton mine, and weighed by the same scales.

During 1918 an average of 15 miners and 5 laborers were employed.

PIEDMONT AND GEORGES CREEK COAL COMPANY

The Piedmont and Georges Creek Coal Company is operating the following mines in Maryland:

Washington Mine No. 1 near Gannon's Station (C-11).

Washington Mine No. 2 near Eckhart (C-4, 5).

Washington Mine No. 3 opposite Gannon's Station (C-11).

Washington Mine No. 5 opposite Gannon's Station (C-11).

The company recently renumbered its mines with the above result.

WASHINGTON No. 2 (C-4, 5).—Washington No. 2 is located near the town of Eckhart on the Eckhart branch of the Cumberland and Pennsylvania Railroad. The mine, opened in October, 1902, is operating in two adjoining tracts of Tyson coal, one leased from the Consolidation Coal Company and the other from the Charles Leatham estate. The Tyson coal in this mine averages from 3 feet 4 inches to 4 feet 6 inches in thickness, having neither a shale parting nor any bone coal. The section of the coal where sampled in Room Number 6, off the Fourth Left Heading, shows:

	Feet	Inches
Shale roof.		
Coal	4	2
Shale floor.		

Three 9-foot drift openings have been made into this mine, the main haulage way, the air course, and entry into the "North Side." Ventilation of the mine is maintained by an 8-foot direct-connected Robinson fan driven compressively. At 190 r. p. m. this fan produces 65,000 cubic feet of air per minute. Many of the wooden brattices and overcasts have been replaced by those of brick and concrete. The water in the "North Side" is drained in ditches by gravity to a sump 1200 feet inside the mine. From here the water is pumped to the outside by a Canton Duplex electric pump (size 4 by 4 by 5 inches), which has a capacity of 60 to 70 gallons per minute. In the main part of the mine water is pumped from the several local sumps to a bore hole which has been drilled through to the abandoned workings of the "Big Vein," 250 feet below the Tyson coal. Four Deming electric pumps are used for this latter transfer of water to the bore holes. With the exception of the Sixth South Heading, which is flooded for several months of the year, the mine is kept exceptionally dry. At places where the mining of the "Big Vein" beneath has shattered the strata to the surface, the surface water enters the Tyson mine after a rain. This water, however, is either pumped out or drained after a few days. The mine has been developed on the double entry Room and Pillar system, with 50-foot pillars between the entries and about 35-foot pillars between the rooms. The rooms are 18 to 20 feet wide. The mining now is on the retreat and all the work is done by pick. The secondary haulage, or gathering the cars, is done by three 4-ton Jeffrey electric gathering locomotives, and one 4½-ton Jeffrey electric gathering locomotive in the main workings of the mine; while three mules are used for secondary haulage in the "North Side." The primary haulage in both the "North Side" and the main development is accomplished by one 10-ton Jeffrey electric haulage locomotive. The tracks are 42-inch gauge, 16-pound steel rails being used in the rooms and 35-pound steel rails in the main haulage-ways. The grade of the main haulage-way never exceeds 2 per cent against the loads. Two hundred and thirty-one 1-ton Watt mine cars are used at this mine. The tipple, built in 1906, is located about 1500 feet from and 65 feet below the mouth of the mine, making a grade on the tramroad of about 4 per cent in favor of the loads. Cars are weighted on Standard scales at the tipple and dumped over two automatic cross-over dumps, loading two railroad cars on separate tracks. During 1906 an electric plant was installed, the power house being located near the tipple. This plant consists of one 150 h. p. tubular boiler, with hot-water feed attachment, one 100 k. w. 250-volt belt-driven Jeffrey generator (now geared up to 278 revolutions per minute) and a simple Atlas engine. Coal from this mine is shipped over the Cumberland and Pennsylvania Railroad.

During 1918 an average of 49 miners and 13 laborers were employed at this mine, producing 47,181 tons of coal.

WASHINGTON No. 1 (C-11).—The old Washington Mine No. 1 was located at the head of Washington Hollow, and was closed on May 3, 1913. The present Washington Mine No. 1 is situated near Gannon's Station on the Cumberland and Pennsylvania Railroad and was opened in October, 1913. The property contains about 500 acres, two-thirds of which is owned in fee and the balance worked on a royalty basis. The seam of coal operated is the Upper Freeport (Davis of this work), locally known as the "Split-six" or "Lower Kittanning." The section of the seam measured varies from 17 inches to 24 inches of bottom coal, and from 18 to 30 inches of top coal. These two benches are separated by a slate or rock parting, varying from 8 to 24 inches, although in some places thickening so as to cut out the top bench entirely. Where sampled (1) along the Main Heading, (2) Fourth Right Air Course, the section of the coal showed:

1	Inches	2	Inches
Shale roof.		Shale roof.	
Coal	29	Coal	32
Shale	14	Shale	10½
Coal	7	Coal	3½
Shale	1½	Bone	1½
Coal	16	Coal	17
Shale floor.		Shale floor.	

For analysis of this coal see table of analyses, No. 25.

The mine is mechanically ventilated, the current being produced by a 5-foot Jeffrey electric double inlet blowing fan with a capacity of 70,000 cubic feet of air per minute against a resistance of 2-inch water gauge, the fan running at 290 r. p. m. The mine has an average dip of 2 per cent from the drift entry for a distance of 1500 feet where it crosses the main synclinal, and from here begins to rise to the northwest or in the direction of the western anticlinal. With the exception of local dips the property is self-draining from this point, or from where the main headings cross the synclinal axis. Several small electric pumps are used to drain the local sumps. The mine is laid out and operated on the double-entry Room and Pillar system, using 100-foot barrier pillars on either side of the main heading and air course, and 60-foot pillars between them. The side headings and rooms are driven on 60-foot centers, leaving 40-foot pillars. The coal is cut just above the rock parting by two Jeffrey Arc Wall electric cutting machines. The top coal is taken out first, then the rock, and finally the bottom coal. This insures cleaner coal and easier work. The primary haulage is by a 10-ton Jeffrey electric haulage locomotive. Secondary haulage is by four 5-ton Jeffrey electric gathering locomotives. Washington Mine Nos. 1, 3, and 5 are close together and are all three connected so that the same mine cars can be used in all three mines. Thus the company has about 300 mine cars remodelled after the Watt type, having a capacity of 1½ tons when topped with lumps. The gauge of the mine tracks is 42 inches. Thirty-five-pound steel T-rails are used in the headings and 16-pound steel T-rails are used in the rooms. The seam outcrops about 30 feet above the railroad track and the coal is hauled over a 2000-foot tramroad to the tipple at Washington No. 5. Here the coal is weighed, prepared for market, and loaded into railroad cars to be shipped over the Cumberland and Pennsylvania Railroad.

During 1918 an average of 57 miners and 13 laborers were employed here, producing 52,283 tons of coal.

WASHINGTON No. 3 (C-11).—This mine is located opposite Gannon's Station on the Cumberland and Pennsylvania Railroad. The coal is leased from the West Virginia Central and Pittsburgh Railroad, the Gannon estate, and part owned in fee by the present operators. The drift entries are made into the Piedmont coal, locally known as the Six-foot coal, which here lies 20 feet above the railroad tracks. The seam varies from 24 to 60 inches in pockets. The mine is ventilated by a 5-foot Stine force fan, belt-driven by a 15 h. p. Imperial electric motor. At 875 r. p. m. of motor or 375 r. p. m. of fan, 30,000 cubic feet per minute of air is produced. The drainage of the mine is natural after crossing the base of the syncline which is 600 feet from the mine opening. From this point (the base of the syncline) the water is pumped to the outside by a Deming Triplex pump, having a 3-inch suction and a 2½-inch discharge. This pump is run by a 5 h. p. General Electric motor. The mine is developed on the double entry Room and Pillar system. At present the primary haulage is by a 5-ton Whitcomb gasoline locomotive and the gathering is done by four mules. Thirty-five-pound steel T-rails are used in the headings and 16-pound steel T-rails in the rooms. Gauge of the mine track is 42 inches and mine cars are the same as those used in Washington Nos. 1 and 5.

A separate tipple has been provided for this mine. At this tipple the coal is weighed on Fairbanks Standard scales, and dumped over an end tipple, loading the railroad cars sidewise. Coal is shipped over the Cumberland and Pennsylvania Railroad.

During 1918 an average of 5 miners and 8 laborers were employed who produced 7855 tons of coal.

WASHINGTON No. 5 (C-11).—Washington No. 5 is located west of the synclinal axis of the coal basin. It is opposite Gannon's Station on the Cumberland and Pennsylvania Railroad. The property contains about 400 acres, part of which, known as Michaels Farm, was bought by this company and the balance was leased from the West Virginia Central and Pittsburgh Railway Company. There are three drift openings in the outcrop of the Barton seam, about 450 feet above the Georges Creek. The mines were opened in the fall of 1906 and the first shipment was made in August, 1907.

The coal ranges from 23 to 33 inches, having an average height of 28 inches. A sample of this coal taken from the Second South Heading shows the following section:

	Inches
Shale roof.	
Bone	8
Shale	1½
Bone	7
Blackjack	4
Coal	27
Shale bottom.	

For analysis see table of analyses, No. 27.

The mine is ventilated by a 16-foot Crawford and McCrimmon direct-connected steam-driven fan, working compressively. At 150 r. p. m. this fan produces 65,120 cubic feet of air per minute. The F opening of this mine is ventilated by a 5-foot Stine electric force fan, belt-driven by a 15 h. p. Westinghouse electric motor. At 322 r. p. m. this fan produces 29,760 cubic feet of air per minute. The mine is drained naturally. The mines are opened on the double entry Room and Pillar system with 50-foot pillars between the parallel headings and 40-foot pillars between the rooms. In addition to pick mining, 5 Sullivan Continuous Cutting electric mining machines are used. The main haulage is by one 5-ton Jeffrey haulage locomotive and the secondary haulage is by three 3½-ton Jeffrey gathering locomotives. The mine cars are let down a 2200-foot gravity plane by horizontal gravity-plane machinery. Mine cars are the same os those used in Washington Mines Nos. 1 and 3. Thirty-pound T-rails are used on the entries and 16-pound T-rails in the rooms. Gauge of the mine track is 42 inches.

At the tipple the coal is weighed on Fairbanks Standard scales and dumped over a cross-over dump into a chute equipped with adjustable shaker screen bars to separate the lumps from the fine coal. This tipple separates the coal into four grades, lump, egg, nut, slack or run-of-mine. The tipple is also provided with storage bins. A rather ingenious system of track switches has recently been made to allow railroad cars to be placed at the tipple by the mine haulage locomotive. The railroad cars are weighed at the company's Manifest Office, just below the tipple at No. 5 mine.

An average of 70 men have been employed at this mine during 1918. The output for this year was 62,225 tons.

A 20 h. p. Sullivan electric portable air compressor and hammer drill is used at the mines of this company for rock work in the headings or driving through faults.

The central power plant to furnish power to Washington Mines Nos. 1, 3, and 5 is located just below Gannon's Station on the Cumberland and Pennsylvania Railroad. The equipment of this power plant consists of one 225 h. p. Atlas steam engine which is belt-connected to a 150 kw. Jeffrey electric generator. The steam for this engine is supplied by two 150 h. p. Atlas boilers. The water for these boilers is heated to 200 degrees by an open-water heater (Loew Mfg. Company, Cleveland, Ohio) and fed to the boilers by a "Smith-Vaile" boiler feed pump (Platison Works, Dayton, Ohio). In addition a transmission line has been built to the plant of the West Virginia Pulp and Paper Company at Luke, Maryland, which supplies the mines with 2200-volt A. C. Two 150 kw. General Electric motor-generator sets at the mine power plant are operated by this 2200-volt A. C., producing 250-volt D. C. for use in the mines.

Pine Hill Coal Company

The mine (D-7, 8) of the Pine Hill Coal Company is located on the east side of Georges Creek about three-fourths of a mile southwest of Gilmore. This mine was opened in 1870 by the Georges Creek Coal and Iron Company as Mine No. 2 and was abandoned in 1897. It is owned by the Georges Creek Coal Company, Inc., and leased to the Pine Hill Company on a royalty basis to take out outcrop and pillars. Work was started in

November, 1916, and shipping began June 1, 1917. The mine is in the "Big Vein" coal seam.

Average Section

	Inches
Roof coal.	
Coal	85
Slate	1
Coal	4
Slate	1½
Coal	14½
Slate	¼
Coal	14½
Hard shale floor.	

There are two timbered drifts with natural ventilation and drainage. The Room and Pillar system is used whenever possible. Two horses are used for hauling the standard 2-ton "Big Vein" mine cars, tare weight 1750 pounds. Fifteen hundred feet of 42-inch gauge tramroad laid with 20-pound T-rail leads to the tipple where the coal is loaded over an end dump into railroad cars sidewise. Shipment is made over the Western Maryland Railway at Lonaconing.

During 1918 an average of 30 miners and 5 laborers were employed. The production for the year was 7500 tons.

STANTON-GEORGES CREEK COAL COMPANY

The mine (D-4) of the Stanton-Georges Creek Coal Company is located on the north side of Braddock Run near Short Gap, about 1 mile south of Clarysville. This mine was bought by Mr. Louis Stanton in 1912 from the Georges Creek Basin Coal Company, which in turn had purchased the property from the Braddock Coal Company during the year 1907. The coal of this mine is probably the Montell (Upper Kittanning of this work, called locally the Bluebaugh seam). It averages 40 to 70 inches thick. A sample was taken from a room off the Fourth Right Heading where the seam measured:

	Feet	Inches
Shale roof.		
Coal		7
Shale		2
Coal	2	1½
Shale		9¾
Coal	1	9
Shale bottom.		

For analysis of this sample see table of analyses, No. 31.

The lower shale parting varies in thickness from 4 inches to 2 feet, but in the more newly developed part of the mine this shale parting decreases in thickness. The mine was developed on the Room and Pillar system, but the later work has been by the Panel system. Mining is all by pick work. The grade in the mine is at places as much as 7 degrees. The mine was opened by an 8-foot double drift entry. A 14-foot Crawford and McCrimmon steam force fan direct-connected to a 20 h. p. Crawford and McCrimmon steam fan engine furnishes the artificial ventilation for the mine. At 50 r. p. m. this fan supplies 23,000 cubic feet of air per minute. The mine is naturally drained. The mine cars are gathered by 4 mules and hauled to the inside "lye." A 50 h. p. Touhill stationary steam engine with two 3½-foot winding drums is used for the primary haulage. A ¾-inch steel wire cable is used in the tail-rope haulage system. Seventy 1-ton mine cars of Watt type are used at this mine. Thirty-five-pound steel T-rails are used in the headings and 16-pound T-rails in the rooms. The gauge of the mine track is 42 inches. A tramroad 800 feet long connects the mouth of the mine with the head of the plane. This gravity plane is 1100 feet long and has a 10- to 15-degree grade. Coal is weighed on Fairbanks Standard scales at the tipple and loaded into the railroad cars sidewise over an end dump. Thirty-eight hundred feet of side track has been laid by the company to connect the tipple with the Eckhart Branch of the Cumberland and Pennsylvania Railroad, over which the coal is shipped.

Steam for the haulage and fan engines is supplied by a 75 h. p. Brownville boiler.

During 1918 an average of 8 miners and 2 laborers were employed at this mine, producing 8959 tons of coal.

SULLIVAN BROTHERS COAL COMPANY

The Sullivan Brothers Coal Company operates two mines, Sullivan No. 1 ("Big Vein" and Tyson near Eckhart), and Sullivan No. 2 ("Big Vein" at Carlos).

SULLIVAN MINE NO. 1, TYSON (C-4).—This mine is located about three-fourths of a mile northwest of the town of Eckhart. The land is leased from the New York Mining Company. From 1905 to 1908 the New York Mining Company made various attempts to mine the Tyson coal, which here lies some 120 feet above the "Big Vein," but so many faults were encountered that the operations were abandoned. In the fall of 1910 the Sullivan Brothers Coal Company leased this Tyson coal from the New York Mining Company and operated the seam from the other side of the hill near Eckhart. The present operators have been able to mine the Tyson coal successfully from this point, although the faulting has proved somewhat troublesome. The coal averages here 50 inches.

The mine is opened on the double-drift entry system. The method of mining employed is the Room and Pillar system, and the mining is all by pick work. The mine is ventilated by a 10-foot Stine force fan which is belt-connected to a 15 h. p. Bessemer gas engine. The capacity of this fan is 48,000 cubic feet of air per minute. In addition a 5-foot Stine electric fan is used to ventilate one section of the workings. The water in the mine runs in ditches to a sump from which it is pumped to the surface by a 7 h. p. Demming electric pump. Ten mules are used to pull the mine cars from the working faces to the inside "lye," from which point a 4½-ton Jeffrey electric haulage locomotive pulls the cars out of the mine to the top of the gravity plane. The cars are then sent down a 600-foot plane to the tipple which lies about 75 feet lower than the mouth of the mine. Seven full cars going down the plane pull up seven empties. Ninety-six 1-ton Watt mine cars are used at this mine. The gauge of the mine tracks is 42 inches. At the tipple the cars are weighed on standard scales and the coal is loaded into the railroad cars sidewise over an end dump. The coal is shipped over the Eckhart Branch of the Cumberland and Pennsylvania Railroad. The electric power is purchased from Washington Mine No. 2 of the Piedmont-Georges Creek Coal Company.

An average of 90 miners and 30 laborers were employed at this mine during 1918, producing 69,316 tons of coal.

SULLIVAN MINE NO. 1, "BIG VEIN."—Sullivan No. 1, "Big Vein," mine is located in same hill as Sullivan No. 1, Tyson, mine near Eckhart. This mine consists of pillars, outcrop, and some solid coal leased from the

New York Mining Company. The mine was opened by the present operations during 1916.

Three openings have been made into the "Big Vein" seam. The section measured in opening No. 2 is a fair average of the seam at this locality.

	Feet	Inches
Shale roof.		
Coal	2	
Shale		6-8
Coal	2½	
Shale		½
Coal	1	
Shale		¼
Coal	2-2½	

The workings are ventilated and drained by natural means. The haulage in the mine is by two mules. The three openings are connected with the tipple described above under Sullivan No. 1, Tyson, by 1300 feet of tramroad and a gravity plane 550 feet long. A 6-ton Porter dinkey engine is used to haul the mine cars along the tramroad. The same mine cars are used at Sullivan No. 1 for both Tyson and "Big Vein" workings. The coal is handled over the same tipple.

SULLIVAN MINE No. 2 (B, C-6, 7).—Sullivan Mine No. 2 is located in the hill to the west of the town of Carlos. The land originally belonged to the Barton and Georges Creek Coal Company. The Sullivan Brothers Coal Company purchased the Carlos tract from the Barton and Georges Creek Coal Company on September 1, 1915, and at the same time leased three tracts of land from the Consolidation Coal Company. The Sullivan Brothers made their first shipment from this mine on November 22, 1916. The present operators are mining the outcrops, pillars, and some solid coal left in the workings of former operators. The coal averages 10 feet thick.

Six drift openings have been made into the "Big Vein" around the hillside. The ventilation and drainage (with exception of one local sump) of the entire workings are by natural means. Opening No. 1 is connected with the main tramroad by a 2200-foot gravity plane. About three-fourths of the distance up from the foot of the plane a 540-foot tramroad leads off to the left to opening No. 2. About 50 feet up from the bottom of the plane a second gravity plane, 790 feet long, has been laid to opening No. 4. From the head of this plane a third short plane 470 feet in length leads off to the right to opening No. 3. A switchback tramroad, 700 feet long, leads up to opening No. 6 from the main tramroad. A gravity plane 540 feet long connects opening No. 5 with the switchback tramroad. The main tramroad connecting all with the tipple is about 2000 feet long.

Secondary haulage in opening No. 1 is by one horse and the primary haulage inside the mine and along the tramroad is by a 6-ton Jeffrey electric locomotive. Three horses are used for haulage in No. 2 opening, 2 horses in Nos. 3 and 4, and 1 horse each in Nos. 5 and 6 opening. Four car trips are used on the gravity planes and 8-car trips along the main tramroad. A 200 h. p. Exeter stationary steam engine is used to haul trips along this tramroad. A 1½-inch wire cable attached to both ends of trip of cars and passing around bull wheels at each end of the tramroad and back to the 6-foot drums of the stationary engine constitutes the haulage system along the main tramroad.

Eighty mine cars of the old Potomac "Big Vein" type are in use. The tare weight of these cars is 2140 pounds and their capacity is 3 tons. The gauge of the mine tracks is 48 inches. Thirty-five-pound T-rails are used on the tramroads and planes and 20-pound T-rails inside the mine.

At the company's power house two 150 h. p. Erie City boilers supply steam for the Exeter stationary engine, mentioned above, and also to a 150 h. p. McEwen steam engine. The latter is belt-connected to a 100 kw. (250-275 volt) multipolar electric generator (Goodman Mfg. Company) which generates power for electric locomotive and pumps.

The coal is weighed on Fairbanks Standard scales at the tipple and is then loaded into the railroad cars over an end dump. Tipple is located on the Carlos Branch of the Cumberland and Pennsylvania Railroad over which the coal is shipped.

During 1918 there were employed at the mine an average of 80 miners and 30 laborers. The output for 1918 was 64,605 tons.

UNITED BIG VEIN COAL COMPANY

The United Big Vein Coal Company has leased the property (C, D-3, 4) of the Trimble heirs which lies about three-fourths of a mile south of Mt. Savage. There have been several efforts to develop this property during the past years, the last attempt having been made by the Midland Mining Company during 1911-12.

Average Sections of the "Big Vein" Seam

No. 1	Inches	No. 2	Inches
Shale roof.		Shale roof.	
Slate	2	(Wild) coal and slate	13
Coal	½-8	Coal	9
Slate	1	Slate	2
Coal	8	Coal	7
Slate	1	Slate	2
Coal	26	Coal	23
Shale floor.		Hard shale floor.	

At present there are three timbered drift openings into the coal seam. The mine is developed on the Room and Pillar system with natural drainage and ventilation. Three mules are used inside for hauling. A 17½-ton Porter dinkey engine is used on the tramroad which is 2000 feet long.

Three sizes of cars are used with tare weights of 1350, 1400, and 1500 pounds. The gauge of the tracks is 42 inches. Twenty-pound T-rail is used in the mine, 30-pound on the plane, and 40-pound on the tramroad. The coal in 4-car trips, is sent over a gravity plane 700 feet long (dipping from 18 to 32 degrees) to the timber tipple. The coal is weighed on Fairbanks scales at the tipple and loaded into the railroad cars sidewise over an end dump. The coal is shipped over the Cumberland and Pennsylvania Railroad.

During 1918 the company employed 40 miners and 10 laborers. The output for the year was 34,464 tons.

WESTERNPORT COAL COMPANY

The mines of the Westernport Coal Company (C, 4-11) are located on the east side of Georges Creek just south of Franklin. They have openings in the Davis ("Split-six") and Lower Freeport seams. The "Split-six seam" was opened about 40 years ago by James Howard who drove in a few feet for fuel coal. The company owns a small track of land along the road and leased an adjoining tract of 395 acres from the Morrison heirs. Work was started on April 15, 1917, and first shipment was made on May 27, 1917.

Average Section

Hard gray shale roof.	Inches
Coal, some bone and sulphur near top	24
Shale	16
Coal	35

This entry to the mine is by a timbered slope driven on a light grade. The mine is being developed on the Room and Pillar system. The mine is ventilated by a 72-inch steel fan made by P. B. Sturdevant, Bradeyville, Mass., which is belt-driven by a 15 h. p. Crocker-Wheeler motor, 500 volts. Capacity of this fan has not yet been measured. The mine is drained by a 2½-inch American Vertical Centrifugal pump driven by a 550-volt motor. Two mules are used for haulage. One-ton small-vein cars are in use weighing about 1500 pounds when empty. The track is 42-inch gauge and is laid with 30-pound T-rails. The mine was originally opened as a fuel mine, the coal being shoveled from the mine cars to wagons and hauled to a siding. A tramroad 150 feet long has been laid leading to an end-dump tipple where coal is weighed and dumped into a concrete pit. From this pit a Perkins Company chain-driven scraper conveyor, which has a capacity of 66 tons per hour, is used to elevate the coal, carry it across the state highway, and dump it into railroad cars on the siding. The conveyor is driven by a 20 h. p. Imperial Electric Company 550-volt D. C. motor. The power is purchased from the Cumberland and Westernport Electric Railroad Company. The slate is gobbed, none being brought outside. Shipping point is Franklin on the Cumberland and Pennsylvania Railroad.

During 1918 35 miners and 10 laborers were employed, producing 29,443 tons of coal.

PIEDMONT OR "SIX-FOOT" MINE.—This company is removing the outcrop coal and available pillars from a piece of "Six-Foot" coal on the hill above the Cumberland and Pennsylvania Railroad roundhouse near Westernport. This coal was worked some years ago by Brophy and Fahey.

Section

Shale roof.	Inches
Coal	15
Bone	5
Coal	19
Slate	1
Coal	28

This mine was a timbered drift entry with natural ventilation and drainage. The one mine car is pushed in and out on a 42-inch gauge track laid with 16- and 30-pound T-rails. The coal is dumped over an end-dump tipple into wagons and hauled to Westernport and shipped over the Cumberland and Pennsylvania Railroad. Some coal is sold for fuel.

During 1918 two miners were employed. Work was started June, 1917, and first shipment made July 1, 1917.

WEST VIRGINIA PULP AND PAPER COMPANY

The West Virginia Pulp and Paper Company is operating the Devon (D-12) mine situated one-fourth of a mile north of the town of Luke, Maryland. The mine was opened on February 3, 1916, and the first shipment made on March 29, 1916. The mine has a double-drift opening into the Piedmont coal seam (Lower Kittanning of earlier reports) which averages 5 feet in thickness. A sample of the coal taken from the face of the First Left Heading measured:

Shale roof.	Inches
Coal	11¾
Bone	6¾
Coal	13½
Bone	1½
Coal	26¼
Shale bottom.	

For analysis see table of analyses, No. 33.

The mine is developed on the Room and Pillar system and the mining is all being done by pick work. A 5-foot Jeffrey force fan, belt-driven by a 15 h. p. Westinghouse motor, ventilates the mine. The capacity of the fan is 75,000 cubic feet of air per minute, but at present is only running at one-third of its capacity, against a 3-inch water gauge. The entry for the air course is of concrete, and the fan and motor are inclosed in iron sheds. The mine water drains by gravity into two sumps from which it is pumped to the surface by two 5 h. p. pneumoelectric pumps. The primary haulage in the mine is performed by one 10-ton Jeffrey electric locomotive. The secondary haulage is by two 6-ton Jeffrey electric gathering locomotives with reel attachments. The "rock work" of the mine is taken care of by a 20 h. p. Sullivan electric portable air compressor and hammer drill. The main entry is lighted by electric lights placed at intervals of 30 feet. Fifty 2-ton mine cars are used at this mine. The tare weight of these cars is 1750 pounds. Thirty-pound steel T-rails are used in the headings and 20-pound in the rooms. The gauge of the mine tracks is 42 inches. The cars are weighed on Fairbanks Standard scales at the mouth of the mine. The cars are then let down a 505-foot gravity plane in 2-car trips. At the tipple the coal is loaded sidewise into railroad cars over an end dump. All the coal from this mine is used by the West Virginia Pulp and Paper Company.

Twenty-two hundred volt A. C. power is brought to the substation at the mine from the West Virginia Pulp and Paper Company's plant at Luke. A 2200-volt Westinghouse induction motor direct-connected with a 150 kw. Westinghouse generator produces 250 D. C. used to operate haulage locomotives. Three 25 kw. transformers are used to step down 2200-volt A. C. to 225-volt A. C. necessary to operate fan, pumps, and rock drill.

During 1918 an average of 100 miners and 15 laborers were employed at the Devon mine, producing 143,974 tons of coal.

FUEL MINES OF THE GEORGES CREEK BASIN

Many small mines are operated throughout the region as a source of fuel coal for local use. The operation of these fuel mines depends largely upon the condition of the coal trade as a whole. Indeed, the fuel mines, or "Snow Birds," as they are commonly called, are the pulse of the industry. When the demand for coal slackens, *i. e.,* when the supply is greater than the demand, the fuel mines show the first indication of this condition by closing down. Such was the condition in Maryland during 1915. On the other hand as soon as the demand for coal increases, fuel mines spring into existence over night throughout the region. This, for example, during 1917-18. During such periods the output of these fuel mines is hauled by wagons or sleighs to the railroads for shipment, usually in box-cars, and coal for local use is difficult to secure. Under normal conditions the fuel mines are only operated during the fall and winter months, when there is a local demand for coal. Also, in part, because these mines, being ventilated by natural means, are in many instances only accessible during these months of the year.

A few of these fuel mines are described in the following pages.

ABBOT FUEL MINE

The Abbot fuel mine (C-8) is located on the east side of Koontz Run about one mile north of Lonaconing. The opening has been made into the old Big Vein Mine No. 4 of the Georges Creek Coal Company, Inc., to remove some few pillars and crop coal. The coal is owned by the above-mentioned company which has leased the mine to the present operator, who works the mine only during the winter months.

The ventilation and drainage are both by natural means. Two "Big Vein" mine cars are used. The haulage is by one horse. The gauge of the mine tracks is 36 inches. The coal is dumped into wagons over an end dump on the wagon tipple and hauled to Lonaconing for sale or shipment.

During 1918 2 miners were employed who produced 700 tons of coal.

ALLEGANY BIG VEIN COAL COMPANY

The Allegany Big Vein Coal Company (C-4) has leased from the Union Mining Company the outcrop and pillars in the "Big Vein" seam of the old Union Mine No. 2. The mine is located three-fourths of a mile south of Morantown, just beside the public road.

Average Section

	Inches
Black shale roof.	
Coal	17
Slate	1-1½
Coal	7
Slate	2
Coal	24
Hard sandy shale floor.	

Four openings have been made into the seam at this mine. The mining is by pick entirely. The drainage and ventilation are by natural means. The haulage inside is performed by 4 horses. One-ton home-made mine cars are used. The gauge of the mine track is 36 inches and 16-pound T-rails are used throughout. The coal is dumped from the mine cars to a platform, shoveled into wagons, and hauled to the old Keeley Switch of the Cumberland and Pennsylvania Railroad where it is loaded into the railroad cars for shipment. A tramroad, connecting mines and tipple on railroad siding, is at present under construction.

Nine miners and 2 laborers were employed during 1918, producing 12,489 tons of coal.

BRODE'S FUEL MINE

The Brode fuel mine (B-5) is located about one-eighth of a mile northwest of the city limits of Frostburg. It is a slope opening into the "Big Vein" coal seam.

Section

	Inches
Slate roof.	
Coal	61
Slate	2
Coal	3
Shale	1
Coal	23
Shale floor.	

This mine is operated steadily from October to April, but during the rest of the year the work is very irregular, depending solely upon the demand for coal. The ventilation and drainage are by natural means. Six 1-ton mine cars are used, made by the operator and planned somewhat after the old Potomac type, but have no brake. One horse is used to haul the coal from the mine. The gauge of the track is 36 inches. The mine is not equipped with either tipple, scales, or dump. Coal is shoveled from the mine cars into wagons and hauled to Frostburg to be sold for local use.

During 1918 2 miners and 1 laborer were employed who produced 1786 tons of coal.

THE BIG SAVAGE FIRE BRICK COMPANY

The Big Savage Fire Brick Company (A, B-4, 5) have opened the "Parker" and "Six-foot" coal seams 2¾ miles northwest of the town of

Allegany. These coal seams were cut through in driving the Benson tunnel to reach fire clay beds. The coal has been mined on a small scale for use at the brick yard of the company at Allegany. The mines are naturally ventilated and drained. The company intends to install shortly the Longwall system of mining coal and the machines for same have been delivered at the mine. The coal is brought down from the mines to the brick yard over same plane and tramroad as used for hauling the clay.

Borden Fuel Company

The Borden Fuel Company (B, C-5) is operating two mines, one in the "Big Vein" seam and the other in the Tyson seam, both of which have been leased from the Borden Mining Company.

"Big Vein" Mine.—The opening into the "Big Vein" mine is situated about three-fourths of a mile northwest of Frostburg. The coal in the mine was taken out by former operators, originally by the Borden Mining Company and later the pillars have been reworked by a Mr. Anthony. The Borden Fuel Company is now mining the crop coal. A new opening was made into the crop coal in 1913 from which some 7000 tons of coal have been mined. The mine is ventilated and drained naturally. Eleven 1-ton mine cars are in use which run on 36-inch gauge tracks. One miner is employed in this mine during the year and two extra men during the five winter months. The mine cars are all pushed out of the mine by hand. A tipple has been erected by the railroad for shipping coal and a second tipple along the road to load wagons. Most of the coal is sold in Frostburg for local consumption, very little being shipped.

The Griffith or Tyson Mine.—The opening into the Tyson seam is one-fourth of a mile northeast of Frostburg, near the state road to Mount Savage. This drift opening was started in March, 1916. The ventilation and drainage are natural. The equipment consists of two 1-ton cars which run on a 42-inch gauge mine track. Haulage is by one pony. A wagon tipple with end dump and short chute has been built 60 feet from the mine opening. All coal from this mine will be hauled to Frostburg by wagon for shipment or local use.

During 1918 6 miners and 2 laborers were employed and the tonnage for the year was 3092 tons.

CLIFTON BIG VEIN COAL COMPANY

The Clifton Big Vein Coal Company (C-4) has purchased the right for 10 years from the Union Mining Company to work 32 acres of "Big Vein" outcrop and old workings. The mine is near Borden Yard.

Average Section

	Inches
Roof coal.	
Bone	6
Coal	24
Slate	2½
Coal	34
Slate	1½
Coal	6
Slate	1½
Coal	28
Hard sandy shale floor.	

This mine is developed on Room and Pillar system and has natural drainage and ventilation. Haulage consists of one mule. Four home-made 1-ton cars are used. Gauge of track is 42 inches. Both 16-pound T-rails and 2 by 4-inch wooden rails are in use. Coal is dumped from end-dump tipple into wagons and hauled to the Western Maryland Railroad at Frostburg.

Four miners and 1 laborer were employed during 1918. The output for the year was 5666 tons.

EAGAN MINE

Charles Eagan (D-7) is operating a small mine about .5 mile southeast of Midland. This property was originally opened by the Baltimore and Hampshire Coal Company and was known as the Midland mine. The company sold out to Evans and Spier who sold the "Big Vein" to the Georges Creek Coal Company, Inc. Charles Eagan has leased the outcrop and pillars of the mine from the Georges Creek Coal Company, Inc. Mr. Eagan began working here in 1914 and sold fuel coal until May, 1917, when he began shipping.

Average Section

	Inches
Top coal roof.	
Coal	83
Slate	1
Coal	5
Slate	2
Coal	16
Slate	¼
Coal	19½
Hard shale floor.	

The mine is developed on the Room and Pillar system with natural ventilation and drainage. The one opening is a timbered drift with the grade in favor of the loads. One horse is used for hauling the four cars. The track is 36-inch gauge and laid with 12- and 16-pound T-rails. The coal is dumped over end-dump tipple to motor trucks and hauled to the Western Maryland Railway in Midland.

During 1918 three miners and one laborer were employed.

Evans and Kemp Coal Company

Messrs. Evans and Kemp (B, C-4, 5) have leased some outcrop and pillar coal from the Borden Mining Company. The openings are just west of the Western Maryland Railway bridge over the improved road from Frostburg to Mt. Savage. The openings have been made into the "Big Vein" seam.

Average Section

	Inches
Shale roof.	
Coal	54
Shale	1½
Coal	6
Shale	1
Coal	24
Shale bottom.	

Some 8 to 10 openings have been made into the coal outcrop, although only one slope opening survived after a few months' operation. Ventilation and drainage are both by natural means. Two mules are used for haulage inside the mine. Various types of home-made "Big Vein" mine cars are in use. The tracks are 42-inch gauge, those on the main heading being 20-point steel T-rails and those in the rooms being 4 by 4-inch wooden rails. The coal is dumped from mine cars into wagons at wagon tipple by the roadside. The coal is hauled by wagons to sidings on either the Western Maryland or Cumberland and Pennsylvania railroads in Frostburg and loaded into box cars. Much of the coal is sold for local use in Frostburg.

Six to eight miners and 2 laborers were employed during 1918, producing 12,610 tons of coal.

HITCHINS FUEL MINE

Gladstone Hitchins (B-5) is operating a piece of 20 acres of "Big Vein" coal just west of Frostburg. The surface is owned by Mr. Hutchins but the coal is leased from the Borden Mining Company on a royalty basis. The coal was opened a number of years ago and has been worked by several people.

Average Section

	Inches
Top coal.	
Slate	1
Coal	61
Slate	2
Coal	6
Slate	1
Hard shale floor.	

The mine is developed on the Room and Pillar system with timbered slope entry. The mine has natural ventilation and natural drainage. One mule is used for hauling the four 1-ton home-made mine cars. Sixteen-pound T-rails with 36-inch gauge are used. Coal is loaded into wagons and hauled to Frostburg siding of the Western Maryland Railway or the Cumberland and Pennsylvania Railroad.

During 1918 6 miners were employed. The tonnage produced for the year was 4500.

MEESE MINE

The mine on the property of the Meese heirs (D-9, 10) is on Moors Run, 1½ miles east of Barton. The heirs own both the surface and the mineral rights to about 280 acres. The owners started to work in May, 1917, and began shipping in June of that year.

Average Section

	Inches
Black shale roof.	
Bone	4
Coal	36
Shale	2½
Coal, usually poor	4

The mine is in the Barton or "Four-foot" seam. It has two timbered drift entries, one of which is used for an air course. The workings are developed on the Room and Pillar system. The drainage and ventilation are by natural means. As the grade is in favor of the loads no animals are used for hauling. Three home-made small-vein cars are in use. The gauge is 36 inches and the track is laid with 16- and 20-pound T-rails. The coal is dumped over an end-dump tipple into wagons and hauled .5 mile to the Potomac tramroad belonging to Hoffa Bros. Coal Company. The coal is dumped into the tram cars and hauled to the foot of the plane where it is weighed on the scales and purchased by Hoffa Bros. Coal Company. It is shipped over the Cumberland and Pennsylvania Railroad from Barton.

During 1918 an average of 4 miners and 1 laborer were employed.

METZ FUEL MINE

The fuel mine of William Metz (C-10) is located about 1 mile northwest of Barton. It is a drift opening into the Barton coal seam which averages 28 inches thick at that place. The workings are developed on the Room and Pillar system and the mining is by pick work. The mine is ventilated by an air shaft. The drainage is by natural means. One mine car of 1500 pounds capacity is used at this mine and is pushed in and out of the mine by hand. The gauge of the wooden tracks is 36 inches. Neither tipple, dump, nor scales are used. A measuring box is employed to estimate the quantity of coal sold. One miner is employed who operates mine during 6 months of the year.

MOORE MINE

The mine of George L. Moore (D-10) is located three-fourths of a mile southeast of Barton. The property was opened about 30 years ago by

John Ross. The mine is the property of the Potomac Coal Company and is worked by Mr. Moore on a royalty. There is a timbered drift into the Barton or Four-foot seam. The mine is drained and ventilated by natural means. The one ½-ton car is pushed in and out by hand. The 2 by 4-inch wooden track is 36-inch gauge. The coal is shoveled out of the car into wagons and sold for fuel.

One miner. Output 2 tons per day.

SMITH'S FUEL MINE

Smith's fuel mine is located about one-half of a mile northwest of the town of Midlothian on Smith's farm. The mine consists of a drift opening into the "Big Vein" coal and is ventilated and drained naturally. The mine is only operated for five or six months of the year. Four 1-ton mine cars are used which were made by Mr. Smith. Haulage is by one horse. Neither tipple, dump, nor scales are employed. Mining is all by pick work, two men being employed.

REYNOLDS MINE

The Reynolds mine (C, D-10) is located near the power house at Reynolds Station on the property of the Cumberland and Westernport Electric Railway. All the coal mined here is used by the company for fuel in the power house. The mine is a drift opening into the Lower Bakerstown of this work (Lower Freeport of earlier reports). The method of mining is the Room and Pillar system and all the mining is by pick work. The mine is ventilated by an 8-foot force fan (made by mine operator) which is belt-driven by an 8 h. p. General Electric motor. The capacity of this fan is not known, having never been tested. The mine is drained by a steam siphon having a 2-inch intake and a 3-inch discharge. Steam for this siphon is supplied from the 300 h. p. Keeler boilers in the power house. The haulage in the mine is by 1 mule. Six 1-ton mine cars of the Barnesville type are used. The gauge of the mine tracks is 42 inches. A tramroad about 150 feet long connects the mine with the tipple, where the coal is dumped over an end dump into a bin inside the boiler room of the power house. No scales are used to weigh the coal. An average of 3 miners and 1 driver are employed.

WILLIAMS' FUEL MINE

Daniel Williams' fuel mine (B-2, 3) is located on the Williams farm which adjoins the Brailer property on the west. The mine opening is about 2 miles northwest of Mount Savage. The mine was opened in September, 1915. The seam of coal worked averages about 4 feet. A 9-foot drift entry has been made into the hill and the main heading advanced about 300 feet. The equipment consists of one 1-ton car which is operated by hand. Ventilation and drainage are by natural means. One man is employed in the mine. The coal is hauled to Mount Savage in wagons and sold for local uses. The output of the mine to date has been 1000 tons of coal. A tipple is situated about 100 feet from the mine opening over which the coal is loaded into wagons.

WORKMAN MINE

Clarence O. Workman (B-5) is operating a fuel mine just west of Frostburg. This property was once worked by the Borden Mining Company, but is leased by that company to Mr. Workman. It is a "Big Vein" mine and was opened by Mr. Workman in May, 1917. Shipments were begun in June, 1917.

Average Section

	Inches
Roof coal.	
Coal	49
Slate	½ to 4
Coal	20
Slate	2
Coal	6
Slate	2½
Coal	29
Shale floor.	

This mine is developed on the Room and Pillar system with one timbered drift opening down the dip. The drainage and ventilation are both natural. One horse is used in hauling the one-ton cars. Gauge of track is 36 inches. Sixteen-pound T-rails and some 2 by 4-inch wooden rails are used. The coal is dumped out of mine cars into wagons and hauled to the siding of either the Western Maryland or Cumberland and Pennsylvania railroads in Frostburg.

During 1918 3 miners and 3 laborers were employed. The year's tonnage was 11,900.

UPPER POTOMAC BASIN

The mines in this basin operate in coals beneath the Pittsburgh ("Big Vein") seam, the single tract near Shaw in which that vein was preserved having been worked out. The chief seam mined is the Davis coal which is the Upper Freeport coal of this work and the Lower Kittanning seam of earlier reports.

The shipping mines will be considered first, after which a single fuel mine will be described. The mines are arranged alphabetically according to the name of the operators.

ABERDEEN COAL COMPANY

This company operates a property leased from the Bayard Coal and Coke Company and the Steyer Coal Company in the vicinity of Steyer Station on the Western Maryland Railroad.

The Steyer mine is situated on property formerly owned by the Datesman Coal Company. It was subsequently sold to John Wills who in turn sold it in January, 1905, to the Steyer Run Coal Company. Eight years later, in 1913, the Steyer Run Coal Company sold the mine to the Waitman Smokeless Coal Company, which held the property three years when it sold it on August 10, 1916, to the Steyer Mining Company, the present lessors of the property.

The three drift openings formerly used have been abandoned and a new drift entry has been made into the Davis seam about a fourth of a mile north of Steyer, the tipple being situated on a switch. The mine is being developed on the Room and Panel system and the mining is all done by pick. The ventilation is artificial and secured by the use of a 5-foot Stine fan which at 750 r. p. m. has a capacity of 25,000 cubic feet. The fan is driven by a 8 h. p. New-way air-cooled gasoline engine. The air is forced into the mine through a wooden chute in the haulage way, pending the construction of a regular air course. The drainage of the mine is in part natural and in part artificial. A 3-inch centrifugal pump, belted to a 15 h. p. Fairbanks Morse horizontal gasoline engine is used in draining the mine. The haulage used is by one mule and three ponies within the mine and by a gasoline 6-ton locomotive type L 30 of the Milwaukee Locomotive Manufacturing Company. Sixty-five wooden mine cars with a capacity of 1½ tons gross and 1400 tare weight are used. The trackage is laid on 36-inch gauge, 16- and 30-pound rails being used within the mine and heavier rails on the outside. The coal is hauled along the 1300-foot tramway to Fairbanks scales at tipple where it is dumped endwise on railroad cars.

Tho number of miners employed during the year 1918 was 25, that of the laborers 10. The total tonnage for 1918 was 20,987 net tons.

BLAINE MINING COMPANY

The Blaine Mining Company operates Potomac Manor mine formerly known as the North American mine which is situated at Dill Station on the Western Maryland Railway. Two drift openings have been made into the Davis coal seam.[1] The mine is ventilated by a 12-foot Stine force fan which is direct-connected to a 14 h. p. Stine steam engine. At 80 r. p. m. this fan produces 35,000 cubic feet of air per minute. The primary haulage in the mine is by three 10-ton and one 8-ton Jeffrey electric haulage locomotives, one of the 10-ton locomotives being used only along the outside tramroad which is 1700 feet long. The secondary haulage in the mine is by 18 horses. From the tramroad the coal is brought down a 900-foot gravity plane, having an average grade of 22 per cent, in 8-car trips to the tipple. About 200 1½-ton mine cars, made by the Helmet Machine Foundry, of Fairmont, are used at the mine. These cars have a tare weight of 200 pounds. The gauge of the mine tracks is 36 inches.

[1] The writer was not permitted to enter the mine nor given any information concerning the operation by the superintendent, Mr. James G. Boyd, therefore this description cannot be complete but will cover those things seen on a somewhat hurried inspection of the outside plant.

The tipple, situated in West Virginia on a switch of the Western Maryland Railway, is equipped with Fairbanks automatic scales and a Robbins conveyor, which is used as a picking table. The mine cars unload over an end dump into a 3- to 4-ton feed bin, then over the belt conveyor or picking table, and then by belt into the railroad cars which are loaded sidewise. The power plant for the mine consists of two 125 h. p. boilers, 250 h. p. Ames direct-connected steam engine; 250 h. p. Allis Chalmers generator, generating 550 direct current for the electric haulage motors, and a 5 h. p. General Electric motor to run the Robbins conveyor.

BLOOMINGTON COAL COMPANY

The Bloomington Coal Company is operating the Piedmont or "Six-foot" seam, three-fourths of a mile southwest of Bloomington, Maryland. Seven drift openings are made into this coal seam of which two are at present operating, three are ready for mining of the "crop" coal, and two have been abandoned. These openings are worked as independent mines. A sample of the coal was taken from the third left heading of opening No. 7 where the section of the seam measured:

	Inches
Shale roof.	
Coal	8
Bone	8½
Coal	22
Bone	2½
Coal	22
Shale bottom.	

For analysis of this coal sample see table of analyses, No. 35.

The Room and Pillar system is being used to develop these mines, and the mining is all by pick work. The two working openings are each ventilated by a furnace inside the mine with air shafts and stacks to and above the surface. Six to eight thousand cubic feet of air per minute is thus supplied to the mine. The drainage in these openings is natural with the exception of the first left heading of No. 7 which fills up with water for 6 months of the year. A siphon is used to drain the water from this heading. Haulage in the mine is by 7 mules. In opening No. 7 a string team of 2 mules is used which hauls 3 empties into the mine and 3 loads out. In all other cases one mule is used to haul one car. Haulage along the tramroad to the tipple is by a 5-ton Baldwin dinkey engine which pulls from 10 to 15 mine cars. Forty-five 1-ton mine cars of various types, the tare weight of which varies from 1200 to 1500 pounds, are used at this mine. The gauge of the mine tracks is 42 inches. The tipple is situated on a switch of the main line of the Baltimore and Ohio Railroad, and is connected with the mine openings by a tramroad 6000 feet long. The coal is weighed at the tipple on Fairbanks Standard scales. An end dump is used, loading 2 railroad cars sidewise at the same time. During 1918 about 26 miners and 10 laborers were employed at these mines. The output for the year was 34,043 tons.

Mr. Brydon has made an opening into the Thomas seam above the Davis seam of the Bloomington Coal Company. At the time of writing he had only advanced his heading 30 feet into the coal. His equipment consists of two 1-ton mine cars and 42-inch gauge steel tracks. No plane has yet been constructed to ship the coal.

CHAFFEE COAL COMPANY

The Chaffee Coal Company is operating the Chaffee mine along Three-fork Run about 2 miles northwest of Chaffee, which is the shipping point on the Western Maryland Railroad. The present operators purchased this property from the Three Forks Coal Company in April, 1914, the mine having been originally opened by the latter in 1906.

THE CHAFFEE MINE consists of two slope openings into the Davis coal seam. A sample of this coal was taken at the face of the main heading where the section measured:

	Inches
Sandstone roof.	
Coal (not shipped, removed only in headings for clearance)	8
Shale	12
Coal	7
Bone	1
Coal	20
Bone	1
Coal	16
Shale bottom—with an unusually rough surface.	

For analysis of this coal see table of analyses, No. 36.

The method of mining is the Room and Pillar system, the rooms being driven on 45-foot centers, making rooms and headings 20 feet wide. The mining is all by pick work. The mine is ventilated by a 12-foot Stine force fan which is direct-connected with a 14 h. p. Stine steam engine. At 80 r. p. m. this fan produces 35,000 cubic feet of air per minute. The mine is self-draining. The cars are gathered at the working faces and hauled to the inside lye by 13 horses. From here the cars are hauled to the surface by a double-rope haulage system. Seventy-seven hundred feet of ⅞-inch steel wire cable is used for this haulage system. A 50 h. p. Lidgerwood double-drum stationary steam engine furnishes the power for this primary haulage. Steam for this engine is supplied by an 85 h. p. boiler. The empties are pulled into the mine, and the loads drop out by gravity. One hundred and twenty-five 1-ton mine cars are used here. These cars have Sanford Day trucks, but the bodies are designed and made by the carpenter at the mine. Tare weight of mine cars is 1800 pounds. The gauge of the mine tracks is 42 inches. The mine cars are let down a gravity plane, 450 feet long, having an average grade of 30 degrees, in two-car trips to the tipple. The tipple is equipped with 2-inch stationary bar screen and a 30-foot Link-Belt conveyor picking table. A 20 h. p. steam engine (name not known), steam for which is supplied by an 85 h. p. Erie boiler, is used to operate the picking table. The coal is screened, shale picked from lumps by hand, and the lumps and slack remixed and shipped as run-of-mine. The railroad cars are loaded sidewise from this tipple. A 28-ton Lime dinkey engine is used to pull the railroad cars from the tipple to the main line of the Western Maryland Railroad at Chaffee, a distance of about 2¼ miles. During 1918 an average of 75 miners and 10 laborers were employed at this mine. The output for that year was 79,333 tons.

COVER COAL COMPANY

This company leased a track of coal land in the neighborhood of Steyer during 1918, but up to date have never installed a plant nor shipped any coal.

DAVIS COAL AND COKE COMPANY

The Davis Coal and Coke Company is now operating one mine, No. 42, in Maryland, at Kempton, the underground workings of which extend into West Virginia. The underground workings of its No. 22 mine at Henry, W. Va., also extend into Maryland. Its Buxton mine (No. 17), located near the mouth of the Savage River, two miles above Westernport, was closed in 1910-11 and its Franklin No. 52 mine, located across the river from West Virginia Junction, was abandoned on February 2, 1916.

THE KEMPTON MINE.—The Kempton mine, or Mine No. 42, is without doubt the most modernly equipped of all the coal mines in the State of Maryland. This mine was opened for the shipment of coal in September, 1914. The shaft of the Kempton mine is situated in the southwest corner of Garrett County, about three-fourths of a mile north of Beechwood Station on the Western Maryland Railroad. The coal worked from this shaft lies in both Garrett County, Maryland, and Preston and Grant counties, West Virginia. The entrance to the mine is by two shafts sunk 420 feet to the Davis coal seam. The entire thickness of the coal seam in this mine is not worked, although in places where clearance is necessary the entire seam is removed. There is a top bench averaging 5 feet 2 inches of coal, which contains a 2-inch shale parting at about 12 to 18 inches from the top which is removed by the miners. Below this bench is a bed of hard shale and sandstone 16 inches to 24 inches thick. Below this is a bench 40 inches to 48 inches thick of an inferior coal, interstratified with beds of sulphur, shale and bone. The bottom bench is non-commercial and is only removed for clearance and grading the headings. A sample of this coal was taken from the face of the main heading 3500 feet from the shaft bottom. The section measured there showed:

	Inches	
Shale roof.		
Coal	24	This part of section was sampled, omitting the 2-inch shale binder.
Shale	2	
Coal	36	
Bone	2	
Shale	13	
Bony coal	3	
Shale	5	
Coal	2½	
Bone	2½	
Coal	33½	
Shale floor.		

For analysis of this coal see table of analyses, No. 37.

The method of mining employed here is the Room and Panel system, having 20 rooms to each panel heading. Goodman electric mining machines, of the short wall type, are used, although most of the mining is done by pick work. The mine is ventilated by a 5½ by 4-foot Robinson centrifugal reversible double-inlet electric fan driven compressively. This fan is chain-driven by a 37½ to 75 h. p. A. C. motor with provision made to enlarge motor and increase r. p. m. of fan when necessary up to 150,000 cubic feet of air per minute against a 3-inch water column. At present this fan is running at a rate sufficient to produce 90,000 cubic feet of air per minute. The mine is self-draining to the sump at the foot of the shaft with the exception of the dip heading where two small electric pumps are used. From the sump the water is raised to the surface by two 4-stage centrifugal Platt Iron Works Co. pumps driven by 200 h. p. motors and each capable of pumping 1000 gallons per minute.

The gathering is performed by five 8-ton General Electric gathering motors and the primary haulage by three 10-ton General Electric haulage motors. The mine cars are pulled to the bottom of the shaft where they are caged automatically. The shaft is lined with wooden planks, but has a steel and concrete head frame. This main hoist is electrically driven by a 3-phase alternating current 600 h. p. Allis-Chalmers motor which is geared to a double drum 7 feet 6 inches in diameter. The auxiliary hoist, at the air shaft, used for hoisting men and material, is electrically driven by a 100 h. p. Allis-Chalmers electric hoist geared to a single drum, 7 feet in diameter. Both hoisting motors are equipped with controllers to prevent overwinding of the 1½-inch steel wire cable. Sixteen-pound steel T-rails are used in the rooms, 30-pound steel T-rails in the panel headings, and 45-pound steel T-rails in the main haulage headings. The gauge of the mine tracks is 42 inches. The mine cars are raised to the surface by the hoist described above and are dumped automatically into a chute which conveys the coal to a 400-ton storage bin. The coal is loaded from the storage bin into the railroad cars, it being possible to load two cars at the same time. Scales are used to weigh the coal mined.

The power, 22,000 volts A. C., to operate this mine, is generated at a central power station at Thomas, West Virginia, and carried a distance of 7 miles to the substation at Kempton mine, where it is converted into 550-volt D. C. The equipment of the substation constists of two 300 kw. Rotary synchronous converters, six 100 kw. 22,000 to 380-volt static transformers, three 50 kw. 22,000 to 550-volt static transformers, and A. C. and D. C. switchboards.

During the year 1918 an average of 130 miners and 14 laborers were employed at this mine. The output for the year was 209,302 tons.

HENRY MINE.—The two shafts of the Henry mine, or Mine No. 22, are located at Henry, Grant County, West Virginia, just across the Maryland state line. An area of coal lying beneath the Maryland side of the Potomac River is being worked and therefore this mine will be described in this report. The two shafts were sunk to the Thomas and Davis coal seams in 1901 and 1902. The Thomas, formerly "Upper Freeport," coal lies 197 feet beneath the surface of the Twin shaft (shaft No. 2). It is reached and operated through two of the hoisting compartments of this shaft. The other two compartments of the twin shaft extend from the surface downward 419 feet to the Davis coal seam, which for the present has been abandoned. The latter averages 43 inches of coal in the lower bench and 30 inches in the upper bench, the two benches being separated by a binder of variable thickness. A sample of the Thomas coal was taken on the Maryland side in the third left butt heading off the Webster heading where the section measured:

	Inches
Shale	2-4
Bony coal (removed in the headings for clearance—not shipped)	21
Coal	54
Shale	¼
Bastard fire-clay bottom.	

This mine was originally developed on the Room and Pillar system, the rooms being driven on 60-foot centers. All new development will be by the Room and Panel system, having 20 to 25 rooms to a panel heading. Three Goodman electric mining machines and 1 Jeffrey electric mining machine are used to mine the coal. These machines are used on the shortwall system and make an undercut of 6 feet.

The mine is ventilated by a 14-foot Crawford and McCrimmon reversible double-inlet fan, driven electrically, and is chain-connected to a 50 h. p. General Electric motor. At 109 r. p. m. this fan produces 120,000 cubic feet of air per minute. The fan structure is of brick with a sheet-iron cover. The mine water is drained by gravity to the sump near the bottom of the shaft, except the water of the dip heading which is pumped to the sump by a 10 h. p. Aldrich Triplex pump. From this sump the water is raised to the surface by two 2-stage Platt Centrifugal pumps, each having a capacity of 1000 gallons per minute. These pumps are operated by two 100 h. p. General Electric motors. One of these pumps is usually sufficient to keep the mine free from water.

The secondary haulage, or gathering, is done by three 6-ton General Electric gathering motors. For primary haulage two 10-ton Westinghouse and one 10-ton General Electric haulage motors are used. The mine cars are hauled to the bottom of the shaft where they are loaded automatically on the cages. Shaft No. 1 has three compartments (7 by 12 feet), one hoist way, one stationary way, and one air way. The shaft is 432 feet deep and is sunk 7 feet below the bottom of the Davis seam Two double cylinder Vulcan first-motion steam hoisting engines are used to hoist the cages in the shaft. The same styles of tracks are used here as at Kempton mine. The cages are self-dumping, the coal passing over shaker screens and then on to the picking tables where the lump passes down one side and the slack the other. Slack, lump, or run-of-mine coal can be shipped from this tipple. Slate is picked out by hand. A 20 h. p. General Electric motor is used to operate screen and picking table. The coal is loaded into the railroad cars by end loaders, three railroad cars being loaded at the same time. Scales are installed in this mine to weigh coal. Coal is shipped over the Western Maryland Railway. A belt conveyor passes from the tipple to the boiler house to convey slack and pickings to be used there.

Electric power, 22,000 volts A. C. for the plant, is brought from the central power station at Thomas, West Virginia, which is 10 miles from Henry, and converted to 550 D. C. for motors and stepped down to 550 A. C. for other uses. The substation at Henry is similar to the one at Kempton, in fact the substations at all the mines of the Davis Coal and Coke Company are similarly equipped and interchangeable. To supply the steam hoisting engine, however, there are two 150 h. p. Atlas boilers and two 150 h. p. Phoenix boilers.

An average of 120 miners and laborers were employed at this mine during 1918 and produced 167,573 tons of coal.

Garrett County Coal & Mining Company

The Garrett County Coal & Mining Company is at present operating the Dodson Mines Nos. 1, 3, 5, 6 and 7, which are located on the Maryland side of the Potomac River, about one mile southwest of Harrison, West Virginia. The Dodson Mines Nos. 2 and 4 were abandoned in 1912.

Dodson Mine No. 1.—The mine is a drift opening into the Davis coal seam, section in the Main Heading at 12th Right is as follows:

			Top.
0′ 5″			Coal.
		0′ 0½″	Binder.
0′ 3½″			Coal.
		1′ 2″	Rock.
0′ 10″			Coal.
		0′ 1″	Binder.
1′ 6½″			Coal.
		0′ 0½″	Binder.
0′ 9½″			Coal.
		1′ 4″	Total refuse.
3′ 10½″			Total coal.
	5′ 2½″		Total vein thickness.

The mine is ventilated by a 16-foot Crawford and McCrimmon force fan which is belt driven by a Westinghouse 150 h. p., 2200-volt, 3-phase, 60-cycle motor. At 152 r. p. m. the fan produces 80,000 cubic feet of air per minute. The mine is self-draining. The secondary haulage in the mine is by six mules and one General Electric 6-ton 250-volt gathering locomotive. One Goodman 35 h. p., 250-volt short wall coal cutting machine is used on development work. The new work in this mine is all on the Panel system. One General Electric 10-ton, 250-volt mine haulage locomotive is used for primary haulage from this mine to the head of the outside plane. An average of 35 miners and 6 laborers were employed in this mine during 1918.

DODSON MINE NO. 3.—Dodson Mine No. 3 is also a drift opening in the Davis coal seam, section in 4th butt, 1st Left Heading is as follows:

		Top.
1′ 4″		Coal.
	1′ 3″	Rock.
1′ 0″		Coal.
	0′ 0½″	Binder.
1′ 3½″		Coal.
	0′ 1″	Binder.
1′ 6½″		Coal.
		Bottom.
5′ 2″		Total coal.
	1′ 4½″	Total refuse.
6′ 6½″		Total vein thickness.

The mine is ventilated by an 8-foot Stine force fan which is belt-driven by a Westinghouse 20 h. p., 440-volt, 60-cycle, 3-phase motor. At 312 r. p. m. this fan produces 30,000 cubic feet of air per minute. The drainage is by natural means and also by one portable Fairmont electric mine pump 250-volt, 5-inch cylinder, 4½-inch stroke, 2½-inch suction, 2-inch discharge, capacity 50 gallons per minute. The secondary haulage in the mine is by four mules and one General Electric 6-ton, 250-volt gathering locomotive. One General Electric 10-ton, 250-volt mine haulage locomotive is used for primary haulage. The Room and Pillar system of mining is used in this mine. During 1918 an average of 30 miners and 7 laborers were employed in this mine.

DODSON MINE NO. 5.—This mine is a drift opening into the Piedmont ("Six-foot") seam. The coal in this mine was sampled in Room No. 2 off First Right Heading showing the following section:

	Inches
Shale roof.	
Bone	1
Coal	42
Bone	1
Shale floor.	

The mine is ventilated by a furnace inside the mine, which furnishes 5000 cubic feet of air per minute. The mine water is drained to an inside sump, from which it is brought to the surface by a 2-inch siphon. The secondary haulage in the mine is by one mule. An average of six miners and one laborer were employed at this mine during the year 1918.

DODSON MINE NO. 6.—This mine was opened the latter part of 1917. It is a drift opening in the Davis coal seam. This mine will eventually connect with No. 3 mine by three pair of Panel headings. The Panel system of mining is used. The mine is ventilated by a 5-foot J. C. Stine patented disc fan directly connected to a 15 h. p., 230-volt D. C. motor. At 500 r. p. m. this fan produces 20,000 cubic feet of air per minute. The mine is drained by one portable Fairmont electric mine pump 230-volt, 5-inch cylinder, 4½-inch stroke, 2½-inch suction, 2-inch discharge. Capacity 50 gallons per minute.

The secondary haulage in the mine is by two mules. An average of nine miners and two laborers were employed in this mine during 1918. One Goodman 35 h. p., 210-volt short wall cutting machine is used at this mine.

DODSON MINE NO. 7.—This mine was opened the early part of 1918. It is a drift opening in the Davis coal seam. This mine is connected with No. 1 mine and is ventilated by the fan which ventilates No. 1 mine. Drainage is by natural means. The secondary haulage in the mine is by one mule. An average of eight miners and one laborer were employed in this mine during the year 1918. The Goodman short wall coal cutting machine used in No. 6 mine is also used in this mine. The Room and Pillar system of mining is used.

The primary haulage in the five mines above described and along the tramroad is handled by two General Electric 10-ton, 250-volt mine haulage locomotives. One is used for Nos. 3, 5 and 6 mines, and the other is used for Nos. 1 and 7 mines.

There is 4000 feet of tramroad connecting the mines with the head of the 700-foot incline plane. One hundred and seventy American Car & Foundry Co. mine cars, equipped with Hyatt roller bearing wheels, are used. The gauge of the mine tracks is 42 inches and the rail on outside tramroads, plane, and main headings is 45-pound, panel heading are laid with 25-pound rails.

The incline plane is self-acting and is equipped with J. C. Stine No. 10 special incline plane machine. Six-car trips are run on the plane. A Flory double-friction drum electric hoist, equipped with a General Electric 15 h. p., 440-volt, 60-cycle, 3-phase motor is used for hauling supplies up the plane.

The tipple, at the foot of the gravity plane, is situated in Maryland on a switch of the Western Maryland Railway, over which railroad the coal is shipped.

The mine cars pass over a Fairbanks Standard 6-ton scale, equipped with quick-weighing dial, and onto a Phillips' automatic cross-over dump. The empty cars leave the dump and run up a kick back and over a spring switch by gravity to the foot of a 32-foot car hoist which carries them to the top of the hoist which is 32 feet long. From the top of car hoist the cars run by gravity to the foot of the plane.

The coal is dumped into a bin and is fed into a triple deck shaking screen by means of a plunger automatic feed. The shaker is 5 feet by 12 feet Wilmot Engineering Company triple deck; the top deck is 4-inch round mesh screen, the middle deck 2-inch round mesh screen, the bottom deck ⅞-inch round mesh screen. The fine coal which passes through the ⅞-inch mesh screen is carried by means of a chute onto a 5-foot by 30-foot Wilmot Engineering Company picking table and the lump coal which passes over the 4-inch mesh screen is carried by means of a chute to the same picking on top of the fine coal. The coal which passes through the 4-inch mesh screen and also the coal which passes through the 2-inch mesh screen is carried by means of separate chutes to a second 5-foot by 30-foot Wilmot Engineering Company picking table which is divided in the center. The coal from the picking tables is dumped into a loading chute with adjustable apron which load the railroad cars. Railroad cars are handled under the tipple by means of a Flory double-friction drum electric hoist equipped with a Westinghouse

20 h. p., 440-volt, 60-cycle, 3-phase motor. Any coal containing a band of bone is picked from the table and thrown into chutes which carry it to a Wilmot Engineering Company disintegrator, or revolving screen, the coal passing through the screen into a conveyor line which carries it to the boiler house to be used as colliery fuel, the bone and rock pass out the other end of disintegrator into a chute to conveyor which carries it to the refuse bin. Above conveyors are all flight conveyors constructed of Wilmot Engineering Company's rivetless chain.

Car hoist, plunger feed, shaking screens, picking tables, disintegrator and refuse conveyor lines are all on rope drives from main jack shaft, which is belt-driven by a Westinghouse 50 h. p., 440-volt, 60-cycle, 3-phase motor.

The power for the plant is generated by a General Electric Type ATB-48-375-150, 300 kw., 2300-volt generator driven by a 19½ by 35 by 24 Harrisburg tandem compound engine supplied with Western Electric exciter 25 kw. Steam is supplies by one 300 h. p. Keeler double boiler and one 150 h. p. Keeler single boiler. Power (2200 volts) is carried by means of transmission lines to sub-station located between No. 1 and No. 3 mines, which is equipped with Westinghouse 200 kw. commutating pole 275-volt D. C. rotary converter, 60-cycle, 6-phase, complete with three 73⅓ kw. transformers.

The power for a blacksmith shop and carpenter shop is supplied by a Westinghouse 10 h. p., 440-volt, 60-cycle, 3-phase motor.

Eighty-eight miners and 35 outside laborers were employed for these five mines during 1918. The output of the five mines combined was 132,703.

HAMILL COAL AND COKE COMPANY

The Hamill Coal and Coke Company is operating two mines, which are situated three-fourths of a mile north of Blaine Station, on the Western Maryland Railroad. The mines, Hamill Nos. 1 and 2, are both in the Davis coal seam. (The Upper Freeport seam of this work, the Lower

Kittanning seam of earlier reports.) Sections of this seam measured at various places show the following:

Section A[1]	Inches	*Section B*[2]	Inches	*Section C*[2]	Inches	*Section D*[2]	Inches
Shale roof.		Shale roof.		Shale roof.		Shale roof.	
Coal	7	Coal	14	Coal	14½	Coal	17
Bone ...	1	Shale ...	14	Shale ...	41	Shale ...	19
Coal	6½	Coal	7	Coal	19½	Coal	14
Bone ...	½	Shale	1½	Shale ...	2½	Shale ...	1
Coal	8½	Coal	20	Coal	16	Coal	15
Bone ...	¼	Bone ...	2	Shale bottom.		Bone ...	1
Coal	6½	Coal	19¾				
Shale ...	2½	Shale ...	1		7 ft. 9½ in.		5 ft. 7 in.
Coal	2	Coal	4				
Bone ...	¼	Shale bottom.					
Coal	19						
Shale ...	1		4 ft. 10½ in.				
Coal	7						
Bottom shale.							
	5 ft. 2 in.						

The Room and Pillar system of mining is used in both mines. Double rooms 30 feet wide are used instead of rooms of the usual width, so that each room may have two car tracks. The pillars are 45 feet wide. The mining is all by pick work. Both mines are ventilated by the same fan, a 12-foot Crawford and McCrimmon force fan, which is belt-driven by a 15 h. p. St. Mary's gas engine and at 78 r. p. m. produces 23,400 cubic feet of air per minute. In Hamill Mine No. 1 the water runs by gravity to a sump, although at times two hand pumps have to be used, from which it is forced to the surface by a Demming pump run by a 1 h. p. Stover engine. The water from the sump is Hamill Mine No. 2 is carried to the surface by a 1½-inch siphon. The haulage in both mines is by mules, seven being used in Mine No. 2. The company expects to install later a 7-ton Whitcomb gasoline haulage motor for the primary haulage of both mines.

Mine opening No. 1 is located 30 feet from the upper tipple, while a tramroad of 760 feet connects this tipple with mine opening No. 2. The coal is weighed on Fairbanks Standard scales at the tipple and dumped

[1] Section in Mine No. 2, 2d left heading.
[2] Md. Geol. Survey, Vol. V, 1905.

over an end dump into a 20-ton bin, from which the buckets are loaded. The coal is conveyed from the bin of the tipple at the mine by a Roebling twin-bucket aerial tramway, which stretches across a ravine and over the Potomac River, to the railroad, a distance of 850 feet with a difference in elevation of the two ends of 160 feet. This plant operates by gravity, using two buckets of 2-ton capacity, running on 2-inch cables and connected by a ⅝-inch endless traction rope, which passes around three sheave wheels, at the tipple or upper terminal and around two smaller idle sheaves at the lower or discharging terminal. The sheaves at the upper terminal are 6 feet in diameter. They are set horizontally in a triangular shape. The two outside wheels have a brake band around each, which is connected with a lever located in the extreme forward end of the upper terminal, where are also found the two levers for loading the buckets. One man operates the entire conveying mechanism from this point. The main cables are securely anchored in concrete in front of the pit mouth. They are suspended between these points a distance of 850 feet without support. At the lower terminal they pass over sheave wheels and are kept at an even tention by means of a counter weight of 40 tons attached to the end of each. The buckets discharge automatically into a 50-ton bin at the lower terminal, from which the railroad cars are loaded sidewise. The buckets are loaded from the upper bin, cross the intervening space to the lower terminal and unload their coal into bin in one minute. Ninety-five mine cars of three different types are used at these mines; 9 cars of 1½-ton capacity having a tare weight of 1750 pounds; 6 cars of 1¾-ton capacity having tare weight of 1800 pounds, and 80 cars of 1-ton capacity having a tare weight of 1200 pounds. The gauge of the mine tracks is 42 inches. One hundred and sixty miners and 15 laborers were employed during 1916 and the output of the two mines for the year 1918 was 129,099 tons.

Hubbard Coal Mining Company

The Hubbard Coal Mining Company owns and is operating the old Upper Potomac mines which are situated on the Maryland side of the Potomac River on the Western Maryland Railroad, opposite Hubbard.

These mines have changed ownership several times. They were first opened in 1902 by the Upper Potomac Coal Company, but were closed in 1910; the Ajax Coal Company purchased them in 1912; the Ajax Consolidated Coal Company bought them in 1914; and the Ajax Hocking Coal Company bought them in 1916; the present company, Hubbard Coal Mining Company, purchased them in June, 1918. At present the company is operating two mines, No. 1 and No. 7, both of which are drift openings into the Davis coal seam.

MINE NO. 1.—A sample of the coal in this mine was taken at the face of second right heading where this section measured from top to bottom 39½ inches as follows:

	Inches
Shale roof.	
Coal	6
Shale	2
Coal	13
Shale	2
Coal	15
Shale bottom. This binder varied at other places from ¼ to 2″.	

An analysis of coal furnished by the company is given below. Other analyses made for this report are given in table of analyses, No. 34.

	Per cent
Moisture	2.0
Moisture	.0
Volatile matter	13.0
Fixed carbon	75.8
Ash	9.2
	100.0
Sulphur	2.0%
B. T. U.'s	13,995

This mine has been developed on the Room and Pillar system, but all advance work is being done on the Room and Panel system. Two Sullivan short wall electric mining machines are used to mine the coal, making a 6¼-foot undercut at the base of the seam. The mine is ventilated by a 10-foot Stine force fan which is direct-connected to a 15 h. p. General Electric motor. At 150 r. p. m. this fan produces 60,000 cubic feet of air per minute. The mine is self-draining. A 3-ton Westinghouse Electric gathering motor is used for the secondary haulage and a 6-ton Westinghouse Electric haulage motor for the primary haulage.

Mine No. 7.—This mine is a drift opening into the same seam of coal, the Davis, and the average section is somewhat similar to that given above for Mine No. 1. This mine is developed on the Room and Pillar system and the mining is all by pick work. This mine is ventilated by a 10-foot Stine force fan which is belt-driven by electric motor. At 150 r. p. m. this fan produces 60,000 cubic feet of air per minute. This mine is also self-draining. The secondary haulage in this mine is by 3 mules. The primary haulage is by the same motor used for primary haulage in Mine No. 1. Both mines have 100 1-ton mine cars of their own make, the tare weight of which is 950 pounds. The gauge of the mine tracks is 42 inches.

The power house for the mine is located on the West Virginia side of the Potomac River, opposite Hubbard Station. The equipment of the power house consists of one 236 h. p. McQuien steam engine to run a 150 kw. Jeffrey electric generator to supply current for motors, mining machines, and fan; two 175 h. p. Erie boilers; a York steam boiler feed water pump (3-inch suction and 2½-inch discharge); and a steam suction pump (3-inch suction and 3½-inch discharge) used to pump water from the Potomac River to fill storage tanks for boilers.

The tramroad from the top of the 1080-foot gravity plane to Mine No. 7 is 3000 feet long. The tipple is at the foot of the gravity plane on the West Virginia side of the Potomac River where the coal is weighed on Fairbanks automatic scales. The coal is dumped over an end dump into a short chute which loads the railroad cars sidewise.

During 1918 an average of 15 miners and 5 laborers were employed at these mines. The total output for 1918 was 9801 tons.

McKanwig Coal Company

The McKanwig Coal Company operates the Nethkin mine which is situated about one-eighth of a mile east of Bayard Station on the Western Maryland Railroad. The mine is a drift opening into the Thomas coal seam (the Lower Bakerstown coal of this work, the Upper Freeport of earlier reports). A sample was taken in a room off the main heading near the working face, which shows the following section:

Shale roof.	Inches
Bone	3
Coal	10½
Bone	4½
Coal	3
Bone	3
Coal	4½
Bone	½
Coal	28
Shale floor.	

For analysis see table of analyses, No. 42.

The mine is developed on the Room and Pillar system and the mining is all by pick work. The workings are ventilated by a furnace inside, which supplies about 5000 cubic feet of air per minute. The water in the mine drains by gravity to a sump, with few exceptions where it is pumped by hand-pumps to the sump, whence it is siphoned to the surface by a $1\frac{1}{2}$-inch siphon. The haulage in the mine is by 7 mules. Thirty-five 1-ton mine cars of the Watt type are in use. The gauge of the mine tracks is 36 inches. The coal is weighed on Fairbanks Standard scales at the tipple which is situated on a short switch paralleling the main track of the Western Maryland Railway. The coal is loaded sidewise into railroad cars over an end dump. An average of 30 miners and 2 laborers were employed at this mine during 1918. The output for that year was 20,631 gross tons.

MONROE COAL MINING COMPANY

The Monroe Coal Mining Company is operating the Elk Run Mines Nos. 1 and 3, which are located on the Maryland side of the Potomac River opposite Barnum Station, West Virginia, on the Western Maryland Railroad. This property was purchased by the present operators from the Watson-Loy Coal Company in 1902.

ELK RUN MINE NO. 1.—The mine is a drift entry into the Davis coal seam. A sample of the coal was taken from the 6th left heading where the section of the seam measured:

Roof of shale and sandstone varying.	Inches
Bone	2
Coal	23½
Rock	6
Coal	13
Shale	½
Coal	12
Bone	2
Shale floor.	

For the analysis see table of analyses, No. 43.

The mine is ventilated by a 12-foot Crawford and McCrimmon force fan which is direct-connected to a 15 h. p. Crawford and McCrimmon steam engine. At 80 r. p. m. this fan produces 30,000 cubic feet of air per minute. The mine water is drained by ditches to a sump and from there forced to the surface by a siphon, having a 1½-inch intake and a 1½-inch discharge. The mine cars are gathered at the working face by 3 mules and hauled to the inside lye. From there they are pulled to the tipple by a 7-ton Milwaukee gasoline haulage motor. Fifty 1-ton mine cars of the Hockensmith and Watt types are used in this mine. The tare weight of these cars is 1400 feet.

During 1918 an average of 20 miners and 6 laborers were employed at this mine.

ELK RUN MINE NO. 3.—The Elk Run Mine No. 3 is a drift opening into the Barton coal. A sample from this seam was taken in the seventh right heading where the section measured was a good average for the mine:

Shale roof.	Inches
Bone	8
Black jack	4
Coal	28
Shale bottom.	

For analysis of this coal see table of analyses, No. 44.

The mine is ventilated by an 8-foot Stine disc fan which is belt-driven by a 15 h. p. Atlas engine. This engine is driven by compressed air which is supplied by an Ingersoll Rand compressor. Steam to run the compressor is furnished by two 125 h. p. Erie boilers. At 300 r. p. m. this fan produces 75,000 cubic feet of air per minute. The mine water is drained by ditches to the sump from which it is siphoned to the surface by a

1½-inch siphon. The primary haulage in this mine is by a string team of 2 mules, the gathering is also by 2 mules. Thirty-five mine cars of tare weight of 12,000 pounds are used in this mine. These cars are made by the Helmic Foundry and Machine Company of Fairmont.

An average of 20 miners and 4 laborers were employed at this mine during 1918.

The method of mining used at these mines is the Room and Pillar system. The rooms are driven on 60-foot centers and are usually 20 feet wide. The mining is all by pick work. The gauge of the mine tracks is 42 inches. Cars from Elk Run Mine No. 3 reach the tipple by a plane 1300 feet long, having an average grade of 38 degrees. This gravity plane is equipped with Stine horizontal machinery at the top and uses a ⅝-inch steel wire cable. At the tipple, which is situated on a switch of the Western Maryland Railway on the West Virginia side of the Potomac River, the coal is weighed on Fairbanks Standard scales. The coal is dumped over an end dump into a short chute provided with a stationary bar screen (iron bars set 1½-inch apart), which simplifies the picking of slate from the coal in the railroad cars. The railroad cars are loaded sidewise. At this tipple they have also a second end dump and chute to load wagons, and also an inclined switch to the boiler house. Nine to ten outside laborers are employed at the mine. During the year 1918 35,299 tons of coal were mined, all of which was shipped over the Western Maryland Railroad.

G. C. PATTISON COAL COMPANY

The Pattison Coal Company operates the Pattison Mines Nos. 1 and 2 which are located about one-fourth of a mile west of the town of Bloomington. The tipple for these mines is situated on a siding of the main line of the Baltimore and Ohio Railroad. The coal is operated under a lease from the Empire Coal Company and the Jones and Owens estates.

PATTISON MINE NO. 1.—The 9-foot drift opening of this mine has been made approximately 100 feet east of the tipple, with which it is connected by a short tramroad. The Piedmont seam (the Lower Kittanning coal of earlier reports) is being worked here, and varies in thickness from 18 inches to 44 inches. The roof is a shaly clay, varying in thickness from nothing to 18 inches, above which is a heavy sandstone. The bed is subject to squeezes in which the thickness of the coal is considerably reduced at many places throughout the mine. The mining is confined to pick work upon the pillars of old workings, which necessitates the handling of much gob. The mine is ventilated by a 10-foot Crawford and McCrimmon force fan which is direct-connected with a 20 h. p. Crawford and McCrimmon steam engine. At 80 r. p. m. this fan furnishes 28,000 cubic feet of air per minute. The mine is self-draining. Three mules are used for haulage in the mine and along the tramroad to the tipple. Eighteen 1-ton mine cars of the Fairmont type, tare weight 1800 pounds, are used here. The gauge of the mine tracks is 42 inches.

PATTISON MINE NO. 2.—This mine has been made into the Barton seam, which here lies 410 feet above the coal worked in Mine No. 1. This mine is nearly a mile southwest of the tipple. There are at present two 9-foot drift openings into this seam. The thickness of the coal bed averages 28 inches with 15 inches of bone above it and 5 inches of bone and shale below. The development of the mine has been by the Room and Pillar system, the mining by pick work. A sandstone fault in the coal has been encountered and the headings have been advanced 170 feet without penetrating it. For this work an Ingersol-Sargeant rock drill is used. A Westinghouse steam compressor ($9\frac{1}{2}$ by 9 by 10 inches) has been used to supply air for the drill at a pressure of 90 pounds per square inch. The mine is ventilated by an 8-foot Crawford and McCrimmon force fan which is direct-connected to a 10 h. p. Crawford and McCrimmon steam engine. Steam for this engine is supplied by a 20 h. p. Trenton boiler. At 70 r. p. m. this fan produces 54,000 cubic feet of air per minute. The mine has natural drainage. The haulage in the mine is by 2 mules (1 to each opening) and haulage along the tramroad, which is 3600 feet long, is by 2 other mules. The gravity plane is 1010 feet long and has an average grade of 20 degrees. There are 50 1-ton Watt mine cars for Mine No. 2, but only 35 of these are in use. The gauge of the mine tracks is 42 inches. The coal from both seams is dumped over the same tipple. Cars are weighed at the tipple on Fairbanks Standard scales, and the coal is loaded sidewise into the railroad cars oven an end dump. An average of 27 miners and 4 laborers were employed at these mines during 1918. 26,835 tons of coal were produced during the year.

POTOMAC VALLEY COAL COMPANY

The Potomac Valley Coal Company is operating the Peerless Mines Nos. 2 and 3 and the Louise mine.

PEERLESS MINES NOS. 2 AND 3.—The Peerless Mines Nos. 2 and 3 are situated on the Maryland side of the Potomac River 1 mile north of Blaine. These two drift openings made into the Thomas coal (Lower Bakerstown coal of this work, Upper Freeport coal of earlier reports) are in reality one mine as the workings from both openings connect. Therefore they will be described as one mine. Two sections were measured in the mine, one (I) in Room No. 1 off the right heading and the other (II) where a sample of coal was taken, in Room No. 1 off the fifth right heading. Their measurements are as follows:

I

	Inches
Shale roof.	
Coal	7
Bone	4
Coal	9½
Shale	4
Coal	33
Shale floor.	

II

	Inches
Shale roof.	
Coal	13½
Bone	1½
Coal	36
Shale floor.	

The method of mining has been the Room and Pillar system. The rooms are driven on 50-foot centers and are 18 feet wide, while the headings are 15 feet wide. The mining is all by pick work. The mine is ventilated by a 16 by 4-foot Vulcan force fan, belt-driven by a 20 h. p. Bessemer gas engine (180 r. p. m.). At 105 r. p. m. this fan produces 45,000 cubic feet of air per minute. The mine water is drained to the sump by ditches, and from the sump is pumped to the surface by a Westinghouse pump (1½-inch intake and 1½-inch discharge). A 1 h. p. Fairbanks gasoline engine is used to operate the pump. The cars are gathered at the working face and hauled to the inside lye by 9 mules. A 6-ton Whitcomb gasoline motor hauls the coal to the surface from the inside lye, a distance of 4400 feet. The tramroad is 800 feet long. The gravity plane is 650 feet long, having an average grade of 33 degrees. Three-car trips are run on this plane, the loads pulling up the empties by means of an inch-steel wire cable which passes around a 10- by 6-foot drum at the top of the plane. One hundred and twenty 1-ton Watt mine cars are used at the mine, which run on 42-inch gauge tracks. The tipple is situated on the West Virginia side of the Potomac River on a switch of the Western Maryland Railway, over which railroad the coal is shipped. The coal is weighed on Fairbanks Standard scales at the tipple and loaded into the railroad cars sidewise over an end dump. During 1918 the company employed 48 miners and 25 laborers at this mine. The output for the year was 57,566.01 net tons.

Louise Mine.—The Louise mine is located on Three Fork Run about a mile west of Chaffee. The mine was opened into the Davis coal seam during 1914. The main entry has been driven about 1000 feet into the hill, but they have not been able to get any coal, either on account of a fault or incorrect calculations. They have therefore abandoned the work of advancing the heading and have confined themselves to mining the "crop" coal near the entry. The mining is all by pick work. The mine is ventilated and drained by natural means. The haulage in the mine is by 1 mule. The company has at this mine ten 1-ton mine cars of 1800 pounds tare weight. The gauge of the mine tracks is 42 inches. The tipple near the mouth of the mine is provided with Fairbanks Standard scales. The mine cars dump the coal over an end dump into a 60-foot chute, loading the railroad cars sidewise. A switch has been built to the tipple from the switch leading to the Chaffee Coal Company's tipple, and the latter company's dinkey engine places the railroad cars for the Louise mine output. The coal is shipped over the Western Maryland Railway. During 1918 the company employed 8 miners and 1 driver at the Louise mine. The output for 1918 was 1715.09 net tons.

Standard Coal Company

The Standard Coal Company is operating two mines located north of Three Fork Run about 1 mile northwest of Chaffee. This property of 750 acres was purchased from the Manor Mining and Manufacturing Company during 1917. The present operators started development about

June 1, 1917, and made their first shipment during August of the same year.

MINE NO. 1.—Mine No. 1 consists of two drift openings into the Davis ("Split-six") coal seam.

Section

	Inches
Slate roof.	
Coal	18
Slate	15-25
Coal	34-38
Shale floor.	

The workings are developed on the Room and Pillar system. Both ventilation and drainage are by natural means. The haulage is performed by four mules. Eighteen home-made 1-ton mine cars are used at the mine. The gauge of the mine tracks is 42 inches. Twelve-pound T-rails are used both inside and outside the mine. The coal is hauled from the mine entry over a 1250-foot tramroad to the tipple. There the coal is weighed on Fairbanks scales and dumped over an end dump into the railroad cars, loading same sideways.

MINE NO. 2.—During 1918 the company opened the Upper Kittanning or Montell seam (Clarion of earlier reports) which here averages about 46 inches. The equipment of this mine is similar to that described above. Coal is shipped over same tipple as described under No. 1 mine.

The railroad cars are hauled from Chaffee and back again by the worm-gear locomotive of the Chaffee Coal Company. The shipping point is therefore Chaffee on the Western Maryland Railroad.

During 1918 the company employed an average of 20 miners and 11 laborers. The tonnage for the year was 15,160 net tons.

STRATHMORE COAL MINING CO.

The Strathmore mine of the Strathmore Coal Mining Co. is located on Glade Run about 1½ miles northeast of Gorman, Maryland. The tipple is situated at Deal Station on a switch of the Western Maryland Railroad. This property was originally owned and operated by the Beechwood-Cumberland Coal Company who sold it to the Glade Run Coal Company (S. H. Jordan) in 1909-10. On December 15, 1915, this property was taken over by the Strathmore Coal Mining Co., a company organized by Mr. John Galloway and Mr. W. A. Price. On January 15, 1916, Mr. John Galloway sold his 50 per cent interest in the company which carried with it the absolute control of the Strathmore Coal Mining Co. to Messrs. George W. Kellam and Manuel M. Llera jointly, who at this date constitute the management and have absolute control of the Strathmore Coal Mining Co. The seam of coal worked is supposed to be the Thomas coal (Lower Bakerstown of this work, Upper Freeport of earlier reports). A section measured in the second right heading where the coal was sampled, shows the following:

	Inches
Shale roof.	
Coal	7
Shale binder	1½ to 2
Coal	18
Shale binder	1½ to 2
Coal	5
Bone binder	3½ to 4
Coal	13
Shale binder	4
Coal	8
Shale bottom.	

For analysis of this sample see table of analyses, No. 46.

The mine opening is a slope entry 500 feet long, which has an average grade of 5½ per cent. The method of mining is by the Room and Pillar system. The mining is entirely by pick work. The mine is ventilated by a 7-foot Stine force fan which is belt-driven by a 25 h. p. Erie steam engine. At 75 r. p. m. this fan produces about 6070 cubic feet of air per minute. The mine is drained by a Knowles steam suction pump (3-inch intake and 1½-inch discharge). The cars are gathered from the rooms and hauled to the inside lye by three mules. From here they are pulled out of the mine in 3-car trips by a 22 h. p. stationary steam hoisting engine (name not known). A five-eighths-inch steel cable wire is used which is wound around the drum, 3 feet by 21 inches, of the hoisting engine. This rope is then attached to the last car of the trip which runs down the 1800-foot tramroad to the tipple by gravity. The "empties" are then hauled up by the tramroad from the tipple to the mine by the same engine and run down-slope into the mine by gravity. The steam power to run the stationary hoisting engine and the fan is furnished by a 30 h. p. "O & S" steam boiler. Two sizes of mine cars are used at this mine which have a capacity of one and a quarter tons respectively; 15 remodeled "Big Vein" cars of 1600 pounds tare weight and 11 smaller cars (remodeled Watt type) of 1200 pounds tare weight. These cars run on 42-inch gauge tracks. At the tipple the coal is weighed on Fairbanks Standard scales and then loaded sidewise into the railroad cars over an end dump.

During 1918 Strathmore Coal Mining Co. averaged 18 employees and produced 11,965 tons of coal.

WOLF DEN COAL COMPANY

The Wolf Den Coal Company is operating the Wolf Den and Mt. Vernon mines which are located opposite Harrison Station on the Western Maryland Railway. The company started their operation during July of 1917 and made their first shipment during April of 1918. The company town of Shallmar, which consists of 50 houses, is situated opposite Harrison, West Virginia, on the Maryland side of the Potomac River.

The two mines above mentioned have been made into the Davis seam of coal. An average section of the coal seam at this point measured:

	Inches
Shale roof.	
Coal	18
Rock parting	12
Coal	12
Bone	2
Coal	32
Bone	1½
Coal	8
Shale bottom.	

The mines have been opened on the double drift entry system, there being three openings all told, one air course for the two haulage entries. The workings are being developed on the Room and Pillar system, the panel headings being 1600 feet long, and driven on 550-foot centers to both sides of the main headings. One Jeffrey arc wall and two Jeffrey short wall electric mining machines are used to mine the coal. The workings are ventilated by a 16-foot Crawford and McCrimmon force fan which is driven by a 15 h. p. steam fan engine of the same manufacture. This fan supplies about 50,000 cubic feet of air per minute. A second mine fan will be installed in the near future. Concrete brattices and overcasts are used throughout the mine workings so that trap doors are not needed for the directing of air currents. The mines are self-draining.

The coal is gathered at the working faces by two 10-ton Jeffrey electric locomotives and at the face of the headings by 3 mules. One hundred and twenty-five 2-ton mine cars are used in these mines. The gauge of the tracks is 42 inches. Forty-pound T-rails are used along the headings and the outside tramroad, and 16-pound T-rails in the rooms. The mine openings are connected with the tipple by 1000 feet of tramroad. At the tipple the coal is weighed on Howe's automatic scales and loaded into railroad cars oven an end dump by means of a chute 45 feet long. The tipple is situated on a spur from the Western Maryland Railway, some 1¼ miles long, which connects with the main line at Dodson.

The power used in operating the mines is manufactured by the company. A power house has been built of cut stone and has been made sufficiently large to hold a second unit. The power unit now installed consists of one 150 h. p. and 175 h. p. International steam boilers, one 250 h. p. Skinner steam engine, one 200 kw. Westinghouse electric generator (250-275-volt D. C.). Water for the boilers is stored in two 1200-gallon tanks near the power house.

The company employed an average of 40 miners and 25 laborers during 1918 and produced 32,604 tons of coal.

GILBERT'S FUEL MINE

Gilbert's fuel mine is located about 2½ miles northwest of Wilson Station on the Western Maryland Railway. The mine is a drift opening into the Davis coal seam. A section of the coal measured in a butt leading off the main heading showed:

	Inches
Shale roof.	
Coal	12
Shale	3
Coal	24
Shale	7½
Coal	31
Shale	6
Coal	28
Shale bottom.	

The method of mining is the Room and Pillar system, the rooms being 10 to 15 feet wide and the headings 5 to 6 feet wide. The mining is by pick work. The mine is ventilated and drained by natural means. The haulage is by 1 mule. Nine 1-ton mine cars of local make are in use running on 24-inch gauge wooden tracks in the mine. Coal is hauled out of the mine and dumped on coal pile at the end of a tipple over an end dump. The coal is then loaded into wagons, weighed on Fairbanks wagon scales, and hauled away by purchaser. No coal is shipped from this mine. Five to seven men are employed during the five winter months of the year when the mine is operated.

UPPER YOUGHIOGHENY BASIN

Coal mining is much less extensively developed in the Upper Youghiogheny basin than in the Georges Creek and Upper Potomac basins. A few of the more important operations are described in the following pages.

PENDERGAST AND ASHBY COAL COMPANY

The Pendergast and Ashby Coal Company is operating the Pendergast mine which is located about 2½ miles southeast of Hutton, Maryland. The property has been leased from Jesse J. Ashby.

A drift opening has been made into the Davis (Upper Freeport) seam. The mine has been developed on the Room and Pillar system and the mining is by pick. Both ventilation and drainage is by natural means. The haulage is accomplished by the use of three mules. Twenty wooden cars with a capacity of one ton each are used in the mine. From 12 to 16 miners and 3 laborers were employed at the mine in 1918, which produced during the year 12,321 tons.

Snowy Creek Coal Company

The Snowy Creek Coal Company is operating the Snowy Creek mine which is situated about one-half mile west of Crellin, Maryland. The property is owned by the operating company.

A drift opening has been made into the Davis (Upper Freeport) seam. The Room and Pillar system of mining is here employed and the mining is all by pick. The mine is ventilated and drained by natural means. Three mules are used for haulage inside the mine. Four miners and 1 laborer were employed, producing 3300 tons.

Turner-Douglas Coal Company

Banner Mine No. 1 is situated at Crellin, Maryland, and is operated by the Turner-Douglas Coal Company under a lease from Heavener and Getrick. A drift opening has been developed into the Davis coal seam. The mine workings are developed on the Room and Pillar system. At the present time the mining is all by pick work, but arrangements are being made to equip the mine electrically and install mining machines. At the present stage of the development work the mine is ventilated by natural means. The drainage is natural. The haulage inside the mine is by means of 5 mules. The tramroad from the mine opening to the tipple has been laid at such a grade that the loaded cars run by gravity from the mine entry to the tipple. The empty cars are pulled back to the mine by an 8 h. p. steam hoisting engine. Power is also supplied by a 4½ h. p. oil engine and by a 2½ h. p. gasoline engine.

Ashby's Fuel Mine

Ashby's mine is located about one-half of a mile southwest of Crellin. The mine is a drift entry into the Davis coal seam (Upper Freeport of this work, Lower Kittanning of earlier reports), which shows the following section in this mine.[1]

	Inches
Coal	6-10
Bone, sometimes shale	8
Coal	23
Bone, rejected	6
Coal	6
Shale	23
Coal	7
Bone	1
Coal	10
Bone	18

The mine has not been worked since 1912-13, but operations were started again on November 15, 1916. The Room and Pillar system of mining is being used here and the mining is all by pick work. The mine is ventilated by an air shaft driven to the surface. The drainage is by natural means. Haulage is by 2 mules. Six 1-ton mine cars are used which run on a 42-inch gauge track laid with 16-pound steel T-rails. The coal is hauled out of the mine and along a tramroad to the tipple where it is unloaded over an end dump into a 100-ton storage bin. From the storage bin the coal is loaded sidewise without being weighed into the railroad cars. The tipple is situated on a switch of the Preston Lumber Company's railroad. This railroad connects with the Baltimore and Ohio Railroad at Hutton, Maryland. Since the operations have been started, ten miners and two drillers have been employed at the mine.

Beeghley Mine

The Beeghley mine is located about 2 miles southwest of Swallow Falls and about 5½ miles northwest of Oakland. The mine is a drift opening into the Piedmont coal seam. The section measured, where sample of the coal was taken, shows:

	Inches
Shale roof.	
Coal	29
Shale bottom.	

For analysis of this coal see table of analyses, No. 47.

[1] Coal Rept., Md. Geol. Survey, Vol. v, 1905, p. 487.

The mine is developed on the Room and Pillar system, the mining being by pick work. The mine is ventilated and drained naturally. Haulage by hand, one mine car being used, having a capacity of 15 bushels. The gauge of the wooden mine tracks is 24 inches. The coal is measured in a box when sold, as the operator does not have scales. Two men are employed to operate the mine during the five winter months. During 1918 1500 tons of coal were produced which were hauled by wagons to Oakland or to neighboring farms.

BROWNING MINE

The Browning mine is located about 2 miles northwest of Oakland near the junction of the roads leading to Hutton and to Cranesville. The opening on the east side of the Cranesville road fell in and was abandoned about 23 years ago. Two men were employed at the time of the writer's visit to clean up and retimber this old opening in order to operate the mine. On the west side of the same road a new drift was opened into this same seam of coal, but, when visited during September, 1916, this new opening had only penetrated far enough to expose the blossom of the Davis coal.

CHISHOLM MINE

The Chisholm mine is located about 4 miles northeast of Oakland and about one-half of a mile south of Round Glade Run. The mine is a drift entry, 4 by 3 feet into the Loarville (Upper Kittanning) seam. Where sampled the section of the seam measured:

	Inches
Shale roof.	
Coal	16
Bone	2½ to 3
Coal	3
Shale and bastard fire-clay bottom.	

For analysis see table of analyses, No. 48.

The method of mining is the Room and Pillar system, the mining being by pick work. The mine is self-draining with exception of dip headings where a hand pump is used. Two one-half-ton mine cars are used which run on 24-inch gauge wooden tracks. No tipple, scales, or dumps are employed. Two men operate the mine only during 5 winter months. The coal produced is hauled by wagon to Oakland where it is sold.

LANCE BROTHERS MINE

Guthrie's mine is located about 2 miles southwest of Crellin near the Maryland and West Virginia boundary line. The Lance Brothers leased the mine from Mrs. Guthrie on May 23, 1916. The mine is a drift opening into the Davis coal seam. A sample of this coal was taken at the face of the 18th left room off the main heading where the section measured showed:

		Inches
Top coal	Shale roof.	
	Coal	18
Breast	Bone	1¼
	Coal	3
	Bony coal	3¼
	Coal	5
	Bone	¾
	Coal	3
	Bone. Sulphur. Shale.	15½
Bottom coal	Shale.	
	Coal	7½
	Bone	2½
	Coal	13½
	Shale bottom.	

For analysis of this coal see table of analyses, No. 49.

The method of mining is the Room and Pillar system. Rooms are driven on 40-foot centers and are 16 feet wide, the headings are also 16 feet wide. The mining is by pick work. The mine is self-draining and ventilating. Haulage is by 1 horse. Ten 1-ton mine cars are in use. The gauge of the wooden track is 36 inches. The coal is hauled out of the mine and dumped at the tipple over end dump onto a large coal pile. It is loaded into wagons, when sold, and weighed on U. S. standard wagon scales. Two men are employed at the mine during the summer months, but during the winter months 4 miners and 1 driver are employed.

LEIGHTON MINE

The Leighton mine is located about 1¼ miles southwest of Swallow Falls (about 5½ miles northwest of Oakland). There are two drift entries made into the Piedmont coal seam at this mine. A section measured where the coal was sampled showed:

	Inches
Shale roof.	
Bony coal	2½
Shale	1¼
Coal	8
Soft shale	½
Coal	12½
Bone	1
Coal	2
Bone	1
Coal	2
Shale bottom.	

For analysis of the coal see table of analyses, No. 50.

The mines are developed on the Room and Pillar system, the mining being by pick work. They are ventilated by natural means, and are self-draining. One mine car is used which has a capacity of 15 bushels, running on 24-inch gauge wooden tracks. Haulage is by hand. During the latter part of the winter of 1915-16 about 500 bushels of coal were sold. Up to this time all the coal mined here was used by the owner. During 1916 2 men were employed, who worked about 6 months of the year.

SHAEFFER MINE

The Shaeffer mine is located about 1 mile east of Swallow Falls. The mine is a drift entry into the Montell coal seam (Upper Kittanning of this report). Where sampled the seam measured:

	Inches
Shale roof.	
Bony coal	17½
Shaly fire-clay	1½
Shale	1½
Coal	24
Shale bottom.	

For analysis of this coal see table of analyses, No. 51.

Mining is by the Room and Pillar system, the method being by pick work. Ventilation and drainage are by natural means. Haulage is by hand. One ½-ton mine car is used. The gauge of the mine tracks is 38 inches. The tracks are of wood with iron strips nailed along the top. Two men operate this mine during the five winter months of the year.

TOWER MINE

The Tower mine is located about 3½ miles north of Oakland near the Youghiogheny River. This mine was leased from the owner, Mr. E. Z. Tower, in 1915 by A. C. Ovil. The mine is a drift opening, 5 by 4 feet, into the Piedmont coal seam. A sample of coal was taken from the mine and a section of the seam measured:

	Inches
Shale roof.	
Coal	7
Shale	½
Coal	21
Shale	1
Coal	6
Shale bottom.	

For analysis see table of analyses, No. 54.

The method of mining used here is the Room and Pillar system, mining being by pick work. The mine is ventilated and drained by natural means. The haulage is by hand. One 1-ton mine car is used which runs on 36-inch gauge wooden tracks. No tipple, scales, or dump are used. Two men are employed at this mine during the 5 winter months; for the rest of the year the mine is idle.

CASTLEMAN BASIN

All the mines in operation in this basin are fuel mines. The more important of these are described in the following pages.

BEACHEY'S FUEL MINE

Aaron Beachey's mine is located about 1 mile west of Grantsville. It is a drift opening into the Davis or Grantsville coal seam (Beachey). It averages 4 feet thick here. A sample of the coal of this seam was taken where the section measured:

	Inches
Shale roof.	
Coal	10½
Shale	1
Coal	23
Shale	1½
Bony coal	7
Shale bottom.	

For analysis of the coal see table of analyses, No. 56.

The workings of the mine are developed on the Room and Pillar system, the mining being by pick work. The mine is ventilated and drained by natural means. The haulage in the mine is by hand. Eight one-half-ton mine cars are in use. Twenty-four-inch gauge wooden tracks are used in the headings, but no tracks are laid in the rooms. This mine is operated 5 months during the year, 5 men being employed. At the mouth of the mine there is an end dump and covered shed to protect the coal from the weather. The coal is weighed on Week's wagon scales, and hauled to Grantsville to be sold.

BEITZEL'S FUEL MINE

John Beitzel's mine is located about 1¾ miles southwest of Bittinger. The mine is a drift entry into the Harlem ("Fossil") seam (the Friendsville coal of earlier reports). The mine is developed on the Room and Pillar system, the working having been advanced over 1800 feet into the hill. The coal is drilled by hand and shot off the solid. The mine is ventilated and drained by natural means. The haulage is by hand. Five 10-bushel mine cars are in use running on 30-inch gauge iron T-rails in the headings and on wooden rails in the rooms. A tramroad about 150 feet long leads from the mine entry to a covered tipple at the road. The coal is dumped over an end dump at the tipple onto a coal pile. The coal is weighed on Osgood farm-wagon scales which have a capacity of 5 tons. Three men are employed at this mine during three winter months.

BITTINGER'S FUEL MINE

The fuel mine of F. M. Bittinger is located about 2¼ miles southwest of the town of Bittinger. The drift openings have been made into the

Upper Bakerstown coal seam, Maynadier or "Slaty vein" at this mine, but one of these openings has fallen shut and been abandoned. The coal itself is a low grade, carrying 24 per cent ash and over 3 per cent sulphur. The seam is full of binders of shale and bone.

The section of the coal at this mine measures as follows[1]:

	Inches
Shale roof.	
Coal	12½
Pyrites nodules.	
Coal	25
Shale floor.	

The mine is developed on the Room and Pillar system. In mining the coal is drilled by hand and short off the solid. The ventilation and drainage are by natural means. The haulage along a tramroad more than 500 feet long is by 1 mule. The haulage in the mine is by hand. Four 12-bushel mine cars are in use at this mine, running on a 30-inch gauge track of steel T-rails in the headings and on wooden rails in the rooms. The tipple is covered to protect the coal from weather. The coal is dumped on a pile at the tipple over an end dump. Osgood farm-wagon scales having a capacity of 5 tons are in use to weigh the coal. None of the coal is shipped. Two men are employed at this mine during the three winter months.

BUTLER'S FUEL MINE

Butler's fuel mine is located about 1 mile northwest of Grantsville and about 600 feet north of Beachey's mine. It is a drift entry into the Davis (Grantsville, "Beachey") coal seam. A section of the seam in this mine is as follows:

	Inches
Shale roof.	
Bone	8
Coal	32
Soft shale floor.	

The Room and Pillar system of mining is used here, the mining being by pick work. The mine is self-ventilating and draining; haulage by hand. One 10-bushel mine car is used which runs on 30-inch gauge wooden tracks. The mine is operated by one man during 3 months of the year.

[1] Coal Rept. Md. Geol. Survey, Vol. v, p. 474, 1905.

CLATTERS' FUEL MINE

The fuel mine of Henry Clatters is located about one-half of a mile southeast of Jennings Mills. The property was purchased from John Miller in 1912-13. The mine is a drift opening into the Davis (Grantsville, "Beachey") coal seam which here averages 20 to 32 inches thick. A section of the coal measures:

	Inches
Shale roof.	
Coal	25
Shale bottom.	

The Room and Pillar system of mining is used and the mining is all by pick work. The mine has natural ventilation and drainage. Haulage is by hand. One 6-bushel mine car is used which runs on 24-inch gauge wooden tracks. Two men are employed for two months during the winter.

HACKMAN'S FUEL MINE

The fuel mine of Louis Hackman is located 2 miles west of Grantsville. It is a drift opening into the Harlem ("Fossil") coal (Friendsville coal of earlier reports). The Room and Pillar system of mining is used. The mine is naturally drained and ventilated. One 4-bushel mine car is employed which runs on 24-inch gauge wooden tracks. The haulage is by hand. This mine is operated by one man for a month or two during the year. No coal is sold, all being used for own consumption.

JENNINGS BROTHERS MINES

The two mines of the Jennings Brothers are located about 3½ miles south of Jennings Mill at the southern end of the Jennings Brothers Railroad. The Lower Bakerstown or Thomas ("Honeycomb") coal is mined here, being found at an elevation of 2250 feet. The Room and Pillar system of mining is used, the mining being done by pick work. The ventilation and drainage are both by natural means. The haulage is by hand. Four 1-ton mine cars are used which run on 30-inch gauge steel T-rails. The coal is discharged at the tipple over an end dump, but no scales are used. Three men are employed at the mine during the entire year. All the coal mined here is used for fuel on the engines of the Jennings Brothers Railroad.

KINSINGER'S FUEL MINE

The mine of J. L. Kinsinger is located about 2 miles southwest of Grantsville. There is a drift opening into the Davis coal (Grantsville, "Beachey") which averages from 28 to 32 inches. A section of this coal seam from this mine measured:

	Inches
Shale roof.	
Coal	26
Shale bottom.	

The coal is mined by pick work on the Room and Pillar system. Ventilation and drainage both are by natural means. One 10-bushel mine car is used which is pushed by hand, running on wooden rails with iron top strips. The gauge of the tracks is 24 inches. Two men operated this mine for several months during 1918.

LEGEER'S FUEL MINE

M. Legcer's fuel mine is located about 2½ miles southeast of Engle Mills. The coal worked in this mine was called the Clarion seam in the report on the Coals of Maryland where the following section is given[1]:

	Inches
Sandstone roof.	
Coal	33
Shale	1
Coal	10
Soft clay floor.	

The mine is entered by a slope entry which is 70 feet long and has a grade of 8 per cent. A rock tunnel on a 1½ per cent slope extends 430 feet before reaching the coal seam. The working face is approximately 1600 feet from the entry. The mine is ventilated by a bore hole to the surface and a stand pipe above the surface. The haulage inside the mine is by hand. The cars are pulled up the slope by a hand windlass. Four mine cars are used which have a capacity of 800 pounds, running on 24-inch gauge steel T-rails in the headings and on wooden tracks in the rooms. The slope entry and the end dump are covered by a large shed. A measuring box is used instead of scales. Three men are employed at the mine during the 5 winter months.

[1] Md. Geol. Survey, Vol. v, 1905, p. 456.

McKenzie's Fuel Mine

The mine of Henry McKenzie is located about 1 mile north of Bevansville. It is a drift entry into the Davis coal (Grantsville, "Beachey" seam). A section of this seam of coal showed the following measurements:

	Inches
Shale roof.	
Coal	26
Shale	3
Coal	5½
Shale bottom.	

The mine is now practically worked out. A new opening has been made which had to be abandoned. The ventilation and drainage are both natural. The haulage is by hand. Two mine cars of 10- and 12-bushel capacity are in use, running on 24-inch gauge wooden tracks. The mine is operated by 2 men working 4 months of the year.

Shaw's Fuel Mine

The fuel mine of G. Fay Shaw is situated about 1½ miles southwest of Grantsville. The mine is a drift entry into the Davis coal (Grantsville, "Beachey") which here averages 36 to 45 inches. One of the sections of this seam showed the following measurements:

	Inches
Shale roof.	
Coal	11
Shale	1½
Coal	22½
Shale	2
Coal	8
Shale bottom.	

The mine is developed on the Room and Pillar system, and the mining is by pick work. The ventilation and drainage are by natural means. The haulage is by hand. Two 10-bushel mine cars are in use, running on 24-inch gauge wooden mine tracks which are now being replaced by 16-pound steel T-rails. No tipple is used. The coal is weighed on 4-ton Weeks' wagon scales. Two miners and one laborer operate the mine during the five winter months.

E. STANTON'S FUEL MINE

The mine of Earl Stanton is located about $2\frac{3}{4}$ miles southwest of Grantsville. It is a slope entry of 4° grade into the Davis coal (Grantsville). The coal seam showed the following section:

	Inches
Black shale roof.	
Coal	21
Shale	¼
Sandstone	18 to 36
Coal	12
Shale	1 to 2
Coal	28
Sand shale bottom.	

The mine is developed on the Room and Pillar system, the mining being done by pick work. The haulage is by hand. One 10-bushel mine car is used, which runs on 24-inch gauge wooden mine tracks. Ventilation and drainage are by natural means. The mine is operated by one man for three months of the year.

U. M. STANTON'S FUEL MINE

The mine of U. M. Stanton is situated about 1 mile southeast of Grantsville. The mine is a drift entry into the Thomas coal (Lower Bakerstown or "Honeycomb"). The Room and Pillar system is used, and the mining is by pick work. Ventilation and drainage are both natural. The haulage is by hand. Two 7-bushel mine cars are used, which run on 24-inch gauge wooden tracks. A measuring box is used instead of scales. The mine is operated by two men three months of the year. During 1918 1000 tons of coal were produced.

WISSEMAN'S FUEL MINE

The mine of Henry Wisseman is situated $2\frac{1}{2}$ miles southeast of Grantsville. It is a drift opening into the Davis coal (Grantsville, "Beachey") which averages 25 inches thick at this mine. A section of this seam showed the following measurements:

	Inches
Shale roof.	
Coal	28
Shale bottom.	

The mine is developed by the Room and Pillar system, mining being by pick work. Ventilation and drainage are natural. The haulage is by hand. One 8-bushel mine car, which runs on a 28-inch gauge wooden track, is used. This mine is operated by two men during three months of the year.

YODER'S FUEL MINE

The fuel mine of S. V. Yoder in the Davis coal is a drift opening about 2 miles northwest of Grantsville. The method of mining is by the Room and Pillar system, the mining being by pick work. Ventilation and drainage are both by natural means. The haulage is by hand. One ½-ton mine car is used, which runs on 26-inch gauge wooden tracks. The coal is weighed at the tipple on Fairbanks Standard scales. This mine is operated for 6 months of the year by two men.

LOWER YOUGHIOGHENY BASIN

All the mines in operation in the Lower Youghiogheny Basin are fuel mines, two of the more important of which are described in the following pages:

FIKE MINE

The McCullough mine, operated by David Fike, is a drift opening in the Lower Kittanning located about 1½ miles south of Friendsville. Where sampled this seam measured:

	Inches
Shale roof.	
Coal	8½
Bone	2
Coal	40
Shale bottom.	

For analysis of the coal see table of analyses, No. 57.

The method of mining is the Room and Pillar system. The coal is mined by pick work. The ventilation and drainage are both by natural means. The haulage is by hand. One mine car is used which has a capacity of 12 bushels. The wooden mine tracks are 24-inch gauge. The coal is hauled to Friendsville by wagons and sold there for local uses. One man is employed at this mine all the year and 2 men during the 5 winter months.

STEELE MINE

The Steele mine is located about one-half of a mile east of Friendsville near the road to Selbysport. The mine consists of two drift openings into the Lower Kittanning coal seam. A section of the coal seam showed:

	Inches
Shale roof.	
Coal	6
Shale	3
Coal	16
Shale	6 to 10 feet.
Coal	28
Shale bottom.	

The method of mining is the Room and Pillar system. The coal is not mined by hand, but is shot off the solid. Ventilation and drainage are both by natural means. The haulage in the mine is by hand. One ½-ton mine car is used. The gauge of the wooden mine tracks is 24 inches. This mine is operated by 2 men, working during 5 or 6 months of the year. During 1918 they produced 1600 tons of coal which was hauled to Friendsville by wagons to be sold there for local consumption.

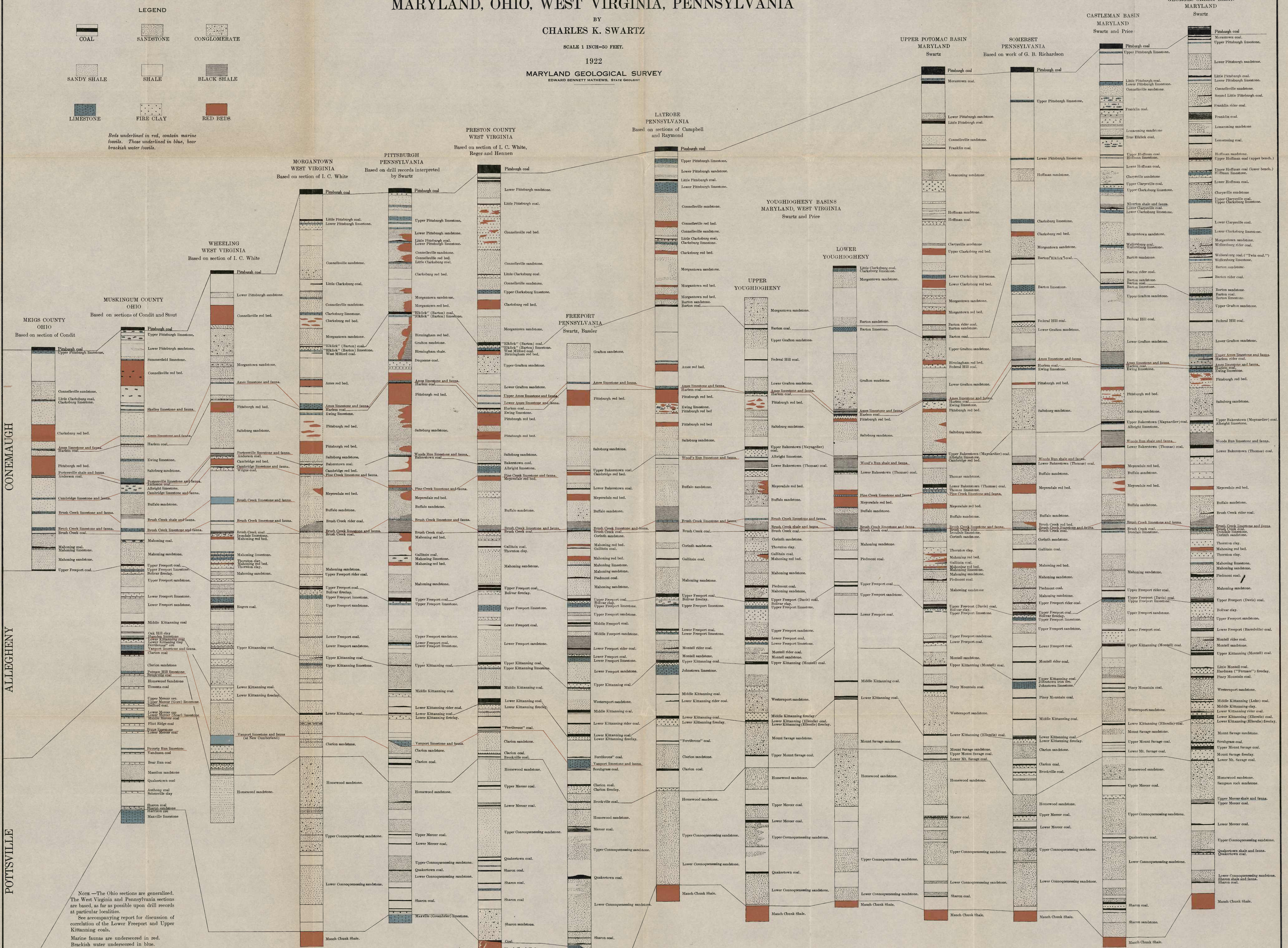
Geology and coals of Georges Creek Basin by C. K. Swartz and G. C. Martin.
Davis, Thomas and Barton coals of Upper Potomac Basin by J. D. Sisler.
Topography by U. S. Geological Survey.

COMPARATIVE SECTIONS OF THE COAL MEASURES
SHOWING
THE BEDS BENEATH THE PITTSBURGH COAL
IN
MARYLAND, OHIO, WEST VIRGINIA, PENNSYLVANIA
BY
CHARLES K. SWARTZ

SCALE 1 INCH=50 FEET.

1922

MARYLAND GEOLOGICAL SURVEY
EDWARD BENNETT MATHEWS, STATE GEOLOGIST



NOTE.—The Ohio sections are generalized. The West Virginia and Pennsylvania sections are based, as far as possible upon drill records at particular localities.

See accompanying report for discussion of correlation of the Lower Freeport and Upper Kittanning coals.

Marine faunas are underscored in red.
Brackish water underscored in blue.

MARYLAND GEOLOGICAL SURVEY

GENERALIZED SECTION OF

THE COAL MEASURES

OF THE

GEORGES CREEK BASIN

BY

CHARLES K. SWARTZ

Scale 1 inch=50 feet

MARYLAND GEOLOGICAL SURVEY

VOLUME XI, PLATE VII.

PART II

THE FIRE CLAYS OF MARYLAND

BY

ARTHUR S. WATTS, H. G. SCHURECHT,
CHARLES K. SWARTZ and GEORGE M. HALL

WITH AN INTRODUCTORY CHAPTER

BY

EDWARD B. MATHEWS

ERRATA

On page 354 and elsewhere the Big Savage Fire Brick Company is referred to as the Mount Savage Fire Brick Company. Their property is in Allegany County and at present they are working the Big Savage Mine and Tunnel, erroneously referred to in this report as the Benson Mine and Tunnel.

ORIGIN, DISTRIBUTION, AND USES OF CLAY
WITH SPECIAL REFERENCE TO THE FIRE CLAYS OF WESTERN MARYLAND

BY

EDWARD B. MATHEWS

Introduction

The clay deposits of Maryland are the most widely distributed of any of the mineral deposits of the State and have been worked from the earliest period of brick-making in this country. The character of the clays varies widely from place to place and the properties for individual localities have been described at length in Volume IV of the Survey reports. The fire clays of the State, especially those of western Maryland, were among the first utilized for refractory ware, but the development of the industry in these specialized products belongs to the second half of the nineteenth century and is contemporaneous with the development of the use of steam and modern metallurgical processes.

Clays suitable for the manufacture of refractory ware are found among the residual deposits of the Piedmont, in the sedimentary deposits of the Coastal Plain, and in the Coal Measures of western Maryland. Each of these classes of deposits in Maryland represents but a part of the larger areas of occurrence of similar materials which extend from New York, New Jersey, and Pennsylvania southward to the southern Appalachian and Gulf states. A complete geological or commercial understanding of many of the deposits requires a knowledge of the deposits in the adjoining states. Concerning the latter much geological and economic information has been published which throws light on the origin, occurrence, and possible uses of these materials. This information is widely scattered in official and scientific publications and the discussion of the results will be summarized in the following pages.[1]

The flint and plastic fire clays of western Maryland occur in irregular masses at certain definite geological horizons which come to the surface at many points in the northern Appalachian province. The most favorable locations for the prospecting for these clays may be determined by a study of the areal distribution of the respective formations as outlined on the geological maps. Such maps on the scale of a mile to the inch have been issued for Allegany and Garrett counties and similar maps covering detached areas in Pennsylvania and West Virginia have been issued from time to time by Federal, State, or private organizations.

Definition of Clay

The term clay is applied generally to those natural deposits composed essentially of earthy materials, of great variability in composition and physical properties, which possess in common the property of being molded when wet to shapes which they retain when dry. They are all marked by fineness of grain, and consist largely of alumina, silica, and water in various combinations. Other popular definitions of the term involve the assumption that clays are mixtures of definite compounds such as kaolinite, or "clay substance," with more or less quartz and other mineral fragments; that they have a characteristic "earthy" odor when breathed upon or moistened; or possess the power of absorbing water and staining-solutions. Although most ordinary clays possess practically all of these characteristics, substances which are called "clay" are often lacking in one or more of them. The propriety of using the term "clay" for shales and underclays which show plasticity only after grinding may be questionable, but the usage is so thoroughly established that it will be

[1] Comprehensive summaries of the literature may be found in Ries: "Clays, Their Occurrence, Properties, and Uses," John Wiley & Sons, 1914; "The Clays of the United States East of the Mississippi River," U. S. Geol. Survey, Prof. Paper No. 11, Washington, 1903.

More detailed statements may be found in the reports of the respective State Geological Surveys.

followed. In practice it is customary to distinguish "clays" from shales on the basis of fissility. This is lacking in the "clays" which break into roughly rhomboidal blocks with conchoidal fracture.

Viewed from a physical-chemical standpoint clays may be regarded as a combination of granular and colloidal materials in such proportions that they possess plasticity when moistened with an appropriate amount of water. The colloidal matter is essentially a colloidal suspension in water of mineral particles probably less than a quarter[1] of a micron (.00025 mm.) in diameter, or in the words of Oden:[2] "clays are disperse systems of mineral fragments in which particles smaller than 2 μ predominate." That is, it is a hydrogel. These minute particles of colloid are crystalline. They may be different in clays of different composition.

Mechanically, clay may be tentatively visualized as a mixture of non-plastic particles covered more or less completely by thin films of colloidal material, the interstices between the larger non-plastic particles being filled with similar particles of small size, the whole mass bound together by the hydrogel which forms the films and fills to a greater or less degree the interstitial pore spaces. According to the mechanical separations by elutriation employed in soil analysis the relative amount of the different sized particles is very variable.

Twenty-three clays from Illinois[3] gave:

Grain Size of 23 Clays from Illinois

	More than 1 mm.	1.0-.10 mm.	.01-.01 mm.	.01-.001 mm.	.001-0 mm.	Comb. H_2O	Hyd. H_2O
Average	5.01	3.28	45.46	27.23	13.29	6.81	1.29
Max.	13.66	12.14	63.75	40.72	26.39	14.95	2.48
Min.	.19	.50	22.50	13.79	6.53	3.32	.47

Fourteen clays from West Virginia[4] gave:

[1] Atterberg defines clay as composed of particles under 2 microns in diameter in view of the marked increase in the strength of the Brownian movement at this point. See Ashley: Bureau of Standards, Technical Paper No. 23, p. 15.

[2] Bull. Geol. Inst. Upsala, Vol. XV, 1918, p. 177; excerpt printed 1916, but not seen by the writer before this paper was written.

[3] Purdy, Ill. Geol. Survey, Bull. 9, 1908, p. 151.

[4] Grimsley and Grout, W. Va. Geol. Survey, Vol. III.

Grain Size of 14 Clays from West Virginia

	More than .15 mm.	.15-.02 mm.	.020-.005 mm.	.005-.001 mm.	.001-.0 mm.
Average	12.77	25.31	31.81	9.71	16.06
Max.	34.20	35.60	46.60	23.00	39.60
Min.	2.40	2.00	15.60	4.00	3.00

One of the most colloidal clays described is the bentonite clay from Wyoming, known in the trade as wilkinite. According to the statement of the company the mechanical composition of an average sample of one hundred tons of ground material gave:

Grain Size of "Wilkinite" from Wyoming

More than .15 mm.	.15-.075 mm.	.075-.033 mm.	.033-.008 mm.	.008-.003 mm.	.003-.0015 mm.	.0015-.0 mm.
0.04	0.41	2.02	3.86	2.23	17.62	73.82

The properties of the disperse system (colloid) may be expected to vary with the concentration and fineness of the grain, *i. e.,* with the degree of dispersion, or in the words of Ashley[1]: "the phenomena produced in disperse systems by variation of external conditions or by addition in reagents—apart from purely chemical effects, such as the ordinary solvent effect of hydrochloric acid upon colloidal ferric hydroxide—are due to variation in the degree of dispersion produced by the chance of circumstances." Thus the addition of an alkali such as sodium carbonate, or fine grinding, tends to decrease the size of the disperse particles while, as shown by Galpin,[2] recrystallization with consequent increase in the coarseness of the microcrystalline texture tends to increase the size of the disperse particles. The particles may be fragments of quartz, feldspar, mica, kaolin, zeolites, etc., but the properties of the clays depend not so much on the mineralogical character as upon their size, shape, the relatively large surface-to-mass, and the relative amounts of the grains of different fineness—especially those below 0.005 mm. in diameter.

[1] Technical Control of the Colloidal Matter of Clays, U. S. Bureau of Standards, Tech. Paper, No. 23, 1913, p. 15.

[2] Galpin, Sidney L., Trans. Amer. Ceramic Soc., Vol. XIV, 1912, pp. 300-346.

ORIGIN OF CLAYS

Clay is always of secondary origin, *i. e.,* it is never a product of the consolidation of a molten magma. While some of the best known kaolin deposits such as those of Cornwall and Zittlitz are probably the product of gases and superheated water acting on pre-existent feldspathic rocks, kaolinite and other clay-forming minerals are formed extensively through the ordinary weathering of many aluminous minerals. This is especially true of the feldspars and lenads (leucite, nephelite, etc.) and occurs less frequently in the case of andalusite and the aluminous amphiboles and pyroxenes. Hydrous aluminates of silica, quartz, hydroxide of iron, and carbonates, are the compounds toward which almost all rocks and minerals trend in their decomposition under atmospheric conditions. These and their antecedent minerals, through mechanical agencies, are constantly being reduced in size by the various processes of comminution. The ultimate source of all clay material is, therefore, the igneous rocks, although the immediate source may be one of their derivatives.

The formation of clay deposits consists essentially of three steps: (1) the formation of the clay substance by comminution of the original minerals and the chemical alteration into new compounds of pre-existing material, (2) the transfer of the material so formed, and (3) its deposition under different subaqueous or subaerial conditions.

FORMATION OF CLAY MATERIAL

The origin of clay-forming material is due to the comminution and alteration of pre-existing rocks and minerals, or to the removal of the more soluble constituents of a rock such as limestone and the residual concentration of the minute, less soluble, generally argillaceous impurities. The former is illustrated by the weathering of granites, the latter by the weathering of limestones and marble.

When a granite or allied rock weathers it is first disintegrated by the shattering action of seasonal and diurnal changes in temperature, producing innumerable minute cracks, by the expansive action of rootlets, and by the influence of the freezing and thawing of the interstitial waters along such cracks and joint planes. This mechanical disintegration, if continued long enough, may reduce the rock to a mass of small, angular fragments or even a sand, but ordinarily it does not develop a clay without contemporaneous or subsequent chemical action.

The original rock from the beginning of exposure to atmospheric conditions is subject to chemical attack which increases with the increased ratio of surface to mass of the individual particles developed by disintegration. The original minerals differ in their degree of solubility in water but all, even quartz, are more or less susceptible, becoming more so with decrease in size, and tend toward the formation of hydrates of alumina, silica, and iron, through the destruction of the original molecules and the removal of the more soluble constituents, such as the alkalies. Most rocks consist largely of feldspar or argillaceous materials which on weathering form kaolinite and other hydrous compounds of alumina. When a limestone or non-feldspathic, slightly argillaceous rock weathers the more soluble portions are removed, leaving behind an increasing amount of finely comminuted hydrous compounds of silica and alumina which, unless subject to mechanical removal, form a residual mantle of clay.

Two other less important methods of producing clay-forming material may also be mentioned. The inclusion of debris in continental ice and glaciers with its subsequent comminution through grinding may produce suitable material although it is probable that the clays of glacial origin largely represent material of argillaceous character which has been picked up by the onward moving ice and more or less altered since its original deposition. Material suitable for the formation of clay may conceivably also be produced by chemical precipitation of material analogous to clay in composition and texture, as has been suggested in the case of certain flint clays. The character of the clays found, whether lateritic, kaolinitic, rich in humus or iron, depends largely on the physical conditions under which they were formed; warm moist climates, causing laterites and black earths; moderate climates, clays; and dry climates, desert sands.[1]

[1] Lang, Rich, Versuch einer exakten Klass, der Böden . . . . Inst. Mitt. f. Bodenkunde, V, 1915, pp. 312-347.

Clay materials formed by any of the above described methods may remain where they were formed, or may be removed and deposited elsewhere under various conditions.

METHODS OF TRANSPORTATION

Clay material, once formed, may be removed by water, ice or wind. This movement may be slight or to a distant locality. Thus the residual mantle of the upland may be carried by gentle rains and rivulets to the nearby slopes and valleys with little or no change in the character of the material and little evidence, other than that of its location of having been removed from its place of formation (Colluvial). If the removal is by running water or wave action there is a sorting of the material into coarser and finer particles according to the local variations in velocity at different points. Since the transporting power of water increases rapidly with velocity, swift waters can carry or roll along the larger with the finer fragments, while gently-flowing currents carry the finer particles in suspension and ultimately deposit them freed from the coarser grains. Transportation by water, therefore, produces a sorting of material and the concentration of the clay-like particles. When material is removed by the ice the viscosity of the latter permits the transportation of fragments of all sizes from the coarsest to the finest at the same rate. As the including ice is melted the material is left in a heterogeneous mass unsorted in size and character. When material is removed by wind there is a partial sorting since the velocity of the wind does not allow of the transportation of any but the smallest particles. If the material is deposited subaerially there may be little or no stratification while the same materials falling in a body of standing water will be further sorted according to the size, shape, and character of the grains, since these influence the rate of sedimentation of the particles. In water-lain, wind-formed sediments there is likely to be some evidence of stratification.

PLACES OF DEPOSITION

The origin and character of clay deposits also differ according to the conditions of the clay material transported from the place of its formation. Thus residual and alluvial deposits may show little or no regularity in thickness or extent since their quantity and occurrence are largely determined by the character of the original bodies from which they are derived. In the case of transported clays the thickness, character, and extent of the deposits may differ according as the material has been deposited in floodplains and terraces, or in lakes, swamps, and estuaries. Variations in the currents due to grade, as well as variations in the amount and character of the sedimentary load due to erosional and climatic irregularities, cause such fluvatile deposits to differ widely in character.

Clays deposited in the sea or in tidal estuaries are usually of greater extent and more marked stratification. The waves and coastwise currents are usually sufficient to hold in suspension material of the size of clay particles so that they are only deposited some little distance off-shore under conditions uniform over a wide area, or in sheltered bays and estuaries where the current is slight.

According to the mode of origin clay deposits may therefore be grouped as follows:

Classification of Clay Deposits

(According to Origin)

Material formed *in situ*.
  From iron-poor rocks.
    Rich in feldspar....................................kaolin.
    Limestones ....kaolin.
  From iron-bearing rocks.............................common residual clay.
Material formed nearby................................colluvial residual clays.
Material formed at a distance.
  Transported by water................................sedimentary clays.
    Deposited in flood plains or terraces.............fluvatile clays.
    Deposited in lakes and swamps.....................lacustrine clays.
    Deposited in estuaries............................estuarine clays.
    Deposited in sea..................................marine clays.
  Transported by ice.
    Deposited direct by melting ice...................boulder clay, till.
    Deposited in water................................stratified till.
  Transported by wind.
    Deposited subærially or in water..................lœss.

SHALES.—Subsequent to the formation of clay material and its deposition, as outlined above, the clay bodies are frequently deeply buried by superposed later sediments and in the case of clays older than the Pleistocene. compressed and folded by movements of the earth's crust. The consolidation by low pressures and the cementation of grains by deposition from solution changes the masses from clays to shales. The latter if their grains are unlocked by grinding still have the essential properties of clays. If, however, the metamorphism goes farther to the formation of slates and schists, the essential properties which make clays valuable are lost through the crystallization of the colloidal material into larger grains. Slates even when ground finely show little or no plasticity when moistened and low tensile strength when molded and dried.

Most of the "clays," brick and fire, mined in the Appalachian region, have been consolidated to a point where they must be ground before they can be used. Some of the "flint" clays show little plasticity after grinding on account of incipient crystallization.

The genetic classification of clays is more scientific and has been adopted by many authorities, but the criteria of genesis do not lead to a classification satisfactory to the ceramists and most of the authorities have attempted to meet this objection by the use of other factors in a manner both unsystematic and illogical. The consideration of clays from the viewpoint of origin is serviceable to the geologist and prospector as an aid in the interpretation of the occurrence and extent—horizontal and vertical—of clay deposits, but is of little value to the ceramist who must select his clays in accordance with the chemical and physical properties such as composition, plasticity, and fusibility.

PROPERTIES AND USES OF CLAYS

The classification of clays according to origin and general character yields results of more service to the geologist than to the worker in clays whose success is determined largely by his knowledge of the properties of the clays rather than their origin. These properties include the chemical and mineralogical character of the clays, their texture, plasticity, and behavior during burning. These may be considered under two groups—the composition, and the physical properties.

COMPOSITION OF CLAYS

Although the properties of clays are more dependent upon their physical features than on their chemical composition, the composition of clays may be treated according to the character and proportion of the minerals actually present in the clay or according to the chemical constituents as shown by ultimate analyses giving the chemical components in proportion to their weight.

Mineralogical Composition of Clays

Clays, as already stated, are usually a complex mixture of minute fragments of different kinds of minerals which have been derived from pre-existing rocks or formed subsequent to the deposition of the clay. Although clays are such on account of the fineness of their grains, it is frequently stated that " clay is a hydrated silicate of alumina " corresponding in composition to the mineral kaolinite or that the mineral kaolinite is itself at the base of all clays which are merely masses of particles of kaolinite with impurities of different mineralogical composition. Analyses show that this statement is far too broad, since the ratio of the various chemical elements and the known mineral constituents disclosed by the microscope indicate the presence not only of kaolinite, with its allied hydrates, hallosite, pholerite, and hydrargillite, but also quartz and lesser amounts of feldspar, mica, tourmaline, rutile, and the iron-bearing minerals.

KAOLINITE.—It is customary in considering the chemical composition of clays by rational analyses to assume that the alumina and silica occur combined in proportions of 1 : 2 (SiO_2 46.3; Al_2O_3 39.8; H_2O 13.9) as far as this is possible and that the excesses, if such occur, are present in the form of quartz and fluxes. This is only partly true since these chemical constituents may be present either in hydrated colloidal form or in different proportion in other silicates. The latter may be especially true of fire clays in which Galpin has shown the frequent occurrence of hydromicas and muscovites, and others have shown the presence of pholerite or some other hydrous silicate of alumina. It is probably safer to speak of the mineralogical composition from the actual determination of the mineral character rather than from the chemical analyses.

QUARTZ is the second constituent in importance in most clays and when coarse is usually recognized by the gritty feel of the clay. If, however, the grains are very fine and rounded the grittiness may not be appreciable. It is estimated that the amount of quartz varies from practically nothing in certain kaolins to 50 per cent or more in various sandy clays. The terms, silica, quartz, and sand are unfortunately used rather loosely in clay literature, sometimes meaning the same thing and at other times indicating a careful discrimination between the chemical constituent, the mineral, and the mixture of quartz and silicates other than those soluble in sulphuric acid. A large percentage of "quartz" in the non-refractory clays increases the refractoriness and decreases the shrinkage but in the clays which are burned to a temperature near or above the kaolinite-quartz eutectic (above cone 25) a large amount of quartz lowers the refractoriness of the clay.

FELDSPAR, generally orthoclase, is frequently found, especially in residual clays derived from granite rocks. Its fusing point is low, varying slightly with the variety and it therefore acts as a flux. Most of the soda and potash noted in chemical analyses is probably in feldspar grains in the residual clays, but these oxides may be present in the sedimentary clays, in the form of glauconite, muscovite, or other mineralogical combination.

MICA either in the form of biotite or more commonly as muscovite, sericite or hydromica, is usually determinable in the coarser constituents of clays by its scaly, lustrous character. The highly micaceous clays are seldom valuable commercially although the muscovite acts as a flux and assists in the vitrification of bodies at low temperatures. If the grains are large they may remain unaffected at moderate temperatures and thus affect the appearance of the burnt ware.

IRON MINERALS.—Compounds of iron such as the hydroxide, limonite; the oxides, hematite and magnetite; and the carbonate, siderite are frequently found in clay, widely distributed in finely divided particles, or in larger nodules or concretions. The latter are objectionable and are usually removed during mining, while the iron in finely disseminated form is essential to the development of strong colors in the burnt ware. Most of the iron near the surface where the clays have been weathered is probably in the form of limonite, or as siderite which, when finely divided, is gray in color and unnoticeable until weathered to limonite. The presence of siderite is often the reason why light-colored clays burn to deeply-colored ware.

Many other minerals such as pyrite, calcite, dolomite, gypsum, rutile, zircon, garnet, and tourmaline, glauconite, wavellite, etc., are frequently present in the clays either as remnants of original grains from the parent rock or as constituents formed subsequently in the clay itself.

Chemical Composition of Clays

The chemical composition of clays is expressed either in the *ultimate* chemical analysis or in a derived form known as the *rational* analysis in which the constituents determined by the ultimate analysis are distributed into the three assumed compounds—clay substance, quartz, and feldspar—which when actually present are known to have characteristic properties that affect the behavior and uses of clays. The rational analysis in practice is made by separating the residue insoluble in sulphuric acid and sodium hydrate, determining the alumina and silica with their allotment into "feldspar" and "quartz"; and regarding the soluble portion as clay substance.[1] More elaborate methods of rational analysis, such as that suggested by Zschokke, which involves the analysis of the specimen both chemically and mechanically, are occasionally employed in investigations, but they are rarely used in the commercial work. The results obtained by rational analyses are serviceable in the preparation of the "batch" by the clay worker, but represent only approximately the actual mineralogical composition of the clay tested.

The constituents determined in the ultimate analysis represent the substances actually present but do not indicate their mode of occurrence or combination. The determinations usually employed in clay analysis are those of the ordinary silicate analysis without the determination of the rarer constituents, except titanic oxide and ferrous oxide. The actual

[1] It should be borne in mind in assigning the soluble portion to clay substance that the solubility of these constituents increases with fineness of grain, and that even quartz is appreciably soluble when the particles are of colloidal size.

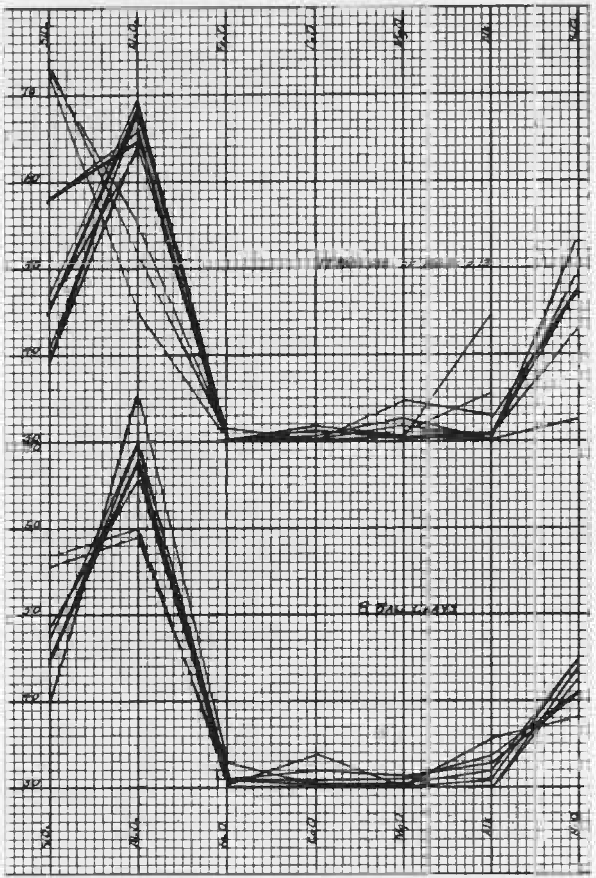


Fig. 1.—Graph Showing Variation in Composition of Kaolins and Ball Clays.

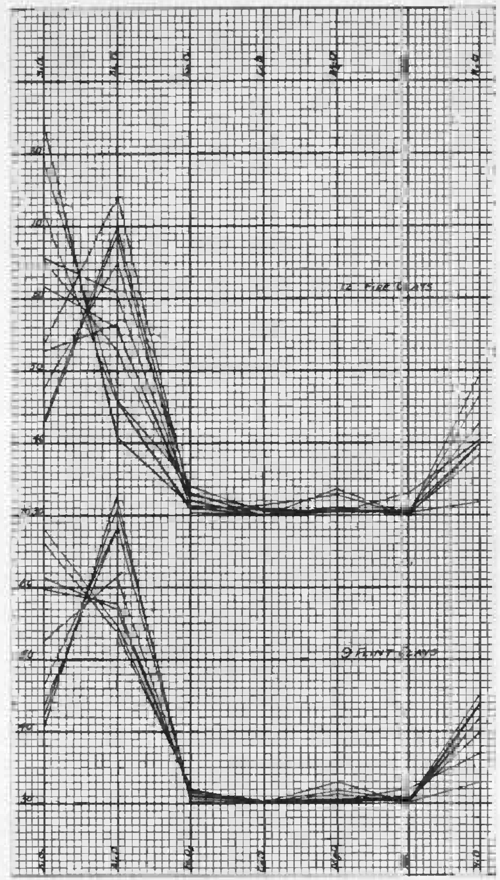


Fig. 2.—Graph Showing Variation in Composition of Fire and Flint Clays.

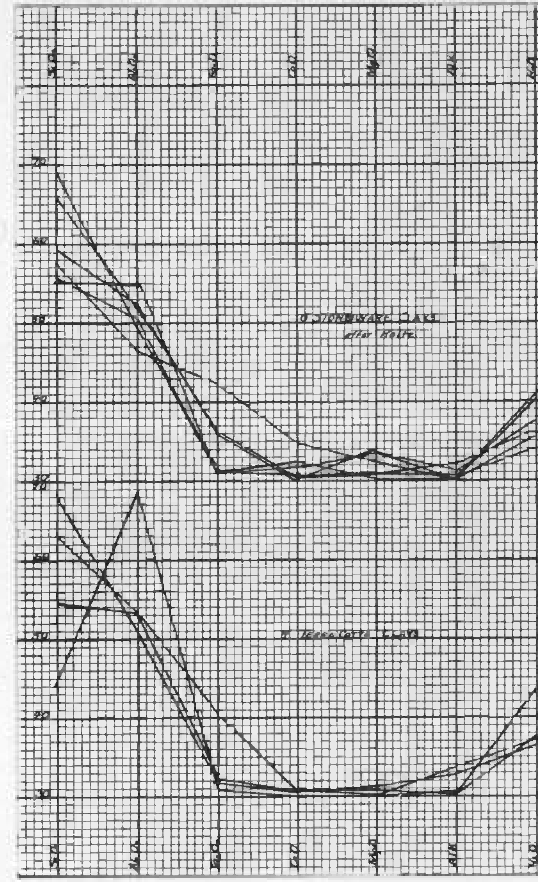


Fig. 3.—Graph Showing Variation in Composition of Stoneware and Terra Cotta Clays.

percentages obtained for the individual oxides vary very widely, and only in a general way with the character and uses of the particular kinds of clay. The following table represents the range and average of the more common constituents as given by Ries in his various publications and the accompanying diagrams show graphically the range and composition of a series of clays selected by Professor Rolfe,[1] to represent extreme variability.

Table Showing Range and Average Composition of Common Clay Types

(After Ries)

		Silica SiO_2	Alumina Al_2O_3	Iron Fe_2O_3	Lime CaO	Magnesia MgO	Alkalies Na_2O+K_2O
Brick	Minimum	34.35	....	.013	.024	0.02	0.17
	Maximum	90.87	....	32.12	15.38	7.29	15.32
	Average	59.27	....	5.21	1.513	1.05	2.77
Pottery	Minimum	45.06	....	....	.011	0.05	0.52
	Maximum	86.98	....	....	9.90	4.80	7.11
	Average	45.83	....	....	1.098	.85	2.86
Fire clays	Minimum	34.40	....	.01	.03	0.02	.048
	Maximum	96.79	....	7.24	15.27	6.25	5.27
	Average	54.30	....	1.506	0.655	.51	1.46
Kaolin	Minimum	32.44	....	....	tr	tr	0.1
	Maximum	81.18	....	....	2.58	0.44	6.21
	Average	55.44	....	....	0.47	.22	1.00

From these figures and diagrams it is clearly evident that any relations between the amount of a given constituent present and the properties of the clays are very general and readily modified by numerous contemporaneous variations either of mechanical composition or physical character. The advantages of ultimate analyses may be summarized as follows:[2]

They give approximate information regarding: (1) The purity of clays, (2) The approximate refractoriness, (3) The color to which they will burn, and (4) Something of their behavior in burning. It is evident that

[1] Rolfe, Ill. Geol. Survey, Bull. No. 9, 1908, pp. 13-14.
[2] *Cf.* Ries, Clays, p. 62.

little is taught by the ultimate analysis regarding the physical properties such as plasticity, tensile strength, and character of the burned ware.

Colloids in Clay

The presence of colloids in clay has been well established by many experiments and yet the conclusion is not accepted by many investigators and writers on clay. This is apparently due to the misconception of the use of the term colloid for a *state* of matter rather than a compound of some special composition, and to the fact that certain authors have introduced Nageli's conception of micellian structure of colloids. This structure is summarized by Ries as "a submicroscopical, web-like porous formation, one of the distinguishing characteristics of which is the peculiar relation to and dependency on water"—which differs from so-called hydroscopic water in that "it is absorbed into the particles of the powder of an inorganic hydrogel without changing the physical appearance when under the microscope, while hydroscopic water is usually absorbed on the particles, producing a distinct appearance of wetness." Again, as Purdy states, since "there can exist from 400 to 1500 trillion free and independent submicroscopic particles, to say nothing about the larger particles, they will find interstices between these grains sufficient to satisfy even the most exaggerated conception of a micellian structure." As the particles in the water of a colloidal suspension are themselves so small that they cannot be seen with the highest powers of the microscope the argument of Ries is hardly applicable and as the countless aggregates of minute particles referred to by Purdy must be of colloidal size the various investigators are apparently in closer accord than appears from their writings.

All of the more recent investigations on clays and soils would indicate that the characteristic properties of clay are due to the existence of an appreciable amount of the material in a colloidal state. They are not due to the presence of some peculiar substance or of certain individual masses but to the fact that numberless mineral fragments are less than .002 mm. in diameter.

PHYSICAL PROPERTIES OF CLAYS

The physical properties of clays are more important for the ceramist than either their origin or composition. Among them the most important in the working of clays are the plasticity, shrinkage, and behavior during burning. Much has been written on these properties and many attempts have been made to explain the interrelationship existing between them. In the present discussion these properties will be considered as they exist in the unburned clays and during the burning. The technical elements relating to variations in the wares produced are discussed at greater length by Professor Watts in a subsequent chapter.

Physical Properties of Unburned Clays

The physical properties of clays before they are burned include fineness of grain; plasticity, with its degree and the amount of water required in tempering; shrinkage in the green ware, known as air shrinkage; and tensile strength. Plasticity is probably the most generally known, but the fineness of grain is probably of more ultimate importance since it affects both the plasticity and air shrinkage.

FINENESS OF GRAIN.—Although all clays are essentially fine grained with few constituents a tenth of an inch in diameter, there are wide variations in the actual size and relative amounts of the different sized constituents below one-tenth of a millimeter (.004 of an inch) in diameter. In practice the chemist regards the various constituents below even one-hundredth of an inch as practically equivalent, although it is highly probable, as shown in the later discussion, that the variations in the relative amounts of different sized constituents even below one-tenth of this diameter have considerable influence upon the physical properties of porosity, plasticity, shrinkage, fusibility, etc.

The variations in size of grain as well as their method of aggregation are frequently considered under the single term texture.

The mechanical or granulametric analysis of clay may be conducted in various ways as described in standard works on clay or soil analysis, and the results presented in different forms with slightly different limits for the various classes. The most general practice is to make four divisions below the diameter of one millimeter, the division lines being at one-tenth (.10), one-hundred (.01), and either five-hundredths or one-one-thousandth (.005 and .001) of a millimeter. It should be borne in mind that these limits while appearing symmetrical really give great differences in the relative size and number of particles in a given mixture, with consequent increase in the importance of the different sizes. Thus the average of 23 clays given by Purdy[1] would show in a section a millimeter in diameter small fractions of single grains of the two larger sizes; about 150 grains of medium size (representing 45.26 per cent between .10 and .01); over 9000 of the fine; and nearly 500,000 of the finest sized particles. From this it is evident that the finer-grained particles with their rapid increase in number and consequent increase in surface have a preponderant influence on any properties involving surface tension. Since the particles of the finest division are below the size of the dispersed particles in a colloidal system it is manifest that whatever amount of so-called colloid may be abstracted from the clay there must be a large percentage of every moist clay in a state of colloidal suspension regardless of the chemical or mineralogical character of the particles involved. It should be constantly borne in mind that clays are mixtures of mineral fragments which are predominantly smaller than the upper limits of colloidal dispersion in water.

It is frequently customary to describe the larger sizes as sand and the smaller as clay with the implied connotation that the coarser grained differ in character from the finer. Grimsley and Grout,[2] however, in their work on the clays of West Virginia have shown, as might be expected, that although there is an increase in the content of silica from the finest to the coarsest there is also a large amount of material of kaolinitic composition in the coarser grained portions. The relationships as determined by them are represented in the diagram, fig. 4.

The fineness of grain of the clays both in the natural state and after grinding is often expressed by use of the ratio of the surfaces in the

[1] Purdy, Ross C., Ill. Geol. Survey, Bull. No. 9, 1908, pp. 133-216.

[2] Grimsley, G. P., and Grout, F. F., West Virginia Geol. Survey, Vol. III, 1905, p. 61.

different mixtures in what is known as the "surface factor." Following Purdy who modified the methods first proposed, this surface factor is obtained by adding the products of the surface factors characteristic of each sized group by the percentage weight represented. The surface factor itself is assumed to be a function of the average diameter of the particles in a given group. This, however, is only an approximation, sufficiently

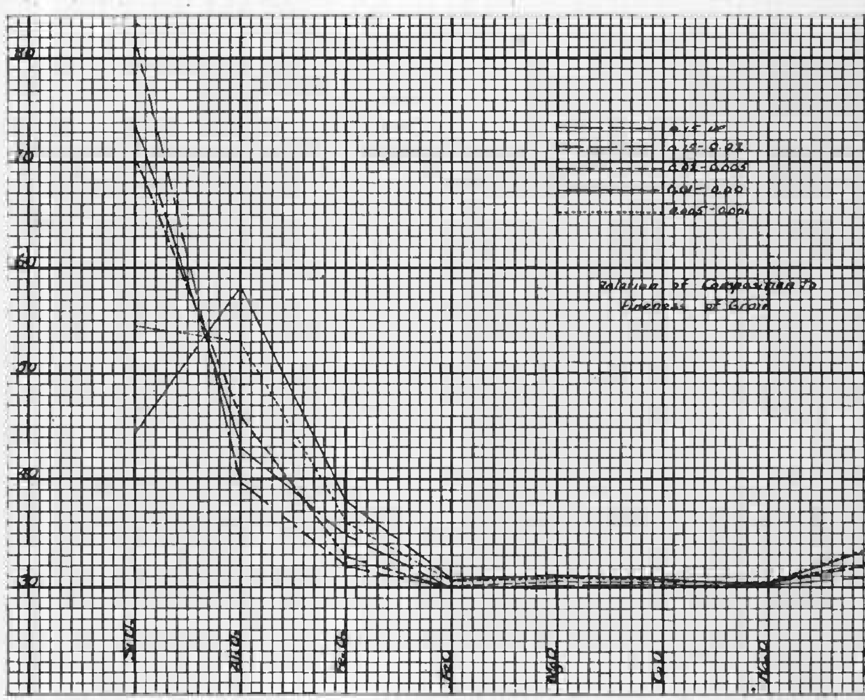


FIG. 4.—GRAPH SHOWING RELATION OF COMPOSITION TO FINENESS OF GRAIN.

close, perhaps, for the values involved. Many relationships between the surface factor and other physical properties of a clay have been suggested and there is little doubt that approximate relationships do exist between the surface factors and the air shrinkage, tensile strength, and porosity of the clays or the green ware. If, as suggested later in the discussion of plasticity, the density of the air-dried ware is a function of the close packing of an aggregate of grains of different size where the maximum density corresponds to that ratio between the grains of different size which conforms to the geometrical ideal, then the surface factor would be an approximate expression of these relationships which might perhaps be better expressed by a study of the conformities of the mixture with the ideal curve of close packing of a heterogeneous series such as is found in the individual clays. No work has been done on this relationship but it is quite possible that similar values for the surface factors might be obtained from clays in which the ratios of the amounts of the different sized particles differed widely among themselves and from the ideal values.

The fineness of grain may be quite different in practice for unconsolidated clays and shales or under clays, since in the former the ratio of the grain is largely fixed in the clay itself while in the latter it is largely determined by the conditions of grinding since here the smaller particles form aggregates held together by a cement and act as units of larger size. With increased grinding or accentuated weathering these shales and clays may break down into the constituent particles by the breaking of the cement bond and the formation of discrete particles of less diameter than the disperse particles of a colloidal system.

How far the properties of clays depend upon the absolute fineness of the clay particles and how far on the ratio between the amounts of the different sizes has not been determined. Provided the majority of the clay grains are less than .10 mm. it seems probable the variation in properties depend more upon relative amounts of the different sizes than upon their absolute sizes. This seems to coincide with the conclusion of Sven Odén[1] who has been conducting extensive experiments on the clays of Sweden, but has not issued the results of his mechanical analyses.

PLASTICITY.—Plasticity is, perhaps, the most characteristic property of moist clay. It is regarded by all authorities as necessary to the proper utilization of clays, but there is no universally adopted method of testing this property quantitatively, and no generally accepted explanation of its cause. This uncertainty is probably due to the complexity of combination of the essential factors, to the difficulties involved in the separation and study of these factors, and to the conflicting conclusions drawn from the data now available.

[1] Odén, Sven, Bull. Geol. Inst. Upsala, Vol. XV, 1918, p. 177.

In general, the term plasticity suggests the property of solid bodies by which they may be deformed without rupture by a finite stress and yet retain the new form when the stress is removed. It differs on the one hand from viscosity with its infinitesimal stress and on the other from elasticity with its recovery of form. As applied to clays the term is less exact. It includes the additional idea of the presence of water and a fair amount of cohesion or tensile strength in the molded ware even after drying. It is applied to shales which become plastic only after grinding, as well as to unconsolidated deposits which become plastic on the absorption of water. In practice there is also the somewhat variable notion of "normal consistence" which means a freedom from stickiness, a maximum suitability for "working" characterized by the addition of a definite per cent of water, and a reasonable range in the amount of water which can be added without serious loss of suitability.

This property of plasticity accordingly involves the antagonistic ideas of internal friction so low as to allow movement with permanent deformation, and yet sufficient to prevent rupture.

Measurement of Plasticity.—The most generally used and perhaps the most serviceable test of the plasticity of a clay is based upon the "feel" and behavior of moist clay as it is pressed between the thumb and finger. This of course involves a personal judgment which is influenced by the smoothness of the flow, the character of the edges, and the texture. A more exact quantitative determination of such an essential property as plasticity is of great importance to the clay worker, but it is doubtful if this can be given until more is known of the laws regarding plastic flow in clay. Twenty or more schemes have been devised for the determination of plasticity, but practically all of these are special tests open to the criticism that they are measuring one or more elements influencing plasticity and not plasticity itself. No attempt will be made to explain these tests in detail since each involves certain standard conditions or steps in manipulation which must be sought in special works on the subject. The tests may be summarized according to the conditions of the clay and the properties actually tested as follows:

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Methods for Measuring Plasticity

(Under Prescribed Standard Conditions)

Condition	Property tested	Manipulation	Plasticity scale
Clay wet	Toughness or moldability......	Cylindrical strand bent into ring without cracks......	degree of curvature.
		Cylindrical strand bent into spiral....................	1 radius of ring.
		Ring of clay bent back and forth....................	Number of movements before rupture.
		Squeezing clay strand through die..................	Length of strand before rupture.
		Clay sphere flattened to one-half its diameter........	Weight or time.
		Cylinder shortened by pressure without rupture......	Amount of shortening.
		Clay sphere rolled out without rupture..............	Length of strand.
	Consistency	Vicat needle sunk standard distance..................	Weight or time.
	Compressibility and tenacity...	Clay bar with fixed ends broken by pressure (Zschokke).	Deflection by force.
		Standard cylinder depressed until cracked, Vicat needle sunk to 3 cm.	Surface by weight.
	Tensile strength	Wet briquet formed by tensile-strength machine with noting of "initial stress, final stress, and weight for rupture" (Purdy).	Plasticity modulus formula (*q. v.*).
Clay dry (natural).	Absorption	Amount of water absorbed in tempering.............	Per cent.
		Amount of water absorbed in moist atmosphere......	
		Amount of water in clay slip........................	
		Fluidity from standard amount of water.............	Viscosity.
	Slaking	Rate of slaking..	Time.
Clay dry (molded).	Tensile strength	Test piece broken with standard blow...............	Number of blows.
		Briquette broken as in cement testing...............	Number of pounds.
Special	Bonding power	Clay column with maximum sand dried and rubbed..	Amount of abrasion.
		Sand added to clay "slip" to normal consistency for rolling out.	Amount of sand.
	Tests involving several determinations	Concentration of suspension at fluidity and upper limits of plasticity.	Difference in concentration.[1]
		Amount of colloid × by cast air shrinkage surface factor	

[1] Atterberg regards the best measure of plasticity to be the distance between the limits of flow and "rolling-out consistency" since this shows the amount of water which a clay can take up without losing its plasticity. This figure also gives the range of practical workability.
Bingham regards plasticity as merely a function of the concentration of its suspension between the limits of fluidity and mobility (approximately close packing). These authors apparently make the degree of plasticity equal to the range of conditions rather than a comparison of optimum consistencies.

No one of these methods for the measurement of plasticity is generally accepted as a standard and few of them are used by many investigators. The results obtained by the different methods have rarely been correlated with each other but many comparisons with other properties for the same clays have been made in an effort to correlate some easily measured or other essential physical property with plasticity. The conclusions though not generally accepted may be summarized as follows:

Tensile Strength.—Plasticity may be related to tensile strength but if so the relation is neither simple nor constant (Ries). This is natural since the tensile strength may depend upon the amount of soluble cementing material which has been precipitated or upon other factors which do not influence the plasticity.

Absorption of Water.—Plasticity may be related in a general way to the amount of water required in tempering, since the consistency of clays depends largely upon the amount of water absorbed without destruction of the working conditions rather than a simple relationship. This is shown by the figure in which 58 clays have been platted with respect to water tempering and air shrinkage. The plastic clays follow the tempering-air shrinkage ratio a little more closely than do the non-plastic or lean clays.

EXPLANATION OF PLASTICITY.—Many attempts have been made to explain the property of plasticity and many experiments have been performed which shed light on the subject, but up to the present time no satisfactory explanation has been generally accepted. This is due, in part, to a lack of knowledge of the laws governing plastic flow, in part to inherent difficulties in the problem, and in part to the acceptance of merely tentative suggestions as true explanations, without a close scrutiny of their validity. During recent years more systematic attempts have been made to solve the problem, but the ultimate solution has not yet been reached. All of the causes suggested may be classified into three or four groups. Plasticity may be due to peculiarities of texture, or peculiarities of composition, or to some relation between two or more physical or chemical properties.

Among the peculiarities of texture are those of fineness of grain, interlockage, or special shape. Among the peculiarities of substance individual explanations assign plasticity to the presence of kaolinite or "clay sub-

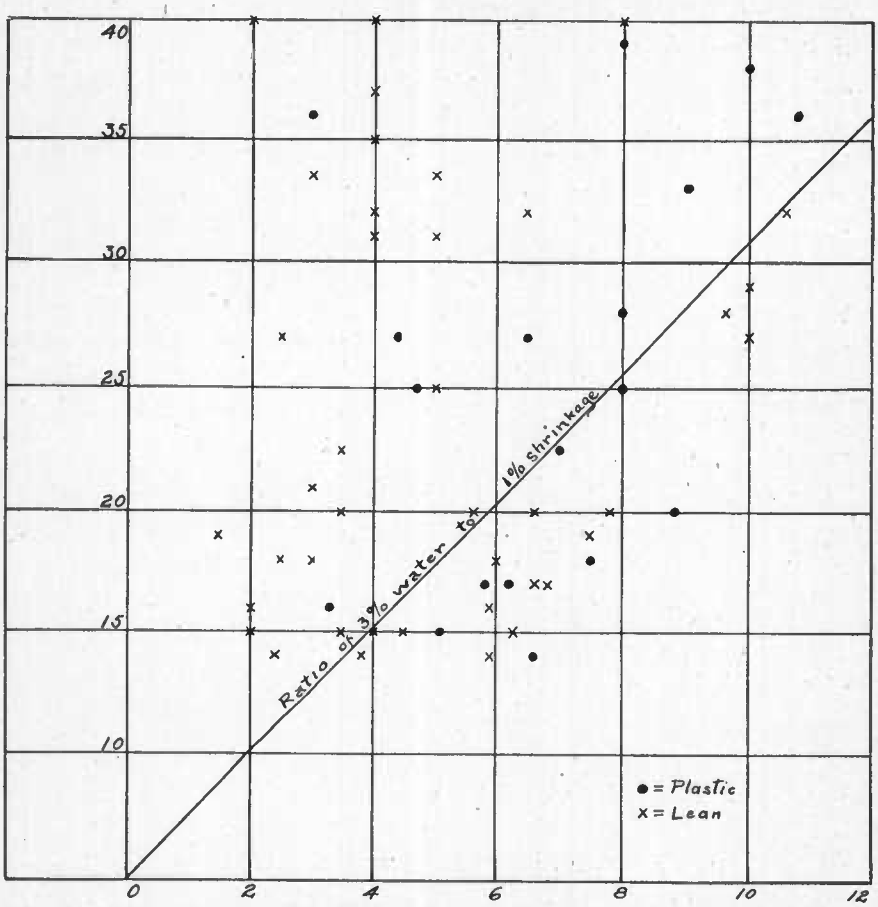

FIG. 5.—GRAPH SHOWING RELATION OF PERCENTAGE OF WATER FOR TEMPERING TO PERCENTAGE OF AIR SHRINKAGE FOR 58 CLAYS WITH FUSION ABOVE CONE 20.

stance," zeolites, hydrates of iron, aluminum or silica, globules of colloidal matter, or to the included water. Among the peculiarities of interrelations are the ratio of granular or non-plastic particles to those which are plastic; the range between the limits of flow and non-plasticity. Certain of these theories will be considered in greater detail but a general review is unnecessary since the various theories have been well summarized by Ries [1] and by Davis.[2]

Theories Based on Texture.—Early observers noted the presence of flakes of kaolinite (Cook, et al.) or peculiar hooked grains (Haworth), and thought these might explain the cohesion and toughness of clays. Johnson and Blake [3] noted the fact that plasticity increased with the degree of the *bundles* of plates and inferred that this was due to an increase in the number of plates. Quite recently Galpin [4] has emphasized this variation in plasticity with the number and size of the bundles but assigns this not to an increase in the number of plates but to the change in the size of the particles. Bingham working recently with spheroidal grains was apparently able to modify at will the degree of plasticity. If the plasticity is due to interlocking grains, as some have thought, there should be a sympathetic variation between the values of plasticity and tensile strength but such a relation has not been established. Thus these peculiarities may have some influence but experiments show that there is no constant relationship between them and plasticity.

Fineness of grain clearly plays an important if not the most important rôle in modifying the physical properties of clay and it may perhaps have a direct causal relationship with the plasticity. Decrease in the size of grain increases the fineness of the pores with consequent slow diffusion of water; it increases the porosity at the lower limit of plasticity with consequent increase in the range of concentration or tempering. Conversely, with increase of porosity there is greater mobility for the same ratio of water and clay material. Moreover the number of contacts between individual grains increases with the reduction in size, thereby increasing the cohesion during drying. With decrease in size there is also a proportional increase in the surface exposed to the action of water. If the internal friction which prevents flowage in the plastic mass depends upon the surface tension between the water and the dispersed particles

[1] Ries, H. Clays, Their Occurrence, Properties, and Uses, 1914.
[2] Davis, N. B. Clay Resources of Southern Saskatchewan. Canada Dept. Mines, 1918.
[3] Amer. Jour. Sci., Ser. II, Vol. LXII, 1867, p. 351.
[4] Amer. Ceramics Soc., Trans., Vol. 14, 1912, pp. 301-346.

of clay then the surface factor must exert a strong influence as has been urged by Purdy [1] who perhaps under-emphasized the fact that the surface tension of the dispersed particles may vary with the specific character of the particles. Since the range of plasticity is between the point of flowage and the point of mobility which lies near the point of close packing the plasticity must vary with the fineness of grain, especially where the system is composed of particles differing in size and character. Many authors have overlooked the fact that the porosity at the point of close packing is the same for any system of units of uniform size arranged the same way, regardless of their diameter. If, on the other hand, we have, as in a concrete mixture, a series of different-sized particles the concentration, or ratio of particles to porosity, increases with the heterogeneity, and the maximum concentration varies with the number of sizes present and the ratio of amounts of their respective diameters. The problem of close packing of material composed of constituents of different size has not been analysed mathematically, but has been developed empirically in concrete mixing where it has been found that the curve of proportions of the different sized constituents for the most dense concrete is practically an ellipse with its tangent. In other words, the percentage by weight of the very fine constituents is very great and that of the larger constituents relatively small and little affected by the range in diameter of the larger constituents. A platting of the average granulometric proportions given by Purdy for certain Illinois clays conforms somewhat closely with the ideal curve of the densest concrete mixture. The surface factor employed by investigators of clay apparently overlooks this question of variable size and it is quite possible that a study with this in mind would explain the conclusions reached by several investigators that the best conditions for plasticity are when the grain is neither too coarse nor too fine. Since the surface factor is largely determined by the amounts of the finest constituents which are below the size of the dispersed particles of a colloidal suspension this may also explain the inference of Bleininger and of Ashley who apparently hold that plasticity is influenced by the fineness of grain

[1] Ill. Geol. Survey, Bull. No. 9, 1909.

since it modifies the surface factor and consequently the ratio of colloidal and granular constituents.

Any setting of the relations of close packing of heterogeneous constituents to plasticity in practical work should regard the fact that the degree of grinding and consequently of fineness of grain does not, in practice, accord with the minute subdivisions of the natural material as determined by mechanical separation. To be of value the tests should be made under comparable conditions.

Theories Based on Composition.—It is a common statement in almost all discussion of clays that the plasticity and other physical properties are largely due to the presence of some particular substance, notably kaolinite, and this in part may be true. It is, however, a well known fact that pure kaolinite may show little or no plasticity while mixtures of high plasticity have been obtained by Wheeler, Vogt, and others, by the proper grinding of many other substances than kaolinite. If the plasticity is due to the presence of kaolinite or an allied hydrous alumino-silicate it is quite possible that this is due to the conditions of surface tension in an aqueous suspension of these constituents which appear to have greater surface tension than is shown by equally finely ground minerals such as quartz. The existence of globules of colloidal matter as noted by Ries[1] seems to imply the presence of a special substance essential to plasticity but this may be due to a misunderstanding of the term colloid which is used in the present discussion in accord with the usage in physical chemistry to denote not a special substance, but a particular state of dispersion of the minute particles. Bleininger conceives that the individual grains of non-plastic material are surrounded by a colloidal envelope which acts as a cementing film. Others have thought that the plasticity of the clay might be explained by the peculiar properties of the hydrates of alumina or iron in the crystalline or colloidal condition, while others have attributed plasticity to the presence of zeolites.

It is a well recognized fact that the addition of an alkali or alkaline carbonate increases the plasticity of the clays although the substance itself may not be plastic. Rohland apparently thinks that the clays are

[1] Md. Geol. Survey, Vol. IV, 1902, p. 251.

not plastic in themselves but become so through hydrolysis due to the presence of free ions and the formation of hydrosols free from hydrogels and that the colloidal substance present is in a state of what might be termed "latent plasticity" which does not become "manifestly plastic" until there has been a coagulation under the action of an electrolyte. Many

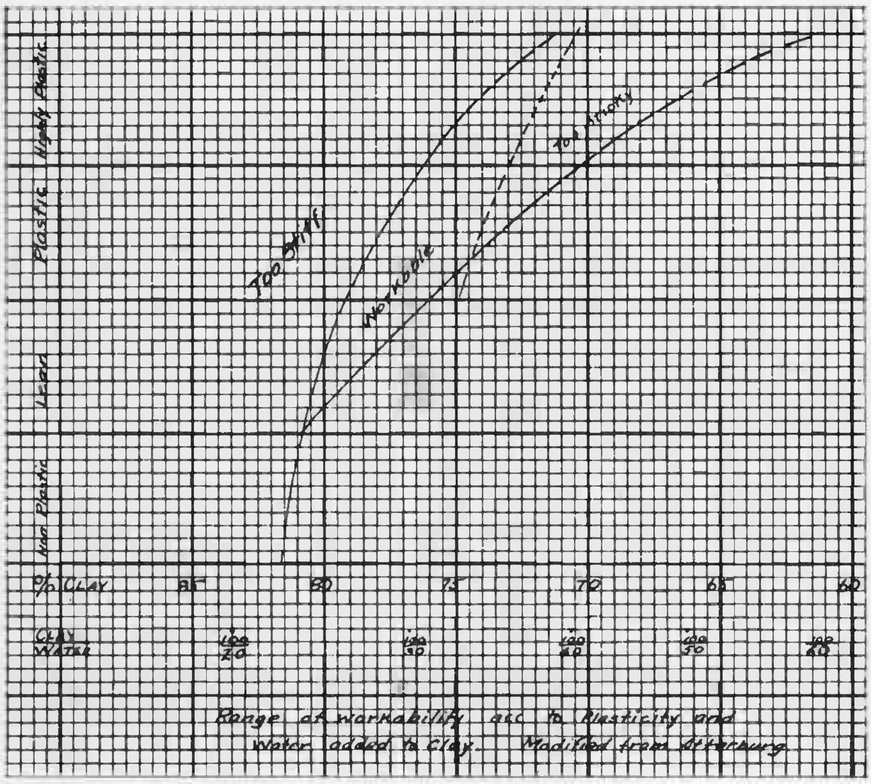

FIG. 6.—GRAPH SHOWING RANGE OF WORKABILITY OF DIFFERENT CLAYS ACCORDING TO AMOUNT OF WATER USED IN TEMPERING.

experiments point to the presence of material in colloidal state, but not necessarily of a definite chemical composition, as the cause of plasticity through its ability to change from the gel to the sol form and vice versa in the presence of an excess of a positive or a negative ion. To this colloidal material Bleininger ascribes a micellian structure in which the water is held in free or absorbed condition.

Theories Based on Interrelation of Properties.—Since many of the simple explanations of the cause of plasticity have failed, investigators have endeavored to discover some combination of the properties which would explain the vague idea covered by the term plasticity. Thus Zschokke[1] regards the plasticity of clay as due to the power of clay to absorb water with the consequent cohesion of this material to foreign bodies. Ashley and others have suggested that the plasticity is due to a certain limited range of ratio between the colloidal and granular matter present. Atterberg would practically make the degree of plasticity and the distance between the concentration ratio of the water to clay at the flowage and rolling-out stages as illustrated in Fig. 6.

Van Bemmelen,[2] after a general review of the ideas of different authors on the causes of plasticity concludes that the nature of this property is a subject for future investigation. In his own words, pp. 13-14:

All authors agree on this point that the particles of clay or of kaolin ought to contain some hydrogel of the substances in a colloidal state. But that neither the fineness or the fine division of the particles, nor the structure of the deposits, nor the chemical composition of the clays, nor their tenor in water, give any light on this question. Only the colloidal state may be recognized. But this explanation is now no longer sufficient. There remains finally as the cause of plasticity the idea of Rohland that it is produced under the influence of electricity by a reticulated coagulum in the material of the clay. This idea, however, gives a close mechanical image neither of the plasticity nor of the maturation of the kaolinitic clay. . . .

SHRINKAGE.—All clays during the process of manufacture vary more or less widely in their volume, through the addition of water necessary to the development of optimum plasticity, its subsequent loss on drying, and to changes incident to the fusion of the clay material. The shrinkage behavior of clays varies in importance according to the character of the clay and the uses to which it is put. In the manufacture of molded ware such as terra cotta, tile, and porcelain, it is highly important that the forms impressed upon the moist clay shall be retained unaltered in the finished ware or at least be only so changed that allowance may be made in manufacture. In the making of refractory goods where the

[1] Beit. z. geol. d. Schweitz, Geol. tech. Serie, lief iv.

[2] Sur la pastieité des terres argileuses Archives Neerland. Sci. Exactes et Nat., Ser. IIIa, Vol. I, 1912, pp. 1-14.

essential property is that of resistance to high temperature the variations in form become of subordinate importance provided they do not reach a limit affecting the usefulness of the finished product.

From the moment when the moistened piece of clay begins to dry the moisture which was essential to the plasticity is withdrawn from the pores and the particles of clay lie closer together until they are in contact and approximate a close-packed system. The shrinkage due to this compacting of the particles which takes place on exposure to dry air or to a temperature not exceeding 100° C. is referred to as *air shrinkage.* The amount varies with the character of the clay, being less in the coarse, sandy, lean clays and greater in the fine-grained, highly plastic clays, where it may amount to 10 to 15 per cent. There is some relation between the amount of shrinkage and the amount of water necessary for maximum plasticity but this relationship is modified by textural peculiarities such as the fineness of grain, the ratio of the different sized particles, and the amount of water which is lost under these atmospheric conditions.

When clays are heated above 100° C. the water remaining in the pores and ultimately that combined in the hydrous minerals is driven off and the newly formed compounds and the thoroughly dry particles are still further compacted. With an increasing rise of temperature some of the constituents are fused with a consequent increase in shrinkage. The loss of volatile constituents during the burning of the clays and the variations in porosity according to the degree of fusion which the clay has undergone causes irregularity in the shrinkage. In general it reaches a maximum near the point of complete vitrification.

TENSILE STRENGTH.—Tensile strength, or the measure of resistance to rupture or pulling apart in the unburned clay, varies within wide limits in different clays. It is a property of great importance in pottery, but like shrinkage, is of relatively less importance in the manufacture of refractory wares where the one essential property seems to be resistance to high temperatures. Where tensile strength is lacking in the refractory wares sufficient clay of proper quality is added to overcome the deficiency.

The range of clays in tensile strength as given in the standard works may be over 400 and the limits characteristic for the several clays may be taken as follows:

Range in Tensile Strength

	Minimum	Maximum
Kaolins	20	60
Fire clays	0 (flint)	150
Brick clays	50	300
Pottery clays	50	250
Gumbo	275	410

Physical Properties of Burned Clay

Burned clays differ in many respects from the unburned since under the influence of heat many changes take place. Beginning with the air-dried brick, an increase in temperature tends to drive off some of the water retained during drying. With further increase in temperature hydrates and carbonates are broken down with consequent loss of combined water, carbon dioxide, and a few other constituents, and more compact molecules may be formed with consequent shrinkage of the body. Since the materials differ widely in their melting points a temperature is soon reached at which some at least of the constituents are fused to a glass. The temperature at which this occurs is termed that of *incipient vitrification.* At this stage all of the pores have not been closed and yet enough of the material has been fused to cement the larger more refractory grains with consequent softening of the clay. The temperature of the incipient vitrification is usually reached below 1800° F. From this point it rises gradually to more than 3000° F. in the highly refractory fire clays.

A further increase in temperature causes the fusion of enough of the constituents to close the pores and render the mass relatively impervious. At this stage the burned ware shows its maximum shrinkage. The stage is usually recognizable by the development of a slight luster and smooth fracture in the burned material. This stage is known as the stage of *complete vitrification.* With increasing temperature the melting

FIG. 1.—VIEW SHOWING FOOT OF PLANE OF THE UNION MINING COMPANY.

FIG. 2.—VIEW OF CLAY DUMP AND TRAM EQUIPMENT OF THE UNION MINING COMPANY.

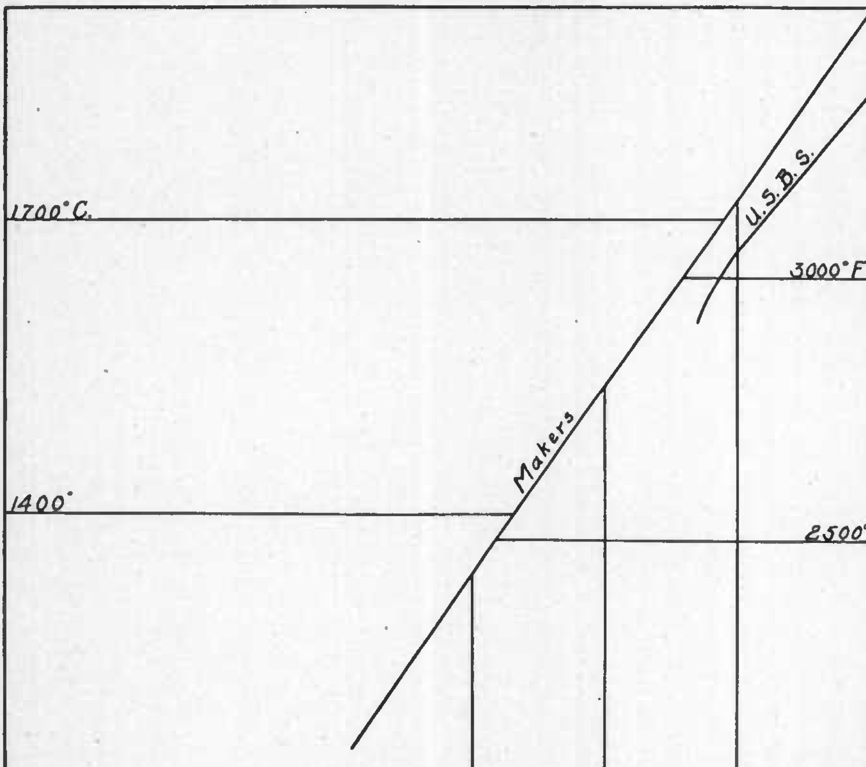

FIG. 7.—GRAPH SHOWING FUSION TEMPERATURES IN CENTIGRADE AND FAHRENHEIT OF SEGER CONES.

points of the other constituents are reached until the body is just self supporting and finally the whole mass becomes viscous and flows. In the change from complete vitrification to viscosity the clays may show expansion due to the release of constituents within the impervious mass through the decomposition of mineral particles.

The determination of these three points are only approximate since the change from one stage to the next is gradual. In general the difference in temperature between the different stages varies with the composition of the clay and slightly with the actual ultimate temperature of viscosity or fusion. The temperature at which fusion begins ranges from over 2100° F. in the purest clays to scarcely 1700° F. in impure clays. Since the condition in a kiln cannot be controlled very closely, or so that the ware in all parts of the kiln is subjected to the same temperature, the range in temperature between conditions of incipient vitrification, complete vitrification, and viscosity of fusion are of considerable commercial importance, although it has been generally known that the range varies in different clays from less than 50° to more than 600° F. and that the range is in part functional on the chemical composition, little has been done to state the facts systematically.

The Temperature Range between Incipient Fusion, Vitrification, and Viscosity.—An attempt has been made by a study of the determinations of over 200 clays of different fusibility and character to determine, at least empirically, these conditions. Two hundred and twenty clays were considered. Of these 190 show a range from incipient vitrification to viscosity of less and 30 of more than 500° F. Of the first group only 43 show greater temperature range between vitrification and viscosity than that between incipient and complete vitrification. In the second group, where the total range is between 5000° and 9000° F., nearly 75 per cent show wider ranges from complete vitrification to fusion. From the figures obtained it is evident that most of the clays of low gross range allow relatively less range in temperature above that of complete vitrification or optimum density than do those clays with a gross range of more than 500°, which also show a greater latitude in temperature before reaching viscosity.

There is no striking relationship shown between clays of low incipient fusion and low range to viscosity beyond the fact that those showing incipient vitrification below 2000° (cone 02) seldom show over 350° gross range from incipient vitrification to viscosity. Clays more refractory than this may show wide differences in range and in a general way the highly refractory clays pass quickly from incipient to complete vitrification.

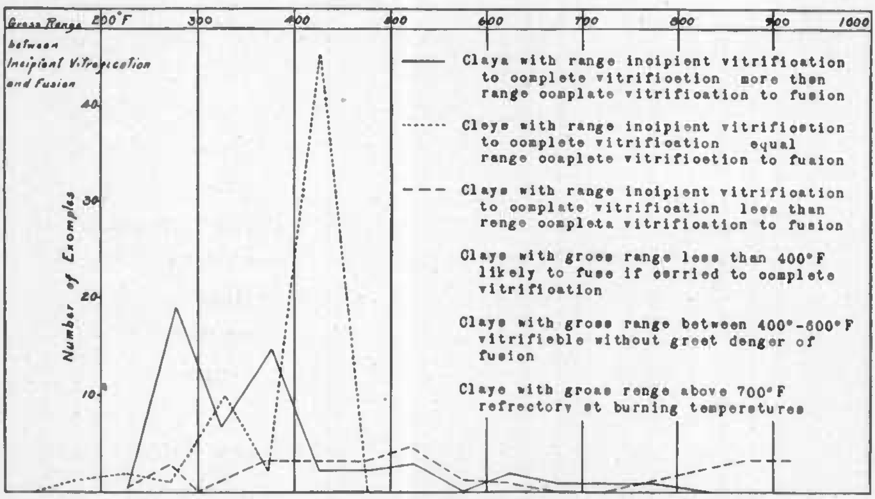

FIG. 8.—GRAPH SHOWING NUMBER OF CLAYS, ARRANGED ACCORDING TO INTERVAL BETWEEN INCIPIENT FUSION, VITRIFICATION AND VISCOSITY.

On the data compiled one might, if desirable, classify the clays in three groups as follows:

a. Those for which the interval between incipient and complete vitrification is more than that between complete vitrification and viscosity.

b. Those for which the range is approximately half of the total range from incipient fusion to viscosity.

c. Those for which the range from incipient to complete vitrification is less than that from vitrification to viscosity.

The fusibility of clays, or the temperature at which the clay fuses, has long been held to vary with the chemical composition. As Ries states it: "other things being equal the temperature of fusion of the clay will fall with an increase in percentage of total fluxes." in a large way this is true, but when examined more closely the relation between the composition and fusibility is not so clear, as is shown in the diagram

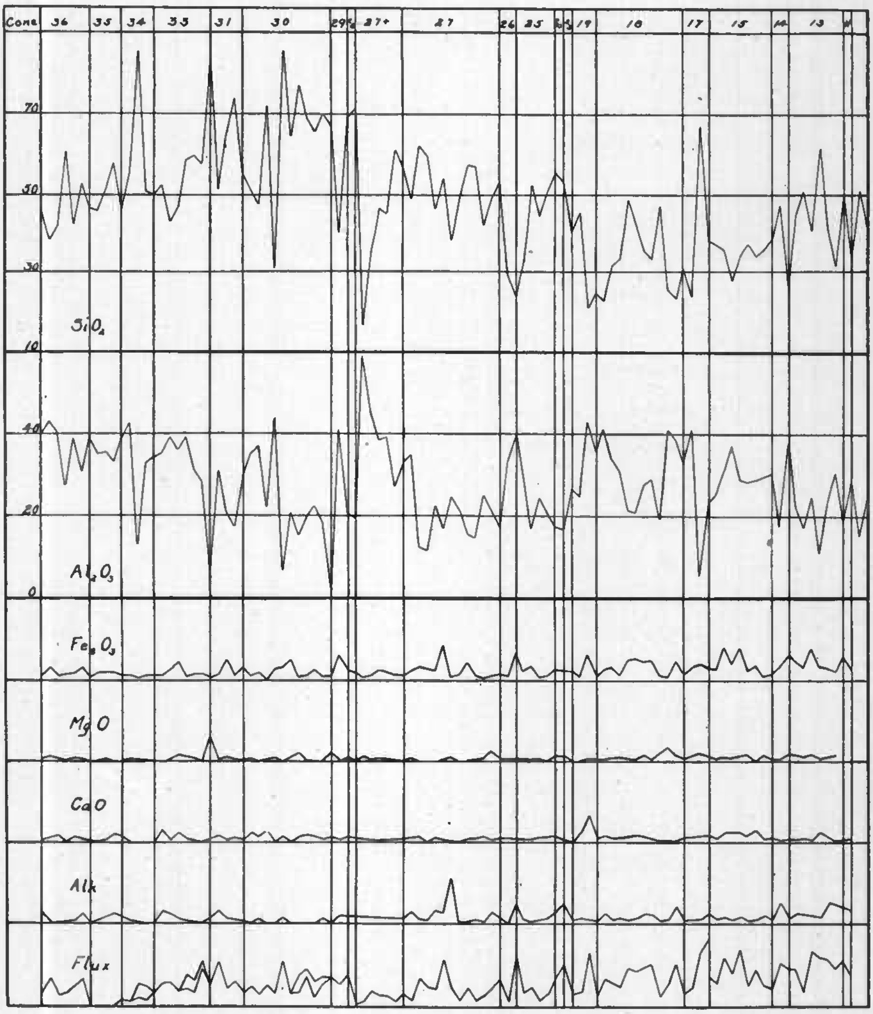

FIG. 9.—GRAPH SHOWING COMPOSITION OF OVER ONE HUNDRED CLAYS ARRANGED ACCORDING TO THEIR FUSION TEMPERATURE.

of more than 50 fire clays arranged according to their fusion period and chemical composition. Many attempts have been made to explain the apparent relationship between the chemical composition and fusibility but these have been only partially successful.

Richter thought that the refractoriness depended upon the amount of fluxes which varied in their influence inversely as their molecular weights, but his experiments show little more than the fact that the melting point is lowered with increase in complexity of the system, and that there are apparently eutectic points between some of the components. This is shown in the mixtures of silica, alumina, and the fluxes where an eutectic was noted in the ratio of silica to alumina of 10 : 1 by weight. Considerable experimental work has been done on pure melts of the CaO-SiO_2, MgO-SiO_2, Al_2O_3-SiO_2, etc., systems, and something may be inferred regarding the behavior beyond the point of fusion of clays containing these constituents. Sinee the ceramist desires primarily an increased knowledge regarding the behavior of clays *before* they reach this point, *i. e.,* in the area where the behavior is modified by many factors such as the fineness of grain or surface factor, the state of the iron, and the mineralogical character of the chemical constituents, it is questionable how far the behavior of pure melts may throw light on the behavior of impure mechanical mixtures. The table represents graphically the results obtained in the case of a number of clays in which the chemical composition and behavior have been carefully studied. From it may be seen the fact that all the clays represented having a high fusion point are low in the fluxes, but it also shows that the observed fusion points are not a function of the absolute amount of the alumina, or of the fluxes, or of a simple relation between them.

Attempts have been made frequently to express the fusibility of the clay by means of some formula, such as those proposed by Bischof, and Seger, Wheeler and the ceramic formulæ x $RO : 1\ Al_2O_3 : y\ S.O_2$.

As a rule such formulæ have proved inadequate or misleading.

BISCHOF

$$FQ = \frac{(O \text{ in } Al_2O_3)^2}{(O \text{ in } RO)(O \text{ in } SiO_2)}$$

SEGER

$$\frac{(Al_2O_3)_2}{RO \times SiO_2} + \frac{Al_2O_3}{RO}.$$

WHEELER

$$F.\,F. = \frac{\%\ SiO_2 + Al_2O_3 + TiO_2 + H_2O + CO_2}{\%\ 2Alk + SO + CaO + MgO + C^* \text{ [grain and S. G.]}}.$$

*C varies from 1-4 increasing with fineness of grain and decrease in specific gravity.

The critical elements in clay burning include beside the temperature of incipient fusion (1) the *rate* at which the clay fuses, and (2) the interval or range from the temperature necessary to produce vitrification to that of fusion or chemical decomposition with its accompanying swelling or warping.

Since clays are burned in order to change the bonding element from an unstable hydroscopic colloid to a more stable form and to reduce the porosity of the clays, it is interesting to know the rate of change as the green ware is heated progressively and to learn the temperature that will produce the sought for results in different kinds of clay. According to the uses to which the burned ware is to be put the ceramist endeavors to reduce porosity in order to gain mechanical strength, or to render it imperviousness to liquids or gases.

In general since the supply of heat is constant the rate of change is shown by the intervals between incipient vitrification, complete vitrification, and fusion.

The progressive loss in porosity as clays are heated from cone to cone and the temperatures at which clays for different proposes are burned are shown in the two accompanying generalized diagrams. The actual changes produced in individual Maryland refractory clays, are shown in the report by Mr. Schurecht.

The relations between the rate of loss in porosity in heating the clay wares from cone to cone, as shown in Fig. 10, and the temperatures at which the different wares are burned, generalized in Fig. 11, show a practice, established empirically, in which burning temperatures have been chosen which will most perfectly produce the desired results with the least coal and the minimum likelihood of spoiling the wares by overburning.

The temperature-porosity diagram shows that any workable clay which will burn fairly dense at a relatively low temperature is usable for the manufacture of common brick. For sewer pipe and paving brick the clays should reach low porosity at a fairly low temperature and at that temperature the paving-brick clay should be quite hard. The curves for clays so used should be concave upward. For refractory wares the clay should remain fairly open through a wide range of temperatures as shown by the curves for No. 1 fire-brick clays which are more nearly straight lines.

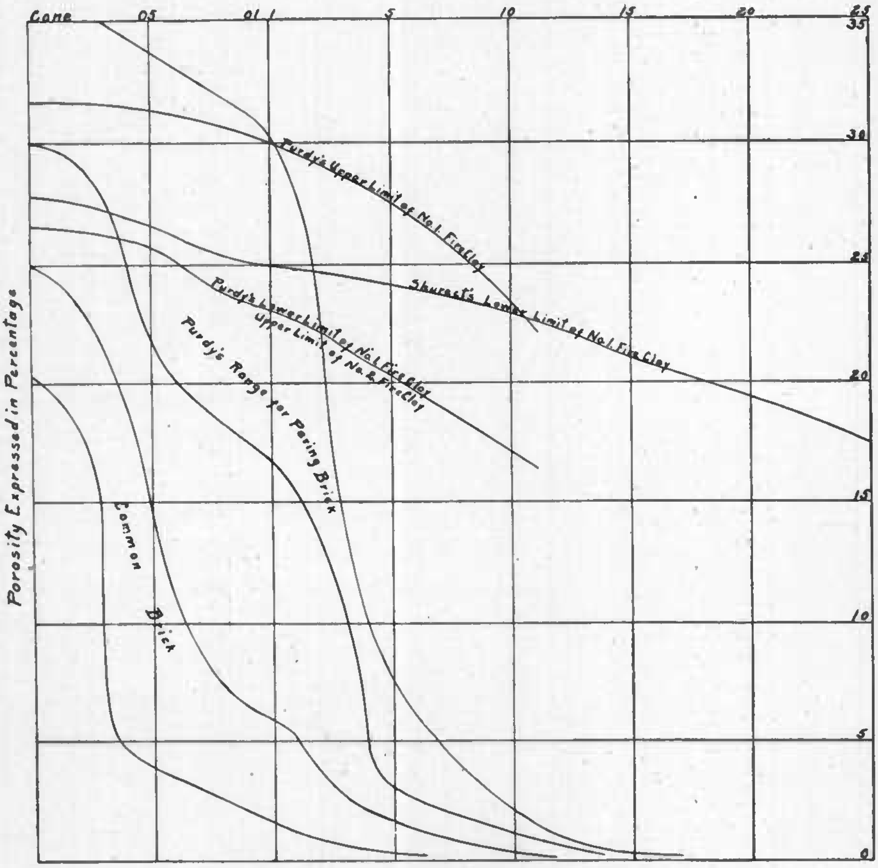

FIG. 10.—GRAPH SHOWING POROSITY OF CLAYS FOR DIFFERENT PURPOSES BURNED AT DIFFERENT TEMPERATURES.

The detailed discussion of the behavior of clays during burning is the province of the ceramic engineer and this aspect is fully treated in subsequent pages. It is sufficient here to note that the clays of western Maryland tested by Mr. Schurecht are for the most part characterized by gentle porosity curves indicating that the progress in densification and vitrification is slow and that many of them show such range between

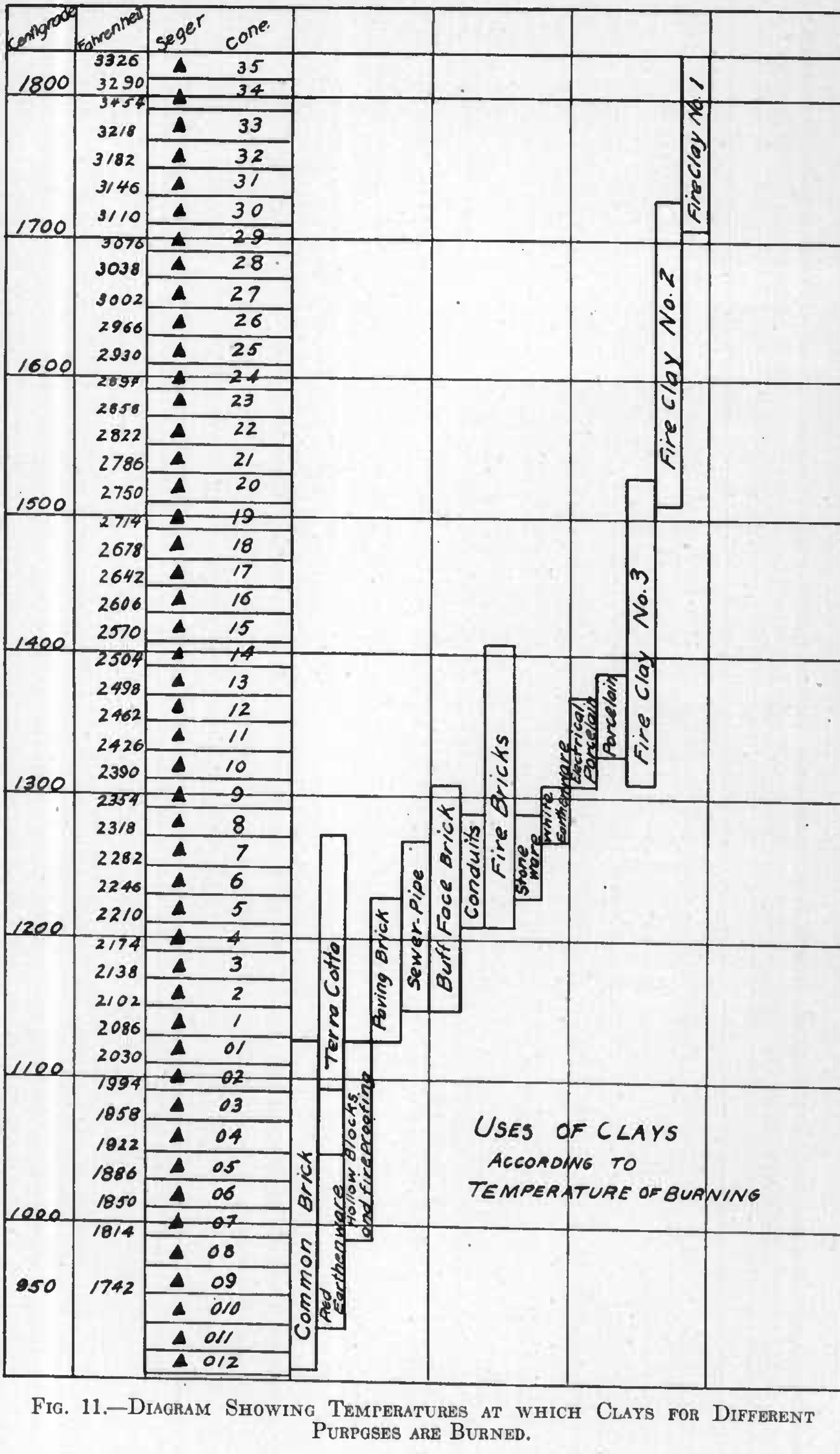

FIG. 11.—DIAGRAM SHOWING TEMPERATURES AT WHICH CLAYS FOR DIFFERENT PURPOSES ARE BURNED.

incipient vitrification and fusion that they may be used in mixtures in the preparation of vitrified wares and by themselves in the making of sound, porous, non-fusible refractory wares. In other words, they are "fire clays."

Fire Clays

DEFINITION

Fire clay is a general term applied to clays which show a considerable resistance to heat. The term is used loosely in this general way as the equivalent of refractory clays. Attempts have been made by various authors to discard the term or to define sharply its limits, and this usage in America would limit the term fire clay to such clays as fuse above cone 27. Some authorities would make the limit at cone 26 and others suggest a fusion point as low as 2500° F. for the lower limit of fire clays. Bleininger places the softening point of No. 1 fire clays above cone 31 and that of No. 2 fire clay above cone 28.

A second even less justifiable general usage prevalent is that which makes the term fire clay practically equivalent to "under clay" and thus includes any clay closely associated (usually under) coal deposits without regard to its fusibility or fire behavior.

CLASSIFICATION

Fire clays, in the stricter sense as outlined above, have been classified on their degree of fusibility, origin, physical characters, and even their use. The classification based on fusibility most frequently employed is that suggested by Ries, which is as follows:

1. Highly refractory clays fusing above cone 33.
2. Refractory clays fusing from cone 31-33 inclusive.
3. Semi-refractory clays fusing between cones 27 and 30.
4. Clays of low refractories fusing between cones 20 and 26 inclusive.

This classification deals only with the upper limit or fusion point without reference to the temperatures of incipient or complete vitrification. Purdy and Moore[1] and subsequently Purdy[2] distinguish the fire clays according to the changes in porosity and specific gravity curves for the behavior at different temperatures. Number 1 fire clays in this classi-

[1] Purdy and Moore: Amer. Car. Soc. Trans., Vol. IX, p. 239.
[2] Purdy: Ill. Geol. Survey, Bull. 9, 1908, p. 270.

fication show a small regular decrease in porosity from the beginning of burning to temperatures above cone 11. Number 2 fire clays show an increase in the loss of porosity with consequent early vitrification the change beginning about cone 04 and becoming marked with increasing temperature. Number 3 fire clay show a marked change with increasing loss of porosity at cone 1 and seldom has a fusion point above cone 16 or 17. This classification is similar to the one suggested by the author in so far as the effects observed are largely determined by the increased range between incipient vitrification and viscosity and the ratio of the intervals between incipient and complete vitrification on the one side and the complete vitrification to viscosity fusion on the other. It has the additional advantage of more exact determination of values. This classification emphasizes the difference in clays used as refractories and for stoneware.

Other classifications based upon the behavior of the burned ware have been employed by Bourry and others. Another type of classification in vogue is based upon the origin or mode of occurrence. Thus, Ries in one of his papers divides the fire clays into residual and sedimentary fire clays, and the latter into plastic and flint clays, according to their occurrence and physical characteristics. Hickling in a similar way distinguishes between kaolins or china clays which are residuals of igneous rocks formed *in situ*, and the transported boulder flint clays which consist of kaolinitic material which has been moved. These various classifications combined with well-known American localities might be summarized as follows:

Residual		Sedimentary	
Associated with feldspathic rocks	Associated with limestone	Not associated with coal beds	Associated with coal beds
Kaolins of S. E. Penn., Delaware and eastern Maryland, Virginia, North Carolina, Archean residuals of Minnesota (?).	Kaolins and flint clays of Alabama, Georgia, and Missouri.	Kaolins and fire clays of the Coastal Plain from New Jersey to Texas, Fire clays of Nova Scotia and Saskatchewan.	Plastic and flint "fire clays" of the Appalachians from Pennsylvania to Kentucky.

OCCURRENCE OF FIRE CLAYS

The foregoing table is by no means complete but it will serve as the basis for the discussion of fire clays in which special emphasis will be laid upon those of the last class to which the fire clays of western Maryland belong.

Residual Fire Clays

The residual kaolins of southeastern Pennsylvania, Delaware, and Maryland arising from the weathering of pegmatite dikes and highly feldspathic granites and gneisses, are composed of kaolinite, feldspar, and quartz in very fine grains and are usually white burning. They are used chiefly in pottery and paper manufacture and do not enter into competition with the fire clays of western Maryland, except incidentally in the manufacture of stove linings and a few fire brick at Northeast, Maryland.

The kaolins and flint clays of Alabama and Georgia, which are associated with the limestone, are relatively undeveloped both because of their situation and their impurity. They may show considerable refractoriness but up to the present time they have not served as the basis of any considerable industry in refractory wares.

Sedimentary Clays, Coastal Plain

Among the sedimentary kaolins and fire clays not associated with coal beds the most important are those along the Coastal Plain from Long Island to the Gulf. The best known are those from New Jersey where the ceramic industry is highly developed in northeastern Middlesex County, in the valley of the Raritan, especially about the towns of Woodbridge, Perth Amboy, and South Amboy. The region is well situated topographically and commercially. The hillsides and lower slopes along the banks of the Raritan and its tributaries offer exceptional opportunities for clay mining while the deeply reëntrant estuaries and the numerous railroads offer excellent transportation facilities, water and rail, to the large nearby markets and more distant distributing points. The district supplies a great variety of clays including the well-known Woodbridge fire clays of high plasticity and refractoriness (cone 35). The refractoriness varies widely in clays from the same opening and from place to place, decreasing on the whole from northeast to southwest along the strike of the bed. The diversity of clays within a limited area is very helpful to the development of a large and diversified ceramic industry in which the fire clays of varying quality are used in producing mixtures of different sorts. This center was perhaps the first to establish factories devoted solely to the manufacture of refractory ware.

Southward from this center kaolinitic fire clays, for which the name plastic kaolin has been suggested, are found at many horizons in the Cretaceous and Tertiary deposits of the Coastal Plain. They have been worked to some extent in Maryland,[1] Virginia,[2] and North Carolina[3] but they are of greater relative importance in Georgia,[4] South Carolina, and Texas.[5]

The refractory clays of Nova Scotia described recently are possibly of the same geologic age but they are there overlain by glacial deposits which have more or less greatly changed their character from the unconsolidated state found in the Coastal Plain deposits.

Appalachian Fire Clays

This term has been more or less generally used for the refractory shales—or "fire clays"—found at different geologic horizons, chiefly in the rocks of Carboniferous age in association with coals. Throughout most of the area the most important "clays" are found in the lower part of the Upper Carboniferous in the Pottsville and Allegheny formations. The most important horizons in both Maryland and Pennsylvania are near the Pottsville-Allegheny contact. Although occurring at the same general horizon and showing over wide areas the same general appearance, similar composition and similar products, the deposits are not continuous, but are in the form of large lenses. The detailed stratigraphy of the geological formations as found in Maryland and the local

[1] Maryland Geol. Survey, Vol. IV, 1902.
[2] Virginia Geol. Survey, Bull. 2, 1906.
[3] North Carolina Geol. Survey, Bull. 13, 1897.
[4] Georgia Geol. Survey, Bull. 18, 1909.
[5] Univ. Texas, Bull. 44, 1916.

peculiarities surrounding the deposits from which samples were taken are discussed in another section of this report.

The fire clays are found in an area extending from Pennsylvania, across Maryland, West Virginia, and Ohio to Kentucky. In the fire clays of Pennsylvania the chief occurrences of Pottsville fire clays are in Clearfield, Clinton, and Cambria counties. The most important field is that at Woodland, Clearfield County. The clay comes from the same general horizon as that worked in Maryland. The bed worked lies directly beneath the Upper Mercer coal and is an excellent deposit of soft clay with flint. Nearby deposits may be predominantly plastic or flint clays mingled together in various ways. Sometimes the flinty clays are in patches, sometimes above and sometimes below the plastic varieties. The same irregularities of occurrence are found in Maryland. Above these clays are the "upper clays" which are generally plastic clays worked for fire brick, sewerpipe, building brick and stoneware. Occasionally they are of high refractoriness, but usually yield at best No. 2 or No. 3 fire brick. These include the Clarion clay mined extensively along the Allegheny River near Kittanning; the Lower Kittanning mined along the Ohio River in Pennsylvania, West Virginia, and Ohio, and the Upper Freeport or Bolivar clay worked at Bolivar and Salina; and the Pittsburg "main clay" mined near Courteney and Manowa. The fire clays of West Virginia are chiefly Carboniferous and associated with coal as in Pennsylvania. Here, however, the beds usually worked occur at horizons correlated with the "upper clays" of Pennsylvania while the lower horizons corresponding to the Mt. Savage or Clarion or Mercer are worked at only one or two places. Since the rocks of the Pottsville and lower Allegheny do not outcrop west of the Monongahela the occurrences are limited to the area to the eastward. The principal fire clay horizons are known as the Thornton (beneath the Mahoning sandstone), Bolivar (or Upper Freeport), Upper Kittanning, Hardman (or Furnace), Lower Kittanning, Mt. Savage, and Hammond. The last was referred by Dr. Grimsley to the Lower Kittanning and later by Hennen to a point just above the Upper Mercer coal or 60 feet below the base of the Allegheny formation. Most of the clays worked are not fire clays although many of the flint clays show fusibility above cone 30.

ORIGIN OF FIRE CLAYS

The manner in which these fire clays, low in alkalies and iron, were formed has been the subject of much discussion. Practically every coal bed in the Appalachian section is underlain by "clay" which shows a relatively high refractoriness, imperfect fissility parallel to the original bedding, and a tendency to break into irregular sharp-edged blocks with conchoidal fracture. It is therefore natural to assume that the peculiarities of the clays are due to association with coal. The *lack of bedding* has been explained as a result of continuous deposition under uniform, non-periodic climatic conditions such as have been assumed to exist during the life of coal plants. Another explanation assumes a reworking of the beds by plants and animals by which an original bedding was destroyed. Ashley has suggested that they may have been due to deposition in glacial ponds. Fire clays, however, also occur in association with limestones where such explanations of origin would not apply.

The *low content*[1] *of alkalies and iron* has been explained (1) as the result of leaching due to deposition in coal-forming swamps where the water was rich in strongly reducing organic acids which would remove the alkalies and change the iron from ferric to the more soluble ferrous state. Under such circumstances one might expect the purest fire clays to occur nearest the coal. This is not always the case as the purest clays are often separated from the coals by one or more feet of non-refractory plastic clays richer in alkalies and iron. (2) Others regard the "underclays" as the soil in which the coal-producing vegetation grew and explain the low alkali content as due to leaching by the organic acids derived from the rootlets. Such an explanation is not suitable for refractory shales apart from coals or for the thick homogeneous "fire clays" which often attain a thickness of 25 to 30 feet. (3) The relatively high

[1] The average shale contains about 18 per cent of alumina while the average fire clay carries 25 per cent. The alkalies of a shale average over 4 per cent, in the fire clays less than 1.00.

alumina in many fire clays and their general association with coals which were formed under genial climatic conditions has suggested that they are due to lateritization. This may be true in some instances but is hardly probable where the silica is high and the iron low. Stout[1] studying the similarity in composition of coal ash and refractory clays concludes that the clays represent the mineral residue (or ashes) of countless generations of plants mixed with more or less extraneous or accessory minerals which were washed into the swamps where the plants were growing. This mineral matter taken from the soil by the rootlets of the growing trees fell to the bottom of the lagoons, forming a fine or colloidal ooze where the organic tissue oxidized and reverted to its original components, chiefly carbon dioxide and water. The varying proportions of pure clay and carbonaceous matter, under this theory, would be explained by the position of the water level which would determine the degree of decomposition of the organic matter. Accumulations under the best oxidizing conditions would form the purest clays. The character of the clays would also vary inversely with the rate of accumulation which would affect the degree of change possible.

"Flint" and "Plastic" Fire Clays

The occurrence at the same horizon and often side by side of "fire clays" which are plastic and others which are non-plastic has long been known. Little, however, has been done to explain the origin of their difference.

In the Mt. Savage deposits the flint clay is found near the middle of the bed, showing great irregularity in thickness, with plastic clay above and below. Examined microscopically the flint clay shows[2] (1) kaolinite in plates, prisms and fans, more commonly "ribbed" by hydromicas, (2) hydromicas in individual flakes or grouped in fan-shaped aggregates composing 50 to 60 per cent of the clay. Minute rutile needles are abundant, small zircon grains common, quartz, muscovite, and tourmaline rare.

[1] Stout, Trans. Amer. Ceramic Soc., Vol. XVII, 1915, pp. 557-580.

[2] Based on Galpin's description. Trans. Amer. Ceramic Soc., Vol. XIV, p. 323.

The individual grains seldom exceed 30 microns or .03 mm. though grouped into areas frequently 200 to 300 microns across. Ground plastic clay showed some kaolinite, but hydromicas approaching muscovite in character are most abundant and muscovite is fairly frequently seen.

The flint clays differ in texture, the grains are larger and often aggregated, while the crystalline particles of the plastic clays are smaller and at the same time more or less separated. It seems probable that when first laid down these clays were very fine-grained, hydrous aluminous silicates with varying amounts of hydrous alumina as a result of the lateritic weathering. With burial some of the pore water was driven off, carrying with it some of the soluble material. Continued burial led to recrystallization resulting in compact masses of kaolinite and hydrated micas characteristic of the flint clays. Under the influence of heat and pressure the flint clay was fractured and the mass destroyed with a development of hydromicas.

At a later stage by removal of the overburden the minute fault planes opened, allowing the entrance of water which began the process of breaking down the grains. This process is still further emphasized by the "weathering" of the flint clays after mining.

The flint clays according to this theory would represent the original finely-grained colloidal sediments, the plastic clays the more highly crystalline aggregates of hydromicas produced by weathering.

STRATIGRAPHY OF THE CARBONIFEROUS OF MARYLAND

BY

CHARLES K. SWARTZ AND GEORGE M. HALL

Introduction

Coal- and clay-bearing rocks form a large part of the surface of Garrett County and outcrop in smaller areas in Allegany County in the western part of the state. The rocks were originally deposited in nearly horizontal beds that were probably continuous over this region. They were folded after their formation into a series of subparallel arches and troughs. The tops of the arches were subsequently eroded so that the coal deposits are now found chiefly in the intervening basins.

The Upper Carboniferous beds lie to-day in three chief structural troughs, an eastern, a central and a western, the axes of which trend in a northeast-southwest direction. The eastern and central troughs are separated by the long Oakland anticline. The eastern trough is divided by the Potomac River into two parts, a northern and a southern. The northern part is called the Georges Creek basin, and the southern, the Upper Potomac basin. These two divisions, however, are artificial and together they constitute a single structural unit. The central trough is cut into two parts by a slight transverse arching of the strata north of Oakland. The part lying south of the arch is known as the Upper Youghiogheny basin, and the northern is called the Castleman basin. The western trough in which Friendsville is situated has been called the Lower Youghiogheny basin.

Lower Carboniferous strata are also found in two parallel ridges, Town Hill and Sideling Hill in eastern Allegany and western Washington counties.

The coal- and clay-bearing strata of Maryland comprises two systems of rocks, the Carboniferous below and the Permian above. These systems are further subdivided into a number of formations whose names and relations are indicated in the following table:

Permian
- Greene formation
- Washington formation

Carboniferous
- Upper or Pennsylvanian series
  - Monongahela formation
  - Conemaugh formation
  - Allegheny formation
  - Pottsville formation
- Lower or Mississippian series
  - Mauch Chunk red shale
  - Greenbrier limestone and shale
  - Pocono group
    - Pinkerton sandstone [1]
    - Myers red shale
    - Hedges black shale
    - Purselane sandstone
    - Rockwell shale

The strata will be discussed in ascending order.

CARBONIFEROUS SYSTEM

The rocks constituting the Carboniferous of Maryland are divisible into two series of formations, the Lower Carboniferous or Mississippian series and the Upper Carboniferous or Pennsylvanian series. The strata of the lower division are chiefly marine and contain but little coal and no suitable fire clays. Those forming the upper series are mainly continental deposits and include the important coal and most of the important fire clay deposits of the eastern United States. These divisions differ not only in the character of the rocks and the conditions under which they were accumulated, but are also separated over wide areas by a pronounced unconformity. The latter feature indicates a considerable lapse of time between the deposition of the lower and upper series during which there was a widespread emergence of the continent and prolonged erosion of the land.

[1] These divisions of the Pocono are recognizable only in the eastern exposures. The Pocono constitutes a single formation in the western part of the state.

The facts cited above, coupled with the considerable thickness of the beds have led many students, including the writers, to consider these divisions to be independent systems. To the lower the name Mississippian has been applied from the excellent exposures of its strata in the bluffs along the Mississippi River. The upper division has received the name of Pennsylvanian from the State of Pennsylvania where its beds were early studied and where they contain important deposits of coal and clay.

LOWER CARBONIFEROUS-MISSISSIPPIAN SERIES.—No coal or fire clay is found in the Mississippian rocks west of Cumberland. The Pocono strata constitute a single divison in the western exposures. They thicken eastward and are divisible in eastern Allegany and western Washington counties into five formations: the Rockwell shale, Purselane sandstone, Hedges shale, Myers red shale, and Pinkerton sandstone, all of which except the Myers red shale contain thin coals. These deposits, however, have no clays that give promise of having commercial value at the present time and will not be further discussed in this report.

UPPER CARBONIFEROUS-PENNSYLVANIAN SERIES.—The Pennsylvanian strata contain the valuable coal deposits of Maryland. They comprise four formations which will be discussed in the order of their deposition.

POTTSVILLE FORMATION

The Pottsville formation was named from Pottsville, Pennsylvania, where its strata are well exposed. It consists of interbedded sandstones and shales. Some of the beds of sandstone are gray, coarse grained, and locally conglomeratic. Such strata are very resistant to weathering, so that the beds of this formation tend to form rugged mountains upon or near the crest of which the more resistant rocks outcrop in bold ledges. The coal seams of the Pottsville of Maryland are few in number and as a whole are of little commercial value. The senior author has greatly revised the stratigraphy of the coal measures and in his revision the commercial fire clays of the Mt. Savage and other regions, placed in the Pottsville in earlier reports, are now placed in the lower part of the Allegheny formation. The Pottsville formation in Maryland varies from 150 to 280 feet, its usual thickness being little over 200 feet.

Pottsville-Mauch Chunk Boundary[1]

The Pottsville overlies the Mauch Chunk formation unconformably. This relation is shown more clearly in the adjoining states where the Mauch Chunk formation is much thinner and where the Pottsville formation may be in contact with the Mauch Chunk, Greenbrier, or even the Pocono formation. The existence of an unconformity at this horizon in Maryland is best seen in the variations in the thickness of the Pottsville, due to the presence or absence of some of its lower beds which were deposited on an irregular land surface.

Members

Because of their great commercial importance, the coal- and clay-bearing strata of the Appalachian Province have been divided into a much larger number of units than are usually recognized in rocks that have less economic value. These divisons are known over wide areas and have received names from localities where they are well exposed. The stratigraphic sequence of the members of the Pottsville formation of Maryland is shown in the following table:

Top
Homewood sandstone
Upper Mercer shale
Upper Mercer coal
Lower Mercer coal
Upper Connoquenessing sandstone
Quakertown shale
Quakertown coal
Lower Connoquenessing sandstone
Sharon shale
Sharon coal
Sharon sandstone
Bottom

[1] The base of the Pottsville formation was drawn by O'Harra in his report on the geology of Allegany County (Md. Geol. Survey, Allegany County, 1900, pp. 112, 113) above a limestone conglomerate found, at many localities, at the bottom of a massive ledge of sandstone. This horizon is in the Mauch Chunk formation as is shown by the occurrence of a thick bed of red shale above it. The latter may be seen in the cut of the Western Maryland Railway at Barrelville and at many other localities.

Inasmuch as none of these members are clays they will not be discussed in detail except that in certain regions thin seams of fire clay of uncertain quality are known.

ALLEGHENY FORMATION

The Allegheny formation consists of interbedded shale and sandstone and contains a number of coal seams, as well as valuable fire clays. Its strata are, on the whole, more shaly than those of the underlying Pottsville and overlying Conemaugh formations and hence tend to disintegrate more readily upon exposure to the weather, although these features are not constant. The lower part of the Allegheny formation, comprising the beds beneath the Hardman ("Furnace") fire clay, contains at many places massive sandstones, often crossbedded, that closely resemble those of the underlying Pottsville, and at a few localities nearly the entire formation is made up of sandstone. The formation could fittingly be divided into two parts in Maryland, the lower characterized by massive, often crossbedded sandstones, the upper by more argillaceous sediments.

The formation received its name from the Allegheny River along whose banks its strata are finely exposed, particularly in the vicinity of Freeport and Kittanning, Armstrong County, Pennsylvania. It was formerly called the Lower Productive Coal Measures. The thickness varies from 250 to 275 feet, being usually about 260 feet.

Allegheny-Pottsville Boundary

It has been thought that the Pottsville sandstones differ from those of the Allegheny formation in being coarser grained, harder, whiter, more compact, and much more resistant to weathering. The lower beds of the Allegheny formation in Maryland, however, consist of sandstones which often so closely resemble those of the underlying Pottsville that they cannot be separated lithologically. Indeed, at some localities the basal sandstones of the Allegheny formation are more massive and more resistant to weathering than the Pottsville formation. The discrimination of the formations is hence artificial rather than natural in Maryland, its chief value being for the purposes of correlation. These facts, coupled with the inconstant character of the strata have led various workers to draw the Allegheny-Pottsville boundary in Maryland at different horizons in the past.

The Pottsville-Allegheny boundary is placed at the top of the massive sandstone lying beneath the Mount Savage coals.

Members

The stratigraphic sequence of the members of the Allegheny formation of Maryland is shown in the following table:

Top

Davis rider coal—Upper Freeport rider coal
Davis coal—Upper Freeport coal
Bolivar clay
Upper Freeport limestone
Upper Freeport sandstone
Barrelville coal—Lower Freeport coal ("Parker coal")
Lower Freeport limestone
Montell sandstone
Montell rider coal
Montell coal—Upper Kittanning coal ("Bluebaugh coal")
Little Montell coal
Mount Savage iron ore—Johnstown iron ore
Hardman fire clay ("Furnace clay")
Piney Mountain coal
Westernport sandstone
Luke coal—Middle Kittanning coal
Luke clay—Middle Kittanning clay
Ellerslie sandstone
Ellerslie coal—Lower Kittanning coal
Ellerslie fire clay—Lower Kittanning fire clay
Mount Savage sandstone—Kittanning sandstone—Clarion sandstone
Mount Savage rider coal—Scrubgrass coal ?
Upper Mount Savage coal—Clarion coal ?
Mount Savage fire clay—Clarion fire clay ?
Lower Mount Savage coal—Brookville coal ?

Bottom

Only the fire clays will be considered in any detail. They follow in order from oldest to youngest.

MOUNT SAVAGE FIRE CLAY.—A valuable and important bed of fire clay, which has long been worked on Big Savage Mountain in the Georges Creek basin, occurs between the Lower and Upper Mount Savage coals. It consists of both plastic and flint fire clay. The former is soft and easily molded, while the latter is hard, lustrous, and breaks with a conchoidal fracture. The flint clay occurs in lenses and irregular masses in the soft clay replacing it entirely at some points. The Mount Savage clay attains a thickness of 5 to 12 feet in the Georges Creek Valley where it forms the basis of a large and flourishing industry.

ELLERSLIE FIRE CLAY—LOWER KITTANNING FIRE CLAY.—A bed of fire clay is found above the Mount Savage sandstone at many localities. It is well shown in the fire clay mines on the summit of Little Allegheny Mountain, west of Ellerslie, Pennsylvania, where it has a thickness of 8 to 9 feet and has been mined commercially, being the upper of the two seams worked at that locality. The same seam is found in the mines near Mount Savage, although it has not been worked there. It appears to be the clay worked in the mines of the Maryland Coal Company near Lonaconing, where it is of fair quality. It is also exposed at a small coal prospect at Swallow Falls. This clay appears to be a persistent bed and occupies the position of an important fire clay worked in eastern Ohio and western Pennsylvania.

LUKE CLAY—MIDDLE KITTANNING CLAY.—An impure bed of clay overlies the Lower Kittanning coal at various localities. It is very lenticular in character and appears to be inferior in quality so that it does not promise to be of commercial value. It is exposed in the cut of the Baltimore and Ohio Railroad opposite Luke from which locality it may be called the Luke clay. This clay occupies the position of a fire clay found at some localities beneath the Middle Kittanning coal in western Pennsylvania.

HARDMAN FIRE CLAY ("FURNACE CLAY").—A valuable bed of fire clay is found 125 to 150 feet above the base of the Allegheny formation in the Georges Creek Valley. It has been called the "Furnace clay" at the mines of the Union Mining Company, west of Mount Savage, where it is associated with Mount Savage iron ore, and attains a thickness of 5 to 15 feet. This clay consists of both plastic and flint clay. It is not as pure as the Mount Savage clay, worked in the same region, although it has a high fusion point. It appears to be replaced in places by a fusible plastic clay which has been burned experimentally into tile, for the manufacture of which it seems well adapted.

BOLIVAR CLAY.—The Davis or Upper Freeport coal is underlain locally by an impure fire clay. This clay is irregularly distributed, being absent in many places and at others attaining a considerable thickness. It occupies the position of the Bolivar fire clay of western Pennsylvania and eastern Ohio.

CONEMAUGH FORMATION

The Conemaugh formation of Maryland consists of interbedded shales and sandstones and contains a number of seams of coal. The formation is further characterized by the presence of red beds, a feature which distinguishes it[1] from the underlying Allegheny formation. The red beds thin eastward, being inconspicuous in Georges Creek Valley but increase in thickness westward, until they form a considerable part of the section in West Virginia and Ohio. Coincident with the increase in the volume of red beds is a diminution in the quantity of coal, so that the strata become increasingly barren westward.

The most important key rocks of the Conemaugh formation are beds of marine limestone and their associated shales, containing remains of marine organisms. These strata have been traced over wide areas and furnish the most valuable known means of correlating the coal beds of this formation. The most important of these beds are the Ames or Crinoidal limestone and the Brush Creek limestone, both of which have been traced with little interruption from southern Ohio through West Virginia into the Georges Creek basin. The formation also contains several less persistent beds of non-marine limestone. The coal beds tend to be more lenticular and variable in character than those of the Allegheny formation and many are mere local developments.

The fire clays are few in number and lower in quality. The Thornton clay near the base is one of the best, but it is far below the requirements for a fire clay at most localities in Maryland.

The Conemaugh formation receives its name from the Conemaugh River of western Pennsylvania where it is well exposed. It contains but

[1] I. C. White has called attention to the importance of these red beds as a diagnostic feature of the Conemaugh formation. W. Va. Geol. Survey, vol. ii, 1903, pp. 225-227; vol. iiA, 1908, pp. 622, 624; and Rept. on Branton and Clay Counties, 1917, pp. 822-829.

little commercial coal in that region and hence was early called the Lower Barren Coal Measures. Numerous coal beds are present in it in Maryland so that the name cannot justly be applied here. The thickness of the Conemaugh formation is known in Maryland only in the Georges Creek, Upper Potomac, and Castleman basins where it varies from about 825 feet to a little over 900 feet. The top of the Conemaugh formation has been eroded away in the Upper and Lower Youghiogheny basins.

Conemaugh-Allegheny Boundary

The base of the Conemaugh is placed at the top of the Davis (Upper Freeport) seam. This horizon is usualy well defined topographically by the heavy Mahoning sandstone that overlies the latter coal. It is also the base of the strata containing red beds.

Members

The stratigraphic sequence of the members of the Conemaugh formation of Maryland is shown in the following table:

Top

Morantown coal
Upper Pittsburg limestone
Lower Pittsburg sandstone
Little Pittsburg coal
Lower Pittsburg limestone
Second Little Pittsburg coal
Connelsville sandstone
Third Little Pittsburg coal (Franklin rider coal)
Franklin coal
Lonaconing sandstone
Lonaconing coal (upper bench)
Lonaconing coal (lower bench)
Hoffman sandstone
Upper Hoffman coal
Middle Hoffman coal
Hoffman limestone
Lower Hoffman coal
Clarysville sandstone
Upper Clarysville coal
Clarksburg limestone (upper bench)
Clarksburg red shale (upper bench)
Nivertown shale and fauna
Lower Clarysville coal

Clarksburg limestone (lower bench)
Clarksburg red shale (lower bench)
Morgantown sandstone
Wellersburg rider coal
Wellersburg coal ("Twin" coal)
Wellersburg limestone
Barton red shale
Barton sandstone
Barton rider coal
Barton coal ("Four-foot" coal)
Upper Grafton sandstone
Federal Hill coal
Birmingham red shale
Lower Grafton sandstone
Ames limestone and shale
Harlem coal
Ewing limestone
Pittsburg red shale
Unnamed coal
Saltsburg sandstone
Upper Bakerstown coal—Maynadier coal
Albright limestone
Cambridge red shale
Cambridge black shale and fauna—Friendsville shale and fauna
Thomas sandstone
Lower Bakerstown coal—Thomas coal (upper bench)
Lower Bakerstown coal—Thomas coal (lower bench)
Thomas limestone
Myersdale red shale (upper bench)
Myersdale limestone and fauna
Myersdale red shale (lower bench)
Buffalo sandstone
Brush Creek rider coal
Brush Creek limestone, shale and fauna
Brush Creek coal
Irondale limestone
Corinth sandstone
Thornton clay
Mahoning red shale (upper bench)
Gallitzen coal
Mahoning red shale (lower bench)
Mahoning limestone
Upper Mahoning sandstone
Piedmont coal ("Six-foot" coal)
Lower Mahoning sandstone
Bottom

Only the clays will be discussed in any detail.

THORNTON CLAY.—The Mahoning red shale occurs in the middle of a thick deposit of clay which is well exposed in the cut of the Baltimore and Ohio Railroad, west of the station at Corinth, West Virginia, in the Upper Youghiogheny basin. It has long been burned into bricks in the vicinity. A similar deposit is found at this horizon at many places in Maryland. It is known as the Thornton clay in West Virginia.

MONONGAHELA FORMATION

The Monongahela formation consists chiefly of interbedded shales and sandstones with a few beds of limestones. The proportion of shale is larger than in the Conemaugh formation. It contains coal beds of great importance, the Pittsburg coal at its base being the most valuable in the region. The formation has long been known as the Upper Productive Coal Measures because of its rich content of coal. The Monongahela formation receives its name from the exposures on the Monongahela River near Pittsburgh, Pennsylvania. Its thickness varies from 240 to 270 feet in Maryland.

Monongahela-Conemaugh Boundary and Members.—The base of the Monongahela formation in Maryland is shown in the following table.

Top
Waynesburg coal—Koontz coal
Waynesburg limestone
Uniontown sandstone
Benwood limestone
Upper Sewickley sandstone
Upper Sewickley coal
Lower Sewickley sandstone
Lower Sewickley coal—Tyson coal (upper and lower benches)
Cedarville sandstone
Redstone coal (upper bench)
Redstone sandstone
Redstone coal (lower bench)
Upper Pittsburg sandstone
Pittsburg coal
Bottom

As there are no commercial clays in the above units, none of them will be discussed.

PERMIAN SYSTEM

Inasmuch as there is but a small areal extent of Permian with but little coal and less clay, the system will not be discussed, the various units being briefly indicated below, the base of the Permian being placed at the top of the Waynesburg coal.

Top

Greene formation
- Unnamed sandstone
- Jollytown limestone
- Jollytown coal

Washington formation
- Upper Washington limestone
- Unnamed limestone
- Unnamed limestone
- Washington coal
- Waynesburg A coal
- Waynesburg sandstone

Bottom

DESCRIPTION OF FIRE CLAY LOCALITIES

BY

GEORGE M. HALL

Introduction

The number of mines producing fire clays from the Carboniferous of Maryland as well as prospects are much smaller than the number of coal mines and prospects. With almost no exceptions the existing mines are far up on the mountain side above the valleys, frequently they are practically at the top of the mountains.

The methods of mining are largely those of coal, the Room and Pillar system being used almost exclusively though in some of the very small mines there is no real systematic plan of exploitation. The mining of fire clay presents certain inherent difficulties. Owing to the softness of the material great care must be exercised to prevent "squeezes" due to removing part of so soft a layer between unyielding heavy masses of strata. The clay being impervious and frequently, if not always, beneath porous strata, immediately upon its removal there is a strong discharge of ground water into the mine, generally from the overlying strata. As the overlying beds are disrupted and settle the flow of water increases.

The mines are usually ventilated by natural means, although in the larger ones fans are used to drive in fresh air. Drainage is always a problem, but usually natural drainage suffices. Siphons are often used to drain low places but pumps are seldom used. The greatest difficulty is in keeping the drainage ditches clean, due to clay getting in them in various ways, such as from the sides and dropping from the trips.

As a whole fire clay mines are less highly developed than coal mines because of the lower value of the product, the difficulties of mining such as the "creep" or "squeeze," the excessive amount of water, and the rather short life of a clay mine due not only to mining difficulties but also to the rapid variability of clay deposits both as to exent and quality. A good face clay may completely disappear in a few yards and not reappear, or the face may retain its integrity but its quality may change so rapidly that it is worthless as a refractory clay.

The center of the industry is along Savage Mountain, with some developments along Dans Mountain. Prospects are scattered over a large area in Allegany and Garrett counties.

THE OUTCROPS OR OPENINGS

NORTH BRANCH OF JENNINGS RUN, 3 MILES NORTH OF WELLERSBURG, PENNSYLVANIA

This outcrop is in Pennsylvania at the northern end of the Georges Creek Basin. The Hardman or Furnace clay is well exposed and the Mt. Savage or Clarion fire clay could be faced up without great difficulty a short distance up-stream although it was very poorly exposed at the time of the writer's visit. The Hardman or Furnace clay is a thick mass of flint and plastic clay, sandy and badly iron stained with many ore balls.

SECTION

	Feet
Concealed.	
Flaggy sandstone.	
Shale	1.3
Coal	0.8
Shale	1.0
Poor coal	0.7
Plastic clay with ore balls at base P 20	1.4
Concealed	4.0
Gray shale	4.0
Very tough brown iron-stained flint clay with numerous ore balls F 8	12.5
Soft plastic gray clay, with a 2-foot yellow iron stained layer at top P 21	5.3
Shale	2.0
Concealed	50.0
Stream.	

Correlation: Upper layer, Clay beneath Montell Coal ?
Lower layer, Hardman or Furnace.

THE UNION MINING COMPANY

The Union Mining Company is the oldest producing company in the district. It now operates Union No. 5 and No. 6 mines, having abandoned

No. 1, or "The Tunnel," which is an old tunnel driven in 1846 to reach the Mt. Savage or Johnstown iron ore, immediately overlying the Hardman or Furnace clay.

Union No. 5 and No. 6 are well developed mines, using the room and pillar system, well developed artificial ventilation, and good drainage systems. No. 5 produces plastic clay and No. 6 flint clay and plastic clay, the latter being used for hollow tile.

The mines are high up on the mountain and the clay, after being weighed, is dumped over simple timber tipples into cars on the plane. This gravity plane was once over a mile long and was probably the longest gravity plane in the world but is now a little less than a mile due to the present openings being lower down the mountain than the older abandoned mine. At the foot of the plane the cars are attached to a dinkey engine and hauled to the plant at Mt. Savage, approximately two miles. The following places in the mines were sampled, sections are given and beds sampled are indicated:

SECTIONS AT THE PLACES SAMPLED

Union Mine No. 5

2¼ Miles N. 70° W. of Mt. Savage

First heading to left.

	Feet
Rotten, yellow, iron-stained sandstone roof.	
Yellow, iron-stained plastic clay P 13	0.6
Very black, carbonaceous clay P 14	1.1
Gray soft plastic clay P 15	5.3
Hard tough flint clay	0.4
Soft plastic gray clay P 35	2.5

Correlation: Hardman or "Furnace" clay.

Second heading to the right.

Coal roof.	
Brown plastic clay P 16	1.0
Brownish-gray plastic clay P 17	1.0
Gray plastic clay with plant remains P 18	3.3
Alternating sandstone and sandy fire clay in layers of varying thickness (rejected)	2.6
Soft gray plastic clay P 19	2.0
Soft clay floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

Station 957 + 63.

	Feet
Rotten sandstone roof.	
Soapstone	1.4
Coal	0.6
Shale parting with considerable pyrite in lower portion	1.2
Coal	1.6
Gray plastic clay containing plant remains P 22	14.6
Sandy floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

Union Mine No. 6

2¼ Miles N. 60° W. of Mt. Savage

Second heading to left, station 73 + 9.

Soapstone roof.	
Coaly streak	0.05
Brown to gray plastic clay P 1	3.7
Brownish conchoidal fracture flint clay with occasional black streaks F 1	3.5
Gray plastic clay with carbonaceous streaks P 2	1.0
Coaly streak	0.1
Sandy shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

First heading to left, station 72 + 2.

Coaly streak	0.5
Gray plastic clay, becoming very hard near bottom and changes to black at junction with flint clay. Contains some nodules of flint clay and ore balls P 3	2.3
Shiny flint clay with conchoidal fracture, grayish to brownish with occasional dark streaks F 2	4.4
Soft gray plastic clay P 4	1.3
Coaly streak	0.1
Sandy shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

Second heading on right of plane 43 feet from the plane.

Soapstone roof.	
Coal streak	0.05
Gray to brownish plastic clay P 5	2.0
Brown shiny conchoidal fracture flint clay F 3	5.0
Plastic gray clay P 6	0.9
Sandy shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

FIG I.—VIEW OF BRICK PLANT OF THE MARYLAND COAL COMPANY NEAR LONACONING.

FIG. 2.—VIEW SHOWING THE NEW PLANT OF THE MARYLAND COAL COMPANY.

Plane heading at station 69 + 92.

	Feet
Soapstone roof.	
Coaly streak	0.05
Soft to hard gray plastic clay P 7	4.0
Brown shiny conchoidal fracture flint clay with brown streaks F 4	3.9
Soft gray plastic clay with carbonaceous streaks P 8	1.5
Sandy shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

First heading on right plane heading.

Clay roof.	
Gray and brownish-gray plastic clay varying from soft to hard. Part of roof. P 9	3.5
Brownish shiny conchoidal fracture flint clay F 5	2.7
Soft gray plastic clay with carbonaceous streaks near bottom P 10	1.5
Sandy shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

First heading to the right on the first on the right on the plane.

Clay roof.	
Gray soft clay, lower layer tough. Used for calcining P 11	2.8
Dull-brown flint clay F 6	1.2
Shiny brown brittle flint clay with some black mottling F 7	2.5
Soft gray plastic clay P 12	1.8
Coaly streak	0.1
Sandy shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

Rock heading 140 feet from main heading.

Coal, bony, with sulphur	7.6
Hard heavy sandstone	18.0
Blackjack and coal	5.5
Sandy soapstone	5.2
Soft gray clay P 65	5.5
Black clay-like material P 66	2.3
Sandstone floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

Surface Prospect 225 Ft. N. 35° W. of Drill Hole near Mine No. 7

Surface material	7.0
Soft pink plastic clay with sandstone pebbles and boulders P 23	4.0
Very plastic gray clay changing to light-gray at bottom P 24.	2.1
Heavy sandy brown shale.	

Correlation: Probably the Ellerslie or Lower Kittanning fire clay.

Along Western Maryland Railway One-Half Mile above Union Plane Bridge

	Feet
Surface.	
Medium to heavy-bedded sandstone	6.0
Thin-bedded shale	2.1
Flint clay, badly iron stained F 11	7.1
Very sandy soft clay	0.3
Thin to medium-bedded sandstone	20.0
Concealed.	

Correlation: Hardman or Furnace clay.

THE MOUNT SAVAGE FIRE BRICK COMPANY

The Mount Savage Fire Brick Company operates the property adjoining the Union Mining Company on the southwest, mining the same bed. At present the work is carried on in the Benson Mine near the top of the mountain. The clay is run down a gravity plane about half a mile long to the level of the Benson Tunnel where the clay is dumped over a timber tipple into other cars on the engine plane and run down to the plant in Little Allegany on the C. & P. R. R. The engine plane is about two miles long, the cars being run down by gravity but are hauled back by an engine. The Benson tunnel was driven to strike the clay lower down but the clay was not sufficiently high grade and the present mine was opened higher up the mountain.

SECTIONS AT PLACES SAMPLED

Benson Mine

2¾ Miles N. 15° W. of Frostburg, Md.

Third heading to right.

	Feet
Sandy soapstone roof.	
Soapstone, lower 10 inches mined as fire clay P 30	2.3
Yellow plastic clay, iron-stained containing pebbles and ore balls P 26	0.7
Brownish shiny brittle flint clay with conchoidal fracture F 10.	5.3
Very plastic clay, pinches out in many places P 27	0.2
Coaly streak	0.05
Black clay (called " dirt " by miners) P 28	1.0
Gray plastic clay P 29	1.1
Sandy shale floor.	

Correlation: Mt. Savage or Clarion fire clay.

First heading on right.

	Feet
Soapstone roof.	
Coaly streak	0.1
Very sandy clay ("dirt")	0.4
Gray to brownish flint clay, iron-stained F 12	5.0
Coaly streak	0.05
Soft gray clay P 31	1.5
Coaly streak	2.0
Brown shaly floor.	

Correlation: Mt. Savage or Clarion fire clay.

Second heading on the right.

Soapstone.	
Gray sandy plastic clay P 32	1.4
Gray iron-stained flint clay F 14 with lenses of soft clay of variable thickness where P 33 was taken	3.9
Soft, very plastic gray clay P 34	2.8
Coaly streak	0.05
Brown sandy shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

Benson Tunnel

2½ Miles N. of Frostburg

Second heading to left behind the brattice.

Massive sandstone roof.	
Gray plastic clay with ore balls and some small pieces of flint clay P 39	4.3
Dark, black carbonaceous flint clay	1.7
Shale floor.	

Correlation: Mt. Savage or Clarion fire clay.

Third heading to left behind brattice.

Iron-stained sandstone roof.	
Gray flint clay with black streaks, tough and hard in upper layers, more brittle in lower F 25	6.0
Soft gray clay	0.2
Black flint clay F 26	1.1
Shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

Extreme end of heading to right.

Clay roof, very sandy.	
Gray sandy clay with many ore balls P 36	3.0
Brownish brittle flint clay with black streaks F 15	2.8
Soft gray clay P 37 (Coaly streak 1.7 from bottom)	3.2
Coal	0.3
Shale floor.	

Correlation: Mt. Savage or Clarion ? fire clay.

Second room on right of heading to left; section left-hand side of room.

	Feet
Massive sandstone roof.	
Brown, brittle flint clay with some small lenses of plastic clay F 16	5.5
Soft gray clay left as floor.	

Right-hand side of room.

Massive sandstone roof.	
Brown shale	0.5
Brown flint clay same F 16 (shows great variation)	4.0
Soft gray clay with ore balls P 38	1.8

Correlation: Mt. Savage or Clarion fire clay.

Clay on right-hand side of tunnel approximately 750 feet from mouth.

Sandstone.	
Hard tough blue iron-stained flint clay F 27	5.5
Soft gray clay	0.2
Hard sandstone.	

Correlation: Hardman or Furnace clay.

THE SAVAGE MOUNTAIN FIRE BRICK COMPANY

The Savage Mountain Fire Brick Company operates southwest of the Mt. Savage Fire Brick Company and works the same bed. The mine is on Savage Mountain just north of the National Road. The clay is hauled out by mules and run by gravity over a tram road about a mile to a timber tipple where the clay was dumped into big wagons pulled by horses and hauled to the works in Frostburg. Auto-trucks are now used for hauling the clay. The empty mine cars are hauled back to the mouth of the mine by horses. On the dumps of this company are numerous ore balls which when cracked open often contain beautiful crystals of quartz and other minerals.

SECTIONS AT PLACES SAMPLED

Frostburg Mine No. 6

1⅝ Miles N. 45° W. of Frostburg

Last heading to right adjoining Benson property.

	Feet
"Soapstone" roof.	
"Soapstone" P 63	1.7
Coaly streak	0.05
Sandy flint clay (thrown away)	0.7
Hard gray flint clay, iron-stained F 32	5.0

	Feet
Soft, very plastic gray clay	0.2
Coaly streak	0.25
Soft, very plastic gray clay P 64	1.2
Gray shale floor.	
Correlation: Mt. Savage or Clarion ? fire clay.	
First heading on left of main heading to right.	
Soft clay roof.	
Soft pinkish clay somewhat iron-stained with many nodules of flint clay in lower part P 47	4.7
Brownish, very brittle flint clay with many seams of red iron-stained soft clay F 29	4.2
Dark-brown to reddish very plastic clay. Rejected	0.3
Bony shale floor.	
Correlation: Mt. Savage or Clarion ? fire clay.	
Main heading to the left.	
"Soapstone" roof.	
Coaly streak	0.2
Gray sandy clay P 46	2.25
Gray flint clay mottled black F 28	5.25
Soft gray clay	0.2
Brown, sandy shale floor.	
Correlation: Mt. Savage or Clarion ? fire clay.	
Extreme end of main right heading.	
Soapstone roof.	
Soapstone mined as dirt P 60	1.0
Coaly streak	0.05
Gray, sandy shale P 61	0.8
Gray, brittle flint clay, iron-stained in places F 31	5.2
Gray soft clay, very plastic P 62	0.5
Coaly streak	0.05
Soft shale floor.	
Correlation: Mt. Savage or Clarion ? fire clay.	

THE MARYLAND COAL COMPANY

In 1916 and 1917 the Maryland Coal Company were developing the fire clay on their property. A magnificent modern plant was erected near Lonaconing, an excellent modern electric tram road was constructed from the plant to mines high up on the mountain and a most substantial entry was made. The volume and quality of the clay have not been up to expectations and the property is idle at present.

In the summer of 1916 only the Hardman Furnace clay could be prospected on the bank of a run. The company in addition to core drilling had sunk several test pits but because of caving the pits were partly full and too dangerous to sample. In the spring of 1917 the entry has progressed far enough to sample the clay. The failure of the company to obtain a large supply of high-grade clay after so large an investment is most regrettable.

SECTIONS AT PLACES SAMPLED

Outcrop on Koontz Run

Approximately 3½ Miles Northwest of Lonaconing

	Feet
Surface.	
Platy sandstone	8.0
Coal	2.5
Very sandy clay	4.3
Sandstone	6.0
Very plastic clay P 48	4.0
Very sandy clay	1.7
Concealed to level of run	3.0
Correlation: Hardman or Furnace clay.	
Main entry.	
Yellow sandstone.	
Dark, sandy clay, stratified in places	5.3
Gray clay somewhat dark at top P 91 (291 feet from mouth).	4.8
Heavy sandstone	12.2
Smooth, gray clay, a soapstone with plant remains	1.2
Blackjack with coal and pyrite	3.5
Gray clay P 90 (370 feet from mouth)	5.5
Argillaceous sandstone.	
Correlation: Ellerslie or Lower Kittanning fire clay.	

THE COOKS MILLS COAL, LUMBER, AND FIRE CLAY COMPANY ONE MILE NORTHWEST OF COOKS MILLS

Although this locality is in Pennsylvania and hence beyond the limits of this investigation it was visited with a view of seeing how the clays varied areally. This place is about five miles northeast along the strike from the Andrew Ramsay Company mine west of Ellerslie but the clay exposed in the prospect visited is considerably more sandy than at Ellerslie although the stratigraphic position is the same.

If this clay should improve as the entry is carried forward it would be an ideal place as there is a standard gage track from the Baltimore and Ohio Railroad to the adjacent coal prospect. The railroad has been used for hauling out timber and bark.

SECTION AT PLACE SAMPLED

	Feet
Surface.	
Massive sandstone	4.0
Clay very sandy	6.6
Fissile black shale with plant remains	4.6
Gray shale, breaking irregularly, might be called a clay	2.4
Thin to medium-bedded sandstone	12.5
Massive white sandstone with many plant impressions	5.5
Soft sandy clay with small sandstone bands stained red and yellow P 25	3.2
Tough brown to gray flint clay with narrow sandstone bands F 9	4.1
Black shale floor.	

Correlation: Ellerslie or Lower Kittanning fire clay.

THE ANDREW RAMSAY COMPANY

The Andrew Ramsay Company operates a fire clay mine on top of Little Allegheny Mountain. The entrance to the mine is across the Pennsylvania line although practically all mining operations are under Maryland, that is the entry crosses the State Line in Pennsylvania. The mine is reached by about a mile and a half of tram road and a half mile of very steep three-rail gravity plane. Both the Ellerslie and the Mt. Savage clays are expossed in the mine but the Ellerslie is the one worked. Unlike most of the Maryland fire clays, this clay is largely used for the manufacture of sanitary ware and not for refractory brick.

SECTIONS AT PLACES SAMPLED

Main heading.

	Feet
Blackjack roof.	
Black slate	1.5
Impure gray clay with black streaks F 21	1.3
Soft gray clay with plant remains P 40	7.0
Shale floor.	

Correlation: Ellerslie or Lower Kittanning clay.

Heading to the right.

Massive sandstone roof.	
Heavy brown shale	1.5
Coal	1.9
Soft clay and smut alternating	0.5
Soft clay	0.3
Brown flint clay F 22	1.0
Soft gray clay P 42	0.9
Coal smut	0.7

	Feet
Soft clay	0.5
Flint clay F 23	1.5
Correlation: Ellerslie or Lower Kittanning fire clay.	
Room off heading to left.	
Sandstone roof.	
Soft clay, rather iron-stained	2.0
Brown, iron-stained flint clay F 24	2.5
Shale floor.	
Correlation: Ellerslie or Lower Kittanning fire clay.	

GEORGES CREEK-PARKER COAL COMPANY ONE-HALF MILE EAST OF BARRELVILLE AND ONE-QUARTER OF A MILE NORTH OF JENNINGS RUN

In 1914 the Cumberland Coal Company who owned this property dug a trench under the supervision of Dr. C. K. Swartz at the end of an old road leading to the clay banks. This prospect, due to its being the Mt. Savage or Clarion? fire clay, may possibly be developed into a valuable property. Further prospecting must be done before any definite opinion can be expressed. Coal is readily available. The railroad is not far away and sidings could be run to the desired location without prohibitive cost.

SECTION AT PLACE SAMPLED

	Feet
Top soil	4.0
Gray flint clay, much sand and iron F 55	3.5
Bluish-gray soft clay changing at base to yellow P 103	4.5
Correlation: Mt. Savage or Clarion fire clay.	

PERCY TRACT, CLARYSVILLE, MD.

This sample was obtained from a pit dug at the caved-in opening into the Barton coal on this property. Considerably more prospecting work would have to be done before any definite opinion could be expressed as to its real value. Transportation by way of the C. & P. R. R. (Eckhart Branch) runs within a few feet of the test pit.

SECTION

	Feet
Surface.	
Shale	1.5
Yellow clay P 69	4.0
Coal smut.	
Correlation: Clay above the Barton coal.	

NORTH MARYLAND COAL MINING COMPANY, NEAR LOARTOWN, MD.

Some years ago the Montell Tunnel was driven through the mountain 2,480 feet making accessible the Upper Freeport coal (Davis) and the Montell (Upper Kittanning) coal. The tunnel cuts all strata until the Upper Freeport is reached and then follows that vein to its outcrop on the eastern side of Dans Mountain. The clay in the tunnel and those below the Upper Freeport and the Montell coals could be easily developed if their quality warrants. The coal is available for burning the clay. On account of the availability of both clay and coal an exceedingly profitable industry might be developed. The clay correlated as Ellerslie was sampled in a small prospect on the east side of Dans Mountain below the tunnel opening. At the time of sampling this prospect had been driven only 25 feet, but appearances would justify additional work before being abandoned. If this clay proves to be high grade it could be developed either through the tunnel or by building a plane to the Western Maryland Railway (C. & C.) or the Eckhart Branch of the Cumberland and Pennsylvania Railroad. This would be expensive as the plane would be over a mile long, and would put the plant far from the mouth of the Montell Tunnel necessitating the hauling of all fuel over the railroad.

SECTION AT PLACES SAMPLED

Sample taken from small opening on north wall 520 feet from mouth of tunnel.

	Feet
Argillaceous sandstone.	
Gray sandy clay	4.2
Coaly streak	0.2
Soft gray clay with some sandstone pebbles P 54	3.1
Sandstone.	

Correlation: This clay not named, above Lower Bakerstown coal.

Sample taken from north wall 840 feet from mouth of tunnel.

	Feet
Slate.	
Plastic gray clay P 53	6.0
Sandstone.	

Correlation: Clay not named, just under shale below Lower Bakerstown coal.

Sample taken 105 feet from start of entry to Montell coal.

	Feet
Arenaceous shale	12.5
Gray plastic fire clay P 50	5.5
Shale, hard and sandy, some fire clay.	

Correlation: This is probably the Bolivar fire clay.

Sample from entry to Montell coal.

	Feet
Coal	0.9
Parting	0.1
Coal	0.9
Heavy, brown, iron-stained shale	12.0
Gray clay P 51	1.7
Spotted, mottled clay P 52	4.3
Gray sandy clay	1.3
Argillaceous sandstone.	

Correlation: Clay below Barrelville coal.

Prospect on east side of Dans Mountain below the tunnel.

Soft sandy clay roof.	
Soft gray clay P 45	5.2
Rather hard gray sandy iron-stained clay	1.0
Black carbonaceous material (smut)	0.2
Shale.	

Correlation: Ellerslie fire clay.

MILLER AND GREENE COAL COMPANY, WESTERNPORT, MD.

The Miller and Greene Coal Company have a well-equipped coal mine just on the edge of Westernport. The coal is thin, varying from 28 to 42 inches, but of good quality. A foot of the clay floor is removed in the rooms while from 1½ to 3 feet must be removed in the headings to provide sufficient clearance. If this clay can be utilized it will be unnecessary to dump it in a very small restricted area as is at present necessary. The clay is too fusible to be a refractory but certain grades of brick, etc., could be made from it. The only difficulty is that the mine is in a district where surface space in the valley is at a premium, making it somewhat expensive to obtain sufficient space to erect a brick plant. The mine is already equipped with a railroad siding.

SECTION AT PLACE SAMPLED

First butt on second heading left.

	Feet
Sandstone roof.	
Coal (varies from 28 to 48 inches)	2.5
Gray clay (varies from 30 to 48 inches) only 25 inches removed P 68	2.5
Clay floor.	

Correlation: Clay beneath Montell coal.

OLD HETZEL PLANE ON POTOMAC RIVER, ONE-HALF MILE EAST OF WESTERNPORT, MARYLAND

This mine, now abandoned, was once known as J. O. J. Greene's Clarion mine. The clay is a gray plastic clay underlying a coal. The clay and coal together should form a profitable industry in spite of the fact that the clay is not as refractory as a true fire clay. The old plane grade is still there though new ties and rails must be laid before using it. The Western Maryland Railway tracks pass the foot of the old plane and afford excellent shipping facilities. The bottom of the clay was not reached but it is reported to vary from 2.5 to 4 feet.

SECTION AT POINT OF SAMPLING

	Feet
Concealed.	
Heavy sandstone forming roof exposed outside	16.0
Coal	2.2
Gray plastic clay P 49	2.5
Clay floor.	

Correlation: The clay beneath the Barrelville coal.

A SLIP ONE-QUARTER MILE SOUTH OF THE OLD HETZEL PLANE, AND THREE-QUARTER MILE EAST OF WESTERNPORT

While the slip has not exposed a thick bed of flint clay it has shown the presence of the clay and warrants the expenditure of a small sum to investigate the possibilities. The hillside, which is very steep, is strewn in places with fragments of fire clay that have been left by processes of erosion. The location of this deposit is ideal for its development. The Western Maryland Railway tracks are below the outcrop and the public road from Westernport is equally convenient.

SECTION AT POINT OF SAMPLING

	Feet
Concealed.	
Sandstone, very massive hackle-toothed	15.0
Concealed	50.0
Tough flint clay, rather sandy F 54	4.5
Bastard soft clay	2.5+
Concealed.	

Correlation: This is the Mt. Savage or Clarion ? fire clay.

THE POTOMAC FIRE BRICK COMPANY, PIEDMONT, WEST VIRGINIA

The Potomac Fire Brick Company mines are on the extension of Dans Mountain across the Potomac in West Virginia. This is another opportunity to study the areal variability of clays along Dans Mountain. Coming southwest along the mountain from the Cooks Mills deposit in Pennsylvania, to the Ramsay Co.'s mine at the State Line, to the North Maryland Coal Co.'s prospect, to the exposures on the north bank of the Potomac, to the Faraday property, and to this mine there is an excellent chance to study this variability. This mine is not large nor highly developed. The clay is hauled out of the mine and sent down a short gravity plane to the plant on the Baltimore and Ohio Railroad.

SECTIONS AT PLACES SAMPLED

Second place on left of right main entry.

	Feet
Clay roof. Impure, left in place.	
Gray, soft clay with flint clay and coal lenses P 70	9.5
Rough, sandy clay floor with coal and bone in place.	
Correlation: Mt. Savage or Clarion ? fire clay.	

New opening, 70 feet from mouth.

Clay roof.	
Hard, tough gray flint clay with black mottling, F 33	6.2
Clay floor, 12 inches impure sandy iron-stained clay. Removed but not used.	
Correlation: Mt. Savage or Clarion ? fire clay.	

THE FARADAY PROPERTY

This adjoins the Potomac Fire Brick Company on the south and east. Several openings have been made as prospects but these are now abandoned. A plant has not been erected on the property.

SECTION AT PLACES SAMPLED

First prospect east of old plane.

	Feet
Sandstone roof, flint clay adhering.	
Hard iron-stained flint clay F 35	6.2
Very ferruginous clay	0.3
Black carbonaceous clay with coaly streaks	2.9
Black sandy clay.	
Correlation: Mt. Savage or Clarion ? fire clay.	

Second prospect east of old plane.

	Feet
Sandstone roof.	
Flint clay (not sampled)	2.3
Ferruginous soft clay	0.6
Black shale	0.4
Coal smut	0.2
Very sandy gray clay P 71	4.7
The floor is in this unit.	

Correlation: Mt. Savage or Clarion ? fire clay.

Fourth prospect east from old plane.

Surface materials.	
Hard sandstone with profusion of plant remains	13.0
Gray shale	2.3
Black shale	0.6
Impure gray iron-stained soft clay with a few nodules of flint clay at base	2.1
Sandstone forming uneven and rolling roof of mine	2.0
Flint clay, gray, iron-stained, hard and tough F 34	1.9
Very ferruginous sandy clay	0.3
Black shale	0.6
Very sandy clay. Too sandy to sample. Contained many ore balls. Floor in this unit	4.0

Correlation: Mt. Savage or Clarion ? fire clay.

CLIFF BEHIND HOUSE AT CROSSING OF C. AND P. R. R. AND W. MD. RY. IN WESTERNPORT, MD.

A thick body of clay is seen behind the house at the intersection of the railroads in Westernport. This clay is very thick and a large body is available, but it is of low grade and could be used only for common brick, etc.

SECTION AT PLACE OF SAMPLING

	Feet
Surface materials.	
Heavy, hackly sandstone with plant impressions	15.0
Gray clay P 76	12.3
Concealed below level of ditch.	

Correlation: Probably the Luke clay. This particular body of clay is 86 feet below the Montell coal.

BALTIMORE AND OHIO RAILROAD, OPPOSITE THE WEST VIRGINIA PULP AND PAPER COMPANY'S MILL

An impure gray clay is exposed in several places along this steep cut opposite the paper mill. This is the so-called Luke which here splits into two beds, separated by a variable thickness of sandstone and shale. The exposures in this cut afford an excellent opportunity to study the great variability of various units in a short distance. Some of the changes are striking. The clay was sampled in two places.

SECTION AT PLACES SAMPLED

	Feet
150 feet west of the Luke Bridge.	
Sandstone, carrying plant remains.	
Soft sandy gray clay P 74	6.2
Concealed below level of railroad.	
Correlation: Luke clay.	
Opposite the paper mill.	
Sandstone.	
Coal smut	1.0
Parting shale	2.0
Coal smut.	
Gray clay P 75	10.0+
Concealed below level of railroad.	
Correlation: Luke clay.	

CUT ON BALTIMORE AND OHIO RAILROAD ONE-QUARTER MILE EAST OF FORMER TUNNEL, EAST OF BOND, MD.

About a quarter of a mile east of the former tunnel on the Baltimore and Ohio is found a thin clay containing many plant impressions. It is doubtful whether this clay is thick enough to justify development, even if it proves to be of high grade. So far as railroad facilities go it is on the main line of the Baltimore and Ohio Railroad.

SECTION AT PLACE SAMPLED

	Feet
Surface, full sandstone boulders.	
Gray shale	5.0
Iron-stained shale	5.5
Greenish-gray shale	2.9
Black, carbonaceous fissile shale	1.0
Gray iron-stained clay, plant impressions P 72	2.8
Gray sandy shale	1.5
Sandstone	8.5
Level of railroad.	
Correlation: Clay beneath Upper Freeport or Barrelville Coal.	

FIRST CUT ON THE BALTIMORE AND OHIO RAILROAD ABOVE THE OLD SIGNAL TOWER WEST OF THE FORMER TUNNEL EAST OF BOND, MD.

The clay exposed in the bank of this cut has an excellent appearance and although the body is not thick there, probably a considerable tonnage is available. With very little expense this clay could be prospected and more thoroughly tested to see if it would justify development. Railroad facilities are at hand as the main line of the Baltimore and Ohio passes the place sampled.

SECTION AT PLACE SAMPLED

	Feet
Surface.	
Heavy yellow sandstone with profuse plant impressions	12.0
Thick-bedded shale weathering to fissile fragments	1.5
Bluish-gray tough flint clay F 36	2.3
Soft clay P 73	3.0
Sandstone	1 +
Concealed below level of railroad.	

Correlation: Ellerslie or Kittanning fire clay.

SMALL EXPOSURE ON NORTH SIDE NEW ROAD TO PIEDMONT DAM, ABOUT ONE-HALF MILE NORTHEAST OF THE DAM

The fire clay exposed here is not very promising but should not be condemned until it is more carefully prospected. The construction of the new road exposed the bed only partially and some work must be done before the entire thickness can be determined. Fragments of flint clay are scattered along the road for about 200 yards but no trace of the source could be found except some nodules of flint clay in the plastic clay sampled. The exposure is readily accessible by the new road to the Piedmont dam. If this clay is worth developing a long tram road would have to be constructed to reach the Western Maryland Railway, or even more expensive installation to reach the B. & O. R. R.

SECTION AT PLACE SAMPLED

Section at point of sampling.

	Feet
Soil and rock.	
Coal blossom	0.2
Gray, somewhat iron-stained clay P 67	2.9
Gray argillaceous sandstone.	

Correlation: This is the Ellerslie or Lower Kittanning fire clay.

CLIFF ON MARYLAND SIDE OF POTOMAC RIVER 450 FEET WEST OF THE TIPPLE OF THE NORTH AMERICAN MINE OF THE BLAINE COAL MINING COMPANY

A considerable thickness of clay is exposed at this point and a large tonnage should be available. To ship the clay or to manufacture it would necessitate the building of a plane across the river into West Virginia. The middle portion of the deposit measuring three feet at the outcrop would probably have to be rejected on account of its low fusion point, although this might be used for hollow tile, etc. The Western Maryland Railway furnishes adequate transportation facilities.

SECTION AT PLACE SAMPLED

	Feet
Gray flint clay F 53	7.0
Gradations of soft to flint clay tending to be interstratified with shaly material P 102	3.0
Soft bluish-gray clay P-102	4.0

Correlation: Probably the Ellerslie fire clay.

CLIFF ON MARYLAND SIDE OF THE POTOMAC RIVER, 1000 FEET WEST OF SMALL RUN MARKING WEST BOUNDARY OF GARRETT COUNTY COAL AND MINING COMPANY

A rather thin bed of fire clay is exposed in the cliff on the Maryland side of the Potomac. Unless this clay shows greater thickness and less limonite at some nearby exposure it will not pay to expend much prospecting it.

SECTION AT PLACE SAMPLED

	Feet
Top soil.	
Tough gray flint clay, very much shattered. The cracks filled with concretions, probably limonite F 52	3.2
Clay grades to shale.	

Correlation: This is probably the Hardman or Furnace clay.

GLEASON COAL AND COKE COMPANY

On Gleasons Run 500 feet west of Gleasons Station, 500 feet south of the Maryland Line. Although this clay outcrops in West Virginia it is an interesting example of the impure fire clay found in places in Maryland and West Virginia below the Davis or Upper Freeport coal; that is, at the horizon of the Bolivar fire clay of Pennsylvania. No attempt has been made to face up this clay and the overlying Davis coal.

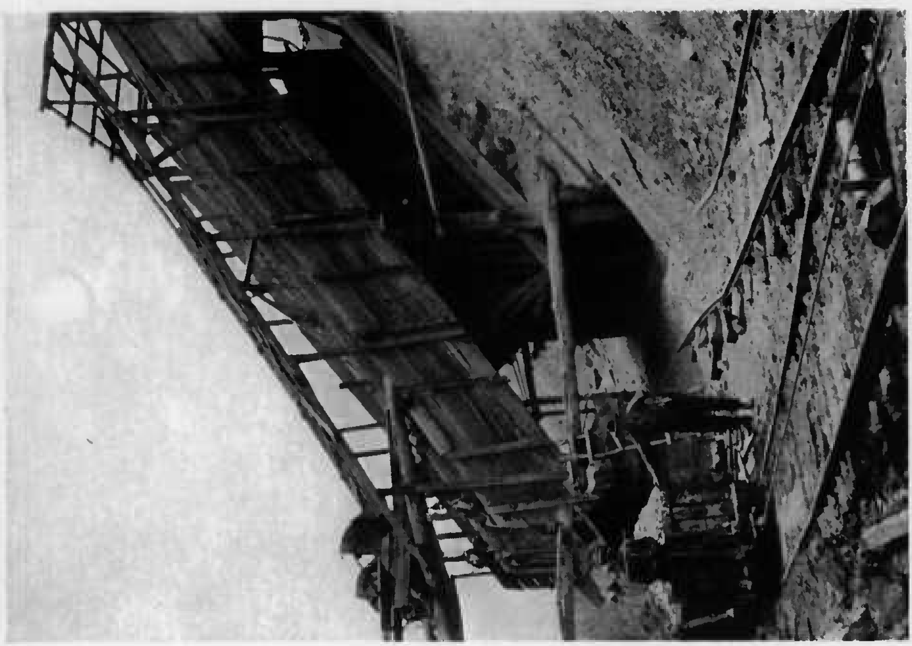

FIG. 1.—VIEW OF TIPPLE AT HEAD OF PLANE AT THE BENSON MINE.

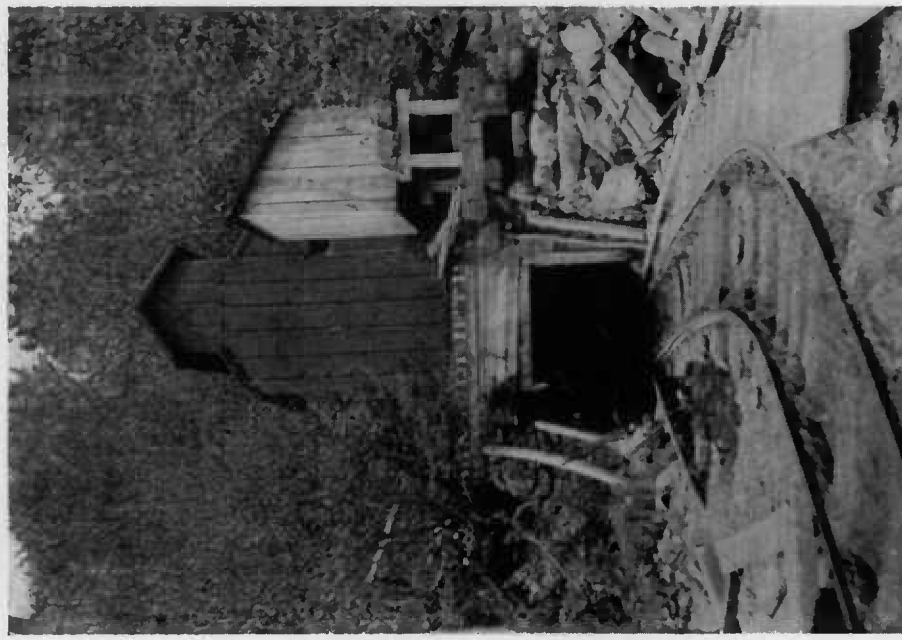

FIG. 2.—VIEW OF ENTRANCE TO MINE NO. 6 OF THE UNION MINING COMPANY.

368 b

SECTION AT PLACE SAMPLED

	Feet
Top soil.	
Clay, top partly weathered, 101a	1.6
Clay, middle 101b	1.9
Clay, bottom 101c	2.0

Correlation: Clay below Davis or Upper Freeport coal, the horizon of the Bolivar fire clay of Pennsylvania.

NORTHWESTERN PIKE, EAST OF CONWAY HILL

A small exposure on the southeast side of Northwestern Pike, 340 feet N. 70° E. of the junction of old lumber road with pike east of Conway Hill.

SECTION AT PLACE SAMPLED

	Feet
Concealed.	
Gray iron-stained flint clay F 51	3±
Concealed.	

Correlation: This clay is probably the Mt. Savage or Clarion ? fire clay.

U. M. STANTON

Outcrop on small run opposite U. M. Stanton, 1¼ miles southeast of Grantsville, Maryland. The coal and clay are exposed in a steep bank along the run. The coal is of good quality and if the clay is of good quality this would be a valuable deposit. Transportation is available, Jennings Bros. Railroad being less than 200 yards distant.

SECTION AT PLACE SAMPLED

	Feet
Surface.	
Brown, thin-bedded shale	14.0
Coal	2.2
Gray clay P 55	5 +
Concealed below stream level.	

Correlation: Clay below Lower Bakerstown (Honeycomb).

SMALL FUEL MINE ON NORTH BRANCH OF CASTLEMAN RIVER, WEST SIDE OF RIDGELY HILL

The clay found between the coal causes considerable trouble, but if it could be utilized it would be valuable. There is a large body of coal and clay available and transportation is at hand as an old standard gage lumber tram passes within a few yards of the opening. The track would have to be relaid before using.

SECTION AT PLACE SAMPLED

	Feet
Concealed from top of hill to	
Thin-bedded sandstone	1.0
Thin-bedded shale	4.3
Coal with a few pyrite streaks	2.1
Clay parting, variable thickness P 58	.9 to 1.3
Coal with top 10 inches somewhat bony	3.2
Medium-bedded gray shale	1.5
Thin-bedded shale	1.2
Sandstone with iron ore nodules	2.7
Gray clay, somewhat iron-stained P 59	5.7
Concealed to stream	4.7

Correlation: Upper clay is parting in Davis or Upper Freeport coal. Lower clay is beneath Davis coal at the horizon of the Bolivar clay of Pennsylvania.

PROSPECT NORTH BANK OF NORTH BRANCH OF CASTLEMAN RIVER 26 FEET ABOVE STREAM AND 180 FEET 5 DEGREES WEST FROM MOUTH OF COAL MINE ON OLD LUMBER TRAM FROM DAVIS, MARYLAND, APPROXIMATELY 3 MILES SOUTHWEST OF GRANTSVILLE

This clay is excellent-looking material, most favorably situated on the old standard gage lumber tram leading to Davis where it connects with Jennings Railroad. It could be mined and shipped or turned into finished products as the operator desired. The Upper Freeport or Davis coal is opened in several places nearby and would furnish fuel for any operation. A large body of this clay should be available.

SECTION AT PLACE SAMPLED

	Feet
Top of hill.	
Concealed.	
Section in mine.	
Fissile shale	3.0
Coal	1.1
Slate	1.2
Concealed	12.0
Hard gray to bluish-black flint clay F 30	8.5
Soft gray clay (rather impure) P 57	2.5
Concealed	4.0
Tram level.	
Concealed to river bottom	10.0
River bottom is a massive sandstone.	

Correlation: Ellerslie or Lower Kittanning fire clay.

SMALL MINE ON BIG SHADE RUN, ONE MILE NORTHWEST OF GRANTSVILLE

This mine, or rather prospect, is in a very poor coal that is practically worthless. One foot of the clay above the coal is shot down to give headroom. The clay is thicker than one foot but its exact thickness could not be determined as neither the coal nor clay are exposed on the surface. This occurrence of coal and clay is not very promising because of the low grade of both and the distance from available railroad facilities.

SECTION AT PLACE SAMPLED

	Feet
Clay roof 1 foot removed P 56	1.0
(Too hard to get any more down without shooting).	
Mixture of clay, coal, slate, bone, and pyrite called the Slate Vein.	3.8
Shale floor.	

Correlation: Clay above the Upper Bakerstown coal.

CUT IN BALTIMORE AND OHIO RAILROAD, CORINTH, WEST VIRGINIA

At Corinth, West Virginia, there has been a considerable brick industry but at the time of the writer's visit the plant was idle. There is a large body of this clay available with plenty of fuel at hand. The bricks can be shipped over the Baltimore and Ohio Railroad which passes within a few yards of the plant. The only difficulty is the distance from the market. The railroad cut affords an excellent chance to study this clay.

SECTION AT PLACE SAMPLED

	Feet
Surface material.	6.0
Sandstone.	14.0
Coal smut.	1.0
Clay stained red and yellow	0.5
White plastic clay (sampled beside east pier of bridge) P 77.	6.8
Iron-rich sandstone.	2.0
Platy, shaly, sandstone	10.6
Coal smut.	.2
Black shale	1.5
White plastic clay P 78	2.0
Sandy shale	5 +
Railroad level.	

Correlation: Thornton clay.

CRELLIN, MARYLAND, TWENTY-FIVE FEET SOUTH OF PUBLIC ROAD BRIDGE OVER THE YOUGHIOGHENY RIVER

The clay exposed here is part of a considerable body of clay and together with the overlying coal may be quite valuable. Railroad facilities are close at hand, a standard gage railroad running from Crellin, Maryland, to Hutton, West Virginia, on the Baltimore and Ohio Railroad.

SECTION AT PLACE SAMPLED

	Feet
Coal exposed	2.7
Clay parting	.8
Soft clay iron-stained P 84	2.3
Sandy shale	5.+

Correlation: Clay beneath Davis or Upper Freeport coal, the horizon of the Bolivar clay.

CRELLIN, MARYLAND, 550 FEET SOUTH OF THE UPPER BRIDGE OVER THE YOUGHIOGHENY RIVER

At best this clay would not be better than a brick clay. On account of the distance from market it would not be easy to make the exploitation a profitable enteprise. The problem of transportation is not difficult due to the accessibilty of the lumber tram connecting Crellin and Hutton, W. Va., the latter being on the Baltimore and Ohio Railroad.

SECTION AT PLACE SAMPLED

	Feet
Coal blossom	0.2
Plastic clay with a 2-inch indurated band 16 inches from top. P 85	2.7
Sandy shale.	

Correlation: This probably is the Thornton clay.

OAK SHOALS, 110 FEET NORTH OF THE FORD ON STEEP BANK ABOVE TERRACE

This prospect is not a very promising one but inasmuch as the clay is in the split of the Lower Bakerstown or Thomas coal an attempt might be made in the vicinity to face up the coal and clay so that tests might be made on perfectly fresh material. However, this development would have to face certain difficulties of transportation, one of which would be bridging the Youghiogheny as the old tram which connects with the B. & O. R. R. at Kendall ends about 3½ miles down the river on the opposite bank.

SECTION AT PLACE SAMPLED

	Feet
Surface material.	
Blue-black slate	1.6
Band of impure limonite	0.5
Gray clay too much limonite to sample	1.2
Gray plastic clay P 83	2.7
Coal smut	0.2
Concealed to river	26.0

Correlation: Clay in the split of the Lower Bakerstown or Thomas Coal.

SMALL CLAY PROSPECT ON WEST BANK OF OAKLAND ROAD, ONE-EIGHTH MILE BELOW MARKLEY'S HOUSE ON TOWER'S PROPERTY

This prospect is a pit dug into a glade clay. Doubtless the material would make good common brick or possibly better grade of brick, but the deposit is so far from transportation that it could not compete with other deposits. The original sample was broken in transit to the Bureau of Mines testing plant and not replaced.

SECTION AT PLACE SAMPLED

	Feet
Surface material	1.0
Soft white clay, iron-stained in places. Contains many inclusions and also impresses resembling wad	5 +

SOUTH BANK OF SMALL STREAM ENTERING THE YOUGHIOGHENY RIVER FROM EAST JUST SOUTH OF COUNTY ROAD NEAR SWALLOW FALLS

This exposure of fire clay is an excellent one. The total thickness is 7.4 feet and an excellent body is apparently available. The old lumber tram runs within a few yards of the exposure. The grading is complete for a standard gage railroad along the river from the county road to Kendall where it connects with a branch of the Baltimore and Ohio Railroad. Fuel is close at hand though most of the coals are rather thin. Both flint and plastic clay are exposed; the flint clay is varicolored but not banded, the plastic clay is gray.

SECTION AT PLACE SAMPLED

Surface.	Feet
Black fossiliferous shale	1.9
Flint clay varied colors. F 38	3.4
Soft gray clay. P 81	4.0
Sandstone (argillaceous)	2.0

Correlation: Hardman or Furnace clay.

JOHN SINES' MINE, SINES P. O., MARYLAND

Mr. John Sines has opened a coal prospect near his home. This coal is overlain by a gray, plastic clay. The coal contains some bone and is not very thick. If the overlying clay is sufficiently high grade to warrant development it would be handicapped by the transportation cost because of its inaccessibility and distance from markets.

SECTION AT PLACE SAMPLED

Surface Materials.	Feet
Soft gray clay, a little iron-stained P 79	4.8
Bone	2.7
Good coal	0.8
Shale	

Correlation: Clay above Lower Kittanning coal.

COAL PROSPECT 114 FEET NORTH OF SWALLOW FALLS

This prospect is ideally situated on the old lumber road which runs down the Youghiogheny to Kendall where it joins a branch of the Baltimore and Ohio Railroad. The body of clay is of fair size but not very thick. However, the prospects justify the expenditure of some money in investigating this deposit. The coal immediately underlying the clay is thin but should furnish sufficient fuel for all ordinary use of a plant. The only drawback would be the high transportation cost as the charges on branch lines are higher than the main line.

SECTION AT PLACE SAMPLED

Surface.	Feet
Tough gray flint clay F 37	1.7
Yellow uron-stained clay	0.7
Gray plastic clay P 80	3.9
Coal, bony	1.5
Coal, good	1.5

	Feet
Slate	0.3
Coal.	
Heavy ferruginous shale in certain beds has a fire clay texture.	4.5
Black sandy shale	1.7
Heavy sandstone to river	20

Correlation: Ellerslie or Lower Kittanning fire clay.

KENDALL, MARYLAND, WEST BANK OF YOUGHIOGHENY RIVER S. 10°E. FROM PROSPECT IN COAL CONSIDERED FREEPORT ON MAP OF GRANTSVILLE-ACCIDENT FOLIO AND N. 60° W. FROM CLUBHOUSE ON EAST BANK OF THE RIVER

This exposure shows the presence of an extensive and reasonably thick body of clay. This outcrop presents a considerable excess of flint clay over soft clay. Plenty of fuel is obtainable in the vicinity. Transportation is at hand except that it would be necessary to bridge the Youghiogheny to reach the Baltimore and Ohio Railroad tracks at Kendall. Careful prospecting on the east bank of the river might expose this fire clay where it could be exploited more cheaply.

SECTION AT PLACE SAMPLED

	Feet
Hard flint clay F 39	2.5
Soft clay	1.0
Hard flint clay F 39	4.0

Correlation: This is probably the Mt. Savage or Clarion? fire clay.

THE TECHNOLOGY OF FIRE CLAYS AND FIRE CLAY REFRACTORIES[1]

BY

ARTHUR S. WATTS

Introduction

FIRE CLAYS

The term "fire clay" is undoubtedly either a contraction of the phrase "fire-resisting clay," or was introduced with that meaning implied. The term has unfortunately two distinct definitions: (a) (Technical) as referring to all fire-resisting clays, (b) (geological) as referring to coal measure clays or clays underlying coal beds.

The fact that in the search for fire-resisting clays the early investigator found the most abundant and satisfactory material underlying coal beds, and that the geologist has applied the name "fire clay" to all coal measure clays, on the ground that they are geologically similar, leaves no choice for the present writer but to accept the term "fire clay" as referring to coal measure clays, regardless of the degree of their refractoriness.

Ries[2] holds that no clay should be called a "fire clay" unless its fusion point is above that of cone 27 (approximately 1620° C. or 3002° F.). This would necessitate the substitution of another term for "fire clay" in geological literature if confusion is to be avoided in future, and in view of the fact that the geologic literature is so much more abundant than the technical literature on this subject it would seem wise to allow the term to stand as in geology and to technically classify our clays as regards their resistance to heat by use of the term "refractory." The words "feuer-

[1] Prepared under an agreement of cooperation with the United States Bureau of Mines.

[2] Clays, Occurrence, Properties and Uses, 1914, p. 205.

fest" and "réfractaire" are synonymous with the English conception of "refractory" as applied to ceramic materials.

The increasing use of the term "refractory" in technical literature dealing with fire-resisting materials will soon cause the term "fire clay," without outside effort, to become obsolete as a technical term.

The term "refractory" as employed in technical literature, is, however, not entirely satisfactory. The popular definition is "difficult to fuse." For technical use a minimum temperature should be indicated which the material must withstand in order to be so classified. Also a refractory may by the above definition be either a metal or a non-metal, whereas the present technical conception of a refractory limits it to non-metals.

CLASSIFICATION OF REFRACTORIES

Refractories may be classified under either of two systems: (a) Technical or (b) industrial.

(a) Under the technical classification all refractories are divided into acids, bases, neutrals, carbon, artificial compounds, and clays.

The acid refractories include SiO_2, ZrO_2, TiO_2, and ThO_2.

The basic refractories include CaO, MgO and calcined dolomite (CaO, MgO).

The neutral refractories include Al_2O_3, Cr_2O_3 and Fe_2O_3.

Carbon includes the various forms of graphite.

Artificial compounds include carborundum and crystalon (SiC), fire sand ($SiC+SiO_2$), alundum (crystalline Al_2O_3), synthetic sillimanite (Al_2O_3, SiO_2) magnesia spinel (MgO, Al_2O_3), aluminum nitride (AlN), and boron nitride (BN).

The clays include all natural aluminum silicates belonging to the kaolin group and so classified according to mineralogical and geological systems.

(b) Under the industrial classification, all refractories are divided into acid, basic and carbon refractories.

This classification is based on the resistance of the refractory to the action of acid and basic slags and to the corrosive action of fused metals.

A refractory may by this classification be considered an acid, basic or neutral refractory even though it contains a considerable amount of material of other classes.

According to the technical classification the clay refractories are a separate group. In the industrial classification a clay refractory may be either acid or basic, dependent upon its exact mineral composition.

LAWS CONTROLLING THE BEHAVIOR OF REFRACTORIES

A refractory element or compound is rarely improved as regards resistance to fusion by being combined with any other element or compound, even though it belongs to the same chemical group. The crystalline combinations with carbon and nitrogen, known respectively as carbides and nitrides, are the recognized exceptions to this rule and in most such cases the increase in refractoriness is evidenced in stability rather than actual increase in fusion temperature.

When two or more refractories are heated together, a mixture known as an eutectic generally develops.

An *eutectic* is defined as a mixture of two or more elements or salts in such proportions that they are mutually miscible or soluble in each other. Such a mixture remains in a fused or fluid state to the minimum fusion temperature of any mixture of the components involved. If any of the components are present in excess of the eutectic proportion, the mixture is rendered more refractory in proportion to the amount of excess present and the fusion temperature of the component present in excess.

Most elements combine with one another to form *compounds* which are stable chemical combinations having definite compositions and properties. Compounds remain fused at temperatures visibly higher than the adjoining mixtures in the series and eutectics generally exist between such compounds and the end members of the series. The development of a compound is evidenced by an absorption of heat which is not the case in the formation of an eutectic which is merely a mixture. The heat absorption and the increase in fusion temperature due to the formation of a compound may be so small, however, that only by the most delicate instruments can the existence of a compound be detected. The fusion phenomena with the accompanying development of compounds and eutectics is well illustrated in the CaO, SiO_2 series. (See Fig. 12.)

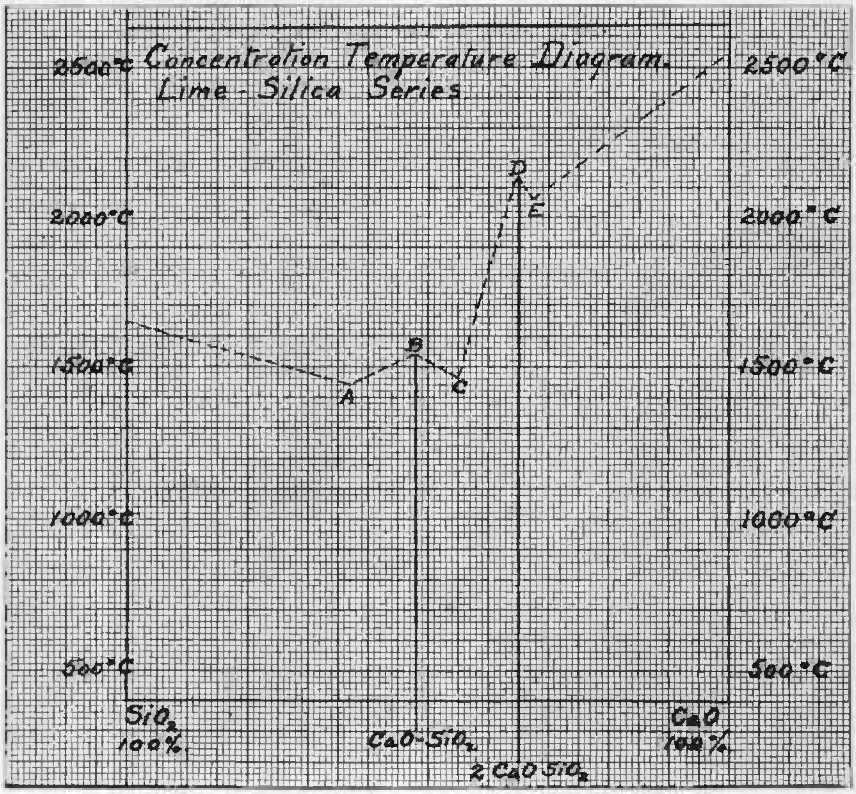

FIG. 12.—TECHNOLOGY OF FIRE CLAYS AND FIRE CLAY REFRACTORIES.

A = Eutectic between SiO_2 and B.
B = Compound CaO-SiO_2.
C = Eutectic between B and D.
D = Compound 2 CaO-SiO_2.
E = Eutectic between D and CaO.

NOTE.—3 CaO-2SiO_2 also separates within narrow limits of concentration and temperature.

ISOLATION OF THE DIFFERENT CHEMICAL GROUPS OF REFRACTORIES is vitally important if their high fusion temperatures are to be retained. While the different members of any single chemical group may suffer in fusion temperature if associated or intimately mixed, the lowering in fusion temperature due to the formation of eutectics is seldom serious, or far below the fusion of the most easily fusible member of the mass. If, however, a member of one group is mixed or even brought in contact with a member of another group, the resultant compound, eutectic, or mixture may be so easily fusible as to render it unfit for any refractory use. An example of such lowering of fusion temperature is observed when calcium oxide and silicon dioxide are mixed or brought into contact at elevated temperatures. Calcium oxide fuses at 2572° C. which classes it as one of the highest grade refractories. Silicon dioxide (silica) fuses at 1625° C. which classes it as a very high-grade refractory. When these two refractories are permitted to combine, an eutectic forms, consisting of 37 per cent calcium oxide and 63 per cent silica and this eutectic fuses at 1436° C., which is distinctly below the fusion temperature of any commercial refractory.

When mixing or even contact of members of two refractory groups is unavoidable, the least injury will result if one of the groups is the neutral group. The greatest injury results when a member of the base group and a member of the acid group combine. This isolation of the different refractory groups is well illustrated in the arrangement of the lining of the modern open-hearth steel furnace. The walls and crown of such a furnace are constructed of silica brick while the hearth is constructed of magnesite brick. Between the walls and the hearth a course of neutral chrome brick has for years been introduced to insulate the highly acid walls and crown from the highly basic hearth. The necessity for this course of chrome brick was obviated during the war period by carrying the magnesium brick up into the walls a sufficient distance so that the heat radiation through the walls would not permit a sufficient temperature to exist to cause the development of an MgO, SiO_2 eutectic.

THE RATE OF FUSION OF A REFRACTORY is almost as important as the temperature of fusion. When the fusion temperature is sufficiently high, so that the mass does not approach it in use, the rate of fusion may generally be ignored, but if the temperature of industrial application approaches within a hundred degrees of the fusion temperature, a refractory having a rapid fusion rate would not be considered practical.

Time as well as temperature must also be considered in the selection of a refractory as it is a vital factor in the fusion process. A mass may fuse at a given temperature when exposed to that temperature for the minimum time. If exposed to a much reduced temperature for a long time, however, the same degree of fusion may result, and the limit of temperature which a refractory can resist continuously is frequently more than a hundred degrees below the fusion temperature as determined for minimum time of exposure.

ATMOSPHERIC CONDITIONS to which a refractory is exposed at elevated temperatures must also be considered. Refractories containing carbon as graphite or coke are very unstable when exposed to oxidizing gases. The carbon oxidizes to carbon monoxide or dioxide both of which are gases and the refractory becomes a skeleton made up of the bonding material with the carbon refractory lost.

MECHANICAL STRENGTH is often vitally important, particularly in the construction of arches or walls upon which a load must be supported. Most high-grade refractories are friable or low in bonding strength and the introduction of sufficient bond or fluxing material to render them mechanically strong would so lower their fusion temperature as to ruin them for service as refractories.

IMPERVIOUSNESS TO GASES OR SLAGS is frequently a necessary requirement in a refractory and this like the requirement of mechanical strength in a refractory limits the field of usefulness of many otherwise ideal refractories. In fact, resistance to the corrosive action of gases and slags often demands a greater degree of density in a refractory ware than would be necessary if mechanical strength alone was considered. Some services require that the refractory be completely vitrified. This raises the question of the definition of vitrifiication.

VITRIFICATION is a very indefinite term because of the fact that it is used both as a technical and a commercial term. In a purely technical sense, vitrification implies absolute non-absorption accomplished by the absolute closing of the pores or interstices between the particles making up the mass, and complete imperviousness of the particles themselves. This is a practical impossibility as evidenced by the fact that investigators have been able to draw liquids through solids that had previously been declared impervious. A porcelain used for the most exacting scientific work should not show an absorption of more than 0.01 per cent and most of this should be held in minute surface cavities. A vitreous floor tile, to insure against permanent discoloration in service, should not absorb more than 0.1 per cent. The purely commercial application of the word vitrification means only sufficient density to develop maximum mechanical strength and prevent injury as a result of the freezing of absorbed water.[1]

Vitrification as the result of heat treatment is progressive and for convenience has been divided into the following stages: Condensation, incipient vitrification, complete vitrification, viscous vitrification and fusion.

Condensation is that stage in which the colloidal and finest grained amorphous grains contract, causing a distinct shrinkage and rendering the mass dense but not non-absorbant.

Incipient vitrification is that stage in which the finest and most fusible particles begin to fuse producing a conglomerate of the coarse grains bonded together by the semi-fused fine grains.

Complete vitrification is that stage in which all the mass shows signs of fusion, the finest and most fusible particles having lost their mineral identity while the coarser particles are merely fused on their surfaces. At this stage the mass generally possesses its maximum mechanical strength.

Viscous vitrification is that stage in which the mass will support its own weight without distortion but if pressure is applied, the mass distorts or loses its shape.

Fusion is that stage in which the mass can no longer support its own weight and deforms without the application of pressure.

FINENESS OF GRAIN.—The progress of vitrification indicates the importance of grain-size in refractory materials. The finer the particles, the more easily will the mass be brought to a state of fusion. This is

[1] See "The Legal Definition of Vitrification"—Edward Orton, Jr.—A. S. T. M., Vol. XV, Part II, p. 245.

especially true when impurities are present, or the refractory consists of ingredients which form eutectics, which corrode or dissolve the remaining constituents of the mass. The greater the number of particles to a given weight of material the greater the surface area will be and hence the solvent will have a proportionately greater surface exposure to attack. Also the smaller the particle, the lower the resistance to heat penetration which influences the time necessary for vitrification to progress to a state of fusion.

BINDERS FOR REFRACTORIES.[1]—The necessity for some form of binder in the manufacture of ware from refractory oxides and compounds must be thoroughly understood and carefully considered if best results are to be obtained. If an intimate mixture of a mineral bond and the refractory is produced, there will be pyro-chemical activity as soon as the temperature is sufficient to permit the eutectic of the constituents to form. When this solvent forms, it begins dissolving the excess refractory constituent and this solvent action progresses with time and temperature until the mass becomes fluid.

In order to retain the maximum degree of refractoriness it is, therefore, important that the minimum amount of eutectic be permitted to develop. To accomplish this and at the same time develop the requisite density and mechanical strength, the proportioning of grain-size of the refractory is vitally important. The grains for ideal results should be proportioned so that the minimum number of small grains will be required to fill the interstices between the large grains. Thus with the surface area and the void space minimum, the amount of solvent necessary to coat the grains and fill the voids is minimum and the degree of refractoriness is maximum. In most cases the refractory is bonded with a mineral which lowers the fusion temperature of the mass but this is not always the case. Some excellent refractories have been made recently by bonding the grains of refractory with very finely pulverized material of the same composition or by using a hydrate of the same element as the refractory. The earlier fusion of this very finely divided material permits the mass to

[1] See "Refractory Oxides"—R. B. Sosman—Geophysics Laboratory.

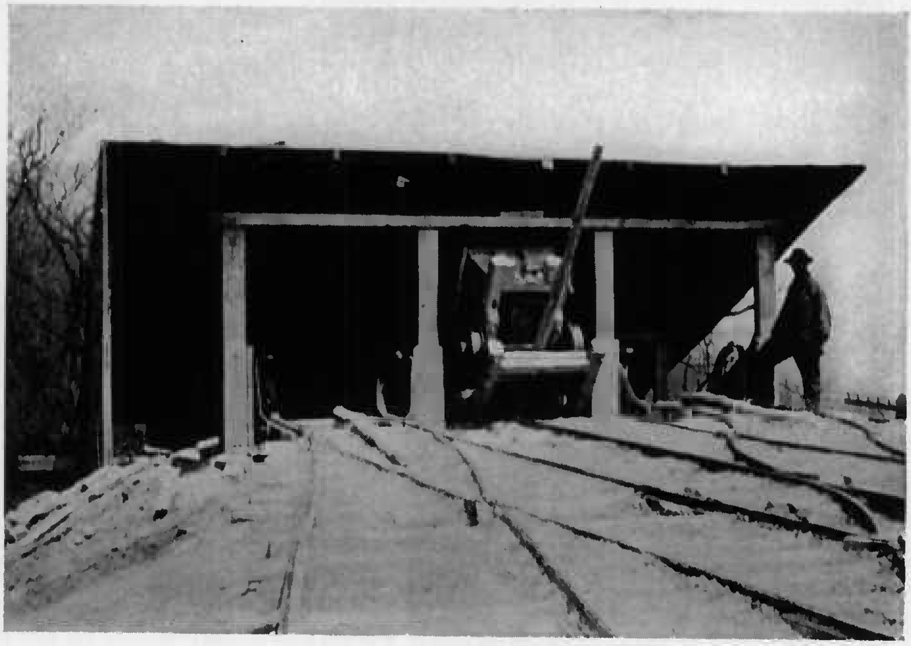

FIG. 1.—VIEW OF TIPPLE AT MINE NO. 5 OF THE UNION MINING COMPANY.

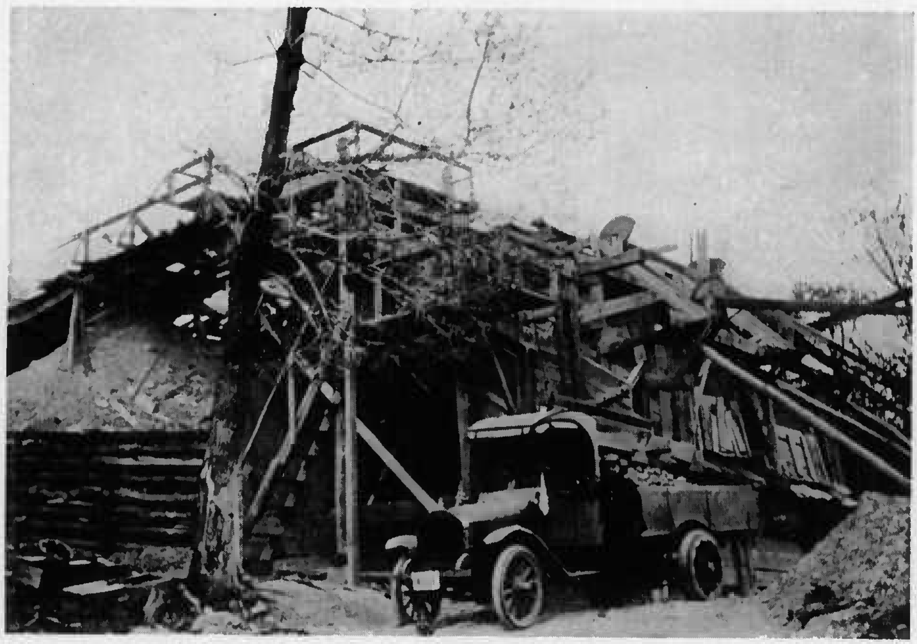

FIG. 2.—VIEW OF TIPPLE AND AUTO TRUCK OF CALDWELL MINE.

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be properly vitrified without injury or distortion. The expense involved in grinding a portion of the mass to the necessary fineness and the expense of burning the ware to a temperature at which a bond develops between the very fine powder and the coarse refractory grains makes the manufacture of one-component refractory ware so expensive that up to the present time it has only been used in special cases where the amount of refractory is small and the service requirements are extremely severe. When the cost of installation and the time lost in replacement are considered, however, it is apparent that many more cases exist where the use of a one-component refractory would result in a reduced cost of production and increased profits.

The low content of bond employed makes the molding of special shapes very difficult and an organic bond is frequently added to the mixture. This adds to the strength of the formed ware during the drying process and lessens the losses from cracking and chipping prior to burning. The addition of organic material must be limited in amount, however, as it burns out and leaves the mass with innumerable minute cavities.

The organic bond is generally in the form of starch or flour. Rye flour is found particularly well adapted to this use as it seems to have more strength than wheat flour. Petroleum and coal-tar bonds have been tried but with mediocre success.

RADIATION VS. INSULATION.—The problem in many cases is how refractory a material can be provided and also meet the other requirements. This may call for sacrifice of heat in order to use a practical refractory. In such cases the refractory must be only of sufficient thickness to support the mechanical load. This will allow sufficient radiation so that only one face of the refractory ware will attain the temperature of the interior of the furnace and the remainder of the mass will be safely below the limit of operating temperature. This method of protecting refractories by permitting radiation, while expensive in fuel consumption, is intensely practical. Kiln crowns that have proven satisfactory in years of service have failed completely in a few burns when covered with a thin layer of insulating material, as kieselguhr (diatomaceous earth). Attempts to reduce further the fuel consumption of the modern tunnel kiln by excess heat insulation have proven disastrous even though the highest grade of clay fire-brick were used. Whether another refractory of superior grade could be substituted for the clay fire-brick and a more complete heat insulation maintained with financial profit is a question.

In the steel furnace the silica brick form only a thin-walled construction and the life of a wall of 4 inches thickness is many times greater than that of an additional 4 inches of wall, due entirely to the protection provided by heat radiation.

CLAY REFRACTORIES

A clay refractory is a refractory which contains clay as its predominating raw constituent.

According to Orton, "Clay is an earthy or stony aggregate sometimes consisting largely of a single mineral, but usually made up of many different kinds. It is generally but not necessarily plastic when ground or kneaded with water. It contains as its essential some form of hydrated silicate of alumina. When the amount of this ingredient falls so low in the mixture as to no longer impart its characteristic properties to an appreciable degree, the mixture is no longer called clay."

The exact mineral identity of this hydrated aluminum silicate essential of clay is one of the subjects of controversy in ceramics. Its chemical composition varies within rather narrow limits and its physical properties vary within wider limits so that there is reasonable doubt if it is a single mineral or rather a group of minerals or perhaps merely an intimate mixture of oxides and hydrates. Of the hydrated aluminum silicates, Dana recognizes among others the following minerals:

Collyrite	$2Al_2O_3$	SiO_2	$9.0\,H_2O$
Allophane	Al_2O_3	SiO_2	$0.5\,H_2O$
Kaolinite	Al_2O_3	$2SiO_2$	$2.0\,H_2O$
Halloysite	Al_2O_3	$2SiO_2$	$2.0\,H_2O$ + aqua
Newtonite	Al_2O_3	$2SiO_2$	$4.0\,H_2O$ + aqua
Pyrophylite	Al_2O_3	$4SiO_2$	$1.0\,H_2O$
Montmorillonite	Al_2O_3	$4SiO_2$	$1.0\,H_2O$ + aqua

All of these minerals have been identified as constituents of clays, but not any one with sufficient uniformity to justify an assumption as to its constituting the essential of even a small group of clays. Kaolinite was at one time considered as the vital constituent of all clays but it is now recognized as a crystalline mineral having the chemical composition indicated by Dana and possessing few of the physical properties attributed to the essential constituents of clays. While known to exist in some clays its occurrence is comparatively rare.

The term "kaolin" is generally recognized by ceramists as an amorphous mineral having a composition very similar to kaolinite but geologists have defined it as a primary or residual clay derived from altered or decomposed feldspar. Ries[1] defines kaolin as "a residual clay derived from a rock composed entirely of feldspar or one containing little or no iron oxide, and burning white." The hydrated aluminum silicate in some clays and in some clay refractories is recognized as kaolin, but in the majority of cases the clay is not residual and hence not a kaolin. In most high-grade clays, whether primary or secondary in nature, the essential constituent more closely resembles kaolin in composition and properties than any other recognized mineral.

For convenience in referring to this essential in clays various writers have created terms, none of which have come into sufficiently general use to avoid confusion. The term "clay" is too general. The term "pure clay" has been suggested, but is condemned because the word clay, as defined, is a mixture of minerals of which the pure clay would then be one. The term "kaolinite" cannot be employed without confusion on account of its established mineral definition. The term "clay substance" is probably as nearly applicable to this essential clay constituent as any term available.

It has been in use for many years as representing that portion of any clay which has a grain-size of 0.01 mm. diameter and less. With plastic clays a mechanical separation of clay substance from other clay constituents is practical, but in semi-plastic and flint clays such a separation is obviously impossible and hence a mechanical method of determining the clay substance in clays in general must be recognized as impracticable.

[1] Clays, Occurrence, Properties and Uses, 1914, p. 8.

The chemical determination of clay substance in clay has caused some confusion because by treatment with hot sulphuric acid any muscovite present is dissolved along with the hydrated aluminum silicate. The chemical analytical process should be modified by the determination of the alkali in sulphuric acid solution, its calculation as muscovite and by making the necessary correction in the amount of clay substance reported.

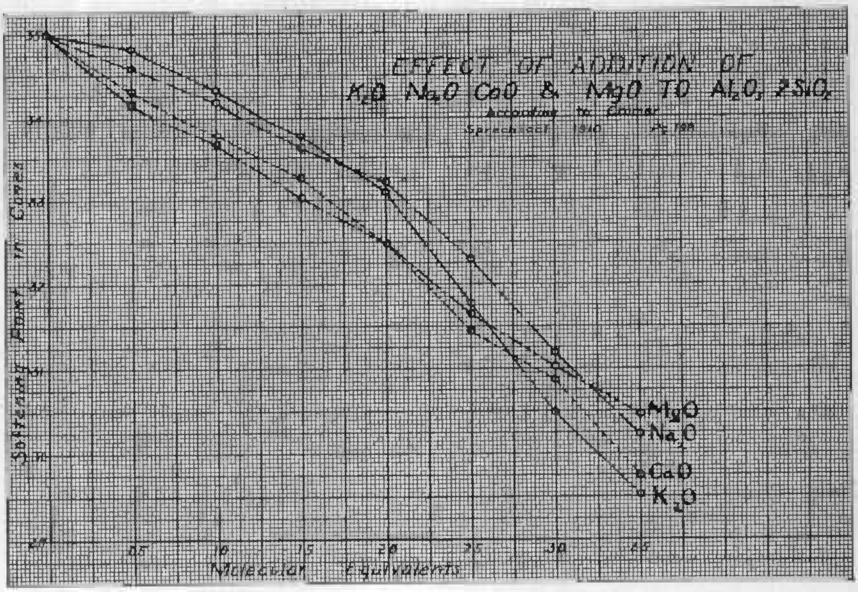

FIG. 13.—TECHNOLOGY OF FIRE CLAYS AND FIRE CLAY REFRACTORIES.

K_2O ———·
Na_2O — — —
CaO - - - - - -
MgO — - — -

Ries [1] reports the term "clay substance" as sometimes used in referring to kaolinite but as the latter is crystalline while the essential clay constituent is almost invariably amorphous, any such misuse of the word would be easily detected.

The term "clay substance" is therefore recommended for use in referring to the amorphous hydrated aluminum silicate essential in clay, regardless of the proportions of Al_2O_3, SiO_2 and H_2O present.

[1] Clays, Occurrence, Properties and Uses, 1914, p. 42.

Clay refractories are, therefore, aluminum silicates after dehydration. Any other elements beside Al_2O_3 and SiO_2 present in the burned refractory may be considered as impurities even though they do not lower its value as a refractory.

If the impurity be an acid, as ZrO_2, or a neutral, as Cr_2O_3, the refractory value of the product may not be appreciably lowered or may even be

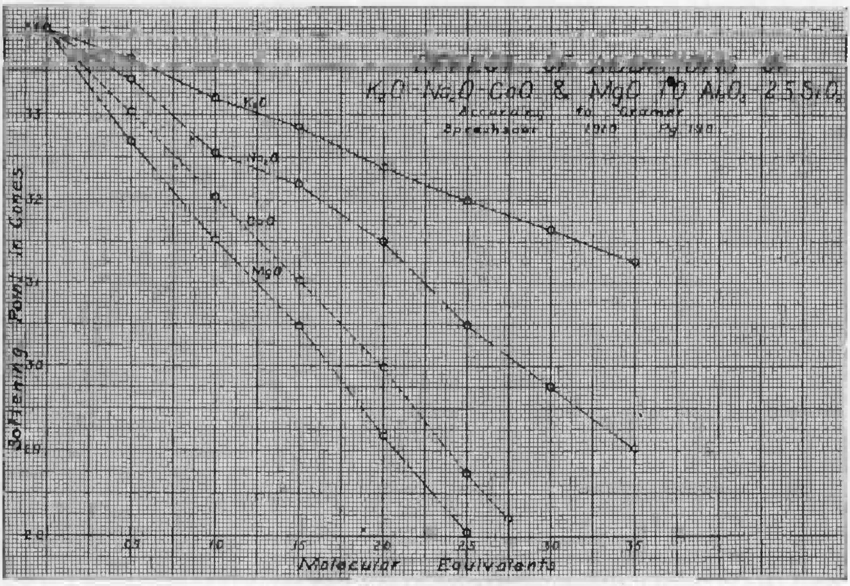

FIG. 14.—TECHNOLOGY OF FIRE CLAYS AND FIRE CLAY REFRACTORIES.

K_2O ———
Na_2O — — —
CaO - - - - - -
MgO — - — -

increased, but according to the work of Cramer, the introduction of even 0.1 equivalent of a base will lower the refractory value of a kaolin one cone and the introduction of 0.2 equivalent will lower the refractory value more than two cones. (See Fig. 13.)

Cramer found that the addition of an alkaline earth to an Al_2O_3, 2.5 SiO_2 mixture was much more injurious than Richter reported for kaolin. The effect was not according to Richter's law that "equal molecular additions of alkali or alkaline earth lowers the fusion temperature the same amount." Cramer found that the activity of the fluxes increased in the following order: K_2O, Na_2O, CaO, MgO, and that in mixtures of kaolin + 0.5 SiO_2 the CaO and MgO were much more active than in kaolin, the NaO_2 was about the same activity while the K_2O was less active. (See Fig. 14.)

The work of both Richter and Cramer was with additions of a single base only and no work was done with two or more bases present in the same mixture.

The work of Ferguson and Merwin[1] shows that while 37 CaO and 63 SiO_2 form an eutectic melting at 1436° C. and 44 MgO and 56 SiO_2 form an eutectic melting at 1543° C., a three-component eutectic of 30.6 CaO, 8 MgO and 61.4 SiO_2 melts at 1320° C.

The work of G. A. Rankin[2] shows that 23.25 CaO, 14.75 Al_2O_3, and 62.0 SiO_2 forms an eutectic melting at $1170 \pm 5°$ C.

The work of Rankin and Merwin[3] shows that 20 MgO, 19 Al_2O_3, 61 SiO_2 form an eutectic melting at 1350° C.

No work has been published on the K_2O, Al_2O_3, SiO_2 and Na_2O, Al_2O_3, SiO_2 series except the feldspar-clay-flint studies of Simonis,[4] but all indications point to the same relative lowering of the refractory value of clays as by additions of CaO and MgO. It is thus apparent that even very small additions of bases have a distinctly injurious effect on any clay in which they are present.

THE INJURIOUS MINERALS ASSOCIATED WITH REFRACTORY CLAYS are not numerous and every manufacturer should have sufficient knowledge of their characteristic appearances and properties to enable him to condemn material in which they are present in dangerous amount.

[1] Geophysics Laboratory, Amer. Jour. Sci., 4th Ser., Vol. 48, August, 1919, pp. 81-123.

[2] Geophysics Laboratory, Amer. Jour. Sci., 4th Ser., Vol. 39, January, 1915, pp. 1-79.

[3] Geophysics Laboratory, Amer. Jour. Sci., 4th Ser., Vol. 45, April, 1918, pp. 301-325.

[4] Sprechsaal, 1907, No. 30; Watts, Trans. Amer. Cer. Soc., Vol. XV, 1913, p. 144; and Wilson, Trans. Amer. Cer. Soc., Vol. XV, 1913, p. 217.

The feldspars are alkaline silicates of alumina. They are white, cream, buff or salmon in color (rarely green) and are generally opaque to the naked eye when associated with refractory clays. The grains have two distinct cleavages at about 90°. The unweathered grains are slightly softer than quartz, but if weathered the hardness is indefinite. The feldspars are the principal source of alkalies in clays. The potash feldspars, microcline and orthoclase (K_2O, Al_2O_3, 6 SiO_2) may contain as much as 16.9 per cent potassium oxide although this may be replaced in part by sodium oxide or in small amount by calcium or barium oxide. The soda feldspar, albite (Na_2O, Al_2O_3, 6 SiO_2) may contain as much as 11.8 per cent sodium oxide although this may be replaced in part by potassium oxide and almost invariably is replaced in considerable amount by calcium oxide. The calcium feldspar, anorthite (CaO, Al_2O_3, $2SiO_2$) may contain as much as 20.1 per cent calcium oxide although it rarely occurs free from potash and soda impurities. The association of calcium and sodium feldspars is so nearly universal and in such a variety of proportions, that a series known as the *plagioclase feldspars* has been developed forming a continuous chemical series from albite to anorthite.

The micas are of two varieties, the transparent mica, muscovite (KlH_2), $Al_3(SiO_4)_3$ and the black mica (biotite), which is similar to the transparent mica in chemical composition except that the Al_2O_3 is largely replaced by Fe_2O_3 and MgO. The micas have typical foliated structure, *i. e.,* the cleavage is so pronounced that they can be split into exceedingly thin sheets. The muscovite sheets are very elastic while the biotite is only slightly so and frequently quite brittle.

Calcite ($CaCO_3$) is a soft transparent to opaque mineral generally white or slightly tinted. It can be readily cut with a knife and dissolves readily in cold dilute hydrochloric acid, with violent effervescence due to liberation of carbon dioxide.

Gypsum ($CaSO_4$, $2H_2O$) resembles calcite on first inspection but differs in being soluble in dilute hydrochloric acid only on heating and the violent effervescence is lacking.

Gypsum also yields water when heated in a closed tube. It is softer than calcite, being easily cut with the finger nail.

Hematite (Fe_2O_3) is easily recognized by its characteristic red-brown color and earthy appearance. It develops an intense red color on slight heating. It dissolves easily in hot hydrochloric acid without effervescence.

Siderite ($FeCo_3$) is generally brown and changes on slight heating to the typical iron red. It dissolves in hot hydrochloric acid with effervescence.

Pyrite (FeS_2) is recognized by its pale brass yellow color and metallic appearance. It is popularly known as "fool's gold." It yields a distinct odor of sulphur on heating.

Rutile (TiO_2) generally occurs as minute particles, often needles of yellow, brown or red-brown color. It has a hardness equal to or greater than feldspar. It is practically insoluble in hydrochloric acid.

Ilmenite (FeO, TiO_2) occurs like and is generally associated with rutile. Its color is iron-black and it is frequently magnetic.

The importance of avoiding clays which contain impurities in dangerous amounts is obvious. However, since the presence of some impurity is almost unavoidable, the relative danger from the different minerals mentioned is worthy of serious consideration.

The danger resulting from feldspars is graphically illustrated in Fig. 3, and discussed in introducing clay refractories. The danger from calcium oxide is discussed under the same heading. The danger from gypsum is the same as from calcium oxide. The open structure of all refractory wares during the early stages of firing permits the elimination of the sulphur in gypsum and hence it does not constitute an added objection of great importance. The danger from the micas depends upon the variety present. Muscovite is generally granular, that is, its fluxing action is not apparent except within a very narrow radius about the grains or flakes. Rieke[1] found that 40 per cent of muscovite did not reduce the fusion temperature of a pure kaolin more than 60° C. The introduction of biotite with its mixed fluxes constitutes a real menace and its presence is a signal for caution as it indicates the presence of three fluxes, K_2O, MgO and FeO.

[1] Sprechsaal, 1907, Nos. 29 and 30 and 1908, No. 42.

The size of grain of the injurious minerals present is an important factor in determining the danger which their presence introduces. If finely divided and distributed the impurity may condemn a clay while if the same amount is present as a few coarse particles, the practical utility of the clay may not be seriously injured. This is especially true with the iron-bearing impurities.

IRON OXIDE AS A FLUX

According to Bleininger and Brown[1] "this substance in the finely divided condition is one of the most potent fluxes, and hence its presence in fire clays is very injurious as regards their behavior when subjected to higher temperatures. When present in the form of coarser particles, occurring as siderite or pyrite, its effect is not so marked, since evidently the action is proportional to the surface factor, *i. e.,* the fineness. At the high temperatures to which refractories are exposed the ferric oxide of the clay dissociates to one of its lower forms. According to Le Chatelier this dissociation takes place at 1300°, according to White and Taylor at 1200°, and to P. T. Walden at 1350° C. The last-named value represents probably the most reliable result. At this temperature the dissociation pressure reaches 160 mm., which is equal to the oxygen pressure of air. Ferric oxide hence cannot exist above this temperature. While this limiting temperature corresponds to the reaction

$$3Fe_2O_3 \rightleftarrows 2Fe_3O_4 + O$$

it does not seem probable that the magnetic oxide would persist at the temperatures involved in contact with a silicate of the fire-clay type. The reduction under these conditions very likely results in FeO, which at the temperatures involved would at once combine with silica to form ferrous silicate. This change is hastened by the reducing condition which usually prevails in the atmosphere of fire-brick kilns. Larger lumps of iron oxide embedded in the clay mass may consist in part of ferro-ferric and ferrous oxide, but the finely divided oxide may be assumed to be only FeO. The reaction between the latter and silica progresses very rapidly,

[1] Technologic Papers, U. S. Bur. Standards, No. 7, 1911, pp. 28-29.

and owing to the low fusion temperature of the ferrous silicate the resulting slag is very corrosive and attacks the clay vigorously. From the work of Cramer it appears that iron oxide is an active flux with the clays of the formula Al_2O_3, 2.5 SiO_2 while it is less active in fire clays approaching more closely the kaolin formula. The addition of 0.2 equivalent $Fe_2O_3 = 0.4\ FeO$ sufficed to lower the softening temperature of a clay mixture of the formula Al_2O_3, 2.5 SiO_2 from cone 34 to cone 27. Ferrous silicate, $FeSiO_3$, has been estimated to fuse at 1110° C. in a reducing atmosphere. However, this value is probably too low. The viscosity of the ferrous silicates is quite low, as has been shown by Greiner, while ferric oxide acts in the opposite direction and increases the viscosity of silicate fusions. The softening temperatures given by Hofman for various ferrous silicates are as follows:

	°C.
4FeO.SiO	1280
$3FeO.SiO_2$	1220
$2FeO.SiO_2$	1270
$3FeO.2SiO_2$	1140
$4FeO.3SiO_2$	1120 "

THE TYPICAL CLAY REFRACTORY

The typical clay refractory has a chemical composition in the raw or unburned state practically the same as kaolinite—Al_2O_3, $2SiO_2.2H_2O$, *i. e.,* Al_2O_3, 39.8 per cent, SiO_2, 46.3 per cent, H_2O, 13.9 per cent.

If the Al_2O_3 content is materially increased above the amount present in kaolinite the refractory is known as an "aluminous clay refractory." If the SiO_2 content is materially increased above the amount present in kaolinite the refractory is known as a "silicious clay refractory."

The refractory value of the various alumina-silica mixtures is grapically illustrated by the accompanying diagram. (See Fig. 15.)

The *aluminous clay refractories* are generally produced by mixing a typical refractory clay with bauxite, which has a composition $Al_2O_3.1 + H_2O$. The Al_2O_3 content is sometimes in this way increased in the refractory up to a composition $Al_2O_3.0.5\ SiO_2$.

When bauxite is employed in compounding a refractory in such amount that the Al_2O_3 exceeds the SiO_2 in chemical equivalents the product generally takes the name bauxite refractory. Among aluminum silicates there is only one compound, which is stable at high temperatures. This is sillimanite—$Al_2O_3.SiO_2$ (63 per cent Al_2O_3, 37 per cent SiO_2) which crystallizes out of nearly all vitreous aluminum silicate masses, in needle-like crystals. These are found in most aluminous clay refractories.

The *silicious clay refractories* are generally produced from clays in which the silica content exists in the clay in excess of that indicated by the typical refractory clay or kaolinite formula. The clay may be a

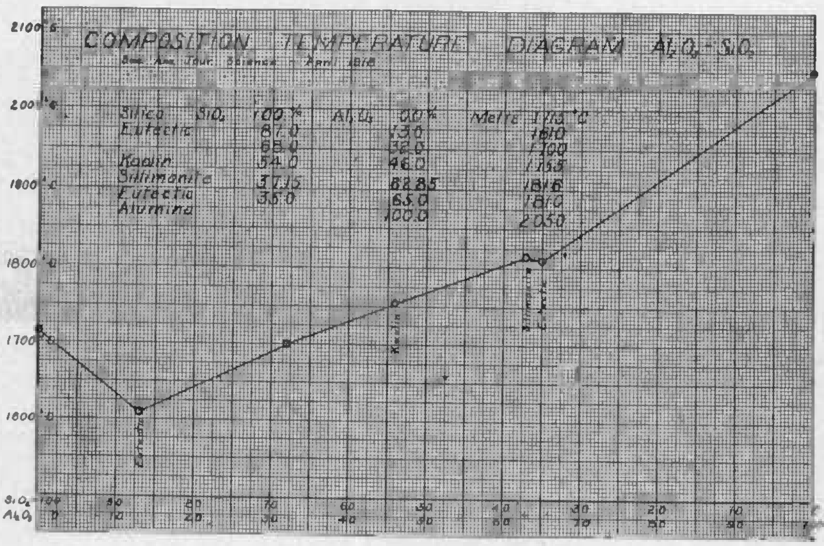

FIG. 15.—TECHNOLOGY OF FIRE CLAYS AND FIRE CLAY REFRACTORIES.

primary kaolin in which the excess silica occurs as quartz particles of various sizes which originally were distributed through the pegmatite mass, from the feldspar of which the kaolin was produced. The clay may also be a secondary clay in which the excess silica was deposited with the clay at the time of its deposition. The clay may also be a typical refractory clay to which the pure silica has been added as a fine sand or powder in the manufacturing process.

Typical clay refractories are sometimes made from a single clay but are generally made up of a mixture of two kinds of refractory clays, (a) a plastic clay with a relatively high drying shrinkage and burning to a marked density at about 1200° C and (b) a less plastic clay with a low drying shrinkage and open burning at 1200° C. The first or plastic clay is commonly known as plastic fire clay and its increased density is due chiefly to increased flux content. The second or less plastic clay may be either a highly refractory clay or a flint fire-clay. The flint fire-clay derives its name from its similarity in appearance, fracture and hardness to chert. It develops little plasticity even when thoroughly pulverized, and in very few cases does it show measurable drying shrinkage. Flint clays, however, show a burning shrinkage equal to that of most kaolins and hence in refractory manufacture it is found advisable to previously calcine and crush any flint clay used. If a flint fire-clay is not employed as the principal refractory constituent of the ware, it is customary to employ a kaolin in the crude state in which it is mined or a high-grade secondary clay other than a fire clay. When flint fire-clay is used it should be calcined prior to introduction into the mixture, but this practice is not universal, many manufacturers calcining only a part of the flint clay added, and in rare cases it is added entirely raw.

The crude kaolin is never calcined but its high silica content gives it a rather low burning shrinkage which is the object attained by calcining the flint clay and other secondary clays. A very general practice in the manufacture of refractory wares is to make up the mixture of a certain proportion of crushed fire-clay ware previously burned but rejected on account of flaws or imperfect burning. This material is known as "bats" or "grog." It is crushed to different degrees of fineness dependent on the ultimate use of the ware into which it is to be introduced. If the ware is to be exposed to sudden temperature changes and special resistance to spalling or surface scaling as a result of such treatment is of primary importance, the grog or calcined portion should be as coarse as practical. If resistance to heat penetration is an important consideration, the previously burned portion should likewise be as coarse as will permit satisfactory molding. If the product is to be exposed to the action of corrosive slags or gases or must withstand the abrasive action of ores, or other hard materials, the previously calcined portion should be of as fine grain as possible without injury to the refractory qualities of the product.

The relative merits of clay refractories using the different forms of non-plastic or calcined material are not settled and probably will always remain a subject for dispute. The purity of the non-plastic as regards flux is probably the greatest single factor to be considered.

WEATHERING OF PLASTIC CLAYS

Since the degree of plasticity is a vital factor in determining the amount of plastic material required for the proper bonding of a clay refractory in the unburned state, the weathering of a plastic fire clay or bond clay is often of great importance as the bonding strength is thus greatly increased in most cases.

Weathering, as it is referred to in the treatment of raw clays, involves exposure to both summer and winter weather. This includes repeated wetting by rain and subsequent drying and also repeated freezing and subsequent thawing. Weathering has also a distinct influence on the refractory value of most clays since any soluble salts present are taken into solution and at least partly removed. True flint fire-clays are not influenced by weathering as regards refractoriness since they are impervious to water, but semi-flint clays which possess plasticity in a very limited degree are frequently distinctly improved as regards refractoriness, although their drying shrinkage is generally increased at the same time. The merits of pulverizing a clay prior to weathering are questionable as the mass of material packs much more rapidly when in this state than when in coarse lumps and moisture has less opportunity to penetrate into the mass.

PREPARATION OF THE CLAYS FOR MOLDING

While the non-plastic constituents may be coarse or fine, depending upon the ultimate service requirements of the product manufactured, the plastic or bond clay should always be as finely divided as practical since the amount required decreases in proportion to the fineness of grain of this constituent and the refractory value of the product is thus proportionately increased. If the bond clay is of a shaly nature and does not slake readily when wet, it should be first crushed by rolls or a jaw crusher if neccssary, and then reduced to the desired fineness of grain. The non-plastic is then added. The mixing or pugging process now begins and for this there are two different types of machines employed: (a) The wet pan in which the mixture of clays, etc., are placed in a shallow horizontal circular machine in which wheels or discs travel, stirring and mixing the material until it is commercially uniform throughout, and (b) the more modern pug mill which has revolving blades that are attached to a central shaft and mix the material as they revolve.

The thoroughness of the pugging process is of vital importance as regards the strength of the finished product. R. M. Howe[1] reports a batch of refractory material insufficiently pugged as producing brick having an end crushing strength of 31,667 pounds, whereas a properly pugged batch of the same material produced brick having an end crushing strength of 42,767 pounds. Another similar test showed end crushing strengths of 36,366 pounds for insufficiently against 46,000 pounds for properly pugged material, the other conditions being the same.

The same writer shows the remarkable influence of a careful control of the content of water in the material as molded. With the same proportions of other ingredients a series of batches were made up using different amounts of water.

The results are shown in the following table:

Per cent water	Per cent porosity	Modulus of rupture	Modulus of rupture after 20 immersions from 1,300° C. into cold water	Relative strength after immersions per cent	Working consistency
7.5	24.0	2,491	804	32.1	Very stiff mud.
9.0	20.3	6,019	2,776	46.2	Stiff mud.
10.0	20.6	4,020	3,298	82.1	Soft mud.

An addition of 1½ per cent water increases the mechanical strength of the product about 150 per cent and its resistance to sudden temperature change is increased nearly 250 per cent. An addition of 2½ per cent

[1] Journal of Industrial and Engineering Chemistry, December, 1919, p. 1145.

water, however, produces a product of only 60 per cent increased mechanical strength but with 300 per cent increase in resistance to sudden temperature change. The porosity is practically the same with 10 per cent as with 9 per cent water. Hence, the resistance to sudden temperature change in this case does not depend on the porosity alone.

The pressure applied in molding is also an important factor and one which is much more difficult to control than most others. If the mixture contains insufficient water, the pressure is not evenly distributed throughout the mass. If too much water is present it acts as a cushion and prevents the particles of solid matter being compressed into the minimum space. A slight excess of water is not so dangerous, however, as a slight shortage.

THE MANUFACTURE OF FIRE-BRICK AND SHAPES

Fire-brick shapes are manufactured by three distinct processes, based primarily on the water content.

(1) Dry pressing process, by which the amount of water present is only sufficient to permit the forming of the ware with the aid of great pressure. The material to be molded is generally in the form of a damp powder.

(2) Stiff mud process by which the amount of water present is just sufficient to permit the molding of a product of the maximum density. A moderate pressure is employed.

(3) Soft mud process by which the amount of water present is sufficient to permit the forming of the ware with the use of minimum pressure, and generally without pressure.

The ware after being formed is dried to remove the mechanically combined water. It was formerly dried on enormous "hot floors" with a very moderate temperature and the process was very slow. The introduction of humidity controlled driers has permitted the drying period to be greatly reduced and with even less rejection from cracking than with the old process. This humidity control insures a uniform temperature throughout the mass of ware and a regulation of the rate of evaporation from all surfaces during the drying process. The cause of cracking being either an uneven rate of evaporation from different surfaces causing uneven shrinkage, or a strain created from uneven distribution of pressure in forming, it is evident that with a proper control of water content in forming and a proper control of humidity in the drying process, the principal causes of faulty ware are eliminated.

MANUFACTURE OF GLASS FURNACE REFRACTORIES

Preparation of Body

The composition of some glass pot bodies are as follows:

Plastic fire clay	40 per cent.
Pot shells	25 " "
Calcined plastic	15 " "
Calcined flint clay	20 " "

The plastic clay is ground in a dry pan and screened through an 8-mesh screen. The burnt material is first crushed either in a jaw crusher or a set of rollers and then is finally ground through 8-mesh in a dry pan. The ground material is then mixed together in the proper proportions by means of four compartment mixing cars from which it is dumped into wooden mixing troughs. Here the dry material is thoroughly mixed by shoveling and then the mixture is carried up in hoppers which are stationed above the wet pans or pug mills. If wet pans are used the rollers are raised about ½ inch above bottom of pan to prevent the grog from becoming ground.

After the material is pugged thoroughly it is stored in a damp place. In storing, layer upon layer of the pugged body is stacked horizontally. Upon using this material cuts are taken vertically thus helping in making the body more uniform. Storing clay improves its working properties as a result of the decay of organic matter in the clay.

Molding and Shaping of the Ware

Three types of refractories are made for the glass industries (1) tank blocks for glass furnaces, (2) glass pots used largely for plate and high lead glasses, and (3) flattening stones for rolling plate glass.

Tank blocks are either tamped in wooden molds or made with a large auger machine. In making them by an auger machine the body is run through a large auger and then is trimmed to size with wire cutters.

Pots are made in three ways: (1) Molded by hand, (2) pressed in plaster or wooden molds, and (3) cast in plaster molds. In molding pots by hand the pot is built up on a porous slab of either plaster or burnt clay. Commencing at the base one foot is built up at intervals of one or two days, the bottom layer being allowed to dry enough to support the upper layers. Layer upon layer is molded to the pot in this manner until it is completed. The drying is retarded by covering the ware with moistened burlap and takes about six months. The drying rooms have double windows to reduce drafts which may cause cracking of the ware.

In making glass pots and similar ware the pots are pressed in plaster or wooden molds by skilled pressers. The pressed pots remain in the molds until they have become sufficiently strong to hold together after which the molds are removed and the ware is dried in the usual manner.

In casting pots, plaster molds supported in vacuum casings are sometimes used. A predetermined amount of sodium carbonate and sodium silicate are used to thin the slip and the slip is poured into the molds. The air is exhausted from the vacuum chamber and when the proper thickness has been cast the excess slip is drained off. A vacuum is maintained in the chamber about the mold until the ware has become leather hard after which the ware is allowed to dry in air. Pots made in this way are said to be of better quality and cheaper than the pressed pots.

In the manufacture of flattening stones one-third of the body is finely ground while the rest is left about ½ inch in diameter. Both portions are moistened and stored at least eight weeks, after which the stone is formed in a wooden mold upon straw. One thin layer is built up after another and partially dried until the stone is completed. This process takes about 15 days. After three months of gradual drying the ware is burned, this taking about 15 days. After the ware is burned the surface is polished true and smooth with a flattening stone polish. The composition of one of these polishes is as follows:

Burnt clay	3	parts.
Raw clay	1	"
Silver polish	2	"
Red lead	1	"
Water glass	1	"
Water	3	"

Tank blocks are burned in about 15 days. Glass pots are shipped in the unburned state and are burned in the glass furnaces.

SPECIAL TESTS FOR CLAY REFRACTORIES, DEPENDING ON SERVICE REQUIRED

The fact that clay refractories are used under conditions when the physical requirements are extremely different, requires a great variety of tests if useful data are to be obtained.

SOFTENING TEMPERATURE OF A REFRACTORY

This test determines the temperature at which the refractory will not support its own weight. Since nearly all clay refractories contain a large amount of relatively coarse grains, the deformation does not indicate the fusion of the entire mass, but merely the softening of a sufficient portion to cause distortion without external pressure.

There are two methods of conducting the test:

Method 1.[1] Chips should be taken from different portions of a number of bricks made from the refractory to be tested. These should be crushed and then pulverized until all passes a 60-mesh sieve. During the process of pulverizing, the material should be frequently sieved so that the finest portion will not be pulverized too much below the 60-mesh size. The pulverized material must be thoroughly mixed and a representative portion removed. To this is added a solution of dextrine or glue and the plastic mass thus produced is formed into tetrahedrons 25 mm. long and 5 mm. wide on each side at the base.

The cones are dried and then subjected to a preliminary burn of not more than 1300° C. (Cone 8-9) in order to develop the necessary strength for handling.

The test cones are then mounted with standard pyrometric cones on a plaque of refractory material which will withstand at least cone 35 (approximately 1830° C.) without distortion. Such a plaque can be produced by mixing 50 per cent kaolin and 50 per cent alumina. The plaque should be fired to at least 1300° C. before the cones are inserted, as

[1] Based on tentative test of the A. S. T. M. *Cf.* Proc., Vol. XIX, pp. 594-596.

otherwise the shrinkage in the rapid fire of the test kiln may crush the cones. The indentations for holding the cones erect are made in the plaque while in the plastic state, and should be amply large. The cones after insertion are packed in place by calcined kaolin or alumina. The arrangement of the cones on the plaque are preferable clockwise in the order of their number, every second cone being of the material being tested.

The fusion temperature of the material being tested is considered as reached when the cone bends until its point reaches the level of the plaque, or when it contracts into a sphere. The temperature is expressed by cone number rather than in degrees Centigrade.

Method 2. Sections of the refractory being tested are cut from the mass by means of a thin abrasive wheel and the size and shape should approximate that of the standard cone described under Method 1. The cone thus prepared does not require any preliminary treatment before testing. The test process is the same as described from Method 1.

Neither of the foregoing tests are entirely satisfactory. Method 1 will generally show a lower fusing temperature than that of the mass refractory because the grinding process distributes the bond clay more thoroughly and permits it to act more quickly on the refractory portion. Method 2 may be inaccurate because a coarse particle of refractory material may constitute the entire cross-section of the cone, and when the bond clay above and below it begins to fuse, the coarse particle will cause distortion of the portion of the cone above it. These considerations make it important that a number of fusion tests be made on any refractory product being investigated and the data be considered collectively.

RESISTANCE TO PRESSURE AT ELEVATED TEMPERATURES

This test is designed to indicate the load carrying capacity of a refractory under conditions of service.[1] For this test a specimen of the dimensions of the standard fire-brick 9″ x 4″ x 2½″ is employed. The test piece is placed in a suitably constructed gas- or oil-fired furnace with heat evenly distributed. It rests on a solid fire-brick base. Half a chrome

[1] See Amer. Soc. Testing Materials, Vol. XIX, 1919, Part I, pp. 581-585.

brick is placed on top of the test specimen and on top of this is placed a refractory cylinder which protrudes through the roof of the furnace. When a temperature of 1350° C. is reached the load is applied. The time required for reaching this temperature throughout the interior of a standard fire-brick was determined by Bleininger and Brown[1] as 285 minutes. The load is applied to the upper end of the refractory cylinder by means of a balanced steel I-beam which operates as a lever.

The design of the furnace and the construction of the devices for applying and measuring the load have been changed by different investigators who have worked on this problem.[2]

The principles involved are, however, the same. The values obtained are expressed in inches of linear compression, with fixed load and temperature or in pounds of load required to cause compression at a fixed temperature, or in temperature required to cause compression with a fixed load. Although no standard test is established, it is agreed that a first-grade refractory clay brick should stand a load of 40 pounds per square inch at a temperature of 1350° C. with a compression of not more than 5.5 per cent.

RESISTANCE TO PRESSURE AT ATMOSPHERIC TEMPERATURE

This is the ordinary crushing test applied to the vertical test piece and is according to standard practice. A cold crushing strength of 1000 pounds per square inch is generally considered the minimum for first grade clay refractories.

SPALLING TEST

This test is conducted by two different methods:[3]

Method 1. By heating one end of the brick at a standard temperature (1350° C.) for one hour, and then plunging for three minutes in flowing

[1] Tech. Paper No. 7, 1912, Bureau of Standards, p. 50.

[2] See Bureau of Standards, Tech. Paper No. 7, 1912, pp. 117-130, Trans. Amer. Cer. Soc., Vol. XIX, 1917, pp. 498-506; Journal Amer. Cer. Soc., August, 1919, pp. 602-607.

[3] For details of Method (1) see "Nesbitt and Bell," Amer. Soc. Testing Materials, Vol. XVI, 1916, Part II, p. 369. Test No. 2 is recommended by W. H. Fulweiler.

cold water. The brick is heated and quenched ten times and then dried at 110° C. to constant weight. The loss in weight due to spalling is expressed in percentage of the original weight of the brick and is termed "spalling value."

Method 2. By heating the entire brick for one hour at a standard temperature (1000° C.) and then plunging in running cold water for three minutes. This treatment is repeated until the brick breaks into two parts of approximately equal size. The resistance to spalling is indicated by the number of times this treatment must be applied to produce the result indicated.

No standard has been established for a spalling test. Some investigators condemn the practice of chilling in water and recommend the use of an air blast which is much less severe but approaches closer to the requirements of industrial application.

SLAG PENETRATION TEST[1]

This test is designed to indicate the rate at which the refractory will be attacked by a slag such as it encounters in blast furnace service. The test is conducted by cementing a standard clay ring 2½ inches inside diameter to the face of a fire brick and heating the brick to 1350° C. is not less than five hours. Thirty-five grams of a synthetic slag, previously fused and powdered and of standard composition, is then placed inside the ring and the whole retained at 1350° C. for two hours. After cooling the brick is sawed in two, bisecting the ring, and the slag penetration, as indicated by an area of discoloration, is determined by the aid of a planimeter. The results are expressed in square inches.

HEAT CONDUCTIVITY

This test is designed to indicate the rate at which heat will pass through a refractory. The data obtained have great industrial importance in the control of heat losses in furnaces. In the design of muffle walls inside a furnace where the heat must penetrate with minimum resistance, or in the construction of outside walls of furnaces where the

[1] See Amer. Soc. Testing Materials, Vol. XIX, 1919, Part I, pp. 586-589.

minimum radiation is often desired, the data obtained from these tests are equally important.

There are two general systems of heat conductivity measurement: (1) Actual measurement, by which the amount of heat passing through a given area of refractory is determined, and (2) relative measurement, by which the difference in temperature between two faces of the refractory is determined.

By the first method the heat passing through a given thickness and surface area is collected in a known amount of air or water and expressed in gram-calories, per second, per square centimeter surface, per centimeter thickness, per degree Centigrade temperature difference.[1]

The second method which is comparatively simple consists of placing a thermocouple in contact with the heated face of a refractory mass. From the opposite face bore a hole into the block to within a given distance of the directly heated face. Into this hole another thermocouple is inserted, touching the extreme end. The heating process is continued until with a constant temperature prevailing on the face directly heated, no increase in temperature is indicated on the face heated by conduction. The difference in temperature between the two faces are determined for a variety of known refractories and the values expressed in per cents of the value obtained for a standard refractory.

From data compiled by Wologdine and Queneau, the following table is compiled:

Relative Heat Conductivity

Graphite brick	100 per cent.
Corborundum brick	92.4 " "
Magnesia "	28.4 " "
Chromite "	22.8 " "
Clay (fire) "	16.7 " "
Checker "	15.8 " "
Gas retort "	15.2 " "
Bauxite "	13.2 " "
Glass pot "	12.4 " "
Silica "	7.8 " "
Kieselguhr "	7.1 " "

[1] This process is described in detail and the data obtained are presented by Wologdine and Queneau in Electro-chemical and Metallurgical Industry for September and October, 1909.

The above values are questioned by many practical engineers who claim that clay refractories are not superior to silica refractories as heat conductors. The values presented by Wologdine and Queneau are based on refractories burned to the same temperatures, 1300° C. Chas. S. Kinnison brought out the fact (Brick and Clay Record, Apr. 21, 1914) that the silica refractory is normally burned to a much higher temperature than the clay refractory, and indicates by curves that by extrapolation of the data at hand, as well as by popular observation, the silica refractory should be equal or superior to the clay refractory. No actual data are presented, however, to confirm this claim.

THE TESTING OF THE CLAYS[1]

BY

H. G. SCHURECHT[2]

Description of Tests

TESTS MADE

In the green state the water required for normal consistancy, the drying shrinkage, the relation between shrinkage water and pore water, the relation between shrinkage water and total water, and the time of disintegration in water were determined.

In studying the burning properties of the clays the softening point of each was determined. On those having a softening point equal to or greater than cone 26, porosity, shrinkage, apparent specific gravity, and bulk specific gravity tests were made on the clays fired between 1150° C. and 1400° C.

TESTS IN THE GREEN STATE

In determining the water required the clay was worked to normal consistancy, the wet and dry weights determined, and the loss of water was expressed in terms of dry clay as the water required. By normal consistency[3] is meant that condition in which the clay is most workable, is no longer sticky, and will not adhere to metal. The linear drying shrinkage was determined on briquettes molded at normal consistency and expressed in terms of dry length of the briquette.

The per cent shrinkage water in terms of true clay volume and the per cent total water in terms of true clay volume were calculated as follows:

[1] Published by permission of the Director U. S. Bureau of Mines.

[2] Jr. Ceramic Chemist U. S. Bureau of Mines.

[3] Kinnison, C. S., A study of the Atterberg plasticity method: U. S. Bureau of Standards Tech. Paper 46, 1915, p. 4.

From this the relation[1] between shrinkage water and pore water, and shrinkage water and total water can readily be calculated.

$$S = \frac{D(V_1 - V_2)100}{W}$$

$$T = \frac{D(W_1 - W)100}{W}$$

S = Per cent shrinkage water in terms of true clay volume.
D = Specific gravity of powdered clay.
V_1 = Volume of clay briquette in wet state.
V_2 = Volume of clay briquette in dry state.
W = Weight of clay briquette in dry state.
T = Per cent total water in terms of true clay volume.
W_1 = Weight of clay briquette in wet state.

For measuring the time of disintegration in water one inch cubes containing one part of clay and one part of potter's flint were made. After the cubes had been dried to a constant weight at 110° C. the time necessary to disintegrate them in water at room temperature was measured by suspending them in water on a coarse mesh wire basket.

BURNING PROPERTIES

Clays do not possess definite melting points like metals. Softening takes place during a long interval of temperature. That point at which a small tetrahedron of clay bends over completely or forms a round ball is called the softening point of the clay. Standard Seger cones are set alongside of the clay for comparison and the clay is said to have the softening point of the cone which bends at the softening point of the clay.

[1] Bleininger, A. V., and Schurecht, H. G., Properties of some European plastic fire clays: Bureau of Standards Tech. Paper 79, 1916, p. 23.

According to Kanolt's corrected values the standard cones soften at the following values:

Cone	Degrees Centigrade	Cone	Degrees Centigrade
26	1600	31	1685
27	1620	32	1705
28	1635	33	1720
29	1650	34	1740
30	1670	35	1755

In studying the burning properties of the clays, briquettes 2 x 1 x 1 inch were fired at intervals between 1150° C. and 1400° C. Porosity, shrinkage, apparent specific gravity, and bulk specific gravity determinations were made on each of the pieces. The following formulas were used in calculating these values:

$$\text{Apparent porosity} = \frac{(W-D)100}{(W-S)}.$$

$$\text{Volume shrinkage} = \frac{(V_2-V_3)100}{V_2}.$$

$$\text{Apparent specific gravity} = \frac{D}{(D-S)}.$$

$$\text{Bulk specific gravity} = \frac{D}{(W-S)}.$$

W = Weight of saturated briquette.
D = Weight of dry briquette.
S = Saturated suspended weight.
V_2 = Dry volume of unburned briquette.
V_3 = Dry volume of burned briquette.

Classification of the Fire Clays

Fire clays are often classified according to their softening point. Although there are many exceptions which fall out of the limits of this classification this applies to the majority of clays. According to Bleininger[1] a No. 1 fire clay should not soften below cone 31, or approxi-

[1] Bleininger, A. V., Some aspects of testing refractories: The Engineers Society of Western Pennsylvania, Vol. 32, 1916, p. 613.

mately 1685° C. The division between the No. 2 and No. 3 fire clays is cone 28, or about 1635° C.

Another method[1] of classification used in this work is by the apparent porosities and specific gravities of the clays when fired to different tem-

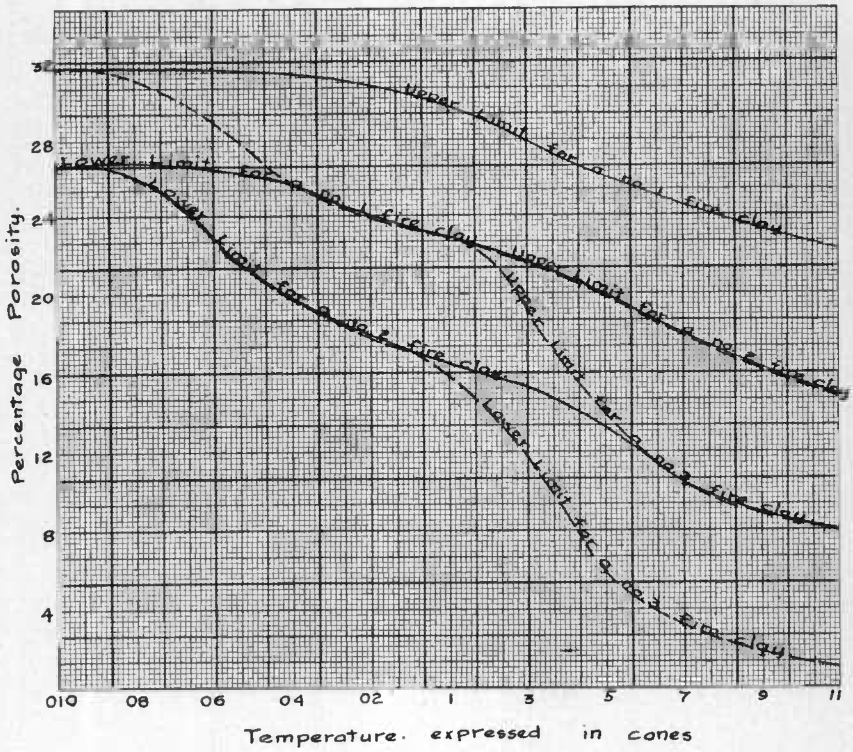

FIG. 16.—CLASSIFICATION OF FIRE CLAYS.

peratures. In this classification there are also exceptions falling outside of these limits but it applies to most clays. The above chart shows this method of classification with apparent porosities.

[1] Purdy, R. C., Paving brick and paving brick clays of Illinois: Illinois State Geol. Survey Bull. 9, 1908, p. 271-278.

RESULTS OF TESTS

ALLEGANY COUNTY, MARYLAND

Mount Savage. Union Mining Co.

MINE No. 6. STATION 73 + 9 FEET

This section is 9 feet beyond station 73 in the second heading to the left in mine No. 6 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 1, F 1, and P 2 were sampled and tested and the results are given below:

Properties of the Clays from Section at Station 73 + 9 Feet in Mine No. 6

	P 1	F 1	P 2
Per cent water required	16.9	....	17.9
Plasticity, judged by feel	Fair.	None.	Fair.
Drying skrinkage, per cent dry length	4.0	....	4.1
Ratio of per cent shrinkage water to per cent pore water	1:1.74	....	1:1.80
Per cent shrinkage water in terms of total water	36.6	:...	35.7
Time of disintegration, minutes	4.6	....	3.5
Softening point, cones	30 +	33	22

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 1	23.4	19.3	17.9	15.9	14.9	13.7	12.2	12.1	12.1
	F 1	25.0	26.2	....	28.3	27.7	26.5	24.3	25.4	26.3
	P 2	17.9	12.3	11.4	11.7	11.3	10.7	9.4	8.4	6.4
Volume shrinkage.	P 1	7.8	9.2	10.1	9.2	9.3	7.7	7.4	5.9	6.7
	F 1	15.9	17.9	....	18.6	18.6	17.3	16.8	16.3	14.0
	P 2	15.9	17.4	18.2	18.4	15.3	13.7	12.7	....	10.6
Apparent specific gravity.	P 1	2.63	2.53	2.50	2.43	2.39	2.32	2.28	2.23	2.24
	F 1	2.37	2.45	....	2.48	2.51	2.46	2.39	2.42	2.39
	P 2	2.66	2.53	2.54	2.46	2.43	2.37	2.31	....	2.21
Bulk specific gravity.	P 1	2.01	2.03	2.06	2.04	2.03	2.00	2.00	1.96	1.96
	F 1	1.77	1.80	....	1.78	1.82	1.81	1.81	1.81	1.77
	P 2	2.18	2.22	2.25	2.18	2.16	2.12	2.09	....	2.07
Color	P 1	Buff.	Buff.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
	F 1	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.
	P 2	Gray.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
Hardness	P 1	S	S	S	H	H	H	H	H	H
	F 1	S	S	S	S	S	S	S	S	S
	P 2	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 1 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are also similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of No. 2 refractories and similar ware.

The softening point of F 1 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 2 does not meet the requirements of a fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. This clay shows a tendency to swell, due to overburning, above 1300° C. In refractoriness it is inferior to both F 1 and P 1 and therefore precaution should be taken in mining, to separate it from the more refractory ones. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware, but not for refractories.

MINE No. 6. STATION 72 + 22 FEET

This section is 22 feet beyond station 72 in the first heading to the left of mine No. 6 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 3, F 2, and P 4 were sampled and tested and the results obtained are given below:

Properties of Clays from Section at Station 72 + 22 Feet in Mine No. 6

	P 3	F 2	P 4
Per cent water required	16.4	....	16.6
Plasticity, judged by feel	Poor.	None.	Fair.
Drying shrinkage, per cent dry length	2.4	....	4.5
Ratio of per cent shrinkage water to per cent pore water	1:3.30	....	1:1.43
Per cent shrinkage water in terms of total water	23.3	....	41.0
Time of disintegration, minutes	2.9	....	3.4
Softening point, cones	30	32 +	30

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 3	28.4	25.1	20.5	20.1	18.6	19.1	19.4	18.9	17.0
	F 2	....	29.5	28.8	29.2	27.7	27.7	27.2	27.9	27.9
	P 4	18.0	14.0	13.4	12.4	12.3	11.3	11.1	10.5	9.4
Volume shrinkage.	P 3	9.1	8.5	11.2	10.8	11.5	10.8	9.4	8.5	10.5
	F 2	....	10.7	10.3	11.1	8.8	9.4	9.1	9.2	7.9
	P 4	15.00	17.5	17.5	16.9	16.6	16.5	15.6	15.5	14.9
Apparent specific gravity.	P 3	2.85	2.62	2.52	2.51	2.49	2.43	2.42	2.41	2.40
	F 2	....	2.40	2.40	2.41	2.37	2.34	2.34	2.33	2.31
	P 4	2.67	2.62	2.61	2.56	2.56	2.53	2.50	2.48	2.43
Bulk specific gravity.	P 3	1.93	1.94	2.00	2.00	2.03	1.99	1.95	1.95	1.99
	F 2	....	1.69	1.71	1.70	1.73	1.70	1.70	1.68	1.66
	P 4	2.19	2.25	2.26	2.24	2.24	2.24	2.22	2.21	2.20
Color	P 3	Buff.	Buff.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
	F 2	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.
	P 4	Buff.	Buff.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
Hardness...	P 3	S	S	H	H	H	H	H	H	H
	F 2	S	S	S	S	S	S	S	S	S
	P 4	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 3 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay, being open burning. The ratio of shrinkage to pore water indicates a poor bond clay. It appears promising for the manufacture of high grade No. 2 fire brick and similar ware.

The softening point of F 2 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 4 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay, being a medium tight burning clay. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of No. 2 refractories and similar ware.

MINE NO. 6. 43 FEET FROM STATION 68 + 95 FEET

This section is 43 feet from center of track at station 68 + 95 feet in mine No. 6 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 5, F 3, and P 6 were sampled and tested and the results are given below:

Properties of Clays from Section at 43 Feet from Station 68 + 95 Feet in Mine No. 6

	P 5	F 3	P 6
Per cent water required	18.0	....	18.0
Plasticity, judged by feel	Fair.	None.	Fair.
Drying shrinkage, per cent dry length	3.9	....	4.3
Ratio of per cent shrinkage water to per cent pore water	1:1.95	....	1:2.26
Per cent shrinkage water in terms of total water	34.0	....	37.2
Time of disintegration, minutes	3.4	....	4.2
Softening point, cones	30	33	30

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 5	15.7	12.9	13.1	11.5	10.0	10.3	8.0	6.7	....
	F 3	35.5	34.8	36.2	37.1	36.7	37.1	36.3	36.3	38.2
	P 6	14.0	14.3	14.3	13.1	12.5	11.9	11.3	12.5	....
Volume shrinkage.	P 5	16.6	14.7	11.9	9.7	7.4	8.5	6.1	1.9	....
	P 6	16.7	16.2	15.8	15.1	14.1	14.8	13.6	12.2	....
Apparent specific gravity	P 5	2.57	2.46	2.40	2.30	2.20	2.22	2.13	2.01	....
	F 3	2.66	2.64	2.68	2.69	2.68	2.66	2.65	2.64	2.65
	P 6	2.58	2.58	2.56	2.52	2.47	2.48	2.41	2.41	....
Bulk specific gravity	P 5	2.17	2.15	2.08	2.03	1.98	2.00	1.96	1.88	....
	F 3	1.71	1.72	1.74	1.69	1.70	1.68	1.68	1.68	1.64
	P 6	2.21	2.21	2.19	2.18	2.16	2.18	2.14	2.11	....
Color	P 5	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
	F 3	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
	P 6	Gray.	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.
Hardness	P 5	H	H	H	H	H	H	H	H	H
	F 3	S	S	S	S	S	S	S	S	S
	P 6	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

Chemical Analysis of F 3

Loss on ignition	12.39
SiO_2	49.60
Al_2O_3	32.65
Fe_2O_3	1.31
CaO	None
MgO	.12
TiO_2	2.41
Na_2O	.33
K_2O	.38
S	.13
H_2O at 105° C	1.25
	100.57

Ceramic Formula

$$\left.\begin{array}{l} .051\ FeO \\ .009\ MgO \\ .013\ K_2O \\ .017\ Na_2O \end{array}\right\} 1.0\ Al_2O_3 \left\{\begin{array}{l} 2.575\ SiO_2 \\ .094\ TiO_2 \end{array}\right.$$

$$.090\ RO$$

The softening point of P 5 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. This clay shows a bad tendency to swell up at high temperatures which is shown by the decrease in volume shrinkage. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. P 5 might cause trouble if used in fire brick and therefore precaution should be taken, in mining, to separate it from F 3 and P 6, which are more refractory.

The softening point of F 3 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. The chemical analysis shows .090 equivalents RO which is exceptionally low indicating that this clay is a high grade refractory clay. F 3 together with a highly refractory bond clay appears promising for the manufacture of No. 1 refractories.

The softening point of P 6 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are also similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of No. 2 refractories and similar ware.

MINE No. 6. STATION 69 + 72 FEET

This section is 72 feet beyond station 69 at the top of plane heading in mine No. 6 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 7, F 4, and P 8 were sampled and tested and the results are given below:

Properties of Clays from Section at Station 69 + 72 Feet in Mine No. 6

	P 7	F 4	P 8
Per cent water required	16.6	....	19.6
Plasticity, judged by feel	Good.	None.	Good.
Drying shrinkage, per cent dry length	3.0	....	5.6
Ratio of per cent shrinkage water to per cent pore water	1:2.51	....	1:1.25
Per cent shrinkage water in terms of total water	28.5	....	44.5
Time of disintegration, minutes	4.0	....	4.4
Softening point, cones	30	33	30

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 7	14.6	11.2	11.4	6.4	5.0	3.9	3.1	3.1	....
	F 4	25.3	26.3	27.8	25.4	25.2	25.1	24.4	24.9	26.6
	P 8	11.8	12.2	11.9	11.5	11.0	12.3	9.5	9.8	....
Volume shrinkage.	P 7	17.5	17.7	15.3	15.2	11.7	11.0	11.1	4.3	....
	P 8	19.6	18.7	18.6	17.0	16.1	13.1	13.3	12.1	....
Apparent specific gravity.	P 7	2.58	2.49	2.43	2.31	2.13	2.13	2.11	1.97	....
	F 4	2.32	2.37	2.38	2.38	2.37	2.34	2.32	2.34	2.33
	P 8	2.55	2.55	2.55	2.49	2.45	2.43	2.34	2.31	....
Bulk specific gravity.	P 7	2.35	2.21	2.22	2.22	2.06	2.09	2.08	1.93	....
	F 4	1.74	1.75	1.82	1.77	1.73	1.75	1.75	1.76	1.73
	P 8	2.26	2.23	2.24	2.20	2.17	2.13	2.11	2.09	....
Color	P 7	Buff.	Buff.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
	F 4	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
	P 8	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
Hardness	P 7	H	H	H	H	H	H	H	H	H
	F 4	S	S	S	S	S	S	S	S	S
	P 8	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 7 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures appear to be inferior to a No. 3 fire clay, due to a swelling and deformation above 1300° C. The ratio of shrinkage to pore water indicates a poor bond clay. This clay might cause trouble if present in refractory ware and therefore precaution should be taken to separate it from F 4 and P 8.

The softening point of F 4 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 8 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are also similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates a good bond clay. It appears promising for the manufacture of No. 2 refractories and similar ware.

MINE No. 6. STATION 70 + 32 FEET

This section is 32 feet beyond station 70 in the first heading to right of plane heading in mine No. 6 of the Union Mining Co., Mount Savage, Maryland. The clay marked P 9, F 5, and P 10 were sampled and tested and the results are given below:

Properties of Clays from Section at Station 70 + 32 Feet in Mine No. 6

	P 9	F 5	P 10
Per cent water required	18.8	....	19.0
Plasticity, judged by feel	Poor.	None.	Fair.
Drying shrinkage, per cent dry length	4.9	....	5.2
Ratio of per cent shrinkage water to per cent pore water	1:1.44	....	1:1.35
Per cent shrinkage water in terms of total water	41.0	....	42.6
Time of disintegration, minutes	2.8	....	3.4
Softening point, cones	26	33	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 9	19.6	15.4	14.0	12.7	8.8	8.5	18.9	23.1	....
	F 5	26.3	26.0	26.7	27.5	26.5	23.7	24.9	25.0	24.8
	P 10	15.6	....	11.4	11.0	10.4	9.8	9.1	7.4	5.9
Volume shrinkage.	P 9	8.8	9.6	8.3	7.0	2.6	0.6	18.6	25.7	....
	F 5	8.7	8.3	9.8	8.0	8.4	7.7	8.1	6.4	6.1
	P 10	14.2	....	12.3	11.9	12.3	12.8	11.9	12.0	11.9
Apparent specific gravity.	P 9	2.57	2.45	2.39	2.02	2.12	2.03	1.97	1.99	....
	F 5	2.38	2.41	2.44	2.42	2.38	2.29	2.32	2.24	2.29
	P 10	2.59	....	2.39	2.37	2.36	2.37	2.33	2.28	2.25
Bulk specific gravity.	P 9	2.06	2.08	2.06	1.76	1.94	1.85	1.60	1.53	....
	F 5	1.75	1.78	1.79	1.75	1.75	1.74	1.74	1.72	1.72
	P 10	2.18	....	2.12	2.10	2.12	2.14	2.12	2.12	2.11
Color.......	P 9	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
	F 5	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.
	P 10	Buff.	Buff.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
Hardness...	P 9	H	H	H	H	H	H	H	H	H
	F 5	S	S	S	S	S	S	S	S	S
	P 10	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 9 does not meet the requirements of a No. 2 fire clay and its properties when fired to different temperatures are inferior to a No. 3 fire clay. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of fireproofing and hollow block, but could not be used in refractory ware owing to a swelling and softening above 1275° C. In mining precaution should be taken to separate it from F 5 which is much more refractory.

The softening point of F 5 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 10 does not meet the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

MINE No. 6. STATION 71 + 43 FEET

This section is 43 feet beyond station 71 in the first room to the right of first heading to right of plane heading, in mine No. 6 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 11, F 6, F 7, and P 12 were sampled and tested and the results are given below:

Properties of Clays from Section at Station 71 + 43 Feet in Mine No. 6.

	P 11	F 6	F 7	P 12
Per cent water required	16.9	....	....	18.6
Plasticity, judged by feel	Fair.	None.	None.	Fair.
Drying shrinkage, per cent dry length	5.3	....	....	5.2
Ratio of per cent shrinkage water to per cent pore water	1:1.13	....	....	1:1.32
Per cent shrinkage water in terms of total water	47.2	....	....	43.1
Time of disintegration, minutes	3.8	....	....	3.5
Softening point, cones	20	28	34	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 6	24.4	20.8	21.0	....	18.9	17.8	15.8	15.0	14.0
	F 7	27.8	26.5	....	24.8	25.3	25.4	25.9	26.4	27.9
	P 12	16.7	15 4	10.6	10.4	9.5	9.9	8.8	8.2	7.5
Volume shrinkage.	F 6	4.5	4.4	4.4	....	3.9	4.2	2.7	2.2	3.9
	P 12	15.3	16.9	13.3	13.5	13.3	13.2	12.7	12.5	11.9
Apparent specific gravity.	F 6	2.46	2.40	2.41	....	2.28	2.29	2.70	2.16	2.17
	F 7	2.27	2.22	....	2.17	2.20	2.17	2.16	2.19	2.18
	P 12	2.61	2.60	2.36	2.35	2.35	2.35	2.31	2.28	2.29
Bulk specific gravity.	F 6	1.86	1.90	1.91	....	1.85	1.88	1.85	1.85	1.86
	F 7	1.63	1.64	....	1.65	1.65	1.62	1.60	1.61	1.51
	P 12	2.17	2.19	2.11	2.11	2.13	2.12	2.10	2.09	2.12
Color	F 6	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Black spots.	Black spots.	Black spots.
	F 7	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
	P 12	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.
Hardness	F 6	S	S	S	S	S	S	H	H	H
	F 7	S	S	S	S	S	S	S	S	S
	P 12	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

Judging from the low softening point of P 11 this clay is not promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates a good bond clay.

The softening point of F 6 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay. It appears promising for the manufacture of No. 2 refractories and similar ware.

The softening point of F 7 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 12 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

MINE NO. 6. ROCK HEADING

This section is in the rock heading in mine No. 6 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 65 and P 66 were sampled and tested and the results are given below:

Properties of Clays from Rock Heading of Mine No. 6

	P 65	P 66
Per cent water required	14.8	16.5
Plasticity, judged by feel	Poor.	Fair.
Drying shrinkage, per cent dry length	3.3	2.8
Ratio of per cent shrinkage water to per cent pore water	1:2.02	1:2.86
Per cent shrinkage water in terms of total water	33.2	26.7
Time of disintegration, minutes	3.3	4.5
Softening point, cones	26	28

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 65	25.1	23.7	20.8	18.6	19.3	18.0	17.1	14.4	11.8
	P 66	28.2	25.1	22.1	21.0	19.0	17.8	18.0	14.7	31.8
Volume shrinkage.	P 65	5.5	8.3	9.2	9.7	8.9	8.7	9.3	9.7	9.5
	P 66	8.9	11.2	13.3	14.1	12.3	14.9	13.7	13.9	15.2
Apparent specific gravity.	P 65	2.63	2.57	2.56	2.52	2.49	2.43	2.39	2.35	2.33
	P 66	2.45	2.41	2.36	2.35	2.32	2.32	2.27	2.34	2.52
Bulk specific gravity.	P 65	1.94	1.97	2.03	2.04	2.01	2.00	1.98	2.02	2.05
	P 66	1.75	1.81	1.84	1.85	1.83	1.88	1.87	1.86	1.73
Color.......	P 65	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
	P 66	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness...	P 65	H	H	H	H	H	H	H	H	H
	P 66	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 65 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of No. 2 refractories and similar ware.

The softening point of P 66 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates poor bonding properties in the green state. It appears promising for the manufacture of No. 2 fire brick and similar ware.

MINE No. 5. FIRST HEADING LEFT

This section is in the first heading left and 62 feet from center of main heading of mine No. 5 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 13, P 14, and P 15 were sampled and tested and the results are given below:

Properties of Clays from Section at First Heading Left in Mine No. 5

	P 13	P 14	P 15
Per cent water required	44.3	36.2	23.9
Plasticity, judged by feel	Good.	Excellent.	Good.
Drying shrinkage, per cent dry length	10.3	11.5	6.4
Ratio of per cent shrinkage water to per cent pore water.	1:1.10	1:0.75	1:1.26
Per cent shrinkage water in terms of total water	47.9	57.3	44.2
Time of disintegration, minutes	4.2	6.9	6.3
Softening point, cones	13	16	18

Properties of P 14 when Fired to Temperatures Between 1150° and 1300° C.

	1150°	1200°	1250°	1275°	1300°
Apparent porosity	13.4	6.1	18.1	20.2	19.3
Volume shrinkage	35.2	22.8	13.3	—9.1	—20.0
Apparent specific gravity	2.94	2.31	1.83	1.75	1.57
Bulk specific gravity	2.04	2.17	1.50	1.40	1.26
Color	Gray.	Gray.	Black.	Black.	Black.
Hardness	H	H	H	H	H

H = Harder than steel.

Judging from the low softening point, P 13 is not refractory enough to be classed as a fire-clay. The ratio of shrinkage to pore water indicates good bonding properties in the green state.

The softening point of P 14 is too low to be classed as a fire clay. The ratio of shrinkage to pore water indicates good bonding properties in the green state.

The softening point of P 15 is too low to be classed as a fire clay. The ratio of shrinkage to pore water indicates good bonding properties in the green state.

MINE NO. 5. STATION 960 + 81 FEET

This section is 81 feet beyond station 960 in the second heading to right in mine No. 5 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 16, P 17, P 18, and P 19 were sampled and tested and the results are given below:

Properties of Clays from Section at Station 960 + 81 Feet in Mine No. 5

	P 16	P 17	P 18	P 19
Per cent water required	20.2	24.7	19.6	19.1
Plasticity, judged by feel	Good.	Good.	Fair.	Good.
Drying shrinkage, per cent dry length	2.9	4.9	5.9	6.1
Ratio of per cent shrinkage water to per cent pore water	1:3.14	1:1.98	1:1.14	1:1.04
Per cent shrinkage water in terms of total water	24.2	33.5	46.8	49.0
Time of disintegration, minutes	3.4	3.7	5.2	5.9
Softening point, cones	26	29	28	25

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 16	....	28.7	27.3	27.2	27.7	24.8	24.3	23.0	20.9
	P 17	22.8	22.0	10.1	9.6	6.6	6.3	1.4	0.7	0.4
	P 18	20.3	21.9	9.4	6.1	2.9	2.8	2.3	2.2	1.4
	P 19	27.5	....	16.9	12.4	8.0	4.3	4 0	3.2	2.8
Volume shrinkage.	P 16	....	3.3	4.2	3.8	4.5	5.1	5.2	6.1	7.7
	P 17	8.0	8.9	19.1	20.8	17.6	16.1	19.3	19.5	19.5
	P 18	7.2	6.1	15.4	16.1	16.2	15.9	14.8	14.2	13.7
	P 19	2.9	....	12.2	14.4	14.7	14.1	12.6	11.9	10.6
Apparent specific gravity.	P 16	....	2.59	2.57	2.56	2.53	2.52	2.50	2.48	2.46
	P 17	2.52	2.51	2.42	2.44	2.32	2.29	2.24	2.25	2.25
	P 18	2.53	2.52	2.44	2.39	2.31	2.29	2.25	2.23	2.19
	P 19	2.62	....	2.54	2.49	2.36	2.25	2.22	2.19	2.15
Bulk specific gravity.	P 16	....	1.85	1.87	1.87	1.88	1.89	1.90	1.91	1.95
	P 17	1.94	1.96	2.18	2.21	2.17	2.14	2.22	2.23	2.24
	P 18	2.01	1.98	2.22	2.24	2.25	2.22	2.20	2.18	2.16
	P 19	1.90	....	2.11	2.16	2.17	2.16	2.13	2.11	2.09
Color	P 16	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
	P 17	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
	P 18	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
	P 19	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	P 16	S	S	S	S	S	S	H	H	H
	P 17	S	S	H	H	H	H	H	H	H
	P 18	S	S	H	H	H	H	H	H	H
	P 19	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

Although the softening point of P 16 does not meet the requirements of a No. 2 fire clay, its properties when fired to different temperatures are similar to a No. 1 fire clay, being open burning. The ratio of shrinkage to pore water indicates poor bonding properties in the green state. It appears promising for the manufacture of No. 2 fire-brick and similar ware.

The softening point of P 17 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware, but could not be used in manufacture of refractories because of its tendency to swell and soften at a low temperature.

The softening point of P 18 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to clays used for making graphite crucibles. This clay becomes vitrified at a low temperature, 1250° C., and does not show serious signs of swelling at 1400° C., this being a property of considerable importance in the manufacture of graphite crucibles for melting brass. The ratio of shrinkage to pore water indicates good bonding properties in the green state. It therefore appears promising for the manufacture of graphite crucibles and glass pots as well as for other No. 2 refractories.

The softening point of P 19 does not meet the requirements of a fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates good bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, and similar ware.

MINE NO. 5. STATION 957 + 63 FEET

This section is 63 feet beyond station 957 in mine No. 5 of the Union Mining Co., Mount Savage, Maryland. The clay marked P 22 was sampled and tested and the results are given below:

Properties of P 22 from Section at Station 957 + 63 Feet in Mine No. 5

	P 22
Per cent water required	27.4
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	5.1
Ratio of per cent shrinkage water to per cent pore water	1:1.97
Per cent shrinkage water in terms of total water	33.6
Time of disintegration, minutes	6.3
Softening point, cones	30

Properties of P 22 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	12.1	2.8	2.2	1.4	0.8	2.1	6.0	10.1	11.1
Volume shrinkage	22.8	28.0	26.9	25.9	27.6	24.3	19.2	14.8	12.6
Apparent specific gravity.	2.44	2.36	2.34	2.30	2.29	2.25	2.18	2.19	2.15
Bulk specific gravity	2.15	2.29	2.29	2.27	2.28	2.18	2.05	1.98	1.89
Color	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	H	H	H	H	H	H	H	H	H

H = Harder than steel.

Chemical Analysis of P 22

Loss on ignition	8.94
SiO_2	58.19
Al_2O_3	24.45
Fe_2O_3	2.00
CaO	None
MgO	.12
TiO_2	1.55
Na_2O	.66
K_2O	2.74
S	.23
H_2O at 105° C	.93
	100.57

Ceramic Formula

$$\left.\begin{array}{l} .105\ FeO \\ .012\ MgO \\ .122\ K_2O \\ .044\ Na_2O \end{array}\right\} 1.0\ Al_2O_3 \left\{\begin{array}{l} 4.030\ SiO_2 \\ .081\ TiO_2 \end{array}\right.$$

$$\overline{.283\ RO}$$

The softening point of P 22 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The range between incipient and viscous vitrification is about 175° C. The chemical analysis shows that it contains .283 equivalents of RO which is too high for a high-grade fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. P 22 would cause trouble if used in high-grade refractories to any great extent because it swells up and softens above 1300° C. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

MINE NO. 5. 25 FEET FROM ENTRANCE

This section is 25 feet from the entrance of mine No. 5 of the Union Mining Co., Mount Savage, Maryland. Clay marked P 35 was sampled and tested and the results are given below:

Properties of P 35 from Mine No. 5

	P 35
Per cent water required	19.1
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	6.1
Ratio of per cent shrinkage water to per cent pore water	1:1.04
Per cent shrinkage water in terms of total water	49.2
Time of disintegration, minutes	6.8
Softening point, cones	15

Properties of P 35 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	16.1	10.9	6.8	11.0	17.6	18.2	13.0	4.5	1.2
Volume shrinkage	11.6	14.6	14.0	5.1	6.6	10.0	13.3	18.2	14.7
Apparent specific gravity.	2.57	2.51	2.39	2.27	2.20	2.15	1.94	1.70	1.69
Bulk specific gravity	2.16	2.24	2.22	2.02	1.81	1.76	1.70	1.63	1.67
Color	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray
Hardness	S	S	S	S	S	S	S	S	H

S = Softer than steel. H = Harder than steel.

The softening point of P 35 does not meet the requirements of a fire clay and therefore does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates good bonding properties in the green state. Because of its short vitrification range its use would be limited in ceramics.

PROSPECT NEAR MINE No. 7

This section is 225 feet N. 35° W. of drill hole near Mine No. 7 of the Union Mining Co., Mount Savage, Maryland. The clays marked P 23 and P 24 were sampled and tested and the results are given below:

Properties of Clays from Prospect Near Mine No. 7

	P 23	P 24
Per cent water required	27.9	34.8
Plasticity, judged by feel	Good.	Excellent.
Drying shrinkage, per cent dry length	7.1	7.1
Ratio of per cent shrinkage water to per cent pore water	1:1.27	1:1.64
Per cent shrinkage water in terms of total water	44.1	37.9
Time of disintegration, minutes	6.3	4.4
Softening point, cones	26	31

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 23	18.6	8.7	4.3	0.4	0.6	0.5	0.8	9.5	10.6
	P 24	11.5	3.4	1.4	0.9	0.5	1.1	1.2	1.4	2.0
Volume shrinkage.	P 23	15.8	22.8	24.5	25.4	25.2	24.1	22.0	13.6	12.8
	P 24	28.7	30.6	34.2	34.9	34.5	34.2	33.7	32.0	29.7
Apparent specific gravity.	P 23	2.56	2.47	2.42	2.39	2.36	2.34	2.27	2.25	2.27
	P 24	2.46	2.39	2.36	2.37	2.35	2.35	2.33	2.30	2.23
Bulk specific gravity.	P 23	2.08	2.25	2.31	2.35	2.35	2.32	2.25	2.04	2.05
	P 24	2.18	2.31	2.33	2.34	2.34	2.33	2.30	2.28	2.19
Color	P 23	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
	P 24	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	P 23	H	H	H	H	H	H	H	H	H
	P 24	H	H	H	H	H	H	H	H	H

H = Harder than steel.

The softening point of P 23 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The range between incipient and viscous vitrification is about 150° C. and above 1350° C. it swells and becomes soft. The ratio of shrinkage to pore water indicates good bonding properties in the green state.

The softening point of P 24 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to the dense burning type of glass pot and crucible clays. It will be seen by examining the porosity and volume shrinkage data that the clay is practically vitrified at 1200° C. having a porosity of only 3.4 per cent. This is a property important in the manufacture of graphite crucibles where a clay is required that will vitrify at a low temperature to prevent the oxidation of the graphite and which will retain this condition at a high temperature without softening. This clay retains this condition until it is fired to 1375° C. when it becomes more porous due to a spongy structure caused by overburning. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of graphite crucibles and glass pots as well as the manufacture of fire brick, stoneware, and similar ware.

Prospect on Western Maryland R. R. Cut

This section is an exposure on north bank of the W. Md. R. R. cut, ½ mile above Union Mining Company's plane, near Mount Savage, Maryland. The clay marked F 11 was sampled and tested and the results are given below:

Properties of F 11 When Fired to Temperatures Between 1150° and 1375° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°
Apparent porosity........	37.5	37.8	37.8	38.2	38.1	38.1	36.6	37.1
Volume shrinkage........	3.3	3.5	3.3	1.1	—3.2	—0.5	—2.9	—0.5
Apparent specific gravity.	2.67	2.67	2.67	2.64	2.62	2.63	2.48	2.56
Bulk specific gravity.....	1.67	1.66	1.66	1.63	1.63	1.63	1.57	1.61
Color....................	Brown	Brown	Brown	Brown	Brown	Brown	Black	Black
Hardness.................	S	S	S	S	S	S	S	S

S = Softer than steel.

The softening point of F 11 is cone 29 and meets the requirements of a No. 2 fire clay and its properties when burned to different temperatures are similar to a No. 1 fire clay. With a No. 2 bond clay it appears promising for the manufacture of No. 2 refractories.

Barrelville. Prospect on Old Road to Clay Bank

This section is ½ mile east of Barrelville, Maryland, and ¼ mile north of Jenning's Run in trench end of old road to clay bank. The clay marked P 103 was sampled and tested and the results are given below:

Properties of P 103 Near Barrelville

	P 103
Per cent water required	22.7
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	4.2
Ratio of per cent shrinkage water to per cent pore water	1:1.44
Per cent shrinkage water in terms of total water	41.0
Time of disintegration, minutes	6.1
Softening point, cones	23

The softening point of P 103 does not meet the requirements of a fire clay and therefore does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the dry state.

Barrelville. Prospect East of Barrelville.

This prospect is ½ mile east of Barrelville, Maryland. The clay marked F 55 was sampled and tested and the results are given below:

Properties of F 55 When Fired to Temperatures Between 1200° and 1400° C.

	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	47.0	46.8	46.1	44.6	41.3	46.9	46.6	44.3
Apparent specific gravity	2.67	2.72	2.69	2.74	2.61	2.76	2.71	2.73
Bulk specific gravity	1.41	1.45	1.47	1.52	1.53	1.41	1.42	1.50
Color	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
Hardness	S	S	S	S	S	S	S	S

S = Softer than steel.

The softening point of F 55 is cone 31 and meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of high-grade refractories.

Ellerslie. Andrew Ramsey Co.

ELLERSLIE FIRE CLAY MINE. SOFT CLAY HEADING

This section is in the so-called soft clay heading of the Ellerslie Fire Clay Mine, Ellerslie, Maryland. The clays marked F 21 and P 40 were sampled and tested and the results are given below:

Properties of Clays from Soft Clay Heading of Ellerslie Fire Clay Mine

	F 21	P 40
Per cent water required	....	17.8
Plasticity, judged by feel	None.	Fair.
Drying shrinkage, per cent dry length	....	6.3
Ratio of per cent shrinkage water to per cent pore water	....	1:1.59
Per cent shrinkage water in terms of total water	....	38.6
Time of disintegration, minutes	....	4.8
Softening point, cones	33	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 21	34.2	35.4	33.7	33.8	35.0	35.0	37.5	37.7	....
	P 40	....	20.5	13.4	10.2	7.1	4.0	8.4	14.3	12.2
Volume shrinkage.	P 40	....	6.9	10.8	11.4	9.6	6.4	0.5	—5.7	—8.1
Apparent specific gravity.	F 21	2.50	2.51	2.47	2.54	2.50	2.44	2.44	2.43	....
	P 40	....	2.57	2.47	2.40	2.30	2.14	2.12	2.13	2.04
Bulk specific gravity.	F 21	1.64	1.61	1.61	1.64	1.55	1.58	1.54	1.52	....
	P 40	....	2.04	2.14	2.16	2.14	2.05	1.94	1.83	1.79
Color	F 21	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
	P 40	..	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	F 21	S	S	S	S	S	S	S	S	S
	P 40	..	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of F 21 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 40 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a

No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. This clay has a short vitrification range and therefore its use would be limited.

ELLERSLIE FIRE CLAY MINE. HEADING TO RIGHT

This section is in the heading to right in the Ellerslie Fire Clay Mine, Ellerslie, Maryland. The clays marked F 22, P 42, and F 23 were sampled and tested and the results are given below:

Properties of the Clays from Heading to Right in Ellerslie Fire Clay Mine

	F 22	P 42	F 23
Per cent water required	....	16.0	....
Plasticity, judged by feel	None.	Poor.	None.
Drying shrinkage, per cent dry length	....	4.0	....
Ratio of per cent shrinkage water to per cent pore water.	....	1:1.63	....
Per cent shrinkage water in terms of total water	....	37.8	....
Time of disintegration, minutes	....	4.1	....
Softening point, cones	33	30 +	34 +

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 22	39.0	38.9	41.3	40.3	40.1	41.8	40.2	41.0	43.0
	P 42	28.4	29.3	27.1	29.3	26.4	26.7	22.7	22.9	22.0
	F 23	38.3	37.9	36.8	36.6	34.7	34.1	33.3	33.2	33.5
Volume shrinkage.	F 22	17.7	17.1	15.0	12.5	10.7	9.2	9.7	10.3	12.3
	P 42	9.1	13.0	14.3	14.6	15.3	14.6	15.2	15.8	16.1
	F 33	12.2	13.2	16.1	14.3	14.9	14.8	15.2	16.2	15.7
Apparent specific gravity.	F 22	2.70	2.74	2.72	2.67	2.60	2.63	2.61	2.63	2.63
	P 42	2.70	2.70	2.69	2.68	2.64	2.61	2.60	2.60	2.60
	F 23	2.68	2.69	2.68	2.66	2.63	2.59	2.58	2.59	2.58
Bulk specific gravity.	F 22	1.65	1.67	1.64	1.59	1.56	1.53	1.56	1.56	1.50
	P 42	1.93	1.91	1.96	1.90	1.94	1.91	2.01	1.99	2.02
	F 23	1.65	1.67	1.70	1.69	1.72	1.71	1.72	1.74	1.72
Color	F 22	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Few black spots.	Few black spots.
	P 42	Buff.	Buff.	Buff.	Buff.	Brown	Few black spots.	Few black spots.	Few black spots.	Few black spots.
	F 23	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.
Hardness	F 22	S	S	S	S	S	S	S	S	S
	P 42	S	S	S	S	H	H	H	H	H
	F 23	S	S	S	S	S	S	S	S	S

S = Softer than steel. H = Harder than steel.

The softening point of F 22 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 42 meets the requirements of a No. 1 fire clay and therefore it may be used as bond for the flint clay.

The softening point of F 23 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

East Side of Dan's Mountain

This section is on the east side of Dan's Mountain below Montell Tunnel, southeast of Mount Savage, Maryland. The clay marked P 45 was sampled and tested and the results are given below:

Properties of P 45 from East Side of Dan's Mountain

	P 45
Per cent water required	22.2
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	4.7
Ratio of per cent shrinkage water to per cent pore water	1:1.86
Per cent shrinkage water in terms of total water	35.0
Time of disintegration, minutes	5.0
Softening point, cones	28

Properties of P 45 when fired to temperatures between 1150° 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	15.8	9.2	6.9	9.1	8.5	8.9	10.0	10.6	12.5
Volume shrinkage	15.5	18.3	12.3	4.7	5.2	5.0	0.5	4.0	3.7
Apparent specific gravity.	2.60	2.49	2.26	2.14	1.25	2.10	2.04	2.00	2.05
Bulk specific gravity.	2.19	2.26	2.21	1.94	1.97	1.91	1.83	1.78	1.80
Color	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.	Black spots	Black spots.
Hardness	H	H	H	H	H	H	H	H	H

H = Harder than steel.

Chemical Analysis of P 45

Loss on ignition	8.34
SiO_2	55.97
Al_2O_3	26.64
Fe_2O_3	2.77
CaO	Trace
MgO	.20
TiO_2	1.55
Na_2O	.46
K_2O	2.61
S	.49
H_2O at 105° C	1.22
	100.25

Ceramic Formula

$$\left.\begin{array}{l} .136\ FeO \\ .019\ MgO \\ .106\ K_2O \\ .029\ Na_2O \end{array}\right\} 1.0\ Al_2O_3 \left\{\begin{array}{l} 3.550\ SiO_2 \\ .075\ TiO_2 \end{array}\right.$$

.290 RO

The softening point of P 45 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay, showing signs of swelling due to overburning above 1200° C. The chemical analysis show .290 equivalents RO which is too high for a high-grade refractory clay. The ratio shrinkage to pore water indicates fair bonding properties in the green state. The use of this clay for ceramic purposes would be limited owing to its short vitrification range which is less than 100° C.

GARRETT COUNTY, MARYLAND

Frostburg. Big Savage Fire Brick Co.

BENSON'S MINE. THIRD AND LAST HEADING TO RIGHT ON AUGUST 3, 1916

This section is in the third and last heading to right on August 3, 1916, and is at the intersection of old heading in Benson's Mine, north of Frostburg. The clays marked P 30, P 26, F 10, P 27, P 28, and P 29 were sampled and tested and the results are given below:

Properties of the Clays from Section of Benson's Mine

	P 30	P 26	F 10	P 27	P 28	P 29
Per cent water required.......	29.1	20.0	......	36.6	21.0	19.3
Plasticity, judged by feel......	Good.	Fair.	None.	Excellent	Fair.	Good.
Drying shrinkage, per cent dry length.	4.8	3.5	......	8.0	6.0	3.8
Ratio of per cent shrinkage water to per cent pore water.	1:2.27	1:2.52	......	1:1.84	1:1.18	1:2.22
Per cent shrinkage water in terms of total water.	30.6	38.4	......	31.5	46.0	31.2
Time of disintegration, minutes	3.2	4.0	......	11.7	4.9	5.9
Softening point, cones.........	27	29	34	32+	26	27

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 30	13.5	6.0	0.8	0.8	0.2	3.0	5.3	1.9	0.7
	F 10	35.9	36.2	36.5	38.2	38.1	38.1	36.6	37.1	.....
	P 28	21.5	19.8	7.0	6.6	5.3	2.6	0.6	0.3	0.5
	P 29	20.4	15.4	7.1	4.7	0.6	0.2	0.3	0.5	0.3
Volume shrinkage.	P 30	24.7	28.4	30.6	29.8	26.8	23.7	18.5	21.3	19.6
	F 10	16.3	17.4	16.8	17.1	17.1	17.2	16.1	15.2	.....
	P 28	9.7	11.3	20.0	20.2	18.9	18.2	17.9	18.5	17.8
	P 29	10.6	14.4	19.3	22.3	20.4	19.0	16.4	14.1	12.7
Apparent specific gravity.	P 30	2.47	2.41	2.35	2.33	2.24	2.13	2.09	2.07	2.04
	F 10	2.74	2.73	2.73	2.74	2.73	2.70	2.70	2.70	.....
	P 28	2.55	2.55	2.43	2.43	2.37	2.28	2.25	2.21	2.19
	P 29	2.62	2.52	2.44	2.43	2.32	2.27	2.18	2.13	2.10
Bulk specific gravity.	P 30	2.14	2.26	2.34	2.31	2.24	2.07	1.98	2.06	2.03
	F 10	1.75	1.74	1.74	1.73	1.72	1.69	1.71	1.69	.....
	P 28	2.00	2.04	2.23	2.27	2.25	2.22	2.23	2.21	2.17
	P 29	2.05	2.14	2.27	2.32	2.30	2.26	2.17	2.13	2.10
Color.......	P 30	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
	F 10	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
	P 28	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.
	P 29	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.
Hardness...	P 30	H	H	H	H	H	H	H	H	H
	F 10	S	S	S	S	S	S	S	S	S
	P 28	H	H	H	H	H	H	H	H	H
	P 29	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 30 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures appears to be inferior to those of the average No. 3 fire clay, showing a swelling due to overburning above 1300° C. The range between incipient and viscous vitrification is about 150° C. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

The softening point of P 26 meets the requirements of a No. 2 fire clay and therefore a separation of this clay from the other plastic clays is not necessary in mining.

The softening point of F 10 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 27 meets the requirements of a No. 1 fire clay and therefore a separation of this clay from the other plastic clays is not necessary in mining.

The softening point of P 28 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a glass pot clay. The ratio of shrinkage to pore water indicates good bonding properties in the green state. It appears promising for the manufacture of glass pots as well as other refractories.

The softening point of P 29 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to some glass pot clays. The ratio of shrinkage to pore water indicates good bonding properties in the green state. It appears promising for the manufacture of glass pots, fire-proofing, hollow block, stoneware, and similar ware.

BENSON'S MINE. FIRST HEADING ON RIGHT, AUGUST 8, 1916

This section is in the first heading on right in Benson's Mine, north of Frostburg, Maryland. The clays marked F 12 and P 31 were sampled and tested and the results are given below:

Properties of the Clays from Section in Benson's Mine

	F 12	P 31
Per cent water required	....	19.7
Plasticity, judged by feel	None.	Good.
Drying shrinkage, per cent dry length	....	3.8
Ratio of per cent shrinkage water to per cent pore water	....	1:1.89
Per cent shrinkage water in terms of total water	....	34.6
Time of disintegration, minutes	....	5.5
Softening point, cones	34	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 12	31.7	33.8	29.8	29.6	31.6	30.8	31.7	28.3	....
	P 31	18.5	14.3	8.3	3.6	1.8	1.8	9.3	7.9	3.7
Volume shrinkage.	F 12	17.9	18.8	16.9	17.8	14.8	13.7	15.0	14.8	....
	P 31	17.9	12.6	16.5	16.0	14.1	10.6	5.1	1.1	—0.7
Apparent specific gravity.	F 12	2.52	2.51	2.45	2.48	2.44	2.41	2.43	2.40	....
	P 31	2.54	2.49	2.44	2.31	2.23	2.14	2.17	2.07	1.95
Bulk specific gravity.	F 12	1.72	1.66	1.74	1.71	1.66	1.68	1.66	1.73	....
	P 31	2.07	2.14	2.24	2.23	2.18	2.10	1.97	1.90	1.88
Color	F 12	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
	P 31	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	F 12	S	S	S	S	S	S	S	S	S
	P 31	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of F 12 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 31 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. It shows signs of swelling due to overburning when fired above 1275° C. The ratio of shrinkage to pore water indicates good bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

BENSON'S MINE. SECOND HEADING TO RIGHT IN LAST ROOM TO RIGHT

This section is in the second heading to right in last room to right of Benson's Mine, north of Frostburg, Maryland. The clays marked P 32, F 14, P 33, and P 34 were sampled and tested and the results are given below:

Properties of Clays from Benson's Mine

	P 32	F 14	P 33	P 34
Per cent water required	17.7	....	35.0	37.4
Plasticity, judged by feel	Poor.	None.	Excellent.	Excellent.
Ratio of per cent shrinkage water to per cent pore water	1:1.27	....	1:1.20	1:1.09
Per cent shrinkage water in terms of total water	44.0	....	45.0	48.0
Time of disintegration, minutes	3.3	....	7.5	7.7
Softening point, cones	26	35	32	32

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 32	22.4	20.7	20.0	17.7	18.6	14.4	15.6	12.0	11.4
	F 14	35.9	36.7	34.2	34.0	33.1	34.8	33.9	32.1	....
	P 34	4.6	2.3	1.3	3.4	2.1	1.9	0.8	2.8	2.4
Volume shrinkage.	P 32	7.5	6.7	7.4	7.8	8.2	8.2	8.5	9.2	11.3
	F 14	16.5	17.6	17.4	16.8	17.1	14.5	14.6	15.4	....
	P 34	34.1	36.0	37.4	36.5	36.1	35.5	35.7	34.5	33.3
Apparent specific gravity.	P 32	2.54	2.50	2.49	2.44	2.39	2.37	2.36	2.35	2.35
	F 14	2.71	2.71	2.71	2.70	2 67	2.61	2.62	2.63	....
	P 34	2.46	2.47	2.50	2.50	2.48	2.45	2.41	2.42	2.39
Bulk specific gravity.	P 32	1.97	1.98	1.99	2.01	2.01	2.03	2.04	2.06	2.10
	F 14	1.74	1.72	1.79	1.79	1.74	1.70	1.68	1.79	....
	P 34	2.34	2.41	2.47	2.42	2.43	2.42	2.41	2.35	2.32
Color	P 32	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
	F 14	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
	P 34	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	P 32	S	S	S	S	S	S	H	H	H
	F 14	S	S	S	S	S	S	S	S	S
	P 34	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 32 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates good bonding properties in the green state. It appears promising for the manufacture of No. 2 refractories and similar ware.

The softening point of F 14 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 33 meets the requirements of a No. 1 fire clay and therefore a separation of this clay from the others in mining is not necessary.

The softening point of P 34 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to the high-grade crucible clays. It has remarkable burning properties being vitrified at 1150° C. and showing no signs of swelling at 1400° C., which are properties of considerable importance in the manufacture of graphite crucibles used for melting brass. The ratio of shrinkage to pore water indicates very good bonding properties in the green state. It appears especially promising for the manufacture of graphite crucibles and glass pots.

Benson's Tunnel. Extreme End of Heading to Right

This section is at the extreme end of heading to right of Benson's Tunnel, north of Frostburg, Maryland. The clays marked P 36, F 15, and P 37 were sampled and tested and the results are given below:

Properties of Clays from Benson's Tunnel

	P 36	F 15	P 37
Per cent water required	17.7	....	17.5
Plasticity, judged by feel	Fair.	None.	Good.
Drying shrinkage, per cent dry length	4.9	....	4.1
Ratio of per cent shrinkage water to per cent pore water	1:1.36	....	1:1.77
Per cent shrinkage water in terms of total water	42.5	....	36.0
Time of disintegration, minutes	7.0	....	5.4
Softening point, cones	27	34	25

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 36	24.2	22.8	18.8	16.8	11.7	9.9	8.1	7.3	5.0
	F 15	29.2	26.5	26.7	28.2	28.5	28.9	28.1	28.0	26.8
Volume shrinkage.	P 36	7.3	8.7	11.8	12.5	13.0	13.3	12.8	12.5	12.5
	F 15	....	14.0	14.6	14.1	13.4	12.9	12.6	11.8	12.6
Apparent specific gravity.	P 36	2.67	2.66	2.60	2.57	2.44	2.40	2.36	2.31	2.28
	F 15	2.49	2.35	2.39	2.39	2.38	2.37	2.37	2.38	2.34
Bulk specific gravity.	P 36	2.02	2.05	2.11	2.13	2.16	2.16	2.15	2.15	2.17
	F 15	1.70	1.73	1.75	1.72	1.71	1.69	1.71	1.71	1.71
Color	P 36	Buff.	Buff.	Buff.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.	Black spots.
	F 15	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
Hardness...	P 36	S	S	H	H	H	H	H	H	H
	F 15	S	S	S	S	S	S	S	S	S

S = Softer than steel. H = Harder than steel.

The softening point of P 36 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

The softening point of F 15 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond it appears promising for the manufacture of No. 1 refractories.

The softening point of P 37 does not meet the requirements of a fire clay and therefore does not appear promising for the manufacture of refractories.

BENSON'S TUNNEL. FIRST ROOM ON RIGHT OF LAST HEADING TO LEFT

This section is in the first room on the right of last heading to left of Benson's Tunnel, north of Frostburg, Maryland. The clays marked F 16 and P 38 were sampled and tested and the results are given below:

Properties of the Clays from Benson's Tunnel

	F 16	P 38
Per cent water required	....	18.3
Plasticity, judged by feel	None.	Fair.
Drying shrinkage, per cent dry length	....	4.4
Ratio of per cent shrinkage water to per cent pore water	....	1:1.68
Per cent shrinkage water in terms of total water	....	37.2
Time of disintegration, minutes	....	5.7
Softening point, cones	34	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 16	33.0	32.6	32.8	32.2	32.3	32.3	31.0	30.6	30.8
	P 38	25.0	22.3	17.5	14.3	11.1	9.4	8.8	7.7	6.7
Volume shrinkage.	F 16	10.4	9.3	10.6	9.9	8.7	9.0	8.8	8.7	8.7
	P 38	4.1	6.5	10.0	11.0	12.4	11.8	11.4	13.6	14.4
Apparent specific gravity.	F 16	2.50	2.49	2.52	2.52	2.52	2.55	2.49	2.44	2.48
	P 38	2.65	2.62	2.57	2.50	2.44	2.39	2.36	2.40	2.40
Bulk specific gravity.	F 16	1.67	1.68	1.70	1.70	1.71	1.72	1.72	1.70	1.71
	P 38	1.98	2.03	2.11	2.14	2.17	2.17	2.15	2.22	2.24
Color	F 16	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
	P 38	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.	Few black spots.	Few black spots	Few black spots.
Hardness	F 16	S	S	S	S	S	S	S	S	S
	P 38	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of F 16 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 38 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to the average No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the dry state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

BENSON'S TUNNEL. SECOND HEADING TO LEFT, SEPTEMBER 6, 1916

This section is in the second heading to the left, behind brattice, in Benson's Tunnel, north of Frostburg, Maryland. The clay marked P 39 was sampled and tested and the results are given below:

Properties of P 39 from Benson's Tunnel

	P 39
Per cent water required	18.1
Plasticity, judged by feel	Fair.
Drying shrinkage, per cent dry length	3.7
Ratio of per cent shrinkage water to per cent pore water	1:2.11
Per cent shrinkage water in terms of total water	32.1
Time of disintegration, minutes	6.3
Softening point, cones	29

Properties of P 39 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	24.2	21.4	18.3	15.7	13.2	10.6	6.9	7.6	3.2
Volume shrinkage	11.3	14.1	16.0	17.0	15.2	15.4	14.2	16.1	19.3
Apparent specific gravity.	2.72	2.71	2.67	2.64	2.54	2.43	2.32	2.38	2.36
Bulk specific gravity	2.06	2.13	2.18	2.23	2.21	2.18	2.16	2.20	2.28
Color	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Few black spots.	Few black spots.	Few black spots.
Hardness	S	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

Chemical Analysis of P 39

Loss on ignition	9.57
SiO_2	52.84
Al_2O_3	28.20
Fe_2O_3	4.60
CaO	Trace
MgO	.05
TiO_2	1.72
Na_2O	.50
K_2O	1.80
S	.13
H_2O at 105° C.	1.00
	100.41

Ceramic formula

$$\left.\begin{array}{l} .150\ FeO \\ .005\ MgO \\ .069\ K_2O \\ .029\ Na_2O \end{array}\right\} 1.0\ Al_2O_3 \left\{\begin{array}{l} 3.170\ SiO_2 \\ .276\ TiO_2 \end{array}\right.$$

.253 RO

The softening point of P 39 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The chemical analysis shows .253 equivalents RO which is too high for a highly refractory fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

BENSON'S TUNNEL. THIRD AND LAST PLACE TO LEFT

This section is in the third place to left behind brattice in Benson's Tunnel near Frostburg, Maryland. The clays marked F 25 and F 26 were sampled and tested and the results are given below:

Properties of P 39 When Fired to Temperatures Between 1150 and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 25	.....	29.6	31.2	31.0	32.3	33.1	33.1	32.7	33.3
	F 26	33.6	31.8	29.9	31.8	31.5	28.1	29.7	28.7	29.1
Volume shrinkage.	F 26	15.2	17.0	17.6	19.8	18.6	18.9	18.5	17.9	17.7
Apparent specific gravity.	F 25	.....	2.14	2.18	2.18	2.20	2.18	2.17	2.11	2.12
	F 26	2.58	2.58	2.55	2.55	2.53	2.50	2.49	2.46	2.46
Bulk specific gravity.	F 25	.....	1.51	1.50	1.51	1.49	1.46	1.45	1.42	1.42
	F 26	1.72	1.76	1.79	1.74	1.73	1.79	1.75	1.76	1.74
Color......	F 25	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Few black spots.	Few black spots.	Few black spots.
	F 26	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness...	F 25	S	S	S	S	S	S	S	S	S
	F 26	S	S	S	S	S	S	S	S	S

S = Softer than steel.

The softening point of F 25 is cone 33 which meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a No. 1 bond clay it appears to be promising for the manufacture of No. 1 refractories.

The softening point of F 26 is cone 30 which meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures appears to be similar to a No. 1 fire clay. With a refractory bond clay it appears to be promising for the manufacture of No. 2 refractories.

BENSON'S TUNNEL. SMALL CUT INTO FURNACE CLAY

This section is in small cut into furnace clay in Benson's Tunnel of the Big Savage Fire Brick Co., near Frostburg, Maryland. The clay marked F 27 was sampled and tested and the results are given below:

Properties of F 27 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity..	38.7	38.2	38.2	39.9	40.0	40.0	40.0	40.9	40.5
Volume shrinkage..	2.0	2.6	....	0.2	—1.3	—2.9	—3.4	—4.5	—4.4
Apparent specific gravity.	2.67	2.67	2.64	2.62	2.57	2.54	2.54	2.54	2.54
Bulk specific gravity	1.63	1.65	1.64	1.57	1.54	1.53	1.52	1.50	1.51
Color..............	Buff.	Buff.	Buff.	Buff.	Buff.	Few black spots.	Few black spots.	Few black spots.	Few black spots.
Hardness...........	S	S	S	S	S	S	S	S	S

S = Softer than steel.

The softening point of F 27 is cone 27 and meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a No. 2 bond clay it appears promising for the manufacture of No. 2 refractories.

Frostburg. Savage Mountain Fire Brick Co.

FROSTBURG MINE NO. 6

This section is in Frostburg Mine No. 6 of the Savage Mountain Fire Brick Co., Frostburg, Maryland. The clays marked P 46 and F 28 were sampled and tested and the results are given below:

Properties of Clays from Frostburg Mine No. 6

	P 46	F 28
Per cent water required	13.6	....
Plasticity, judged by feel	Poor.	None.
Drying shrinkage, per cent dry length	3.2	....
Ratio of per cent shrinkage water to per cent pore water	1:1.89	....
Per cent shrinkage water in terms of total water	34.6	....
Time of disintegration, minutes	3.9	....
Softening point, cones	30	35

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 46	25.9	22.4	22.0	20.0	17.5	15.4	13.6	14.2	14.3
	F 28	40.0	40.4	40.4	40.4	40.2	41.4	40.3	40.2	38.7
Volume shrinkage.	P 46	9.6	10.2	12.2	12.3	13.8	13.4	13.6	12.8	12.4
	F 28	17.6	19.2	17.4	16.8	16.0	17.1	14.7	14.6	12.1
Apparent specific gravity.	P 46	2.64	2.54	2.57	2.56	2.52	2.46	2.42	2.42	2.41
	F 28	2.70	2.69	2.72	2.70	2.67	2.66	2.65	2.65	2.58
Bulk specific gravity.	P 46	1.96	1.97	2.01	2.05	2.08	2.08	2.09	2.08	2.06
	F 28	1.62	1.60	1.62	1.61	1.59	1.62	1.57	1.58	1.53
Color	P 46	Buff.	Buff.	Gray·	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
	F 28	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
Hardness...	P 46	S	S	H	H	H	H	H	H	H
	F 28	S	S	S	S	S	S	S	S	S

S = Softer than steel. H = Harder than steel.

The softening point of P 46 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of No. 2 refractories and similar ware.

The softening point of F 28 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to those of a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

Frostburg Mine No. 6. First Heading to Left of Main Right Heading

This section is in the first heading on left of main right heading of Frostburg Mine No. 6, northwest of Frostburg, Maryland. The clay marked P 47 was sampled and tested and the results are given below:

Properties of P 47 from Frostburg Mine No. 6

	P 47
Per cent water required	25.9
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	6.0
Ratio of per cent shrinkage water to per cent pore water	1:1.49
Per cent shrinkage water in terms of total water	40.0
Time of disintegration, minutes	6.1
Softening point, cones	32

Properties of P 47 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	17.8	17.8	17.2	15.7	11.0	7.2	4.8	3.1	2.6
Volume shrinkage	15.7	18.7	22.2	23.5	26.6	28.6	29.8	31.6	28.8
Apparent specific gravity	2.60	2.62	2.58	2.57	2.54	2.53	2.49	2.48	2.41
Bulk specific gravity	2.02	2.05	2.14	2.16	2.26	2.34	2.36	2.40	2.35
Color	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Few black spots.	Few black spots.	Few black spots.
Hardness	S	S	S	S	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

Chemical Analysis of P 47

Loss on ignition	10.54
SiO_2	51.90
Al_2O_3	31.91
Fe_2O_3	1.57
CaO	Trace
MgO	.04
TiO_2	1.76
Na_2O	.26
K_2O	1.61
S	.03
H_2O at 105° C	.53
	100.15

Ceramic Formula

$$\left.\begin{array}{l} .063\ FeO \\ .003\ MgO \\ .055\ K_2O \\ .015\ Na_2O \end{array}\right\} 1.0\ Al_2O_3 \left\{\begin{array}{l} 2.750\ SiO_2 \\ .071\ TiO_2 \end{array}\right.$$

$$\overline{.136\ RO}$$

The softening point of P 47 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a glass pot clay. The chemical analysis shows .136 equivalents of RO which is within the limits of a high-grade refractory. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of glass pots as well as for other high-grade refractories.

FROSTBURG MINE No. 6. EXTREME OF MAIN RIGHT HEADING

This section is in the extreme of the main right heading of Frostburg Mine No. 6, northwest of Frostburg, Maryland. The clays marked P 60, P 61, F 31, and P 62 were sampled and tested and the results are given below:

Properties of the Clays from Caldwell's Mine

	P 60	P 61	F 31	P62
Per cent water required	20.7	14.1	....	36.5
Plasticity, judged by feel	Good.	Poor.	None.	Excellent.
Drying shrinkage, per cent dry length	4.8	3.3	....	7.4
Ratio of per cent shrinkage water to per cent pore water	1:1.69	1:1.91	....	1:1.42
Per cent shrinkage water in terms of total water	37.2	34.5	....	41.4
Time of disintegration, minutes	6.2	3.6	....	21.0
Softening point, cones	26	26	32 +	32 +

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 60	18.6	13.1	8.9	7.9	6.1	5.6	4.8	3.6	4.4
	P 61	32.1	31.1	30.2	29.9	29.6	28.4	29.1	27.6	26.6
	F 31	39.3	38.7	39.5	39.7	38.7	38.8	39.1	38.8	39.0
Volume shrinkage.	P 60	14.2	17.1	19.1	19.1	17.6	14.8	14.2	8.5	9.1
	P 61	5.3	8.1	6.9	5.6	6.0	5.5	5.5	4.9	5.5
	F 31	13.6	16.8	17.7	15.6	15.7	14.4	14.6	14.4	14.3
Apparent specific gravity.	P 60	2.57	2.49	2.42	2.40	2.34	2.27	2.21	2.08	2.06
	P 61	2.66	2.63	2.58	2.56	2.54	2.50	2.51	2.46	2.44
	F 31	2.66	2.00	2.71	2.71	2.66	2.61	2.65	2.64	2.64
Bulk specific gravity.	P 60	2.09	2.16	2.21	2.21	2.20	2.15	2.10	2.01	1.98
	P 61	1.81	1.81	1.81	1.79	1.79	1.75	1.78	1.77	1.79
	F 31	1.62	1.66	1.64	1.65	1.63	1.60	1.62	1.62	1.62
Color	P 60	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
	P 61	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.
	F 31	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.
Hardness	P 60	H	H	H	H	H	H	H	H	H
	P 61	S	S	S	S	S	S	H	H	H
	F 31	S	S	S	S	S	S	S	S	S

S = Softer than steel. H = Harder than steel.

The softening point of P 60 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

The softening point of P 61 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of No. 2 refractories.

The softening point of F 31 meets the requirements of a No. 1 fire clay and the properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 62 meets the requirements of a No. 1 fire clay and therefore a separation of this clay from the others in mining is not necessary.

FROSTBURG MINE NO. 6. HEADING ON LEFT OF MAIN RIGHT HEADING

This section is in the last heading on left of main right heading where it joins Benson's. The clays marked P 63, F 32, and P 64 were sampled and tested and the results are given below:

Properties of the Clays from Frostburg Mine No. 6

	P 63	F 32	P 64
Per cent water required	31.7	....	22.4
Plasticity, judged by feel	Very good.	None.	Good.
Drying shrinkage, per cent dry length	6.7	....	5.2
Ratio of per cent shrinkage water to per cent pore water	1:1.83	....	1:1.61
Per cent shrinkage water in terms of total water	35.4	....	38.4
Time of disintegration, minutes	5.4	....	6.6
Softening point, cones	26	35	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 63	9.1	.....	0.7	1.1	0.6	5.5	8.3	8.7	8.6
	F 32	36.0	36.3	37.8	38.1	39.1	37.7	39.4	39.7	39.9
	P 64	18.4	9.1	5.7	3.6	1.1	0.6	0.5	9.8	14.7
Volume shrinkage.	P 63	27.5	.....	31.0	30.8	24.4	18.7	17.8	14.7	12.8
	F 32	20.6	19.7	18.9	18.3	17.4	17.6	14.5	14.5	13.1
	P 64	13.6	19.8	23.6	22.8	24.0	23.7	20.5	10.1	7.4
Apparent specific gravity.	P 63	2.44	2.34	2.34	2.33	2.14	2.17	2.12	2.05	2.01
	F 32	2.52	2.53	2.61	2.62	2.61	2.63	2.57	2.58	2.56
	P 64	2.48	2.41	2.39	2.36	2.34	2.31	2.22	2.16	2.22
Bulk specific gravity.	P 63	2.22	2.33	2.33	2.30	2.12	1.95	1.94	1.87	1.84
	F 32	1.61	1.61	1.63	1.62	1.59	1.58	1.56	1.55	1.54
	P 64	2.02	2.19	2.26	2.27	2.31	2.30	2.21	1.94	1.89
Color.......	P 63	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Few black spots.	Few black spots.	Few black spots.
	F 32	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Few black spots.	Few black spots.	Few black spots.
	P 64	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Few black spots.	Few black spots.	Few black spots.
Hardness...	P 63	H	H	H	H	H	H	H	H	H
	F 32	S	S	S	S	S	S	S	S	S
	P 64	S	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 63 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are inferior to a No. 3 fire clay. The difference between incipient and viscous vitrification is about 175° C. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

The softening point of F 32 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 64 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are inferior to a

No. 3 fire clay. The difference between incipient and viscous vitrification is about 175° C. The ratio of shrinkage to pore water indicates a fair bond clay in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

Koontz Run. Maryland Coal Co.

This section is near Koontz Run on the property of the Maryland Coal Co., Maryland. The clay marked P 48 was sampled and tested and the results are given below:

Properties of P 48 from Koontz Run

	P 48
Per cent water required	22.7
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	6.6
Ratio of per cent shrinkage water to per cent pore water	1:1.15
Per cent shrinkage water in terms of total water	47.0
Time of disintegration, minutes	9.0
Softening point, cones	18

The softening point of P 48 does not met the requirements of a fire clay and therefore it is not promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates good bonding properties in the green state.

Loarville

MONTELL TUNNEL. 108 FEET FROM START OF ENTRY TO 5-FOOT VEIN

This section is 108 feet from start of entry to 5-foot vein in the Montell Tunnel near Loarville, Maryland. The clay marked P 50 was sampled and tested and the results are given below:

Properties of P 50 from Montell Tunnel

	P 50
Per cent water required	13.7
Plasticity, judged by feel	Poor.
Drying shrinkage, per cent dry length	2.3
Ratio of per cent shrinkage water to per cent pore water	1:3.04
Per cent shrinkage water in terms of total water	24.7
Time of disintegration, minutes	3.4
Softening point, cones	26

The softening point of P 50 meets the requirements of a No. 3 fire clay. The ratio of shrinkage to pore water indicates poor bonding properties in the dry state.

MONTELL TUNNEL. FIRE CLAY IN ENTRY TO 5-FOOT VEIN

This section is in the Montell Tunnel, Loarville, Maryland. The clays marked P 51 and P 52 were sampled and tested and the results are given below:

Properties of Clays from Montell Tunnel

	P 51	P 52
Per cent water required	15.2	12.9
Plasticity, judged by feel	Poor.	Poor.
Drying shrinkage, per cent dry length	4.2	1.7
Ratio of per cent shrinkage water to per cent pore water	1:1.41	1:4.15
Per cent shrinkage water in terms of total water	41.6	19.4
Time of disintegration, minutes	5.5	4.7
Softening point, cones	22	17

The softening point of P 51 does not meet the requirements of a fire clay and therefore this clay does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

The softening point of P 52 does not meet the requirements of a fire clay and therefore does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates poor bonding properties in the green state.

MONTELL TUNNEL. 840 FEET FROM MOUTH

This section is in small opening in clay on north wall of the tunnel, 840 feet in from mouth of mine. The clay marked P 53 was sampled and tested and the results are given below:

Properties of P 53 from the Montell Tunnel

	P 53
Per cent water required	17.1
Plasticity, judged by feel	Poor.
Drying shrinkage, per cent dry length	5.5
Ratio of per cent shrinkage water to per cent pore water	1:1.63
Per cent shrinkage water to per cent total water	38.0
Time of disintegration, minutes	4.6
Softening point, cones	17

The softening point of P 53 does not meet the requirements of a fire clay and therefore does not appear promising for the manufacture of refractory wares. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

MONTELL TUNNEL. 520 FEET FROM MOUTH

This section is in a small opening in clay on the north wall of the Montell Tunnel, 520 feet from the mouth. The clay marked P 54 was sampled and tested and the results are given below:

Properties of P 54 from Montell Tunnel

	P 54
Per cent water required	17.0
Plasticity, judged by feel	Fair.
Drying shrinkage, per cent dry length	4.5
Ratio of per cent shrinkage water to per cent pore water	1:1.20
Per cent shrinkage water in terms of total water	45.5
Time of disintegration, minutes	4.6
Softening point, cones	17

The softening point of P 54 does not meet the requirements of a fire clay and therefore does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates good bonding properties in the green state.

Castleman River

PROSPECT 1¼ MI. S. E. OF GRANTSVILLE

This section is on a small run of Castleman River. Exposure opposite mine of U. M. Stanton. Clay marked P 55 was sampled and tested and the results are given below:

Properties of P 55 1¼ Mi S. E. of Grantsville

	P 55
Per cent water required	20.4
Plasticity, judged by feel	Fair.
Drying shrinkage, per cent dry length	5.3
Ratio of per cent shrinkage water to per cent pore water	1:1.40
Per cent shrinkage water in terms of total water	41.7
Time of disintegration, minutes	5.6
Softening point, cones	13

The softening point of P 55 does not meet the requirements of a fire clay and it therefore could not be used for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

PROSPECT 3 MI. S. W. OF GRANTSVILLE, 180 FEET S. 48° W. OF MOUTH OF COAL MINE

This section is on the north bank of Castleman Run above stream and 180 feet S. 48° W. of mouth of coal mine on old lumber tram from Davis, Maryland. F 30 and P 57 were sampled and tested.

Properties of Clays from 3 Mi. S. W. of Grantsville

	F 30	P 57
Per cent water required	....	25.3
Plasticity, judged by feel	None.	Good.
Drying shrinkage, per cent dry length	....	5.5
Ratio of per cent shrinkage water to per cent pore water	....	1:1.72
Per cent shrinkage water in terms of total water	....	36.8
Time of disintegration, minutes	....	5.0
Softening point, cones	33	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 30	31.0	30.8	29.4	30.5	30.9	31.0	30.0	29.1	29.4
	P 57	24.1	18.7	15.1	11.9	8.5	6.2	3.4	1.8	7.0
Volume shrinkage.	P 57	13.0	17.0	19.5	21.2	21.8	22.6	22.1	18.3	15.6
Apparent specific gravity.	F 30	2.02	2.10	2.08	2.09	2.11	2.12	2.06	2.03	2.04
	P 57	2.59	2.55	2.51	2.45	2.38	2.33	2.29	2.15	2.20
Bulk specific gravity.	F 30	1.40	1.46	1.46	1.46	1.46	1.46	1.45	1.44	1.46
	P 57	1.97	2.08	2.13	2.16	2.18	2.18	2.21	2.11	2.04
Color	F 30	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
	P 57	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Few black spots.	Few black spots.	Few black spots.
Hardness	F 30	S	S	S	S	S	S	S	S	S
	P 57	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of F 30 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a

No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 57 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

FUEL MINE. ON WEST SIDE OF RIDGELY HILL

This section is in a small fuel mine on west side of Ridgely Hill on Mr. Bevon's farm in Garrett County, Maryland. The clay marked P 58 was sampled and tested and the results are given below:

Properties of P 58 on West Side of Ridgely Hill

	P 58
Per cent water required	18.8
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	5.7
Ratio of per cent shrinkage water to per cent pore water	1:1.14
Per cent shrinkage water in terms of total water	46.6
Time of disintegration, minutes	7.9
Softening point, cones	26

Properties of P 58 when fired to temperatures between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	22.1	21.3	16.7	14.6	12.8	11.4	8.7	7.8	6.5
Volume shrinkage	8.6	9.3	8.5	7.0	5.2	3.6	1.2	2.1	2.1
Apparent specific gravity.	2.58	2.58	2.41	2.33	2.25	2.15	2.10	2.08	2.06
Bulk specific gravity	2.02	2.03	2.01	1.99	1.96	1.90	1.91	1.92	1 93
Color	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 58 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates a good bond clay in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware and similar ware.

FUEL MINE. NEAR CASTLEMAN'S RIVER

This section is in small fuel mine on the west side of Ridgely Hill, Garrett County, Maryland. The clay marked P 59 was sampled and tested an the results are given below:

Properties of P 59 on West Side of Ridgely Hill

	P 59
Per cent water required	19.9
Plasticity, judged by feel	Fair.
Per cent drying shrinkage, per cent dry length	4.1
Ratio of per cent shrinkage water to per cent pore water	1:2.00
Per cent shrinkage water in terms of total water	33.3
Time of disintegration, minutes	5.0
Softening point, cones	19

The softening point of P 59 does not meet the requirements of a fire clay and it therefore could not be used for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

Big Shade Run. Small Mine 1 Mi. N. W. of Grantsville

This section is in a small mine on Big Shade Run, Garrett County, Maryland. The clay marked P 56 was sampled and tested and the results are given below:

Properties of P 56 from Big Shade Run

	P 56
Per cent water required	15.4
Plasticity, judged by feel	Poor.
Drying shrinkage, per cent dry length	2.1
Ratio of per cent shrinkage water to per cent pore water	1:3.65
Per cent shrinkage water in terms of total water	21.5
Time of disintegration, minutes	2.7
Softening point, cones	16

The softening point of P 56 does not meet the requirements of a fire clay and it therefore could not be used for the manufacture of refractories.

The ratio of shrinkage to pore water indicates poor bonding properties in the green state.

Prospect. On Road to Piedmont Dam

This section is in a small fire clay prospect on the north side of new road to Piedmont Dam, about ½ mile northeast of dam. The clay marked P 67 was sampled and tested and the results are given below:

Properties of P 67 from Prospect on Road to Piedmont

	P 67
Per cent water required	22.0
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	5.5
Ratio per cent shrinkage water to per cent pore water	1:1.45
Per cent shrinkage water in terms of total water	40.8
Time of disintegration, minutes	7.6
Softening point, cones	26

Properties of P 67 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	12.2	8.4	7.7	7.4	6.6	8.3	11.4	13.1	13.9
Volume shrinkage	15.8	19.2	20.3	19.9	19.9	17.2	12.8	9.2	7.3
Apparent specific gravity.	2.44	2.43	2.42	2.43	2.40	2.37	2.33	2.29	2.25
Bulk specific gravity	2.14	2.23	2.24	2.25	2.23	2.27	2.06	1.99	1.93
Color	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Few black spots.	Few black spots.	Few black spots.
Hardness	H	H	H	H	H	H	H	H	H

H = Harder than steel.

The softening point of P 67 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are inferior to a No. 3 fire clay. The difference between incipient and viscous vitrification is about 175° C., the clay becoming soft and swelling above 1325° C. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow ware, stoneware, and similar ware.

Westernport. Miller and Greene Coal Co.

This section is in a coal mine of the Miller and Greene Coal Co. in Westernport, Maryland. The clay marked P 68 was sampled and tested and the results are given below:

Properties of P 68 from Coal Mine of the Miller and Greene Coal Co.

	P 68
Per cent water required	19.2
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	5.3
Ratio of per cent shrinkage water to per cent pore water	1:1.32
Per cent shrinkage water in terms of total water	43.0
Time of disintegration, minutes	4.9
Softening point, cones	23

The softening point of P 68 does not meet the requirements of a fire clay and it therefore could not be used for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the dry state.

Westernport. Three-fourth Miles East of Westernport

This section is three-fourths mile west of east of Westernport, Maryland. The clay marked F 54 was sampled and tested and the results are given below:

Properties of F 54 When Fired to Temperatures Between 1250° and 1375° C.

	1250°	1275°	1300°	1325°	1350°	1375°
Apparent porosity	31.0	32.1	32.4	37.9	33.0	38.5
Apparent specific gravity	2.09	2.20	2.21	2.27	2.26	2.29
Bulk specific gravity	1.48	1.50	1.49	1.40	1.51	1.42
Color	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.
Hardness	S	S	S	S	S	S

S = Softer than steel.

The softening point of F 54 is cone 34 and meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

Clarysville. Old Percy Opening

This section is in Old Percy opening in bottom of 4-foot coal at level of track at Clarysville, Maryland. Opening is 25 feet south of C. & P. R. R. and bearing on power house is N. 31° W. The clay marked P 69 was sampled and tested and the results are given below:

Properties of P 69 from Clarysville, Maryland

	P 69
Per cent water required	25.6
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	6.0
Ratio of per cent shrinkage water to per cent pore water	1:1.48
Per cent shrinkage water in terms of total water	40.3
Time of disintegration, minutes	5.8
Softening point, cones	18

The softening point of P 69 does not meet the requirements of a fire clay and it therefore does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

Bond. Cut on B. & O. R. R.

This section is from a cut on the B. & O. R. R., ¼ mile east of former tunnel east of Bond, Maryland. The clay marked P 72 was sampled and tested and the results are given below:

Properties of P 72 from Bond, Maryland

	P 72
Per cent water required	21.5
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	4.4
Ratio of per cent shrinkage water to per cent pore water	1:1.99
Per cent shrinkage water in terms of total water	28.3
Time of disintegration, minutes	4.2
Softening point, cones	20

The softening point of P 72 does not meet the requirements of a fire clay and it therefore does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates only fair bonding properties in the green state.

Bond. Cut on Railroad 410 Feet from Tower

This section is in first railroad cut above signal tower, west of former tunnel, and east of Bond, Maryland. The clays marked F 36 and P 73 were sampled and tested and the results are given below:

Properties of Clays from Railroad Cut East of Bond, Maryland

	F 36	P 73
Per cent water required	....	20.1
Plasticity, judged by feel	None.	Good.
Drying shrinkage, per cent dry length	....	5.9
Ratio of per cent shrinkage water to per cent pore water	....	1:1.18
Per cent shrinkage water in terms of total water	....	46.0
Time of disintegration, minutes	....	7.0
Softening point, cones	32	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 36	29.3	34.7	36.0	38.3	40.3	40.5	42.8	.....	.....
	P 73	10.0	5.9	4.4	5.1	4.7	5.1	5.6	8.5	8.3
Volume shrinkage.	P 73	21.2	20.1	23.3	22.2	20.6	18.2	9.8	12.5	11.5
Apparent specific gravity.	F 36	2.06	2.17	2.27	2.32	2.37	2.35	2.46	.....	.....
	P 73	2.48	2.39	2.32	2.37	2.30	2.25	2.11	2.18	2.15
Bulk specific gravity.	F 36	1.46	1.42	1.45	1.44	1.42	1.41	1.40	.....	.....
	P 73	2.25	2.25	2.21	2.25	2.19	2.09	1.99	2.00	1.98
Color	F 36	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.
	P 73	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	F 38	S	S	S	S	S	S	S	S	S
	P 73	H	H	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of F 36 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a

No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 73 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures appear to be inferior to a No. 3 fire clay. The ratio of shrinkage to pore water indicates good bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware and similar ware.

Prospect on the Potomac River

This prospect is from a cliff on the north bank of the Potomac River behind house at crossing of the C. P. & W. Md. R. R. in Westernport. The clay marked P 76 was sampled and tested and the results are given below:

Properties of P 76 from a Prospect of the Potomac River

	P 76
Per cent water required	22.1
Plasticity, judged by feel	Excellent.
Drying shrinkage, per cent dry length	5.0
Ratio of per cent shrinkage water to per cent pore water	1:1.66
Per cent shrinkage water in terms of total water	37.6
Time of disintegration, minutes	6.6
Softening point, cones	22

Properties of P 76 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	13.3	7.0	3.7	3.0	3.5	3.4	3.9	2.2	2.2
Volume shrinkage	19.5	20.6	16.3	13.8	10.5	7.5	7.6	4.9	2.1
Apparent specific gravity.	2.48	2.31	2.11	2.02	1.94	1.88	1.88	1.78	1.76
Bulk specific gravity	2.15	2.15	2.02	1.96	1.87	1.81	1.81	1.74	1.72
Color	Gray.	Gray.	Gray.	Gray.	Gray.	Few black spots.	Few black spots.	Few black spots.	Few black spots.
Hardness	H	H	H	H	H	H	H	H	H

H = Harder than steel.

The softening point of P 76 does not meet the requirements of a fire clay and it therefore does not appear promising for the manufacture of refractories. It reaches incipient vitrification at 1150° C. and viscous vitrification above 1200° C. The vitrification range of the clay is therefore small, about 50° C., and therefore its use would be limited. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

Sines Post Office. John Sines' Mine

This section is in John Sines' Mine at Sines Post Office, Maryland. The clay marked P 79 was sampled and tested and the results are given below:

Properties of P 79 from John Sines' Mine

	P 79
Per cent water required	17.4
Plasticity, judged by feel	Poor.
Drying shrinkage, per cent dry length	4.8
Ratio of per cent shrinkage water to per cent pore water	1:1.38
Per cent shrinkage water in terms of total water	42.2
Time of disintegration, minutes	4.5
Softening point, cones	33

The softening point of P 79 meets the requirements of a No. 1 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties.

Swallow Falls. Coal Prospect

This section is above coal prospect 114 feet north of Swallow Falls, Maryland. The clays marked F 37 and P 80 were sampled and tested and the results are given below:

Properties of Clays from Prospect Near Swallow Falls

	F 37	P 80
Per cent water required	....	20.1
Plasticity, judged by feel	None.	Poor.
Drying shrinkage, per cent dry length	....	4.1
Ratio of per cent shrinkage water to per cent pore water	....	1:2.08
Per cent shrinkage water in terms of total water	....	32.4
Time of disintegration, minutes	....	2.1
Softening point, cones	30	31

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400
Apparent porosity.	F 37	36.8	35.0	32.5	34.5	33.1	32.0	31.5	30.2	29.3
	P 80	24.9	23.0	23.8	21.9	22.1	20.4	20.2	18.7	18.9
Volume shrinkage.	F 37	3.0	4.7	7.0	7.7	7.9	8.2	7.4	8.3	7.9
	P 80	16.6	20.4	22.6	23.0	22.6	22.4	25.3	24.5	23.9
Apparent specific gravity.	F 37	2.62	2.58	2.56	2.55	2.53	2.48	2.46	2.43	2.34
	P 80	2.67	2.67	2.68	2.65	2.64	2.61	2.61	2.61	2.61
Bulk specific gravity.	F 37	1.66	1.68	1.73	1.68	1.69	1.68	1.68	1.69	1.68
	P 80	2.00	2.05	2.04	2.07	2.06	2.08	2.09	2.09	2.11
Color.......	F 37	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Gray.	Gray.	Gray.
	P 80	Buff.	Buff.	Buff.	Gray.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.
Hardness...	F 37	S	S	S	S	S	S	S	S	S
	P 80	S	S	S	S	S	S	S	S	S

S = Softer than steel.

The softening point of F 37 meets the requirements of No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a refractory bond clay it appears promising for the manufacture of high-grade No. 2 refractories.

The softening point of P 80 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of No. 1 refractories.

Prospect Near Youghiogheny River

This section is on south bank of small stream entering the Youghiogheny River, near Swallow Falls, Garrett County. The clays marked F 38 and P 81 were sampled and tested and the results are given below:

Properties of Clays from Prospect Near Youghiogheny River

	F 38	P 81
Per cent water required	....	20.5
Plasticity, judged by feel	None.	Poor.
Drying shrinkage, per cent dry length	....	3.9
Ratio of per cent shrinkage water to per cent pore water	....	1:2.20
Per cent shrinkage water in terms of total water	....	31.2
Time of disintegration, minutes	....	2.8
Softening point, cones	33	26

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 38	36.2	41.8	43.0	43.2	43.8	42.3	41.8	42.8	43.0
	P 81	23.1	19.8	12.9	10.7	6.9	4.5	3.2	4.0	1.1
Volume shrinkage.	P 81	10.3	13.2	17.6	18.5	19.5	19.4	19.3	19.1	18.2
Apparent specific gravity.	F 38	2.24	2.58	2.63	2.63	2.63	2.60	2.55	2.57	2.52
	P 81	2.54	2.50	2.43	2.40	2.38	2.27	2.26	2.25	2.17
Bulk specific gravity.	F 38	1.43	1.51	1.50	1.49	1.48	1.51	1.39	1.47	1.44
	P 81	1.95	2.02	2.12	2.14	2.18	2.17	2.19	2.16	2.15
Color.......	F 38	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
	P 81	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.
Hardness...	F 38	S	S	S	S	S	S	S	S	S
	P 81	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of F 38 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 81 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

Oak Shoals. 110 Feet North of the Ford

This section is 110 feet north of the ford at Oak Shoals, Maryland. The clay marked P 83 was sampled and tested and the results are given below:

Properties of P 83 from Oak Shoals

	P 83
Per cent water required..................	26.8
Plasticity, judged by feel..................	Good.
Drying shrinkage, per cent dry length..................	6.6
Ratio of per cent shrinkage water to per cent pore water..................	1:1.37
Per cent shrinkage water in terms of total water..................	42.2
Time of disintegration, minutes..................	5.0
Softening point, cones..................	27

The softening point of P 83 meets the requirements of a No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

Crellin. Prospect South of Lumber Mill

This section is 25 feet south of southern end of public road bridge over the Youghiogheny River at Crellin, Maryland. The clay marked P 84 was sampled and tested and the results are given below:

Properties of P 84 Near Crellin

	P 84
Per cent water required	31.7
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	6.3
Ratio of per cent shrinkage water to per cent pore water	1:1.71
Per cent shrinkage water in terms of total water	36.8
Time of disintegration, minutes	5.8
Softening point, cones	26

The softening point of P 84 meets the requirements of a No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

Crellin. 550 Feet South of Upper Bridge of the Youghiogheny River

This section is 550 feet south of the upper bridge of the Youghiogheny River, at Crellin, Maryland. The clay marked P 85 was sampled and tested and the results are given below:

Properties of P 85 from Crellin

	P 85
Per cent water required	19.9
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	6.8
Ratio of per cent shrinkage water to per cent pore water	1:0.86
Per cent shrinkage water in terms of total water	53.8
Time of disintegration, minutes	9.0
Softening point, cones	24

The softening point of P 85 does not meet the requirements of a fire clay and it therefore is not promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates good bonding properties in the green state.

Lonaconing. Maryland Coal Co.

370 FEET IN FROM ENTRANCE

This section is 370 feet from the entrance of mine of the Maryland Coal Co. The clay marked P 90 was sampled and tested and the results are given below:

Properties of P 90 of the Maryland Coal Co.

	P 90
Per cent water required	17.4
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	5.4
Ratio of per cent shrinkage water to per cent pore water	1:1.19
Per cent shrinkage water in terms of total water	47.0
Time of disintegration, minutes	6.4
Softening point, cones	26

Properties of P 90 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity..	18.1	13.9	4.8	4.6	4.0	4.7	5.4	5.3	8.2
Volume shrinkage..	12.2	15.1	20.2	19.9	18.9	14.9	6.4	10.5	4.3
Apparent specific gravity.	2.53	2.48	2.38	2.36	2.29	2.21	2.07	2.10	2.12
Bulk specific gravity	2.07	2.14	2.27	2.25	2.20	2.15	1.93	1.99	1.95
Color	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	H	H	H	H	H	H	H	H	H

H = Harder than steel.

The softening point of P 90 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates good bonding properties in the dry state. It appears promising for the manufacture of stoneware, hollow block, fire-proofing, and similar ware.

290 FEET IN FROM ENTRANCE

This section is 290 feet in from entrance of mine of the Maryland Coal Co. The clay marked P 91 was sampled and tested and the results are given below:

Properties of P 91 of the Maryland Coal Co.

	P 91
Per cent water required	15.5
Plasticity, judged by feel	Good.
Drying shrinkage, per cent dry length	4.0
Ratio of per cent shrinkage water to per cent pore water	1:1.77
Per cent shrinkage water in terms of total water	38.7
Time of disintegration, minutes	8.9
Softening point, cones	26

Properties of P 91 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	15.0	15.0	6.1	4.8	3.4	1.9	5.9	8.1	9.4
Volume shrinkage	14.4	20.1	20.7	21.0	25.8	20.9	15.5	13.2	10.3
Apparent specific gravity.	2.48	2.49	2.44	2.43	2.40	2.35	2.28	2.28	2.25
Bulk specific gravity	2.11	2.12	2.29	2.31	2.31	2.30	2.14	2.09	2.04
Color	Buff.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	H	H	H	H	H	H	H	H	H

H = Harder than steel.

The softening point of P 91 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. The ratio of shrinkage to pore water indicates a fair bond clay. It appears promising for the manufacture of stoneware, hollow block, fire-proofing, and similar ware.

Prospect on the Potomac River Near Blaine Coal Mining Co.

This section is in cliff on Maryland side of the Potomac River about 450 feet west of North American Mine of the Blaine Coal Mining Co., Garrett County, Maryland. The clays marked F 53 and P 102 were sampled and tested and the results are given below:

Properties of Clays from Prospect of the Potomac River

	F 53	P 102
Per cent water required	....	13.4
Plasticity, judged by feel	None.	Poor.
Drying shrinkage, per cent dry length	....	3.6
Ratio of per cent shrinkage water to per cent pore water	....	1:1.58
Per cent shrinkage water in terms of total water	....	38.8
Time of disintegration, minutes	....	2.8
Softening point, cones	31	26

The softening point of F 53 meets the requirements of a No. 2 fire clay. This clay together with a No. 2 bond clay appears promising for the manufacture of No. 2 refractories.

The softening point of P 102 meets the requirements of a No. 3 fire clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

Prospect on Southeast Side of Northwestern Pike

This section is on southeast side of the Northwestern Pike, 340 feet N. 70° E. of junction of the Old Lumber Road. The clay marked F 51 was sampled and tested and the results are given below:

Properties of F 51 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity..	33.6	33.2	39.1	40.9	40.7	41.5	41.8	42.5	41.9
Apparent specific gravity.	2.55	2.54	2.67	2.70	2.67	2.66	2.68	2.65	2.64
Bulk specific gravity	1.69	1.69	1.62	1.60	1.58	1.55	1.58	1.53	1.67
Color	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
Hardness	S	S	S	S	S	S	S	S	S

S = Softer than steel.

The softening point of F 51 is cone 33 and meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

Potomac River. Near Garrett Coal and Mining Co.

This section is on new road being made from Gleason west. Place of sampling is 1000 feet west of run making the west boundary line of the Garrett Coal and Mining Co. The clay marked F 52 was sampled and tested and the results are given below:

Properties of F 52 When Fired to Temperatures Between 1150° and 1350° C

	1150°	1200°	1250°	1275°	1300°	1325°	1350°
Apparent porosity	32.6	31.4	37.5	.....	46.0	40.9	41.9
Apparent specific gravity	2.09	2.09	2.24	.....	2.27	2.29	2.32
Bulk specific gravity	1.41	1.44	1.41	.....	1.23	1.35	1.35
Color	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
Hardness	S	S	S	S	S	S	S

S ⟹ Softer than steel.

The softening point of F 52 is cone 30 and meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 2 refractories.

PENNSYLVANIA

Wellersburg. Cumberland Basin Coal Co.

COAL PROSPECT. NORTH BRANCH OF JENNINGS RUN

This section is in a coal prospect on the east bank of the North Branch of Jennings Run about 3 miles north of Wellersburg, Pa. The place is known as the Ridge of Pines and is marked by a hemlock tree. The clay marked P 20 was sampled and tested and the results are given below:

Properties of P 20 from Section in Coal Prospect Near Wellersburg, Pa.

	P 20
Per cent water required	23.0
Plasticity, judged by feel	Fair.
Drying shrinkage, per cent dry length	6.3
Ratio of per cent shrinkage water to per cent pore water	1:1.23
Per cent shrinkage water in terms of total water	44.8
Time of disintegration, minutes	3.0
Softening point, cones	22

The softening point of P 20 does not meet the requirements of a fire clay and it therefore could not be used for the manufacture of refractories. The ratio of shrinkage to pore water indicates good bonding properties in the green state.

CLAY PROSPECT. NORTH BRANCH OF JENNINGS RUN

This section is in a clay prospect on the east bank of the North Branch of Jennings Run, 3 miles north of Wellersburg, Pa. The section sampled is about 50 feet above stream and the place is known as the Ridge of Pines. Clays marked F 8 and P 21 were sampled and tested and the results are given below:

Properties of Clays from Clay Prospect North of Wellersburg, Pa.

	F 8	P 21
Per cent water required	....	21.0
Plasticity, judged by feel	None.	Good.
Drying shrinkage, per cent dry length	....	5.3
Ratio of per cent shrinkage water to per cent pore water	....	1:1.47
Per cent shrinkage water in terms of total water	....	40.6
Time of disintegration, minutes	....	3.5
Softening point, cones	29	24

Properties of F 8 When Fired to Temperatures Between 1150° and 1375° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°
Apparent porosity	25.9	25.2	25.2	24.3	25.0	24.8	25.1	24.1
Volume shrinkage	1.7	0.2	0.7	—0.3	—0.5	—1.2	—2.1	—2.2
Apparent specific gravity	2.32	2.29	2.30	2.26	2.25	2.23	2.18	2.17
Bulk specific gravity	1.72	1.71	1.72	1.71	1.69	1.68	1.63	1.65
Color	Buff.	Buff.	Buff.	Buff.	Black spots.	Black spots.	Black spots.	Black spots.
Hardness	S	S	S	S	S	S	S	S

S = Softer than steel.

Chemical analysis of F 8

Loss on ignition	7.21
SiO_2	68.26
Al_2O_3	19.30
Fe_2O_3	2.31
CaO	None
MgO	.08
TiO_2	.90
Na_2O	.50
K_2O	1.00
S	.11
H_2O at 105° C.	.83
	100.50

Ceramic Formula

$$\left.\begin{array}{l} .153\ FeO \\ .011\ MgO \\ .053\ K_2O \\ .043\ Na_2O \end{array}\right\} 1.0\ Al_2O_3 \left\{\begin{array}{l} 6.000\ SiO_2 \\ .060\ TiO_2 \end{array}\right.$$

$$.260\ RO$$

The softening point of F 8 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. The chemical analysis shows .260 equivalents RO which is too high for a highly refractory clay. With a No. 2 bond clay it appears promising for the manufacture of No. 2 refractories.

Judging from the low softening point, P 21 is not promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

Cooks Mill. Cooks Mill Coal, Lumber and Fire Clay Co.

CLAY MINE. N. 25° W. OF COUNTY ROAD BRIDGE

This section is from clay mine N. 25° W. of bridge of county road and about 50 feet above bridge on north bank of river. The clays marked P 25 and F 9 were sampled and tested and the results obtained are given below:

Properties of Clays from Section of Clay Mine of the Cooks Mill Coal and Coke Co.

	P 25	F 9
Per cent water required	18.7	....
Plasticity, judged by feel	Fair.	None.
Drying shrinkage, per cent dry length	5.1	....
Ratio of per cent shrinkage water to per cent pore water	1:1.36	....
Per cent shrinkage water to per cent total water	42.5	....
Time of disintegration, minutes	5.4	....
Softening point, cones	26	30

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	P 25	20.5	20.7	10.9	9.3	8.8	8.7	8.8	8.8	8.6
	F 9	26.5	26.6	25.4	25.1	24.8	25.1	25.2	25.1	....
Volume shrinkage.	P 25	4.2	5.1	9.9	9.7	7.6	7.3	5.9	4.3	3.3
	F 9	1.8	1.3	1.4	—0.4	—0.8	—1.8	—2.4	—3.0	....
Apparent specific gravity.	P 25	2.59	2.60	2.46	2.40	2.34	2.32	2.31	2.27	2.24
	F 9	2.34	2.34	2.29	2.25	2.24	2.22	2.19	2.18	....
Bulk specific gravity.	P 25	2.06	2.06	2.19	2.18	2.14	2.14	2.10	2.07	2.05
	F 9	1.72	1.72	1.71	1.68	1.68	1.66	1.63	1.63	....
Color	P 25	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Black spots.	Black spots.	Black spots.
	F 9	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
Hardness	P 25	H	H	H	H	H	H	H	H	H
	F 9	S	S	S	S	S	S	S	S	S

S = Softer than steel. H = Harder than steel.

Chemical Analyses of the Clays

	P 25	F 9
Loss on ignition	4.37	7.15
SiO_2	73.22	69.26
Al_2O_3	16.10	19.00
Fe_2O_3	1.60	1.06
CaO	None.	None.
MgO	.12	.12
TiO_2	1.51	2.01
Na_2O	2.24	.50
K_2O	.17	.21
S	.05	.08
H_2O at 105° C	.53	.56
	99.91	99.95

Ceramic Formulas

P 25

$$\left.\begin{array}{l}.128\ FeO\\ .019\ MgO\\ .151\ K_2O\\ .017\ Na_2O\end{array}\right\}1.0\ Al_2O_3\left\{\begin{array}{l}7.750\ SiO_2\\ .120\ TiO_2\end{array}\right.$$

.315 RO

F 9

$$\left.\begin{array}{l}.071\ FeO\\ .018\ Na_2O\\ .016\ MgO\\ .027\ K_2O\end{array}\right\}1.0\ Al_2O_3\left\{\begin{array}{l}6.175\ SiO_2\\ .135\ TiO_2\end{array}\right.$$

.132 RO

The softening point of P 25 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 3 fire clay. It shows a tendency to swell due to overburning above 1250° C. The chemical analysis shows .315 equivalents of RO which is very much too high for a highly refractory clay. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. P 25 appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

The softening point of F 9 meets the requirements of a No. 2 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay. The chemical analysis shows .132 equivalents of RO which is good, but the content of TiO_2 is high. With a No. 2 bond clay it appears promising for the manufacture of No. 2 refractories and similar ware.

WEST VIRGINIA

Piedmont. Potomac Fire Brick Co.

This section is in second place on left of main right entry of the Potomac Fire Brick Co., Piedmont, West Virginia. The clay marked P 70 was sampled and tested and the results are given below:

Properties of P 70 of the Potomac Fire Brick Co.

	P 70
Per cent water required	15.9
Plasticity, judged by feel	Poor.
Drying shrinkage, per cent dry length	3.2
Ratio of per cent shrinkage water to per cent pore water	1:2.25
Per cent shrinkage water in terms of total water	30.7
Time of disintegration, minutes	2.9
Softening point, cones	26

Properties of P 70 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity..	27.8	24.2	22.8	22.4	21.2	17.8	16.7	14.5	....
Volume shrinkage..	7.3	10.0	11.6	12.4	12.7	13.3	13.0	13.2	....
Apparent specific gravity.	2.69	2.66	2.63	2.62	2.57	2.51	2.47	2.40	....
Bulk specific gravity	1.94	2.02	2.04	2.03	2.03	2.06	2.06	2.06	....
Color	Buff.	Buff.	Buff.	Gray.	Gray.	Black spots.	Black spots.	Black spots.	Black spots.
Hardness...........	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of P 70 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates poor bonding properties in the dry state. It appears promising for the manufacture of stoneware, hollow block, fire-proofing, and similar ware.

Piedmont. Potomac Fire Brick Co.

This section is in new opening 70 feet in from mouth of mine at the Potomac Fire Brick Co., Piedmont, West Virginia. The clay marked F 33 was sampled and tested and the results are given below:

Properties of F 33 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity..	36.8	35.2	37.9	39.2	39.7	45.6	43.2	44.2	47.1
Apparent specific gravity.	2.43	2.40	2.35	2.51	2.61	2.60	2.46	2.53	2.56
Bulk specific gravity	1.54	1.56	1.55	1.53	1.46	1.42	1.40	1.41	1.36
Color..............	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.
Hardness...........	S	S	S	S	S	S	S	S	S

S = Softer than steel.

The softening point of F 33 is cone 32 and meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

Piedmont. Faraday Property

This section is in a prospect on Faraday's property adjoining the Potomac Fire Brick Co., Piedmont, West Virginia. The clays marked F 34, P 71, and F 35 were sampled and tested and the results are given below:

Properties of Clays from Faraday's Property

	F 34	P 71	F 35
Per cent water required	....	23.6	....
Plasticity, judged by feel	None.	Excellent.	None.
Drying shrinkage, per cent dry length	....	6.7	....
Ratio of per cent shrinkage water to per cent pore water	....	1:1.17	....
Per cent shrinkage water in terms of total water	....	46.0	....
Time of disintegration, minutes	....	3.8	....
Softening point, cones	32	26	33

Properties of the Clays When Fired to Temperatures Between 1150° and 1400° C.

	Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	F 34	40.8	41.0	39.3	41.2	40.8	41.4	39.0	40.4	40.4
	P 71	27.0	23.0	18.9	17.8	16.9	13.2	11.9	10.1	10.3
Volume shrinkage.	F 34	8.6	8.2	9.9	8.4	7.6	7.3	6.6	4.5	3.2
	P 71	9.7	10.8	5.7	5.3	5.6	4.6	4.9	4.3	5.5
Apparent specific gravity.	F 34	2.64	2.64	2.64	2.63	2.62	2.60	2.58	2.54	2.51
	P 71	2.60	2.48	2.34	2.31	2.24	2.16	2.14	2.08	2.09
Bulk specific gravity.	F 34	1.56	1.56	1.60	1.55	1.55	1.53	1.51	1.51	1.50
	P 71	1.90	1.91	1.90	1.90	1.90	1.87	1.88	1.87	1.86
Color	F 34	Buff.	Buff.	Buff.	Buff.	Buff.	Buff.	Black spots.	Black spots.	Black spots
	P 71	Buff.	Buff.	Buff.	Gray.	Gray.	Few black spots.	Few black spots.	Few black spots.	Few black spots.
Hardness	F 34	S	S	S	S	S	S	S	S	S
	P 71	S	S	H	H	H	H	H	H	H

S = Softer than steel. H = Harder than steel.

The softening point of F 34 meets the requirements of a No. 1 fire clay and its properties when fired to different temperatures are similar to a No. 1 fire clay. With a highly refractory bond clay it appears promising for the manufacture of No. 1 refractories.

The softening point of P 71 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are similar to a No. 2 fire clay. The ratio of shrinkage to pore water indicates good bonding properties in the green state. It appears promising for the manufacture of No. 2 refractories and similar ware.

The softening point of F 35 meets the requirements of a No. 1 fire clay.

B. & O. R. R. Cut West of Luke Bridge

This section is in a B. & O. R. R. cut 150 feet west of Luke Bridge. The clays marked P 74 and P 75 were sampled and tested and the results are given below:

Properties of Clays from R. R. Cut West of Luke Bridge

	P 74	P 75
Per cent water required	16.1	16.0
Plasticity, judged by feel	Poor.	Poor.
Drying shrinkage, per cent dry length	4.1	2.9
Ratio of per cent shrinkage water to per cent pore water	1:1.58	1:2.58
Per cent shrinkage water in terms of total water	38.7	28.0
Time of disintegration, minutes	6.2	4.8
Softening point, cones	26	22

Properties of P 74 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity	12.5	12.5	4.6	7.3	9.7	10.2	....	14.4	13.9
Volume shrinkage	17.4	18.0	14.6	8.5	—1.8	—3.4	....	—6.6	—6.9
Apparent specific gravity.	2.48	2.41	2.19	2.10	1.98	1.94	....	1.99	1.98
Bulk specific gravity	2.17	2.18	2.10	1.96	1.79	1.74	....	1.70	1.70
Color	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness	H	H	H	H	H	H	H	H	H

H = Harder than steel.

The softening point of P 74 meets the requirements of a No. 3 fire clay and its properties when fired to different temperatures are inferior to those of the average No. 3 fire clay. The range between incipient and viscous vitrification is only 125° C. and the clay becomes soft and swells, due to overburning, above 1275° C. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, and similar ware but could not be used in No. 2 refractories.

The softening point of P 75 does not meet the requirements of a fire clay and it therefore does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates poor bonding properties in the green state.

Corinth. From Cut of B. & O. R. R.

This section is in a cut on the B. & O. R. R. west of Corinth, West Virginia. The clays marked P 77 and P 78 were sampled and tested and the results are given below:

Properties of Clays Near Corinth, West Virginia

	P 77	P 78
Per cent water required	23.2	27.2
Plasticity, judged by feel	Good.	Good.
Drying shrinkage, per cent dry length	5.4	5.2
Ratio of per cent shrinkage water to per cent pore water	1:1.57	1:1.92
Per cent shrinkage water in terms of total water	38.8	34.4
Time of disintegration, minutes	25.4	5.7
Softening point, cones	18	20

Properties of P 77 When Fired to Temperatures Between 1150° and 1400° C.

	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
Apparent porosity.	17.9	6.6	2.3	3.3	21.0	24.0	28.6	32.1	33.2
Volume shrinkage.	14.6	21.7	21.0	16.0	3.2	—4.3	-12.5	-20.9	-24.4
Apparent specific gravity.	2.48	2.40	2.27	2.15	2.29	2.21	2.19	2.15	2.14
Bulk specific gravity	2.03	2.24	2.22	2.08	1.81	1.68	1.57	1.46	1.42
Color.	Buff.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.	Gray.
Hardness.	H	H	H	H	H	H	H	H	H

H = Harder than steel.

The softening point of P 77 does not meet the requirements of a fire clay and it therefore does not appear promising for the manufacture of refractories. It reaches the point of incipient vitrification at 1150° C. and the point of viscous vitrification at 1275° C., so the vitrification range between these points is 125° C. The ratio of shrinkage to pore water indicates fair bonding properties in the green state. It appears promising for the manufacture of fire-proofing, hollow block, stoneware, and similar ware.

The softening point of P 78 does not meet the requirements of a fire clay and it therefore does not appear promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

Gleason Run

This section is along Gleason Run in Mineral County, West Virginia. The clay marked P 101 were sampled and tested as one sample.

Properties of P 101 Along Gleason Run

	P 101
Per cent water required	17.0
Plasticity, judged by feel	Poor.
Drying shrinkage, per cent dry length	4.0
Ratio of per cent shrinkage water to per cent pore water	1:1.80
Per cent shrinkage water in terms of total water	35.7
Time of disintegration, minutes	4.1
Softening point, cones	22

The softening point of P 101 does not meet the requirements of a fire clay and therefore it is not promising for the manufacture of refractories. The ratio of shrinkage to pore water indicates fair bonding properties in the green state.

SUMMARY

SUMMARY OF THE PROPERTIES OF THE CLAYS

Miscellaneous Properties of the Clays

Plastic Clays

Clays	Per cent water required	Plasticity, judged by feel	Drying shrinkage, per cent dry length	Ratio of per cent shrinkage water to per cent pore water	Per cent shrinkage water in terms of total water	Time of disintegration, minutes	Softening point, cones
P 1	16.9	Fair.	4.0	1:1.74	36.6	4.6	30+
P 2	17.9	Fair.	4.1	1:1.80	35.7	3.5	22
P 3	16.4	Poor.	2.4	1:3.30	23.3	2.9	30
P 4	16.6	Fair.	4.5	1:1.43	41.0	3.4	30
P 5	18.0	Fair.	3.9	1:1.95	34.0	3.4	30
P 6	18.0	Fair.	4.3	1:2.26	37.2	4.2	30
P 7	16.6	Good.	3.0	1:2.51	28.5	4.0	30
P 8	19.6	Good.	5.6	1:1.25	44.5	4.4	30
P 9	18.8	Poor.	4.9	1:1.44	41.0	2.8	26
P 10	19.0	Fair.	5.2	1:1.35	42.6	3.4	26
P 11	16.9	Fair.	5.3	1:1.13	47.2	3.8	20
P 12	18.6	Fair.	5.2	1:1.32	43.1	3.5	26
P 13	44.3	Good.	10.3	1:1.10	47.9	4.2	13
P 14	36.2	Excellent.	11.5	1:0.75	57.3	6.9	16
P 15	23.9	Good.	6.4	1:1.26	44.2	6.3	18
P 16	20.2	Good.	2.9	1:3.14	24.2	3.4	26
P 17	24.7	Good.	4.9	1:1.98	33.5	3.7	29
P 18	19.6	Fair.	5.9	1:1.14	46.8	5.2	28
P 19	19.1	Good.	6.1	1:1.04	49.0	5.9	25
P 20	23.0	Fair.	6.3	1:1.23	44.8	3.0	22
P 21	21.0	Good.	5.3	1:1.47	40.6	3.5	24
P 22	27.4	Good.	5.1	1:1.97	33.6	6.3	30
P 23	27.9	Good.	7.1	1:1.27	44.1	6.3	26
P 24	34.8	Excellent.	7.1	1:1.64	37.9	4.4	31
P 25	18.7	Fair.	5.1	1:1.36	42.5	5.4	26
P 26	20.0	Fair.	3.5	1:2.52	38.4	4.0	29
P 27	36.6	Excellent.	8.0	1:1.84	31.5	11.7	32+
P 28	21.0	Fair.	6.0	1:1.18	46.0	4.9	26
P 29	19.3	Good.	3.8	1:2.22	31.2	5.9	27
P 30	29.1	Good.	4.8	1:2.27	30.6	3.2	27
P 31	19.7	Good.	3.8	1:1.89	34.6	5.5	26
P 32	17.7	Poor.	5.1	1:1.27	44.0	3.3	26
P 33	35.0	Excellent.	8.4	1:1.20	45.0	7.5	32
P 34	37.4	Excellent.	9.4	1:1.09	48.0	7.7	32
P 35	19.1	Good.	6.1	1:1.04	49.2	6.8	15
P 36	17.7	Fair.	4.9	1:1.36	42.5	7.0	27
P 37	17.5	Good.	4.1	1:1.77	36.0	5.4	25
P 38	18.3	Good.	4.4	1:1.68	37.2	5.7	26
P 39	18.1	Fair.	3.7	1.2.11	32.1	6.3	29
P 40	17.8	Fair.	6.3	1:1.59	38.6	4.8	26
P 42	16.0	Poor.	4.0	1:1.63	37.8	4.1	30+
P 45	22.2	Good.	4.7	1:1.86	35.0	5.0	28
P 46	13.6	Poor.	3.2	1:1.89	34.6	3.9	30
P 47	25.9	Good.	6.0	1:1.49	40.0	6.1	32
P 48	22.7	Good.	6.6	1:1.15	47.0	9.0	18

Miscellaneous Properties of the Clays—Continued

Plastic Clays—Continued

Clays	Per cent water required	Plasticity, judged by feel.	Drying shrinkage, per cent dry length	Ratio of per cent shrinkage water to per cent pore water	Per cent shrinkage water in terms of total water	Time of disintegration, minutes	Softening point, cones
P 50	13.7	Poor.	2.3	1:3.04	24.7	3.4	26
P 51	15.2	Poor.	4.2	1:1.41	41.6	5.7	22
P 52	12.9	Poor.	1.7	1:4.15	19.4	4.7	17
P 53	17.1	Poor.	5.5	1:1.63	38.0	4.6	17
P 54	17.0	Fair.	4.5	1:1.20	45.5	4.6	17
P 55	20.4	Fair.	5.3	1:1.40	41.7	5.6	13
P 56	15.4	Poor.	2.1	1:3.65	21.5	2.7	16
P 57	25.3	Good.	5.5	1:1.72	36.8	5.0	26
P 58	18.8	Good.	5.7	1:1.14	46.6	7.9	26
P 59	19.9	Fair.	4.1	1:2.00	51.6	5.0	19
P 60	20.7	Good.	4.8	1:1.69	37.2	6.2	26
P 61	14.1	Poor.	3.3	1:1.91	34.5	3.6	26
P 62	36.5	Excellent.	7.4	1:1.42	41.4	21.0	32+
P 63	31.7	Very good.	6.7	1:1.83	35.4	5.4	26
P 64	22.4	Good.	5.2	1:1.61	38.4	6.6	26
P 65	14.8	Poor.	3.3	1:2.02	33.2	3.3	26
P 66	16.5	Fair.	2.8	1:2.86	26.7	4.5	28
P 67	22.0	Good.	5.5	1:1.45	40.8	7.6	26
P 68	19.2	Good.	5.3	1:1.32	43.0	4.9	23
P 69	25.6	Good.	6.0	1:1.48	40.3	5.8	18
P 70	15.9	Poor.	3.2	1:2.25	30.7	2.9	26
P 71	23.6	Excellent.	6.7	1:1.17	46.0	3.8	26
P 72	21.5	Good.	4.4	1:1.99	28.3	4.2	20
P 73	20.1	Good.	5.9	1:1.18	46.0	7.0	26
P 74	16.1	Poor.	4.1	1:1.58	38.7	6.2	26
P 75	16.0	Poor.	2.9	1:2.58	28.0	4.8	22
P 76	22.1	Excellent.	5.0	1:1.66	37.6	6.6	22
P 77	23.2	Good.	5.4	1:1.57	38.8	25.4	18
P 78	27.2	Good.	5.2	1:1.92	34.4	5.7	20
P 79	17.4	Poor.	4.8	1:1.38	42.2	4.5	33
P 80	20.1	Poor.	4.1	1:2.08	32.4	2.1	31
P 81	20.5	Poor.	3.9	1:2.20	31.2	2.8	26
P 83	26.8	Good.	6.6	1:1.37	42.2	5.0	27
P 84	31.7	Good.	6.3	1:1.71	36.8	5.8	26
P 85	19.9	Good.	6.8	1:0.86	53.8	9.0	24
P 90	17.4	Good.	5.4	1:1.19	47.0	6.4	26
P 91	15.5	Good.	4.0	1:1.77	38.7	8.9	26
P 101	17.0	Poor.	4.0	1:1.80	35.7	4.1	22
P 102	13.4	Poor.	3.6	1:1.58	38.8	2.8	26
P 103	22.7	Good.	4.2	1:1.44	41.0	6.1	23

Miscellaneous Properties of the Clays—Continued

Flint Clays

Clays	Softening point, cones	Clays	Softening point, cones	Clays	Softening point, cones
F 1	33	F 14	35	F 32	35
F 2	32+	F 15	34	F 33	32
F 3	33	F 16	34	F 34	32
F 4	33	F 21	33	F 35	33
F 5	33	F 22	33	F 36	34
		F 23	34+		
F 6	28	F 24	31	F 37	30
F 7	34	F 25	33	F 38	33
F 8	29	F 26	30	F 51	33
F 9	30	F 27	29	F 52	30
F 10	34	F 28	35	F 53	31
F 11	29	F 30	33	F 54	34
F 12	34	F 31	32+	F 55	31

APPARENT POROSITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.

Plastic Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
P 1	23.4	19.3	17.9	15.9	14.9	13.7	12.2	12.1	12.1
P 2	17.9	12.3	11.4	11.7	11.3	10.7	9.4	8.4	6.4
P 3	28.4	25.1	20.5	20.1	18.6	19.1	19.4	18.9	17.0
P 4	18.0	14.0	13.4	12.4	12.3	11.3	11.1	10.5	9.4
P 5	15.7	12.9	13.1	11.5	10.0	10.3	8.0	6.7	....
P 6	14.0	14.3	14.3	13.1	12.5	11.9	11.3	12.5	....
P 7	14.6	11.2	11.4	6.4	5.0	3.9	3.1	3.1	....
P 8	11.8	12.2	11.9	11.5	11.0	12.3	9.5	9.8	....
P 9	19.6	15.4	14.0	12.7	8.8	8.5	18.9	23.1	....
P 10	15.6	....	11.4	11.0	10.4	9.8	9.1	7.4	5.9
P 12	16.7	15.4	10.6	10.4	9.5	9.9	8.8	8.2	7.5
P 14	13.4	6.1	18.1	20.2	19.3	....	....	....	....
P 16	....	28.7	27.3	27.2	27.7	24.8	24.3	23.0	20.9
P 17	22.8	22.0	10.1	9.6	6.6	6.3	1.4	0.7	0.4
P 18	20.3	21.9	9.4	6.1	2.9	2.8	2.3	2.2	1.4
P 19	27.5	....	16.9	12.4	8.0	4.3	4.0	3.2	2.8
P 22	12.1	2.8	2.2	1.4	0.8	2.1	6.0	10.1	11.1
P 23	18.6	8.7	4.3	0.4	0.6	0.5	0.8	9.5	10.6
P 24	11.5	3.4	1.4	0.9	0.5	1.1	1.2	1.4	2.0
P 25	20.5	20.7	10.9	9.3	8.8	8.7	8.8	8.8	8.6
P 28	21.5	19.8	7.0	6.6	5.3	2.6	0.6	0.3	0.5
P 29	20.4	15.4	7.1	4.7	0.6	0.2	0.3	0.5	0.3
P 30	13.5	6.0	0.8	0.8	0.2	3.0	5.3	1.9	0.7
P 31	18.5	14.3	8.3	3.6	1.8	1.8	9.3	7.9	3.7
P 32	22.4	20.7	20.0	27.7	18.6	14.4	15.6	12.0	11.4
P 33	14.6	1.5	1.4	0.9	0.3	1.1	1.7	1.0	1.3
P 34	4.6	2.3	1.3	3.4	2.1	1.9	0.8	2.8	2.4

APPARENT POROSITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.—CONTINUED

Plastic Clays—Continued

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
P 35	16.1	10.9	6.8	11.0	17.6	18.2	13.0	4.5	1.2
P 36	24.2	22.8	18.8	16.8	11.7	9.9	8.1	7.3	5.0
P 38	25.0	22.3	17.5	14.3	11.1	9.4	8.8	7.7	6.7
P 39	24.2	21.4	18.3	15.7	13.2	10.6	6.9	7.6	3.2
P 40	....	20.5	13.4	10.2	7.1	4.0	8.4	14.3	12.2
P 42	28.4	29.3	27.1	29.3	26.4	26.7	22.7	22.9	22.0
P 45	15.8	9.2	6.9	9.1	8.5	8.9	10.0	10.6	12.5
P 46	25.9	22.4	22.0	20.0	17.5	15.4	13.6	14.2	14.3
P 47	17.8	17.8	17.2	15.7	11.0	7.2	4.8	3.1	2.6
P 57	24.1	18.7	15.1	11.9	8.5	6.2	3.4	1.8	7.0
P 58	22.1	21.3	16.7	14.6	12.8	11.4	8.7	7.8	6.5
P 60	18.6	13.1	8.9	7.9	6.1	5.6	4.8	3.6	4.4
P 61	32.1	31.1	30.2	29.9	29.6	28.4	29.1	27.6	26.6
P 63	9.1	....	0.7	1.1	0.6	5.5	8.3	8.7	8.6
P 64	18.4	9.1	5.7	3.6	1.1	0.6	0.5	9.8	14.7
P 65	25.1	23.7	20.8	18.6	19.3	18.0	17.1	14.4	11.8
P 66	28.2	25.1	22.1	21.0	19.0	17.8	18.0	14.7	31.8
P 67	12.2	8.4	7.7	7.4	6.6	8.3	11.4	13.1	13.9
P 70	27.8	24.2	22.8	22.4	21.2	17.8	16.7	14.5	...
P 71	27.0	23.0	18.9	17.8	16.9	13.2	11.9	10.1	10.8
P 73	10.0	5.9	4.4	5.1	4.7	5.1	5.6	8.5	8.3
P 74	12.5	12.5	4.6	7.3	9.7	10.2	....	14.4	13.9
P 76	13.3	7.0	3.7	3.0	3.5	3.4	3.9	2.2	2.2
P 77	17.9	6.6	2.3	3.3	21.0	24.0	28.6	32.1	33.2
P 80	24.9	23.0	23.8	21.9	22.1	20.4	20.2	18.7	18.9
P 81	23.1	19.8	12.9	10.7	6.9	4.5	3.2	4.0	1.1
P 90	18.1	13.9	4.8	4.6	4.0	4.7	5.4	5.3	8.2
P 91	15.0	15.0	6.1	4.8	3.4	1.9	5.9	8.1	9.4
P 102	20.5	16.2	13.5	12.1	11.0	8.3	6.2	5.0	4.4

Flint Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
F 1	25.0	26.2	....	28.3	27.7	26.5	24.3	25.4	26.3
F 2	....	29.5	28.8	29.2	27.7	27.7	27.2	27.9	27.9
F 3	35.5	34.8	36.2	37.1	36.7	37.1	36.3	36.3	38.2
F 4	25.3	26.3	27.8	25.4	25.2	25.1	24.4	24.9	26.6
F 5	26.3	26.0	26.7	27.5	26.5	23.7	24.9	25.0	24.8
F 6	24.4	20.8	21.0	....	18.9	17.8	15.8	15.0	14.0
F 7	27.8	26.5	....	24.8	25.3	25.4	25.9	26.4	27.9
F 8	25.9	25.2	25.2	24.3	25.0	24.8	25.1	24.1	....
F 9	26.5	26.6	25.4	25.1	24.8	25.1	25.2	25.1	....
F 10	35.9	36.2	36.5	36.8	36.9	37.5	36.7	36.6	....
F 11	37.5	37.8	37.8	38.2	38.1	38.1	36.6	37.1	....
F 12	31.7	33.8	29.8	29.6	31.6	30.8	31.7	28.3	....
F 14	35.9	36.7	34.2	34.0	33.1	34.8	33.9	32.1	....
F 15	29.2	26.5	26.7	28.2	28.5	28.9	28.1	28.0	26.8
F 16	33.0	32.6	32.8	32.2	32.3	32.3	31.0	30.6	30.8
F 21	34.2	35.4	33.7	33.8	35.0	35.0	37.5	37.7	....
F 22	39.0	38.9	41.3	40.3	40.1	41.8	40.2	41.0	43.0
F 23	38.3	37.9	36.8	36.6	34.7	34.1	33.3	33.2	33.5

APPARENT POROSITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400°—CONTINUED

Flint Clays—Continued

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
F 24	34.3	33.0	30.2	29.2	28.9	28.4	28.5	28.8	26.0
F 25	....	29.6	31.2	31.0	32.3	33.1	33.1	32.7	33.3
F 26	33.6	31.8	29.9	31.8	31.5	28.1	29.7	28.7	29.1
F 27	38.7	38.2	38.2	39.9	40.0	40.0	40.0	40.9	40.5
F 28	40.0	40.4	40.4	40.4	40.2	41.4	40.3	40.2	38.7
F 30	31.0	30.8	29.4	30.5	30.9	31.0	30.0	29.1	29.4
F 31	39.3	38.7	39.5	39.7	38.7	38.8	39.1	38.8	39.0
F 32	36.0	36.3	37.8	38.1	39.1	37.7	39.4	39.7	39.9
F 33	36.8	35.2	37.9	39.2	39.7	45.6	43.2	44.2	47.1
F 34	40.8	41.0	39.3	41.2	40.8	41.4	39.0	40.4	40.4
F 36	29.3	34.7	36.0	38.3	40.3	40.5	42.8	....	....
F 37	36.8	35.0	32.5	34.5	33.1	32.0	31.5	30.2	29.3
F 38	36.2	41.8	43.0	43.2	43.8	42.3	41.8	42.8	43.0
F 51	33.6	33.2	39.1	40.9	40.7	41.5	41.8	42.5	41.9
F 52	32.6	31.4	37.5	....	46.0	40.9	41.9	....	....
F 54	....	....	31.0	32.1	32.4	37.9	33.0	38.5	....
F 55	....	47.0	46.8	46.1	44.6	41.3	46.9	46.6	44.3

VOLUME SHRINKAGE OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.

Plastic Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
P 1	7.8	9.2	10.1	9.2	9.3	7.7	7.4	5.9	6.7
P 2	15.9	17.4	18.2	18.4	15.3	13.7	12.7	....	10.6
P 3	9.1	8.5	11.2	10.8	11.5	10.8	9.4	8.5	10.5
P 4	15.0	17.5	17.5	16.9	16.6	16.5	15.6	15.5	14.9
P 5	16.6	14.7	11.9	9.7	7.4	8.5	6.1	1.9	....
P 6	16.7	16.2	15.8	15.1	14.1	14.8	13.6	12.2	....
P 7	17.5	17.7	15.3	15.2	11.7	11.0	11.1	4.3	....
P 8	19.6	18.7	18.6	17.0	16.1	13.1	13.3	12.1	....
P 9	8.8	9.6	8.3	—7.0	—2.6	—0.6	-18.6	-25.7	....
P 10	14.2	....	12.3	11.9	12.3	12.8	11.9	12.0	11.9
P 12	15.3	16.9	13.3	13.5	13.3	13.2	12.7	12.5	11.9
P 14	35.2	22.8	13.3	9.1	-20.0	....	....	....	....
P 16	....	3.3	4.2	3.8	4.5	5.1	5.2	6.1	7.7
P 17	8.0	8.9	19.1	20.8	17.6	16.1	19.3	19.5	19.5
P 18	7.2	6.1	15.4	16.1	16.2	15.9	14.8	14.2	13.7
P 19	2.9	....	12.2	14.4	14.7	14.1	12.6	11.9	10.6
P 22	22.8	28.0	26.9	25.9	27.6	24.3	19.2	14.8	12.6
P 23	15.8	22.8	24.5	25.4	25.2	24.1	22.0	13.6	12.8
P 24	29.7	30.6	34.2	34.9	34.5	34.2	33.7	32.0	29.7
P 25	4.2	5.1	9.9	9.7	7.6	7.3	5.9	4.3	3.3
P 28	9.7	11.3	20.0	20.2	18.9	18.2	17.9	18.5	17.8
P 29	10.6	14.4	19.3	22.3	20.4	19.0	16.4	14.1	12.7

VOLUME SHRINKAGE OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.—CONTINUED

Plastic Clays—Continued

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
P 30	24.7	28.4	30.6	29.8	26.8	23.7	18.5	21.3	19.6
P 31	17.9	12.6	16.5	16.0	14.1	10.6	5.1	1.1	—0.7
P 32	7.5	6.7	7.4	7.8	8.2	8.3	8.5	9.2	11.3
P 34	34.1	36.0	37.4	36.5	36.1	35.5	35.7	34.5	33.3
P 35	11.6	14.6	14.0	5.1	—6.6	-10.0	-13.3	-18.2	-14.7
P 36	7.3	8.7	11.8	12.5	13.0	13.3	12.8	12.5	12.5
P 38	4.1	6.5	10.0	11.0	12.4	11.8	11.4	13.6	14.4
P 39	11.3	14.1	16.0	17.0	15.2	15.4	14.2	16.1	19.3
P 40	....	6.9	10.8	11.4	9.6	6.4	0.5	—5.7	—8.1
P 42	9.1	13.0	14.3	14.6	15.3	14.6	15.2	15.8	16.1
P 45	15.5	18.3	12.3	4.7	5.2	5.0	0.5	—4.0	—3.7
P 46	9.6	10.2	12.2	13.3	13.8	13.4	13.6	12.8	12.4
P 47	15.7	18.7	22.2	23.5	26.6	28.6	29.8	31.6	28.8
P 57	13.0	17.0	19.5	21.2	21.8	22.6	22.1	18.2	15.6
P 58	8.6	9.3	8.5	7.0	5.2	3.6	1.2	2.1	2.1
P 60	14.2	17.1	19.1	19.1	17.6	14.8	14.2	8.5	9.1
P 61	5.3	8.1	6.9	5.6	6.0	5.5	5.5	4.9	5.5
P 63	27.5	....	31.0	30.8	24.4	18.7	17.8	14.7	12.8
P 64	13.6	19.8	23.6	22.8	24.0	23.7	20.5	10.1	7.4
P 65	5.5	8.3	9.2	9.7	8.8	8.7	9.3	9.7	9.5
P 66	8.9	11.2	13.3	14.1	12.3	14.9	13.7	13.9	15.2
P 67	15.8	19.2	20.3	19.9	19.9	17.2	12.8	9.2	7.3
P 70	7.3	10.0	11.6	12.4	12.7	13.3	13.0	13.2	....
P 71	9.7	10.8	5.7	5.3	5.6	4.6	4.9	4.3	5.5
P 73	21.2	20.1	23.3	22.2	20.6	18.2	9.8	12.5	11.5
P 74	17.4	18.0	14.6	8.5	—1.8	—3.4	....	—6.6	—6.9
P 76	19.5	20.6	16.3	13.8	10.5	7.5	7.6	4.9	2.1
P 77	14.6	21.7	21.0	16.0	3.2	—4.3	-12.5	-20.9	-24.4
P 80	16.6	20.4	22.6	23.0	22.6	22.4	25.3	24.5	23.9
P 81	10.3	13.2	17.6	18.5	19.5	19.4	19.3	19.1	18.2
P 90	12.2	15.1	20.2	19.9	18.9	14.9	6.4	10.5	4.3
P 91	14.4	20.1	20.7	21.0	25.8	20.9	15.5	13.2	10.3
P 102	8.8	11.0	9.5	6.9	6.5	5.5	4.7	3.8	4.3

Flint Clays

F 1	15.9	17.9	....	18.6	18.6	17.3	16.8	16.3	14.0
F 2	....	10.7	10.3	11.1	8.8	9.4	9.1	9.2	7.9
F 5	8.7	8.3	9.8	8.0	8.4	7.7	8.1	6.4	6.1
F 6	4.5	4.4	4.4	....	3.9	4.2	2.7	2.2	3.9
F 8	1.7	0.2	0.7	—0.3	—0.5	—1.2	—2.1	—2.1	....
F 9	1.8	1.3	1.4	—0.4	—0.8	—1.8	—2.4	—3.0	....
F 10	16.3	17.4	16.7	17.1	17.1	17.2	16.1	15.2	....
F 11	3.3	3.5	3.3	1.1	—3.2	—0.5	—2.9	—0.5	....
F 12	17.9	18.8	16.9	17.8	14.8	13.7	15.0	14.8	....
F 14	16.5	17.6	17.4	16.8	17.1	14.5	14.6	15.4	....
F 15	....	14.0	14.6	14.1	13.4	12.9	12.6	11.8	12.6
F 16	12.2	13.2	16.1	14.3	14.9	14.8	15.2	16.2	15.7
F 22	17.7	17.1	15.0	12.5	10.7	9.2	9.7	10.3	12.3
F 23	12.2	13.2	16.1	14.3	14.9	14.8	15.2	16.2	15.7

VOLUME SHRINKAGE OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.—CONTINUED

Flint Clays—Continued

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
F 26	15.2	17.0	17.6	19.8	18.6	18.9	18.5	17.9	17.7
F 27	2.0	2.6	....	0.2	—1.3	—2.9	—3.4	—4.5	—4.4
F 28	17.6	19.2	17.4	16.8	16.0	17.1	14.7	14.6	12.1
F 31	13.6	16.8	17.7	15.6	15.7	14.4	14.6	14.4	14.3
F 32	20.6	19.7	18.9	18.3	17.4	17.6	14.5	14.5	13.1
F 34	8.6	8.2	9.9	8.4	7.6	7.3	6.6	4.5	3.2
F 37	3.0	4.7	7.0	7.7	7.9	8.2	7.4	8.3	7.9

APPARENT SPECIFIC GRAVITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400°C.

Plastic Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
P 1	2.63	2.53	2.50	2.43	2.39	2.32	2.28	2.23	2.24
P 2	2.66	2.53	2.54	2.46	2.43	2.37	2.31	....	2.21
P 3	2.85	2.62	2.52	2.51	2.49	2.43	2.42	2.41	2.40
P 4	2.67	2.62	2.61	2.56	2.56	2.53	2.50	2.48	2.43
P 5	2.57	2.46	2.40	2.30	2.20	2.22	2.13	2.01	....
P 6	2.58	2.58	2.56	2.52	2.47	2.48	2.41	2.41	....
P 7	2.58	2.49	2.43	2.31	2.13	2.13	2.11	1.97	....
P 8	2.55	2.55	2.55	2.49	2.45	2.43	2.34	2.31	....
P 9	2.57	2.45	2.39	2.02	2.12	2.03	1.97	1.99	....
P 10	2.59	....	2.39	2.37	2.36	2.37	2.33	2.28	2.25
P 12	2.61	2.60	2.36	2.35	2.35	2.35	2.31	2.28	2.29
P 14	2.94	2.31	1.83	1.75	1.57	....	....	....	....
P 16	....	2.59	2.57	2.56	2.53	2.52	2.50	2.48	2.46
P 17	2.52	2.51	2.42	2.44	2.32	2.29	2.24	2.25	2.25
P 18	2.53	2.52	2.44	2.39	2.31	2.29	2.25	2.23	2.19
P 19	2.62	....	2.54	2.49	2.36	2.25	2.22	2.19	2.15
P 22	2.44	2.36	2.34	2.30	2.29	2.25	2.18	2.17	2.13
P 23	2.56	2.47	2.42	2.39	2.36	2.34	2.27	2.25	2.27
P 24	2.46	2.39	2.36	2.37	2.35	2.35	2.33	2.30	2.23
P 25	2.59	2.60	2.46	2.40	2.34	2.32	2.31	2.27	2.24
P 28	2.55	2.55	2.43	2.43	2.37	2.28	2.25	2.21	2.19
P 29	2.62	2.52	2.44	2.43	2.32	2.27	2.18	2.13	2.10
P 30	2.47	2.41	2.35	2.33	2.24	2.13	2.09	2.07	2.04
P 32	2.54	2.50	2.49	2.44	2.39	2.37	2.36	2.35	2.35
P 34	2.46	2.47	2.50	2.50	2.48	2.45	2.41	2.42	2.39
P 35	2.57	2.51	2.39	2.27	2.20	2.15	1.94	1.70	1.69
P 36	2.67	2.66	2.60	2.57	2.44	2.40	2.36	2.31	2.28
P 38	2.65	2.62	2.57	2.50	2.44	2.39	2.36	2.40	2.40
P 39	2.72	2.72	2.67	2.64	2.54	2.43	2.32	2.38	2.36
P 40	....	2.57	2.47	2.40	2.30	2.14	2.12	2.13	2.04
P 42	2.70	2.70	2.70	2.68	2.64	2.61	2.60	2.60	2.60
P 45	2.59	2.49	2.26	2.14	2.15	2.10	2.04	2.00	2.05

APPARENT SPECIFIC GRAVITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.—CONTINUED

Plastic Clays—Continued

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
P 46	2.64	2.54	2.57	2.56	2.52	2.46	2.42	2.42	2.41
P 47	2.60	2.62	2.58	2.57	2.54	2.53	2.49	2.48	2.41
P 57	2.59	2.55	2.51	2.45	2.38	2.33	2.29	2.15	2.20
P 58	2.58	2.58	2.41	2.33	2.25	2.15	2.10	2.08	2.06
P 60	2.57	2.49	2.42	2.40	2.34	2.27	2.21	2.08	2.06
P 61	2.66	2.63	2.58	2.56	2.54	2.50	2.51	2.46	2.44
P 63	2.44	2.34	2.34	2.33	2.14	2.17	2.12	2.05	2.01
P 64	2.48	2.41	2.39	2.36	2.34	2.31	2.22	2.16	2.22
P 65	2.63	2.57	2.56	2.52	2.49	2.43	2.39	2.35	2.33
P 66	2.45	2.41	2.36	2.35	2.32	2.32	2.27	2.24	2.53
P 67	2.44	2.43	2.42	2.43	2.40	2.36	2.33	2.29	2.25
P 70	2.69	2.66	2.63	2.62	2.57	2.54	2.47	2.40	....
P 71	2.60	2.48	2.34	2.31	2.24	2.16	2.14	2.08	2.09
P 73	2.48	2.39	2.32	2.37	2.30	2.25	2.11	2.18	2.15
P 74	2.48	2.41	2.19	2.10	1.98	1.94	....	1.99	1.98
P 76	2.48	2.31	2.11	2.02	1.94	1.88	1.88	1.78	1.76
P 77	2.48	2.40	2.27	2.15	2.30	2.21	2.19	2.15	2.14
P 80	2.67	2.67	2.68	2.65	2.64	2.61	2.61	2.61	2.61
P 81	2.54	2.50	2.43	2.40	2.38	2.27	2.26	2.25	2.17
P 90	2.53	2.48	2.38	2.36	2.29	2.21	2.07	2.10	2.12
P 91	2.48	2.49	2.44	2.43	2.40	2.35	2.28	2.28	2.25
P 102	2.52	2.44	2.32	2.24	2.19	2.13	2.05	2.03	2.01

Flint Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
F 1	2.37	2.45	....	2.48	2.51	2.46	2.39	2.42	2.39
F 2	....	2.40	2.40	2.41	2.37	2.34	2.34	2.33	2.31
F 3	2.66	2.64	2.68	2.69	2.68	2.66	2.65	2.64	2.65
F 4	2.32	2.37	2.38	2.37	2.37	2.34	2.32	2.34	2.33
F 5	2.38	2.41	2.44	2.42	2.38	2.29	2.32	2.24	2.29
F 6	2.46	2.40	2.41	....	2.28	2.29	2.70	2.16	2.17
F 7	2.27	2.22	....	2.17	2.20	2.17	2.16	2.19	2.18
F 8	2.32	2.29	2.30	2.26	2.25	2.23	2.18	2.17	....
F 9	2.34	2.34	2.29	2.25	2.24	2.22	2.20	2.18	....
F 10	2.74	2.73	2.73	2.74	2.73	2.70	2.70	2.70	....
F 11	2.67	2.67	2.67	2.64	2.62	2.63	2.48	2.56	....
F 12	2.52	2.51	2.45	2.48	2.44	2.41	2.43	2.40	....
F 14	2.71	2.71	2.71	2.70	2.67	2.61	2.62	2.63	....
F 15	2.49	2.35	2.39	2.39	2.38	2.37	2.37	2.38	2.34
F 16	2.50	2.49	2.52	2.52	2.52	2.55	2.49	2.44	2.48
F 21	2.50	2.51	2.47	2.54	2.50	2.44	2.44	2.43	....
F 22	2.70	2.74	2.72	2.67	2.60	2.63	2.61	2.63	2.63
F 23	2.68	2.69	2.68	2.66	2.63	2.59	2.58	2.58	2.59
F 24	2.62	2.62	2.48	2.37	2.42	2.28	2.32	2.34	2.40
F 25	....	2.14	2.18	2.18	2.20	2.18	2.17	2.11	2.12
F 26	2.58	2.58	2.55	2.55	2.53	2.50	2.49	2.46	2.46
F 27	2.67	2.67	2.64	2.62	2.57	2.54	2.54	2.54	2.54
F 28	2.70	2.69	2.72	2.70	2.67	2.66	2.65	2.65	2.58
F 30	2.02	2.10	2.08	2.09	2.11	2.12	2.06	2.03	2.04

APPARENT SPECIFIC GRAVITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.—CONTINUED

Flint Clays—Continued

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
F 31	2.66	2.00	2.71	2.71	2.66	2.61	2.65	2.64	2.64
F 32	2.52	2.53	2.61	2.62	2.61	2.63	2.57	2.58	2.56
F 33	2.43	2.40	2.35	2.51	2.61	2.60	2.46	2.53	2.56
F 34	2.64	2.64	2.64	2.63	2.62	2.60	2.58	2.54	2.51
F 36	2.06	2.17	2.27	2.32	2.37	2.35	2.46	....	....
F 37	2.62	2.58	2.56	2.55	2.53	2.48	2.46	2.43	2.34
F 38	2.24	2.58	2.63	2.63	2.63	2.60	2.55	2.57	2.52
F 51	2.55	2.54	2.67	2.70	2.67	2.66	2.68	2.65	2.64
F 52	2.09	2.09	2.24	....	2.27	2.29	2.32	....	....
F 54	....	....	2.09	2.20	2.21	2.27	2.26	2.29	....
F 55	....	2.67	2.72	2.69	2.74	2.61	2.76	2.71	2.73

BULK SPECIFIC GRAVITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.

Plastic Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
P 1	2.01	2.03	2.06	2.04	2.03	2.00	2.00	1.96	1.96
P 2	2.18	2.22	2.25	2.18	2.16	2.12	2.09	....	2.07
P 3	1.93	1.94	2.00	2.00	2.03	1.99	1.95	1.95	1.99
P 4	2.19	2.25	2.26	2.24	2.24	2.24	2.22	2.21	2.20
P 5	2.17	2.15	2.08	2.03	1.98	2.00	1.96	1.88	....
P 6	2.21	2.21	2.19	2.18	2.16	2.18	2.14	2.11	....
P 7	2.35	2.21	2.22	2.22	2.06	2.09	2.08	1.93	....
P 8	2.26	2.23	2.24	2.20	2.17	2.13	2.11	2.09	....
P 9	2.06	2.08	2.06	1.76	1.94	1.85	1.60	1.53	....
P 10	2.18	....	2.12	2.10	2.12	2.14	2.12	2.12	2.11
P 12	2.17	2.19	2.11	2.11	2.13	2.12	2.10	2.09	2.12
P 14	2.04	2.17	1.50	1.40	1.26	....	....	....	....
P 16	....	1.85	1.87	1.87	1.88	1.89	1.90	1.91	1.95
P 17	1.94	1.96	2.18	2.21	2.17	2.14	2.22	2.23	2.24
P 18	2.01	1.98	2.22	2.24	2.25	2.22	2.20	2.18	2.16
P 19	1.90	....	2.11	2.16	2.17	2.16	2.13	2.11	2.09
P 22	2.15	2.29	2.29	2.27	2.28	2.18	2.05	1.98	1.89
P 23	2.08	2.25	2.31	2.35	2.35	2.33	2.25	2.04	2.05
P 24	2.18	2.31	2.33	2.34	2.34	2.33	2.30	2.28	2.19
P 25	2.06	2.06	2.19	2.18	2.14	2.14	2.10	2.07	2.05
P 28	2.00	2.04	2.23	2.27	2.25	2.22	2.23	2.21	2.17
P 29	2.05	2.14	2.27	2.32	2.30	2.26	2.17	2.13	2.10
P 30	2.14	2.26	2.34	2.31	2.24	2.07	1.98	2.06	2.03
P 31	2.07	2.14	2.24	2.23	2.18	2.10	1.97	1.90	1.88
P 32	1.97	1.98	1.99	2.01	2.01	2.03	2.04	2.06	2.10
P 34	2.34	2.41	2.47	2.42	2.43	2.42	2.41	2.35	2.33
P 35	2.16	2.24	2.22	2.02	1.81	1.76	1.70	1.63	1.67
P 36	2.02	2.05	2.11	2.13	2.16	2.16	2.15	2.15	2.17

BULK SPECIFIC GRAVITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.—CONTINUED

Plastic Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
P 38	1.98	2.03	2.11	2.14	2.17	2.17	2.15	2.22	2.24
P 39	2.06	2.13	2.18	2.23	2.21	2.18	2.16	2.20	2.28
P 40	....	2.04	2.14	2.16	2.14	2.05	1.94	1.83	1.79
P 42	1.93	1.91	1.96	1.90	1.94	1.91	2.01	1.99	2.02
P 45	2.19	2.26	2.21	1.94	1.97	1.91	1.83	1.78	1.80
P 46	1.96	1.97	2.01	2.05	2.08	2.08	2.09	2.08	2.06
P 47	2.02	2.05	2.14	2.16	2.26	2.34	2.36	2.40	2.35
P 57	1.97	2.08	2.13	2.16	2.18	2.18	2.21	2.11	2.04
P 58	2.02	2.03	2.01	1.99	1.96	1.90	1.91	1.92	1.93
P 60	2.09	2.16	2.21	2.21	2.20	2.15	2.10	2.01	1.98
P 61	1.81	1.81	1.81	1.79	1.79	1.75	1.78	1.78	1.79
P 63	2.22	2.33	2.33	2.30	2.12	1.95	1.94	1.87	1.84
P 64	2.02	2.19	2.26	2.27	2.31	2.30	2.21	1.94	1.89
P 65	1.94	1.97	2.03	2.04	2.01	2.00	1.98	2.02	2.05
P 66	1.75	1.81	1.84	1.85	1.83	1.88	1.87	1.86	1.73
P 67	2.14	2.23	2.24	2.25	2.23	2.17	2.06	1.99	1.93
P 70	1.94	2.02	2.04	2.03	2.03	2.06	2.06	2.06	....
P 71	1.90	1.91	1.90	1.90	1.90	1.87	1.88	1.87	1.86
P 73	2.25	2.25	2.21	2.25	2.19	2.09	1.99	2.00	1.98
P 74	2.17	2.18	2.10	1.96	1.79	1.74	....	1.70	1.70
P 80	2.00	2.05	2.04	2.07	2.06	2.08	2.09	2.09	2.11
P 81	1.95	2.02	2.12	2.14	2.18	2.17	2.19	2.16	2.15
P 90	2.07	2.14	2.27	2.25	2.20	2.15	1.93	1.99	1.95
P 91	2.11	2.12	2.29	2.31	2.31	2.30	2.14	2.09	2.04
P 102	2.00	2.04	2.00	1.97	1.96	1.95	1.92	1.92	1.92

Flint Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
F 1	1.77	1.80	....	1.78	1.82	1.81	1.81	1.81	1.77
F 2	....	1.69	1.71	1.70	1.73	1.70	1.70	1.68	1.66
F 3	1.71	1.72	1.74	1.69	1.70	1.68	1.68	1.68	1.64
F 4	1.74	1.75	1.82	1.77	1.73	1.75	1.75	1.76	1.73
F 5	1.75	1.78	1.79	1.75	1.75	1.74	1.74	1.72	1.72
F 6	1.86	1.90	1.91	....	1.85	1.88	1.85	1.85	1.86
F 7	1.63	1.64	....	1.65	1.65	1.62	1.60	1.61	1.51
F 8	1.72	1.71	1.72	1.71	1.69	1.68	1.63	1.65	....
F 9	1.72	1.72	1.71	1.68	1.68	1.66	1.63	1.63	....
F 10	1.75	1.74	1.74	1.73	1.72	1.69	1.71	1.69	....
F 11	1.67	1.66	1.66	1.63	1.63	1.63	1.57	1.61	....
F 12	1.72	1.66	1.74	1.71	1.66	1.68	1.66	1.73	....
F 14	1.74	1.72	1.79	1.79	1.74	1.70	1.68	1.79	....
F 15	1.70	1.73	1.75	1.72	1.71	1.69	1.71	1.71	1.71
F 16	1.67	1.68	1.70	1.70	1.71	1.72	1.72	1.70	1.71
F 21	1.64	1.61	1.61	1.64	1.55	1.58	1.54	1.52	....
F 22	1.65	1.67	1.64	1.59	1.56	1.53	1.56	1.56	1.50
F 23	1.65	1.67	1.70	1.69	1.72	1.71	1.72	1.74	1.72
F 24	1.72	1.75	1.74	1.71	1.72	1.68	1.74	1.67	1.72
F 25	....	1.51	1.50	1.51	1.49	1.46	1.45	1.42	1.42

BULK SPECIFIC GRAVITY OF THE CLAYS WHEN FIRED TO TEMPERATURES BETWEEN 1150° AND 1400° C.—CONTINUED

Flint Clays

Clays	1150°	1200°	1250°	1275°	1300°	1325°	1350°	1375°	1400°
F 26	1.72	1.76	1.79	1.74	1.73	1.79	1.75	1.76	1.74
F 27	1.63	1.65	1.64	1.57	1.54	1.53	1.52	1.50	1.51
F 28	1.62	1.60	1.62	1.61	1.59	1.62	1.57	1.58	1.53
F 30	1.40	1.46	1.46	1.46	1.46	1.46	1.45	1.44	1.46
F 31	1.62	1.66	1.64	1.65	1.63	1.60	1.62	1.62	1.62
F 32	1.61	1.61	1.63	1.62	1.59	1.58	1.56	1.55	1.54
F 33	1.54	1.56	1.55	1.53	1.46	1.42	1.40	1.41	1.36
F 34	1.56	1.56	1.60	1.55	1.55	1.53	1.57	1.51	1.50
F 36	1.46	1.42	1.45	1.44	1.42	1.41	1.40	....	....
F 37	1.66	1.68	1.73	1.68	1.69	1.68	1.68	1.69	1.68
F 38	1.43	1.51	1.50	1.49	1.48	1.51	1.39	1.47	1.44
F 51	1.69	1.69	1.62	1.60	1.58	1.55	1.58	1.53	1.67
F 52	1.41	1.44	1.41	....	1.23	1.35	1.35	....	....
F 54	....	....	1.48	1.50	1.49	1.40	1.51	1.42	....
F 55	....	1.41	1.45	1.47	1.52	1.53	1.41	1.42	1.50

CHEMICAL ANALYSES OF THE CLAYS

Clays	Loss on ignition	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	K_2O	Na_2O	S	H_2O at 105°C
P 22	8.94	58.19	24.45	1.55	2.00	None.	0.12	2.74	0.66	.23	0.93
P 25	4.37	73.22	16.10	1.51	1.60	None.	.12	2.24	.17	.05	.53
P 39	9.57	52.84	28.20	1.72	4.60	Trace.	.05	1.80	.50	.13	1.00
P 45	8.34	55.97	26.64	1.55	2.77	Trace.	.20	2.61	.46	.49	1.22
P 47	10.54	51.90	31.91	1.76	1.57	Trace.	.04	1.61	.29	.03	.53
F 3	12.39	49.60	32.65	2.41	1.31	None.	.12	0.38	.33	.13	1.25
F 8	7.21	68.26	19.30	0.90	2.31	None.	.08	1.00	.50	.11	.83
F 9	7.15	69.26	19.00	2.01	1.06	None.	.12	.50	.21	.08	.56

MOLECULAR EQUIVALENTS

Clays	SiO_2	Al_2O_3	TiO_2	FeO	MgO	K_2O	Na_2O	RO
P 22	4.030	1.0	0.081	0.105	0.012	0.122	0.044	0.283
P 25	7.750	1.0	0.120	0.128	0.019	0.151	0.017	0.315
P 39	3.170	1.0	0.276	0.150	0.005	0.069	.029	.253
P 45	3.550	1.0	.075	.136	.019	.106	.029	.290
P 47	2.750	1.0	.071	.063	.003	.055	.015	.136
F 3	2.575	1.0	.094	.051	.009	.013	.017	.090
F 8	6.000	1 0	.060	.153	.011	.053	.043	.260
F 9	6.175	1.0	.135	.071	.016	.027	.018	.132

VARIATION OF THE CLAYS IN DIFFERENT MINES

The flint clays were found to occur more uniformly and were more refractory than the plastic clays. The plastic clays vary in refractoriness to a surprising degree. For instance in mine No. 6 of the Union Mining Co., Mount Savage, Maryland, the plastic clay above the flint varies from cone 30+ to cone 20. The same is true with the plastic clay below the flint clay which varies from cone 30 to cone 22 in less than 200 feet. In the following table is shown the variations in softening points of clays in the different mines. Only by constant testing and separation of the poorer grades of clay can a high grade of clay be obtained from these mines.

Variation of the Clays

Mines	Clays	No. of clays	Average softening point	Maximum softening point	Minimum softening point	Variation in softening points
Mine No. 6, Union Mining Co.	Plastic.....	P 6	$27\frac{2}{3}$	30+	20	10+
	Flint.......	F 7	$32\frac{2}{7}$	34	28	6
	Plastic.....	P 6	$27\frac{1}{3}$	30	22	8
Mine No. 5, Union Mining Co.	Plastic.....	P 9	$22\frac{2}{9}$	30	13	17
Benson's Mine.....	Plastic.....	P 9	$28\frac{1}{8}$	32+	26	6+
	Flint.......	F 3	33	34	31	3
Benson's Tunnel...	Plastic.....	P 4	$26\frac{3}{4}$	29	25	4
	Flint.......	F 5	$33\frac{1}{3}$	34	29	5
Caldwell's Mine...	Plastic.....	P 6	28	32+	26	6+
	Flint.......	F 3	34	35	32	3
Montell Tunnel......	Plastic.....	P 5	$19\frac{4}{5}$	26	17	9

COMMERCIAL POSSIBILITIES OF THE CLAYS

Based on the results of the foregoing investigation the author has attempted to suggest the commercial possibilities of the clays. The investigation must, however, be recognized as only a preliminary study and subsequent tests and actual factory trials are necessary before any conclusive statement can be made.

The number of clays adaptable for use in the manufacture of graphite crucibles is quite limited and prior to the war most of the clays used for this purpose were imported. Clays P 18, P 24 and P 34 appear promising for use in graphite crucible manufacture. These clays have very remarkable burning properties, vitrifying at a low temperature (1250° C.) and showing no serious evidence of overburning at 1375° C. These clays should especially interest the manufacture of crucibles for brass melting. The clays used in crucibles for steel melting are not required to show vitrification at such low temperatures.

For the manufacture of glass pots and glass-house refractories, the clay P 47 appears very promising. The porosity of this clay is less than 10 per cent at 1350° C.

The call for material from which to manufacture No. 1 and No. 2 fire-brick will probably never exceed the demand. As material of this grade, the following flint clays appear promising for No. 1 fire-brick:

F 1, F 2, F 3, F 4, F 5, F 7, F 10, F 12, F 15, F 16, F 21, F 22, F 23, F 24, F 25, F 28, F 30, F 31, F 32, F 33, F 34, F 35, F 36, F 38, F 51, and F 54.

The following plastic fire clays appear promising for use as bonds in No. 1 fire-brick:

P 24, P 34, P 47, P 80.

Flint clays which appear promising for the manufacture of No. 2 fire-brick are F 6, F 8, F 9, F 11, F 26, F 27, F 37, F 52, and F 53. Plastic No. 2 refractory clays which may be used as a bond for the flint clays are P 1, P 3, P 4, P 6, P 8, P 16, P 32, P 45, P 46, P 61, P 65, P 66, P 70, and P 71.

Clays suitable for stoneware, hollow block, No. 3 fire-brick, fire-proofing and similar ware are usually found in the class of No. 3 fire clays. Clays belonging to this class are P 2, P 5, P 7, P 10, P 12, P 17, P 23, P 25, P 28, P 29, P 31, P 36, P 38, P 39, P 40, P 50, P 57, P 58, P 60, P 67, P 73, P 81, P 83, P 84, P 90, P 91, and P 102.

Clays which are not refractory enough to be called fire clays but which may be used for certain wares not requiring a high degree of refractoriness are P 9, P 11, P 13, P 14, P 15, P 19, P 20, P 21, P 22, P 30, P 35, P 37, P 48, P 51, P 52, P 53, P 54, P 55, P 56, P 59, P 63, P 64, P 68, P 69, P 72, P 74, P 75, P 76, P 77, P 78, P 85, P 101, and P 103.

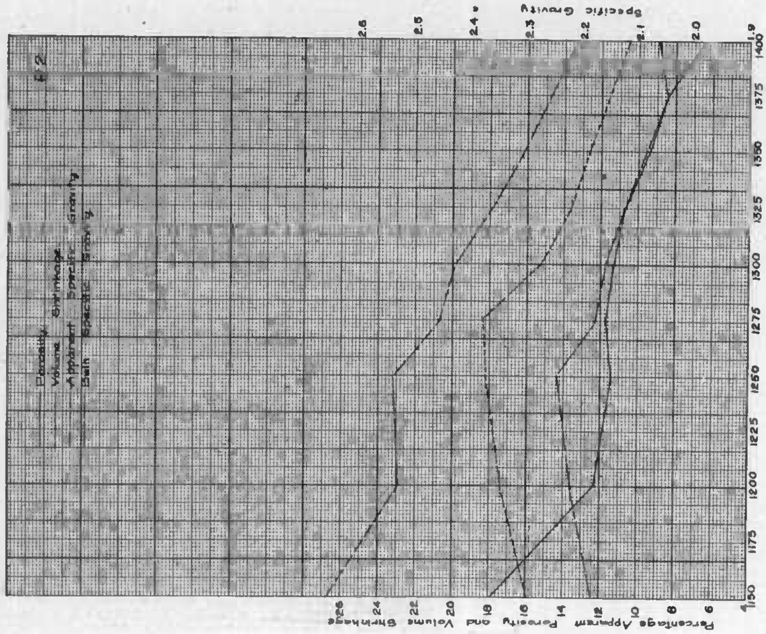

FIG. 18.—PROPERTIES OF P 2 WHEN FIRED TO DIFFERENT TEMPERATURES.

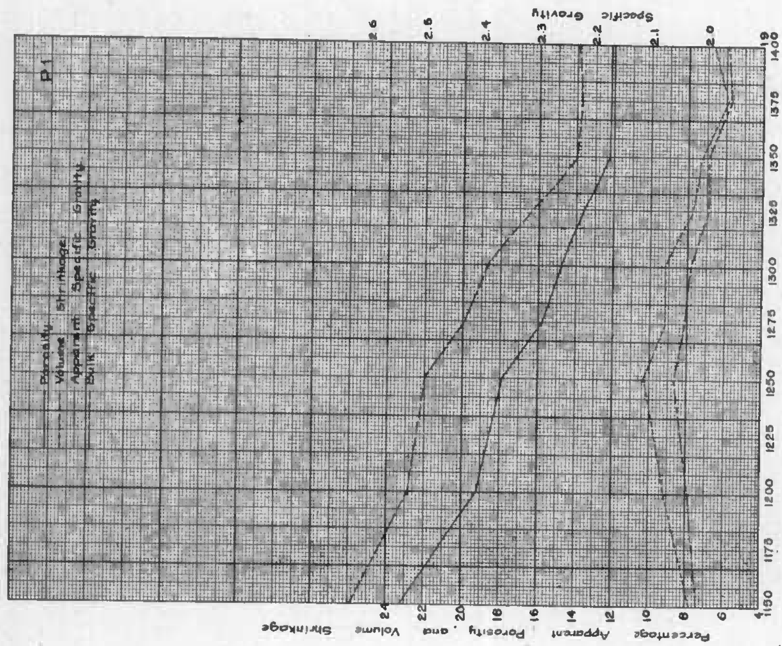

FIG. 17.—PROPERTIES OF P 1 WHEN FIRED TO DIFFERENT TEMPERATURES.

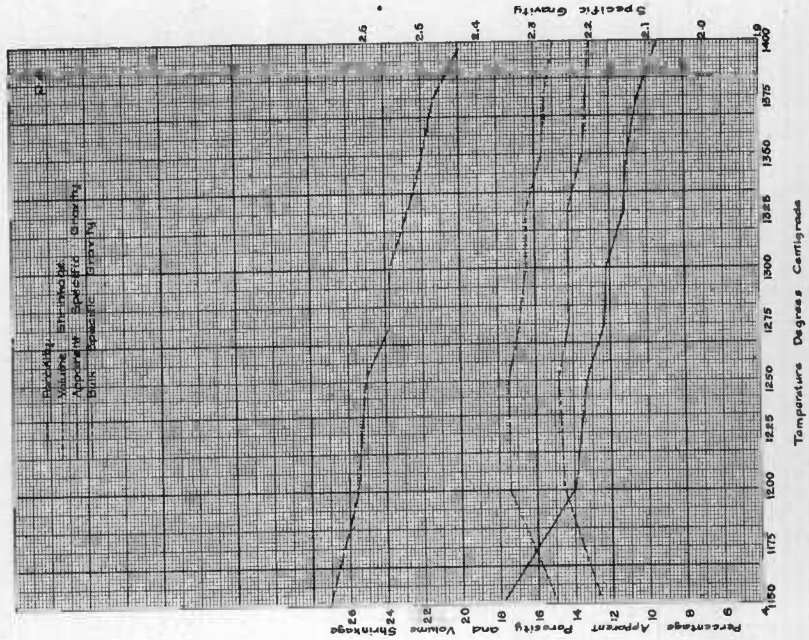

FIG. 20.—PROPERTIES OF P 4 WHEN FIRED TO DIFFERENT TEMPERATURES.

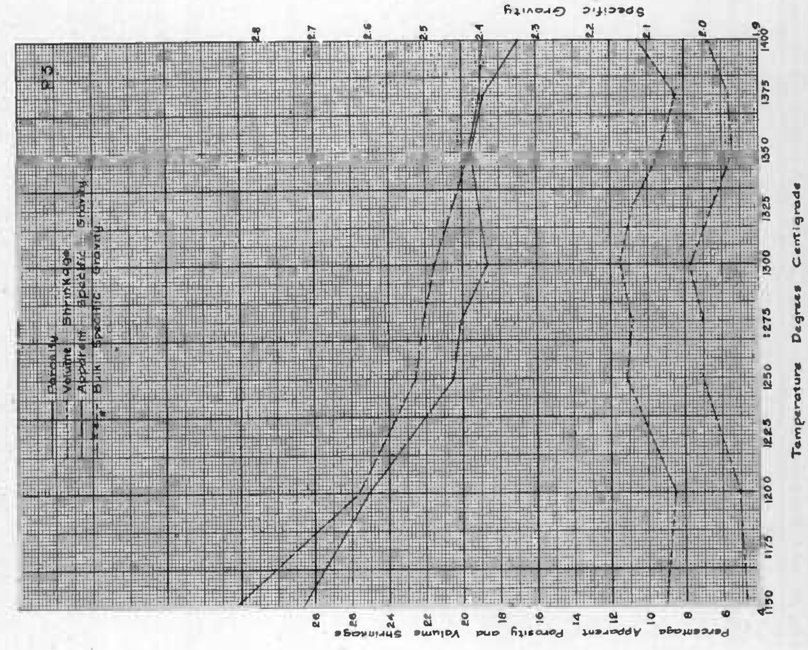

FIG. 19.—PROPERTIES OF P 3 WHEN FIRED TO DIFFERENT TEMPERATURES.

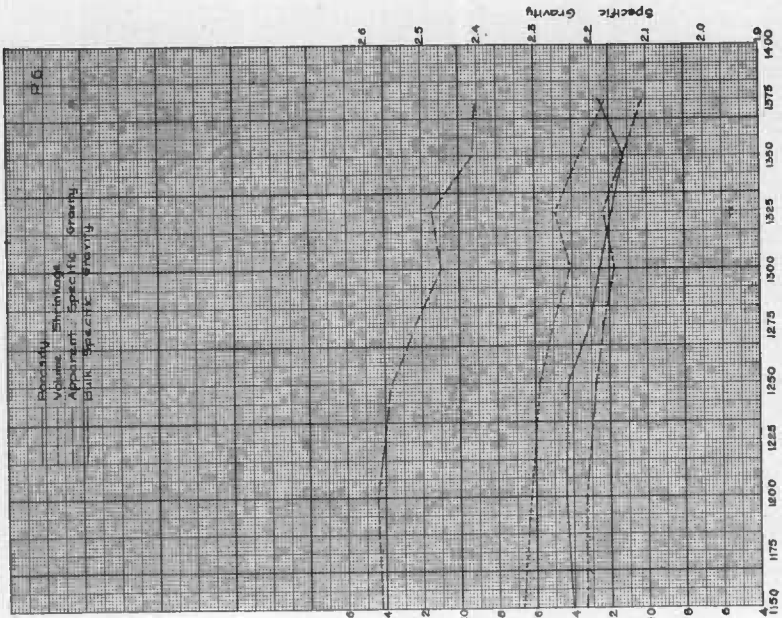

FIG. 22.—PROPERTIES OF P 6 WHEN FIRED TO DIFFERENT TEMPERATURES.

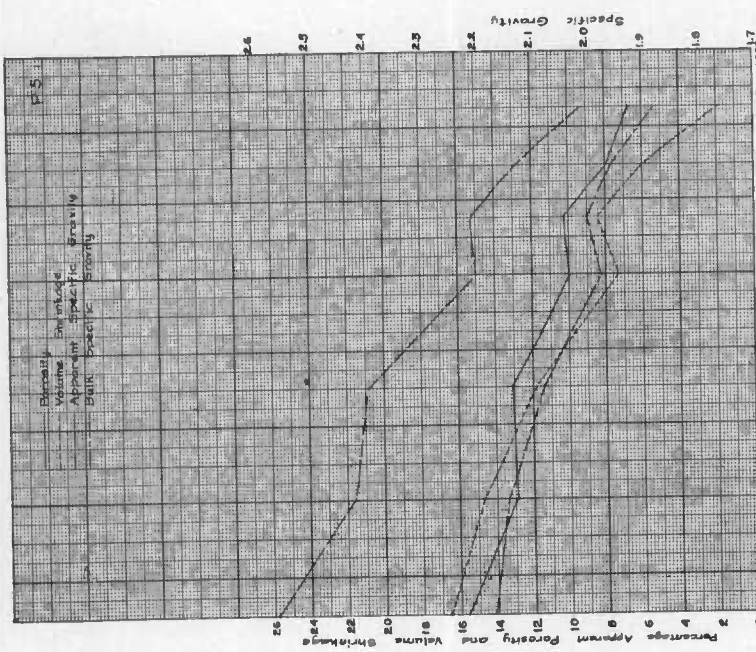

FIG. 21.—PROPERTIES OF P 5 WHEN FIRED TO DIFFERENT TEMPERATURES.

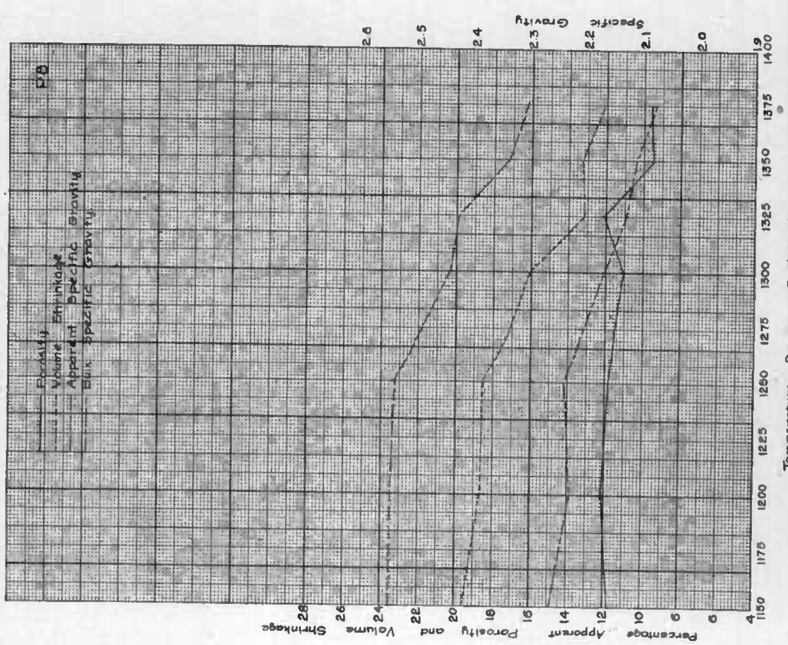

FIG. 24.—PROPERTIES OF P 8 WHEN FIRED TO DIFFERENT TEMPERATURES.

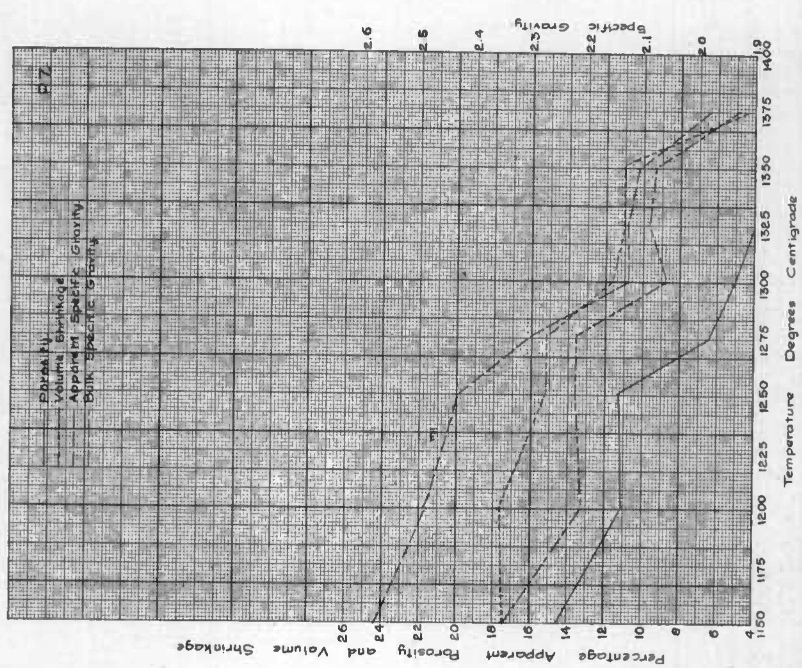

FIG. 23.—PROPERTIES OF P 7 WHEN FIRED TO DIFFERENT TEMPERATURES.

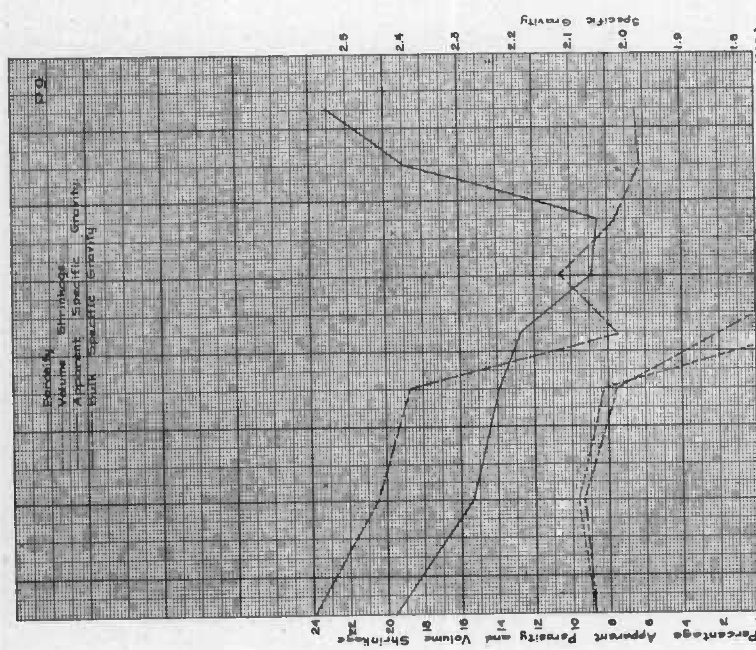

FIG. 25.—PROPERTIES OF P 9 WHEN FIRED TO DIFFERENT TEMPERATURES.

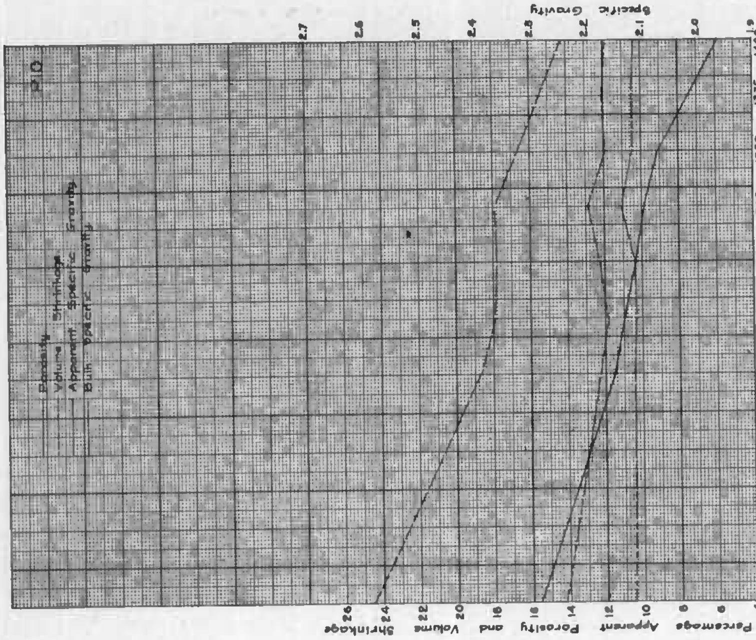

FIG. 26.—PROPERTIES OF P 10 WHEN FIRED TO DIFFERENT TEMPERATURES.

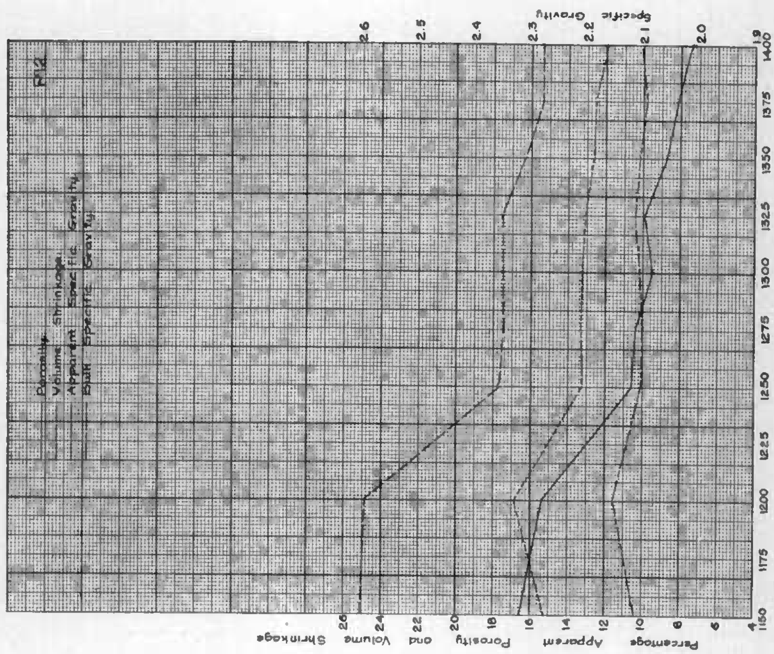

FIG. 27.—PROPERTIES OF P 12 WHEN FIRED TO DIFFERENT TEMPERATURES.

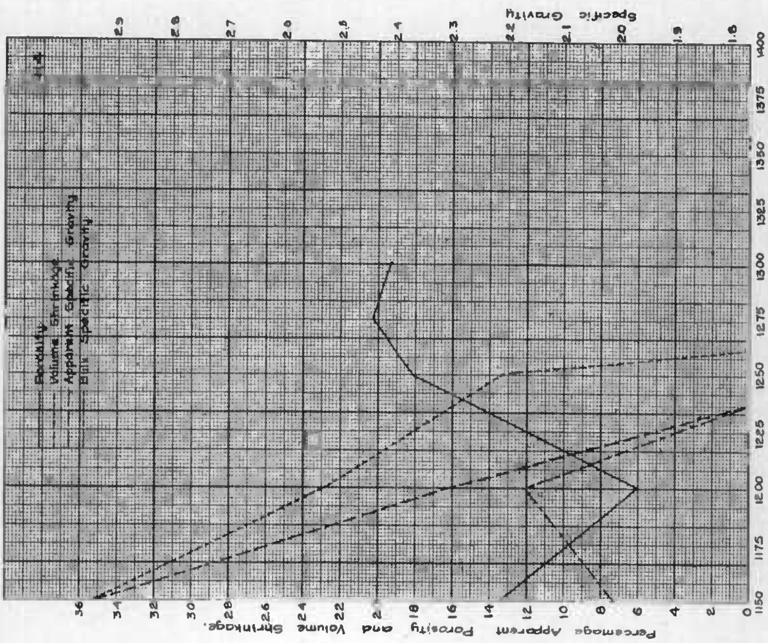

FIG. 28.—PROPERTIES OF P 14 WHEN FIRED TO DIFFERENT TEMPERATURES.

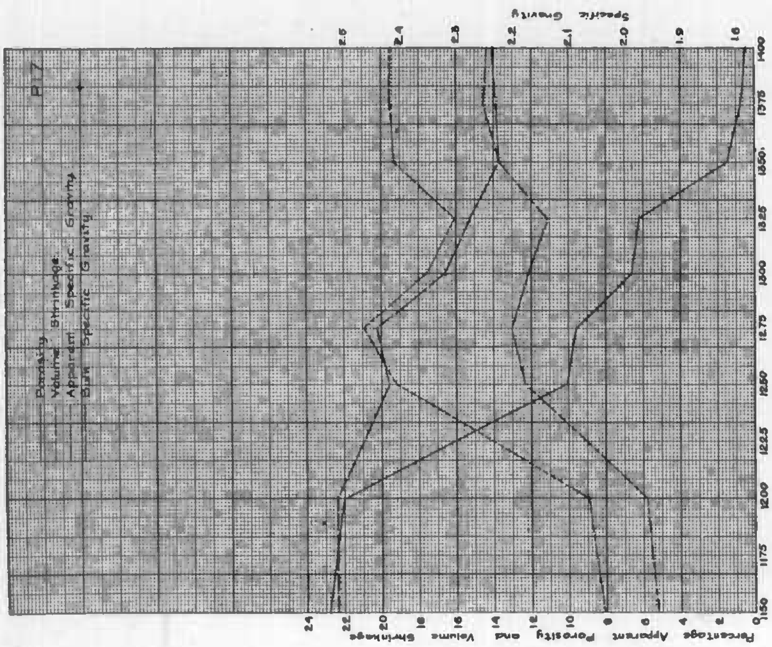

FIG. 30.—PROPERTIES OF P 17 WHEN FIRED TO DIFFERENT TEMPERATURES.

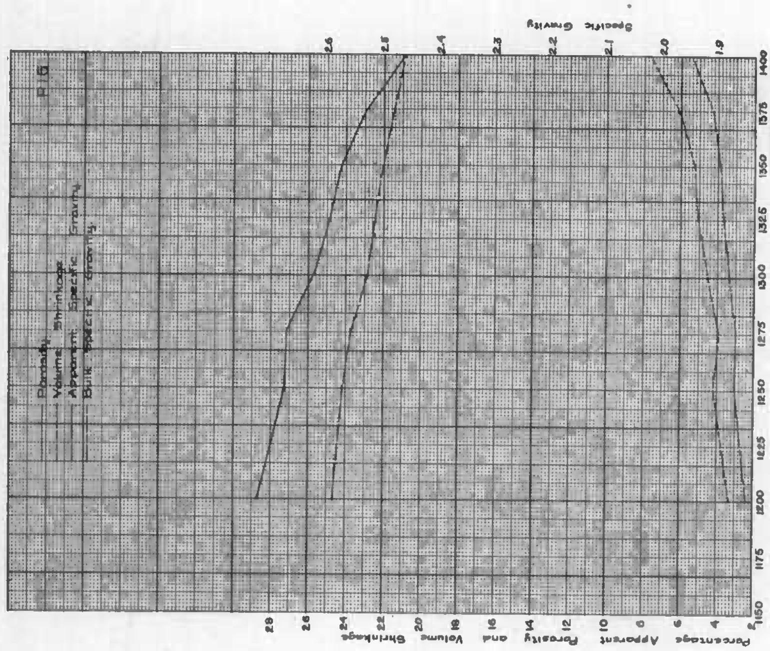

FIG. 29.—PROPERTIES OF P 16 WHEN FIRED TO DIFFERENT TEMPERATURES.

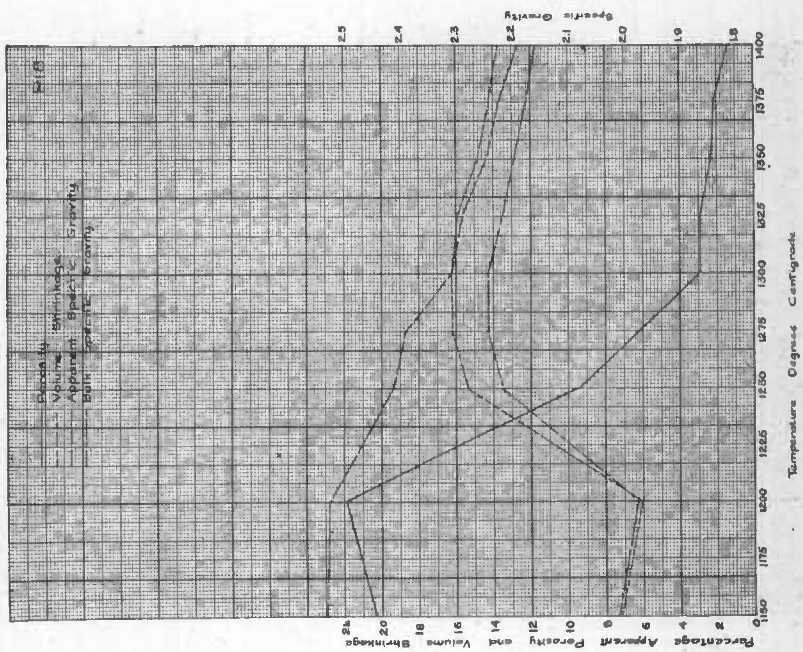

FIG. 31.—PROPERTIES OF P 18 WHEN FIRED TO DIFFERENT TEMPERATURES.

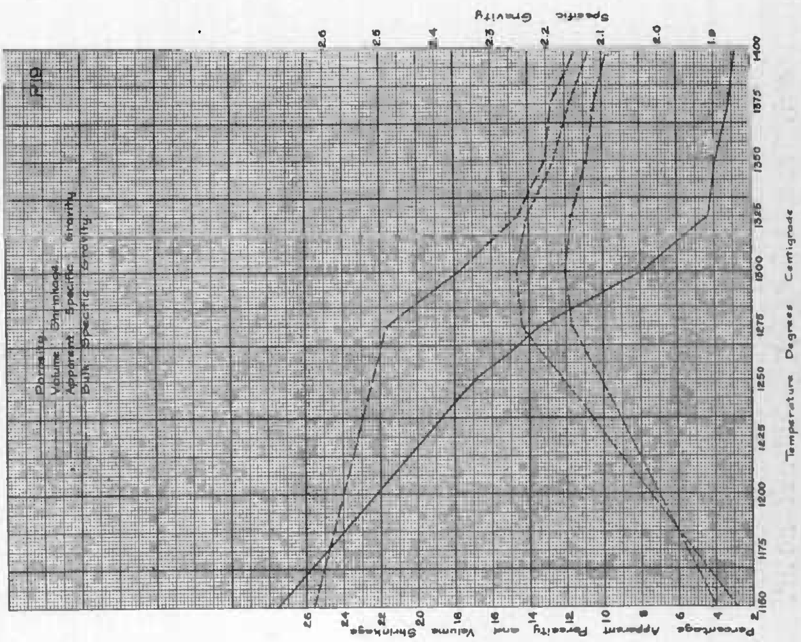

FIG. 32.—PROPERTIES OF P 19 WHEN FIRED TO DIFFERENT TEMPERATURES.

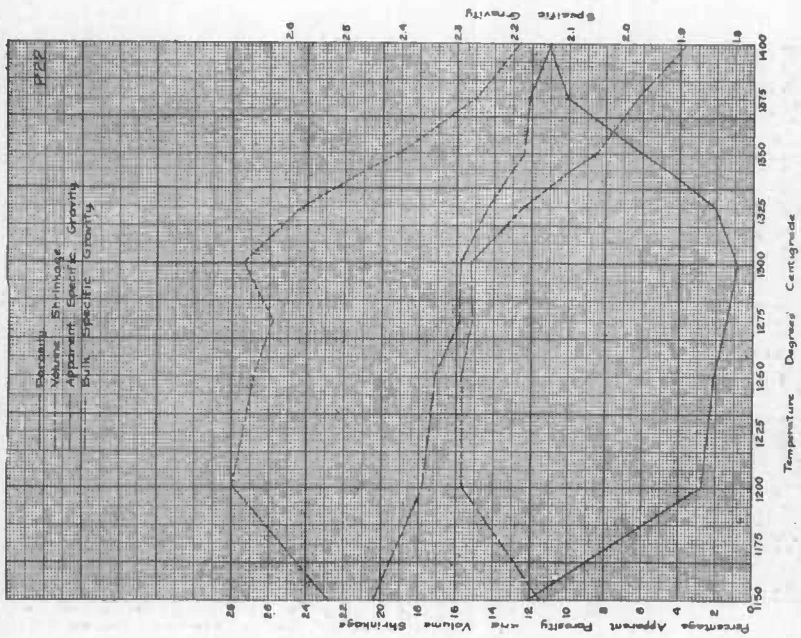

FIG. 33.—PROPERTIES OF P 22 WHEN FIRED TO DIFFERENT TEMPERATURES.

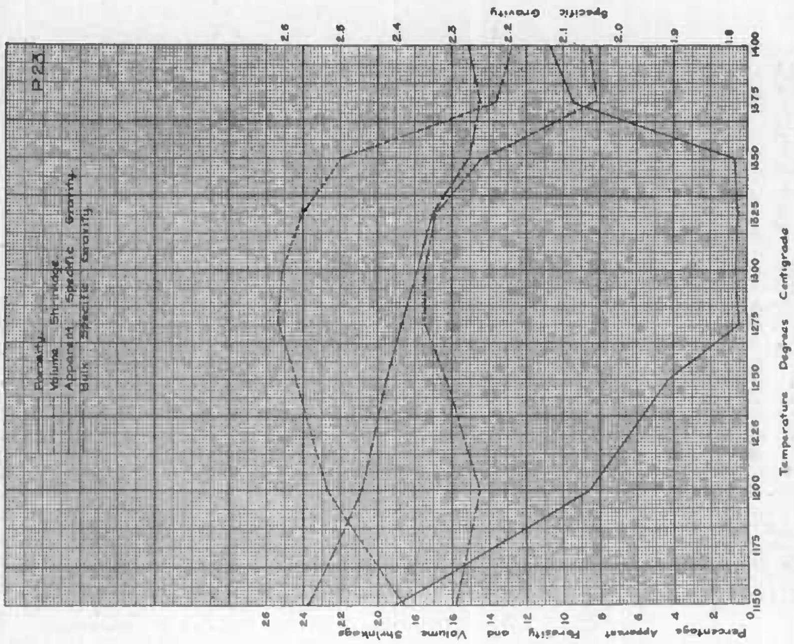

FIG. 34.—PROPERTIES OF P 23 WHEN FIRED TO DIFFERENT TEMPERATURES.

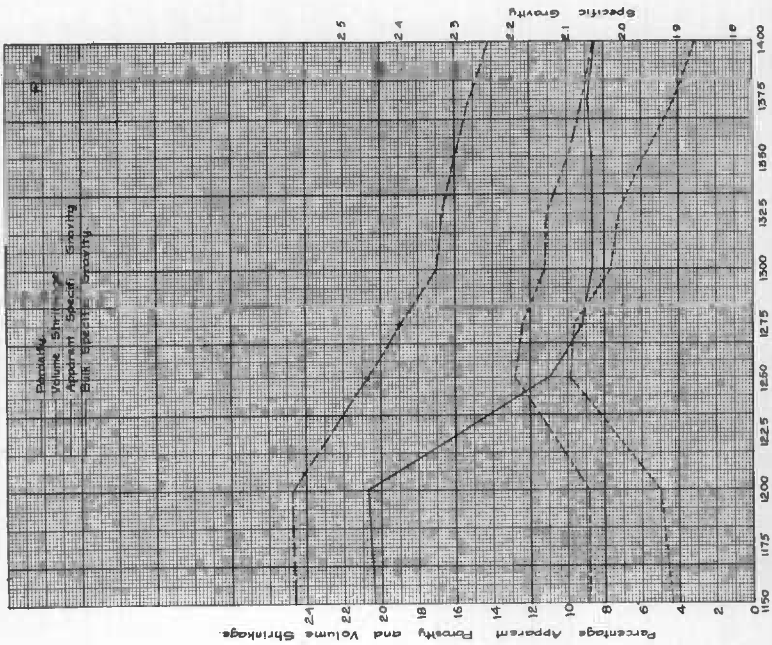

FIG. 36.—PROPERTIES OF P 25 WHEN FIRED TO DIFFERENT TEMPERATURES.

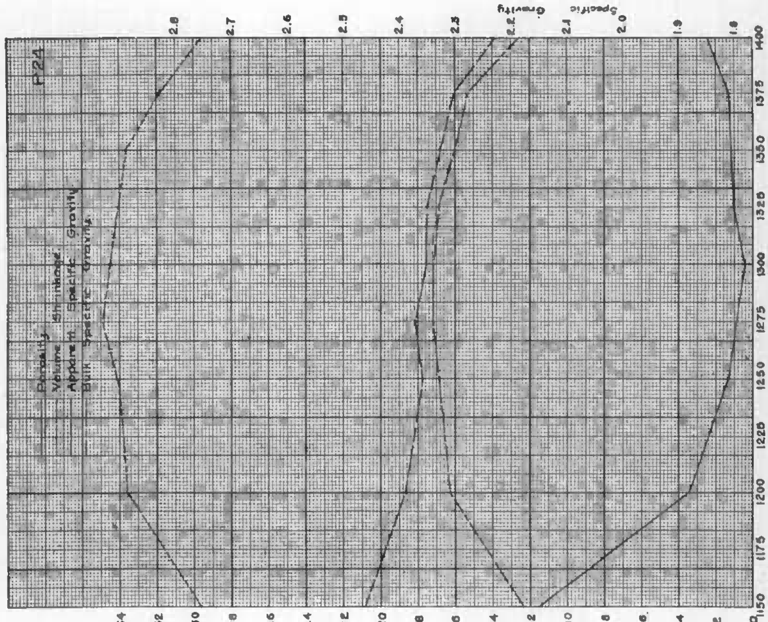

FIG. 35.—PROPERTIES OF P 24 WHEN FIRED TO DIFFERENT TEMPERATURES.

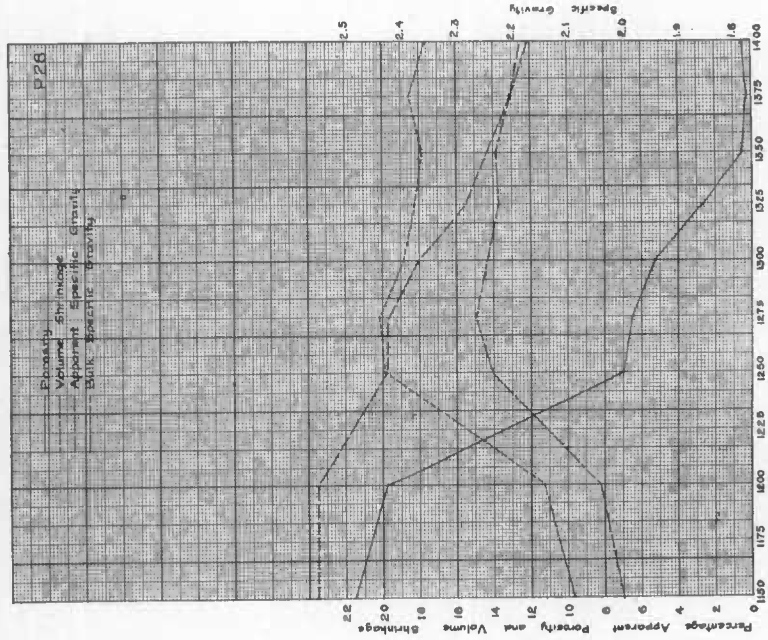

FIG. 37.—PROPERTIES OF P 28 WHEN FIRED TO DIFFERENT TEMPERATURES.

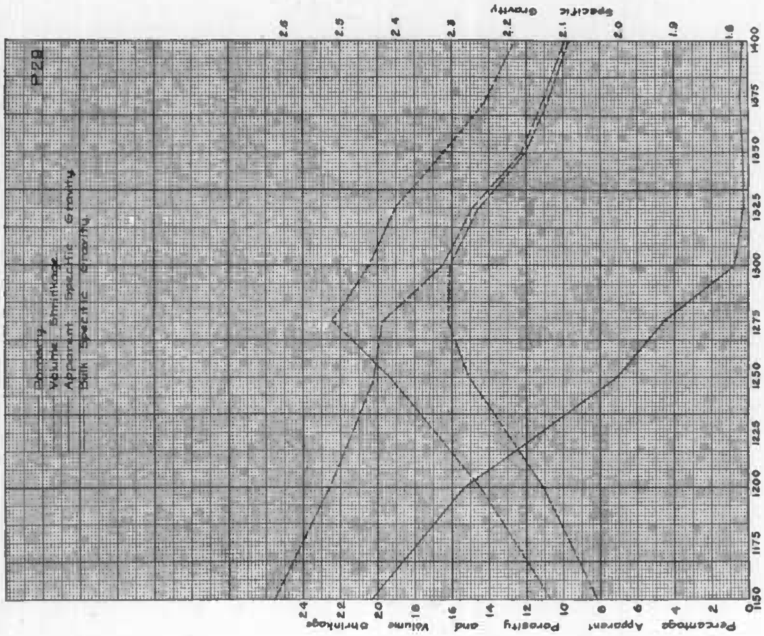

FIG. 38.—PROPERTIES OF P 29 WHEN FIRED TO DIFFERENT TEMPERATURES.

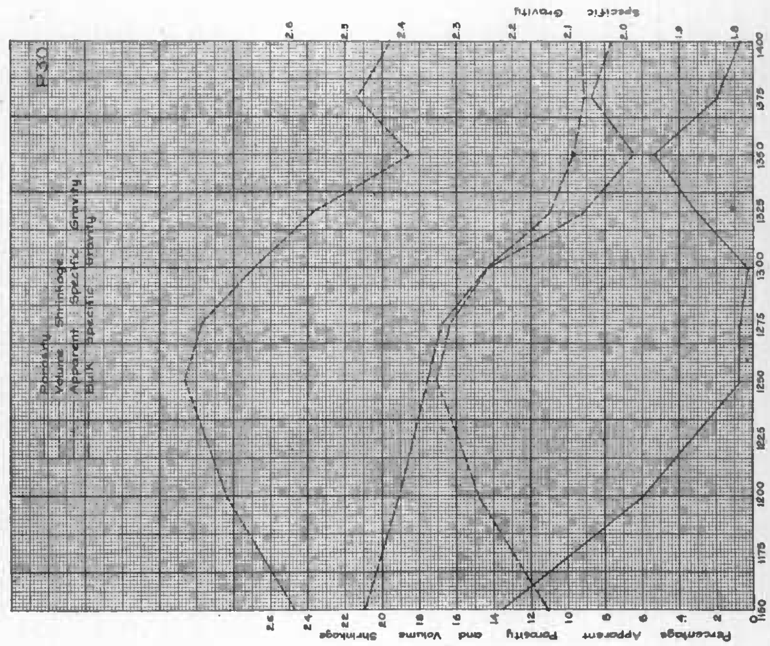

FIG. 39.—PROPERTIES OF P 30 WHEN FIRED TO DIFFERENT TEMPERATURES.

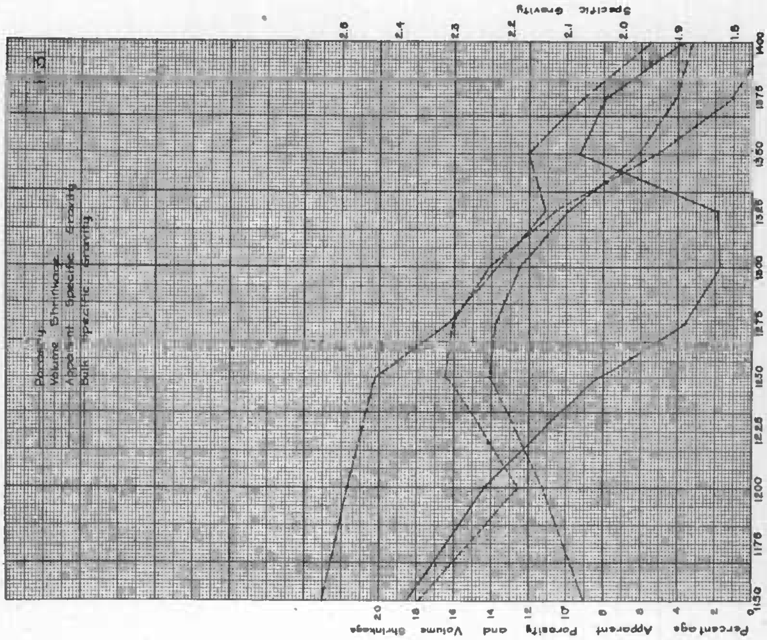

FIG. 40.—PROPERTIES OF P 31 WHEN FIRED TO DIFFERENT TEMPERATURES.

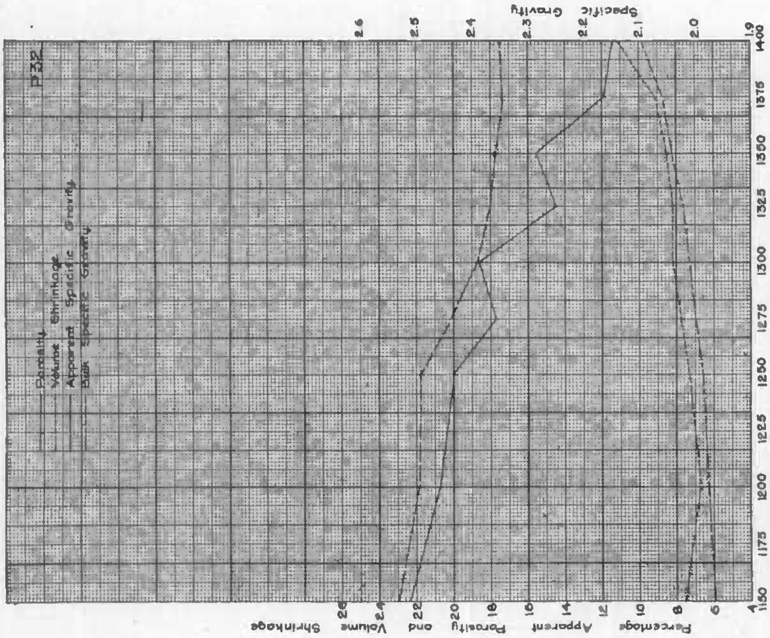

FIG. 41.—PROPERTIES OF P 32 WHEN FIRED TO DIFFERENT TEMPERATURES.

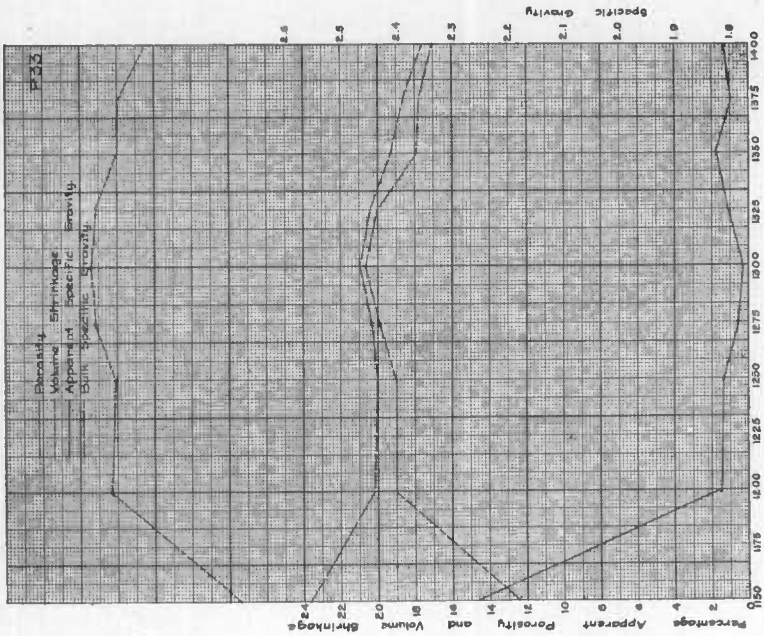

FIG. 42.—PROPERTIES OF P 33 WHEN FIRED TO DIFFERENT TEMPERATURES.

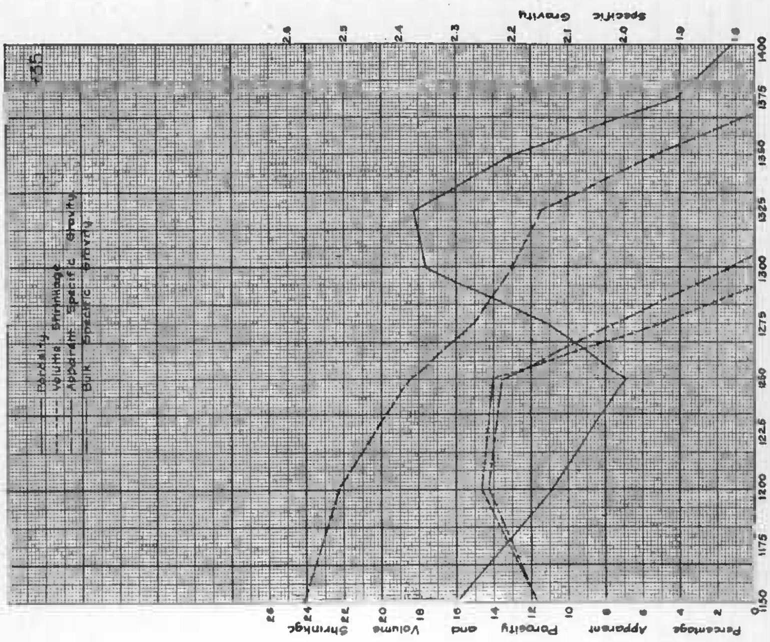

FIG. 44.—PROPERTIES OF P 35 WHEN FIRED TO DIFFERENT TEMPERATURES.

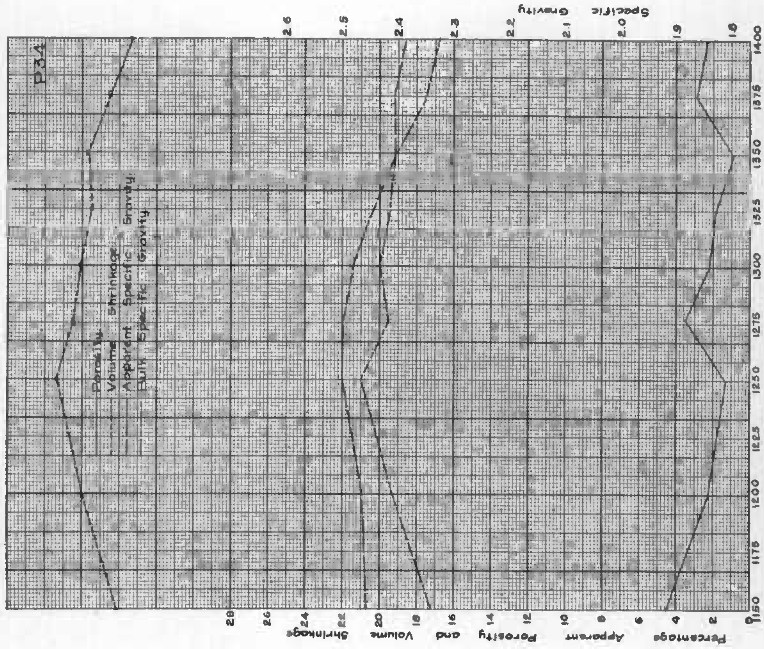

FIG. 43.—PROPERTIES OF P 34 WHEN FIRED TO DIFFERENT TEMPERATURES.

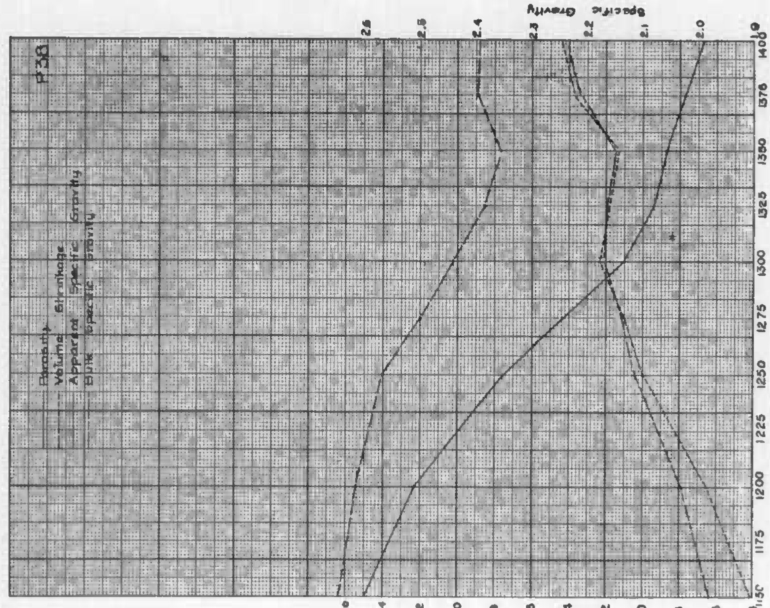

FIG. 46.—PROPERTIES OF P 38 WHEN FIRED TO DIFFERENT TEMPERATURES.

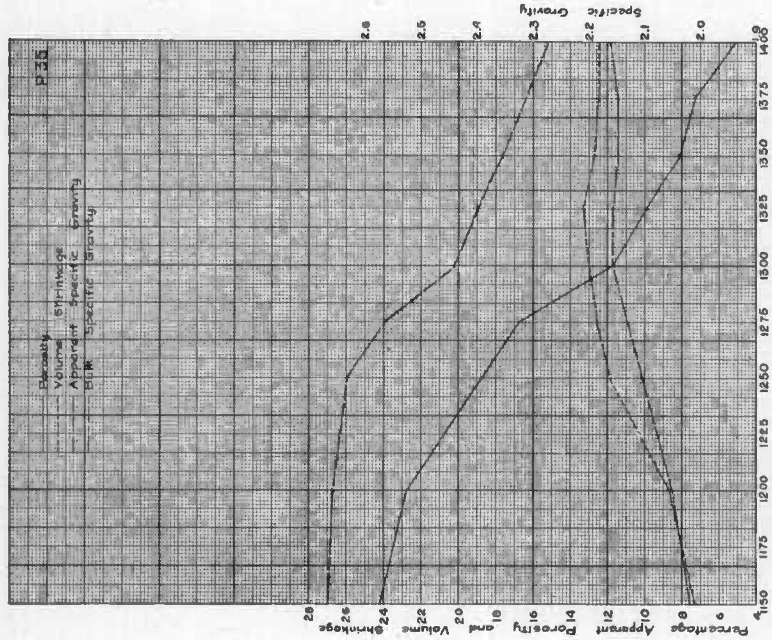

FIG. 45.—PROPERTIES OF P 36 WHEN FIRED TO DIFFERENT TEMPERATURES.

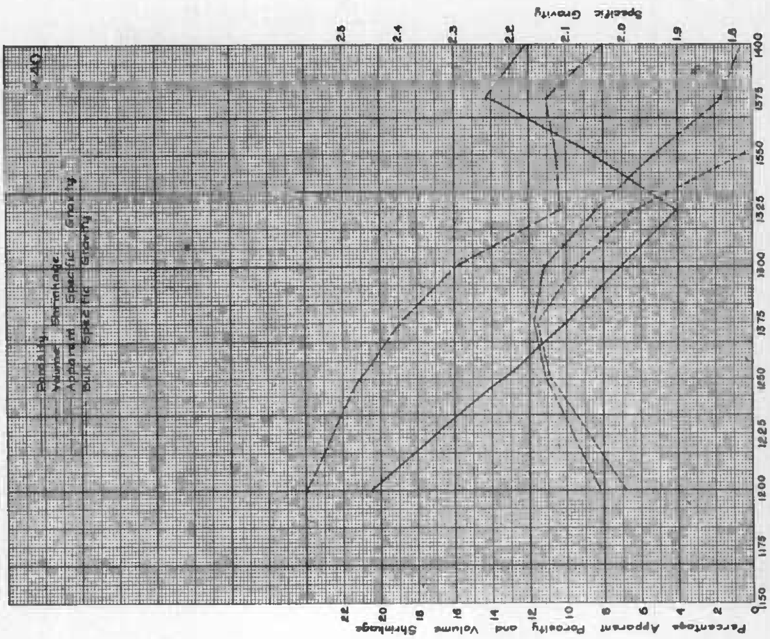

FIG. 48.—PROPERTIES OF P 40 WHEN FIRED TO DIFFERENT TEMPERATURES.

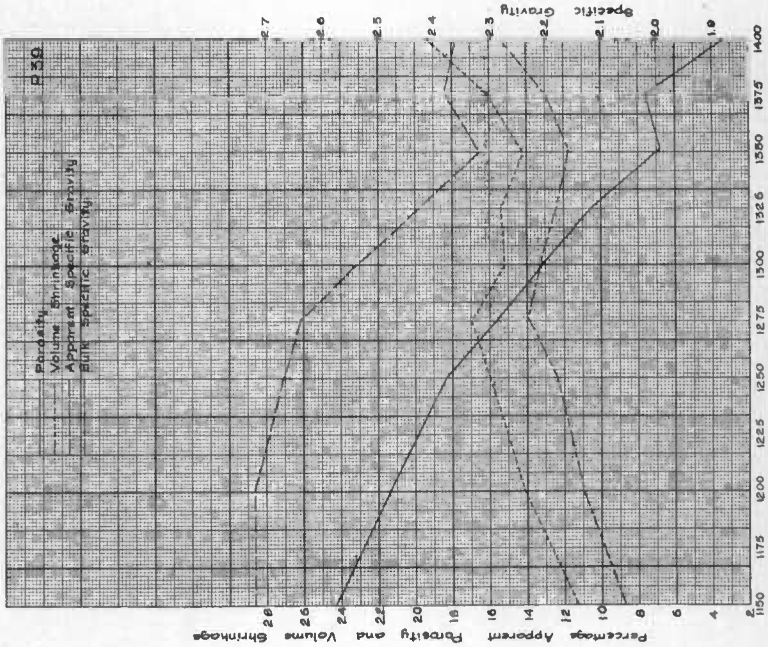

FIG. 47.—PROPERTIES OF P 39 WHEN FIRED TO DIFFERENT TEMPERATURES.

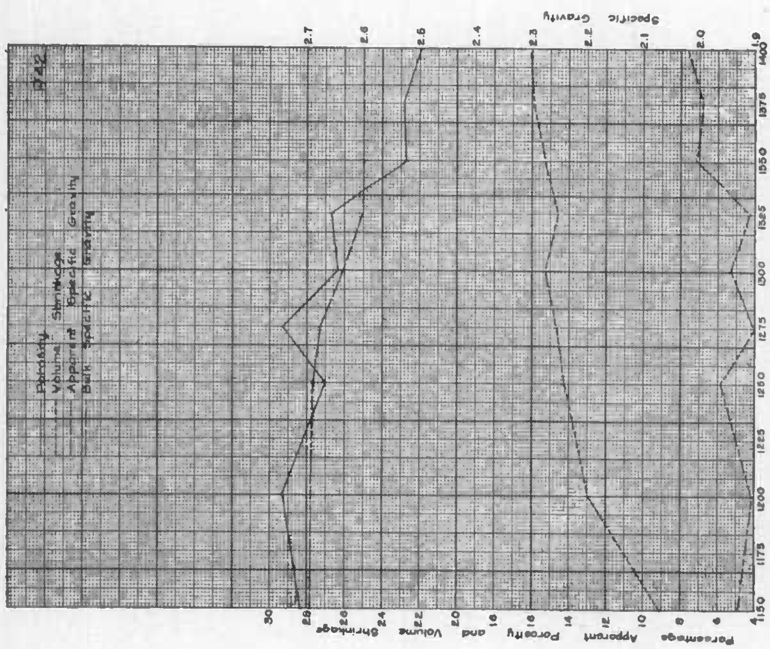

FIG. 49.—PROPERTIES OF P 42 WHEN FIRED TO DIFFERENT TEMPERATURES.

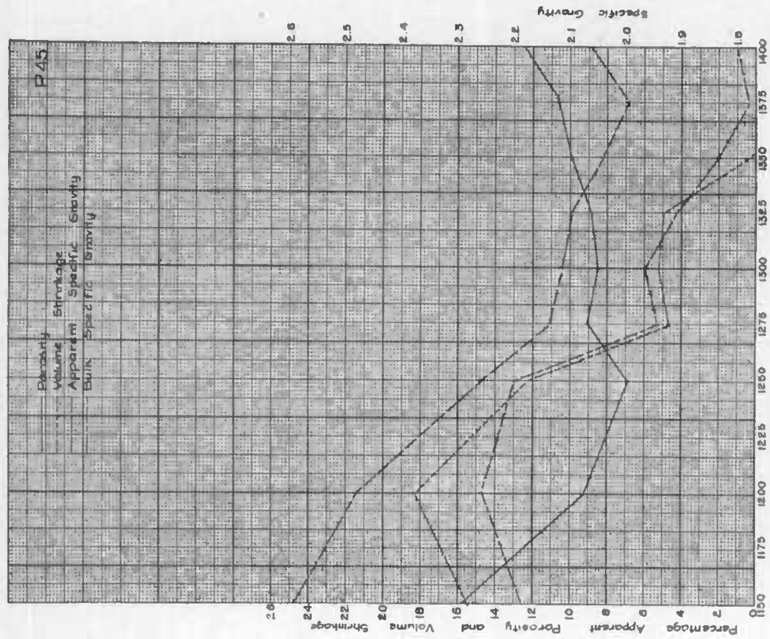

FIG. 50.—PROPERTIES OF P 45 WHEN FIRED TO DIFFERENT TEMPERATURES.

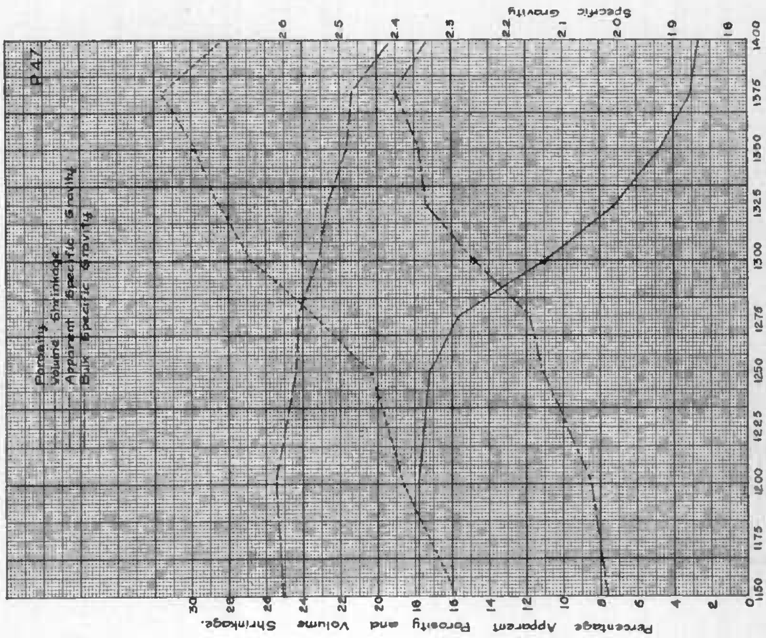

FIG. 52.—PROPERTIES OF P 47 WHEN FIRED TO DIFFERENT TEMPERATURES.

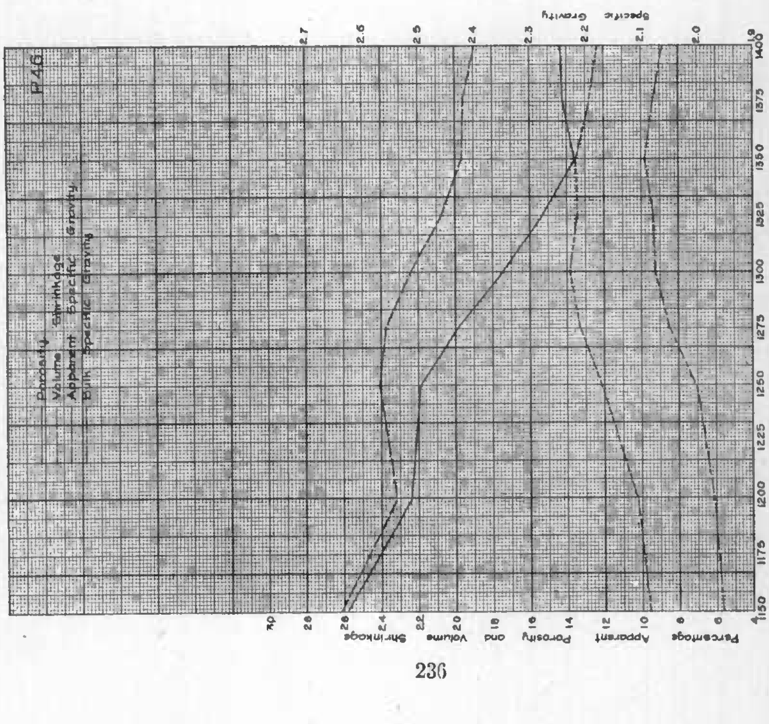

FIG. 51.—PROPERTIES OF P 46 WHEN FIRED TO DIFFERENT TEMPERATURES.

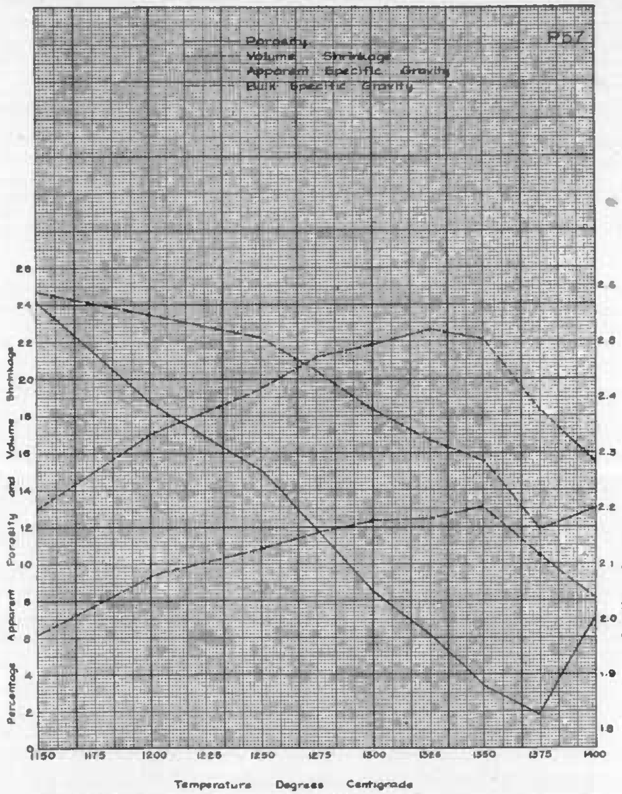

FIG. 53.—PROPERTIES OF P 57 WHEN FIRED TO DIFFERENT TEMPERATURES.

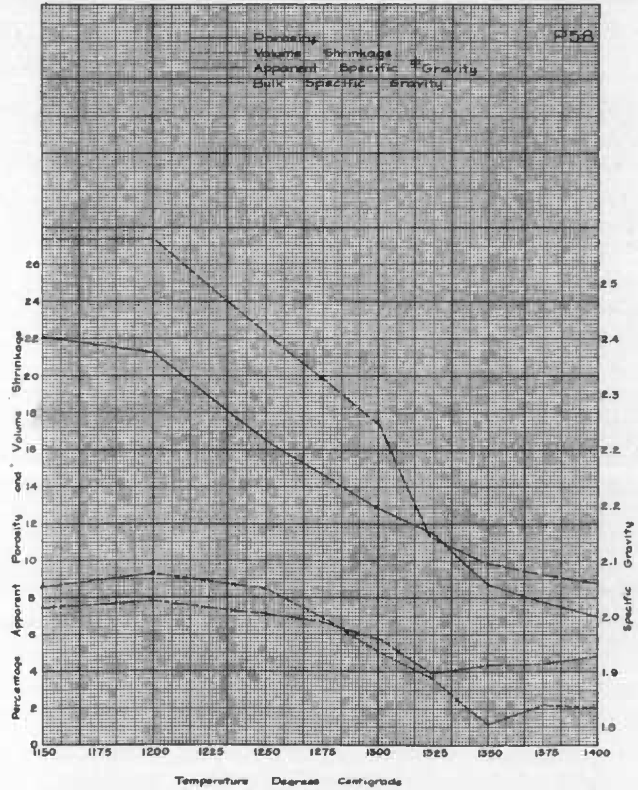

FIG. 54.—PROPERTIES OF P 58 WHEN FIRED TO DIFFERENT TEMPERATURES.

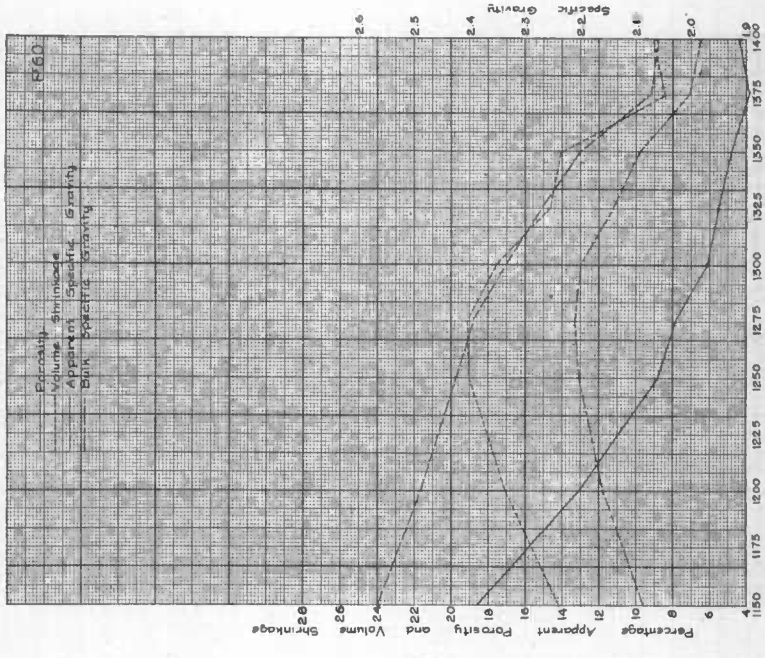

FIG. 55.—PROPERTIES OF P 60 WHEN FIRED TO DIFFERENT TEMPERATURES.

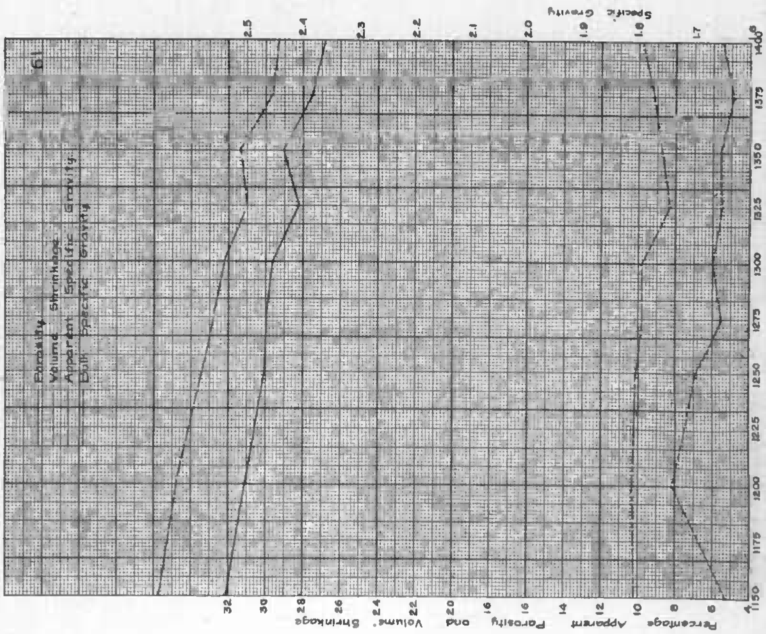

FIG. 56.—PROPERTIES OF P 61 WHEN FIRED TO DIFFERENT TEMPERATURES.

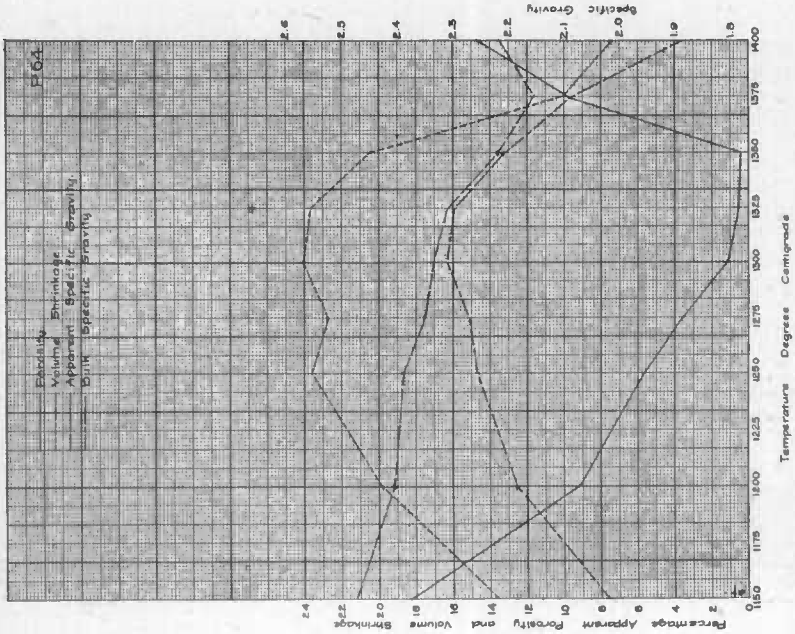

FIG. 58.—PROPERTIES OF P 64 WHEN FIRED TO DIFFERENT TEMPERATURES.

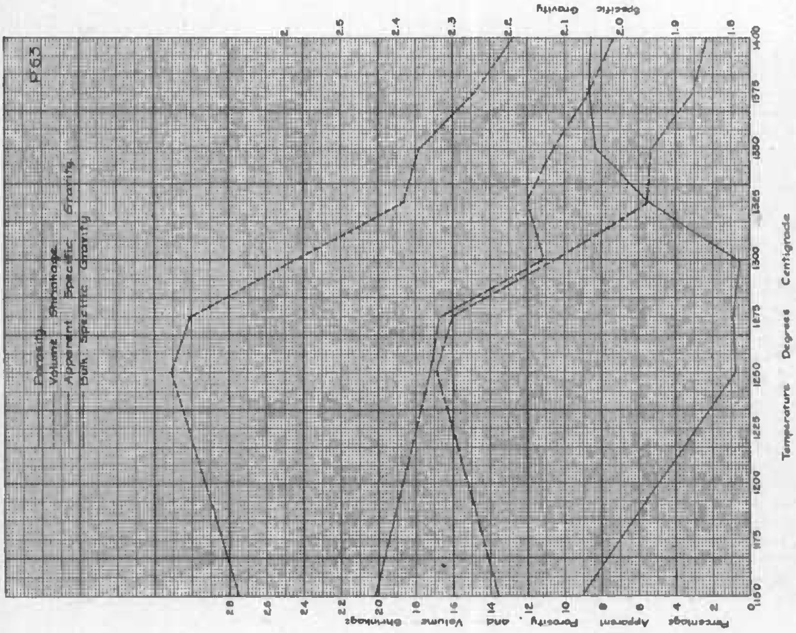

FIG. 57.—PROPERTIES OF P 63 WHEN FIRED TO DIFFERENT TEMPERATURES.

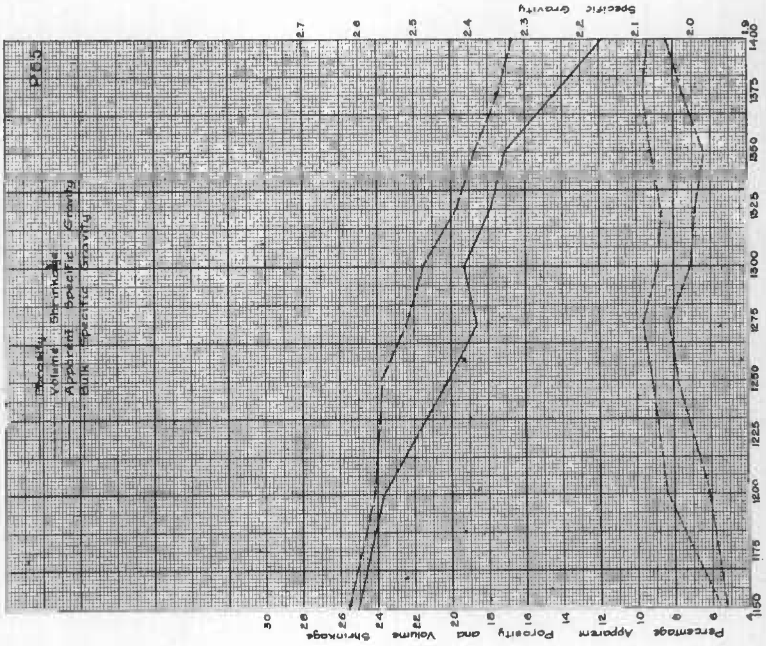

FIG. 59.—PROPERTIES OF P 65 WHEN FIRED TO DIFFERENT TEMPERATURES.

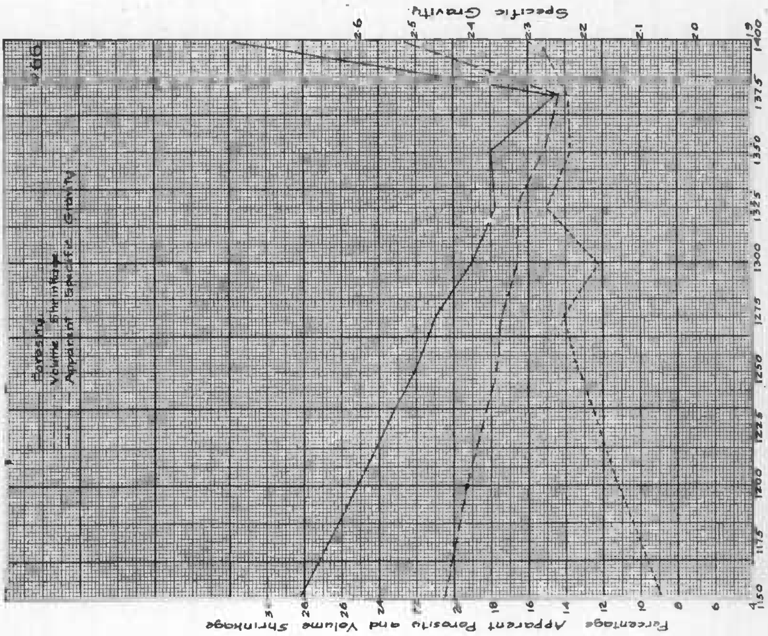

FIG. 60.—PROPERTIES OF P 66 WHEN FIRED TO DIFFERENT TEMPERATURES.

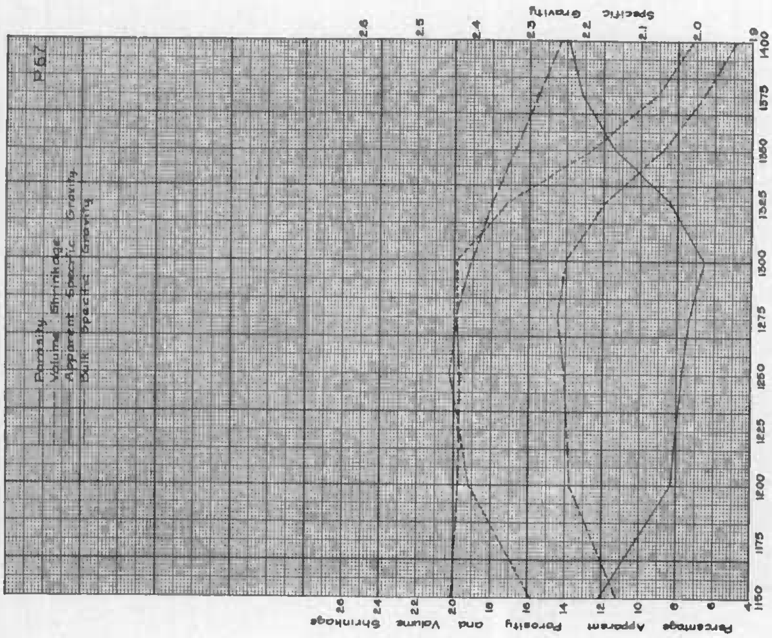

FIG. 61.—PROPERTIES OF P 67 WHEN FIRED TO DIFFERENT TEMPERATURES.

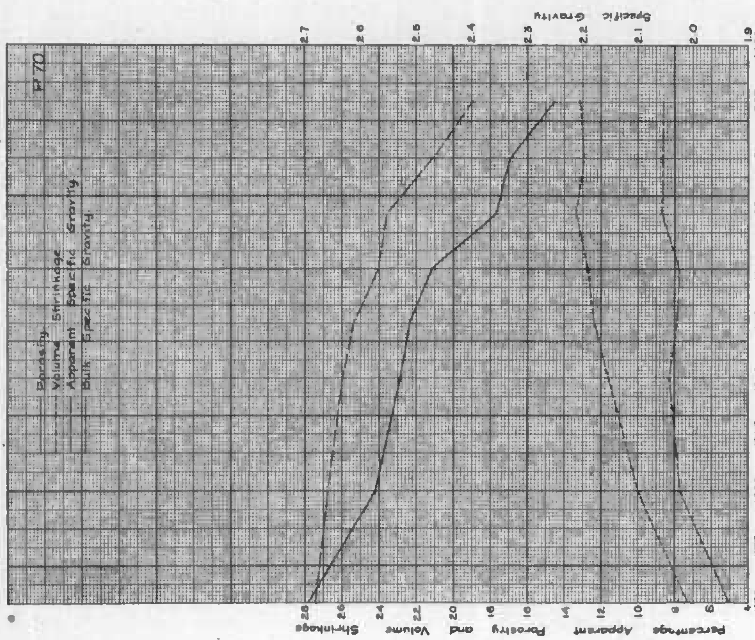

FIG. 62.—PROPERTIES OF P 70 WHEN FIRED TO DIFFERENT TEMPERATURES.

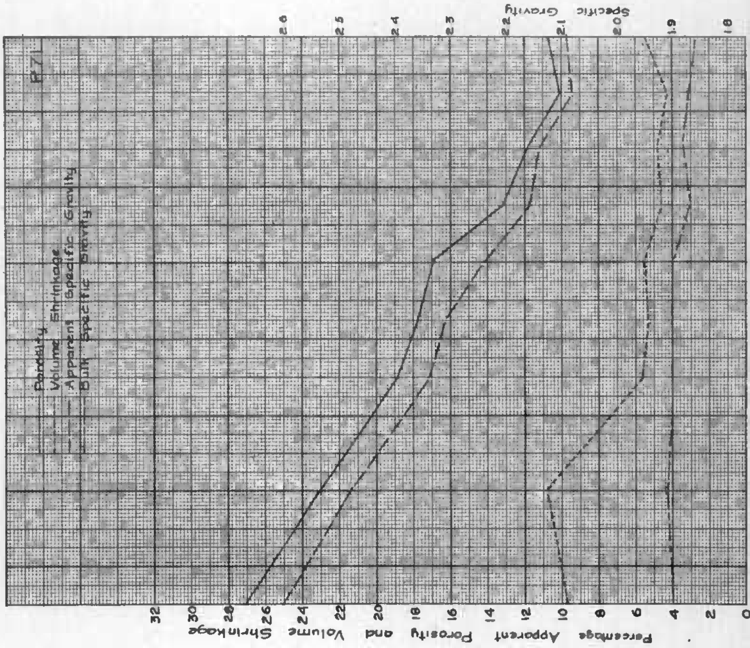

FIG. 63.—PROPERTIES OF P 71 WHEN FIRED TO DIFFERENT TEMPERATURES.

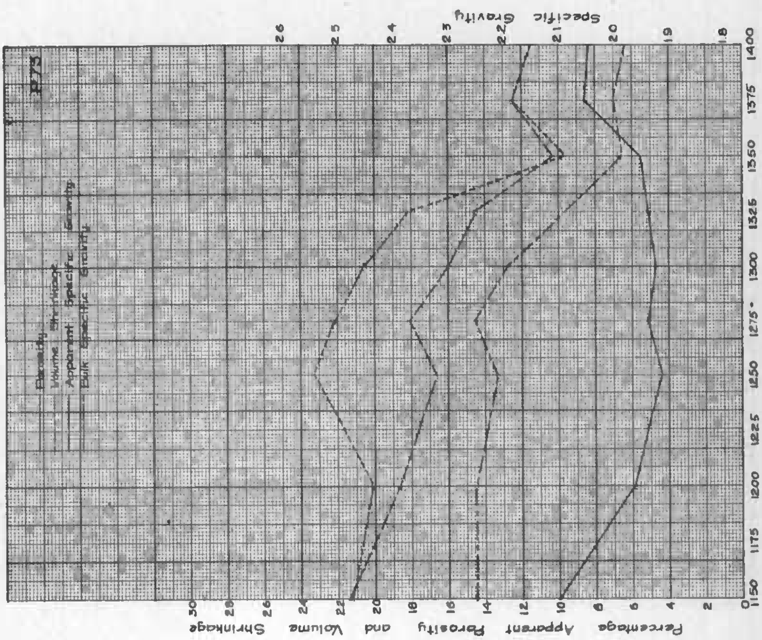

FIG. 64.—PROPERTIES OF P 73 WHEN FIRED TO DIFFERENT TEMPERATURES.

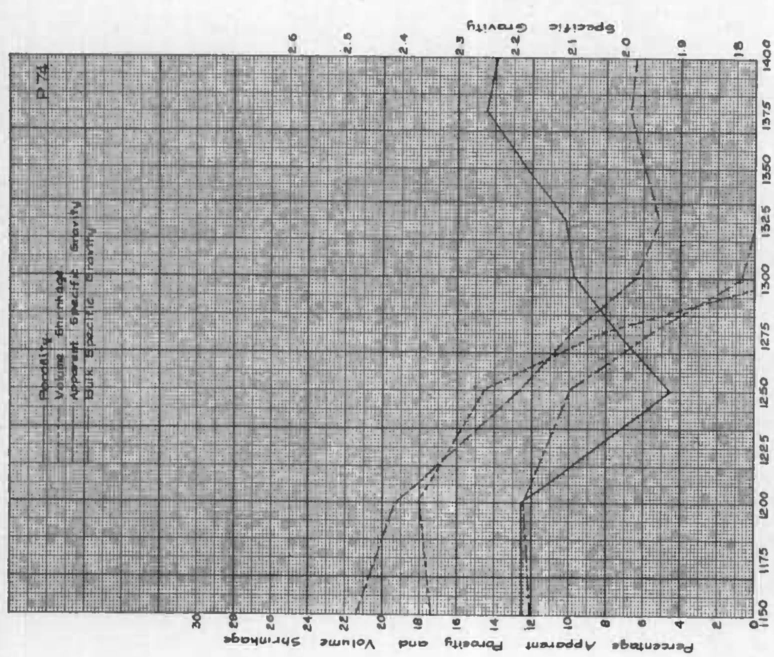

FIG. 65.—PROPERTIES OF P 74 WHEN FIRED TO DIFFERENT TEMPERATURES.

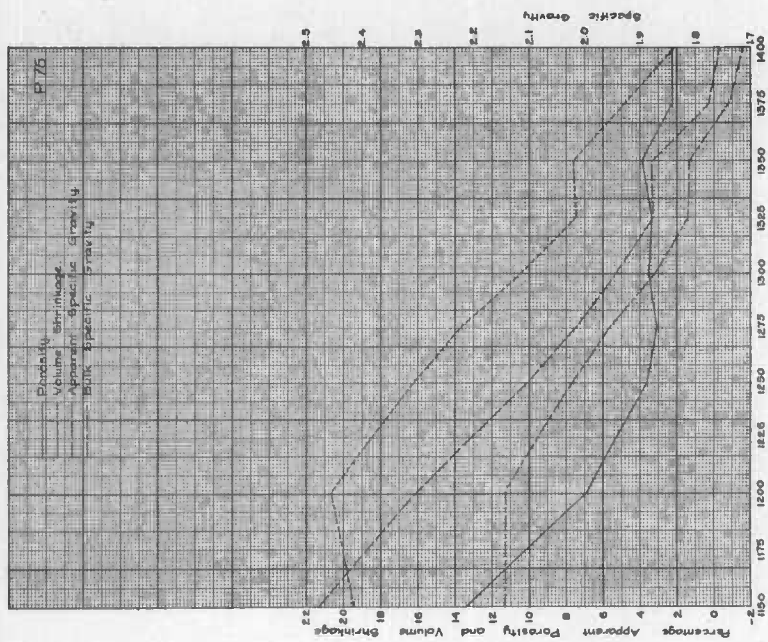

FIG. 66.—PROPERTIES OF P 76 WHEN FIRED TO DIFFERENT TEMPERATURES.

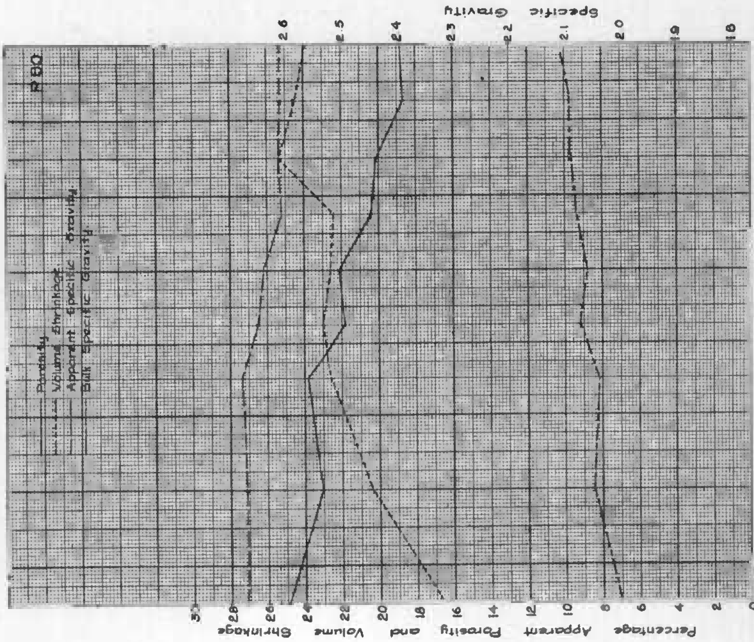

FIG. 68.—PROPERTIES OF P 80 WHEN FIRED TO DIFFERENT TEMPERATURES.

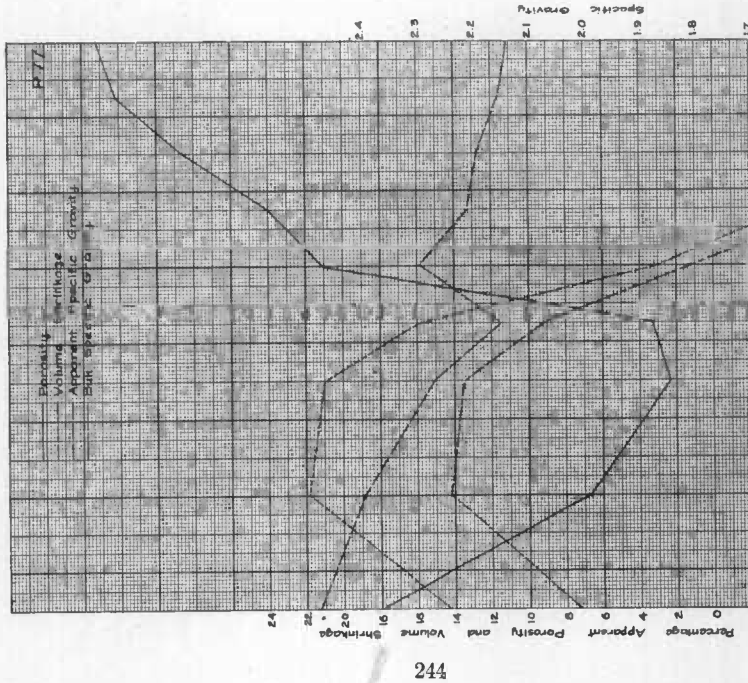

FIG. 67.—PROPERTIES OF P 77 WHEN FIRED TO DIFFERENT TEMPERATURES.

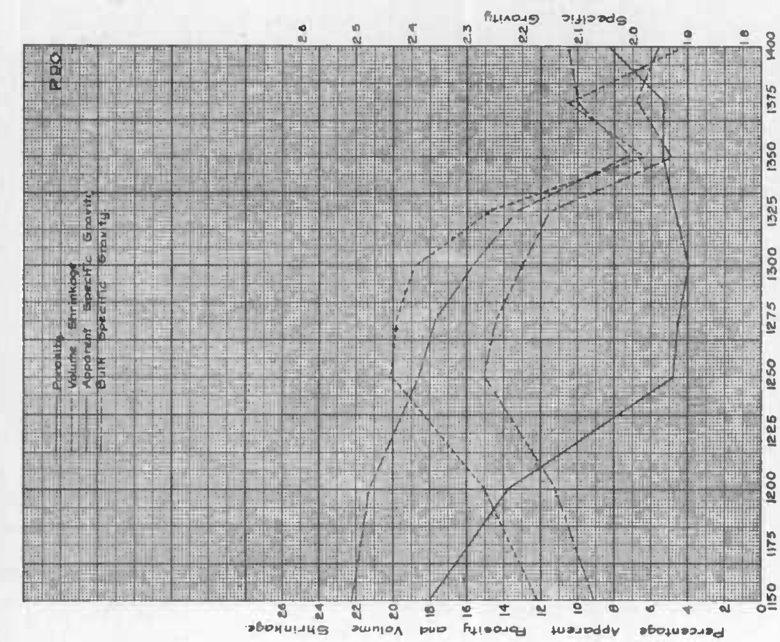

FIG. 70.—PROPERTIES OF P 90 WHEN FIRED TO DIFFERENT TEMPERATURES.

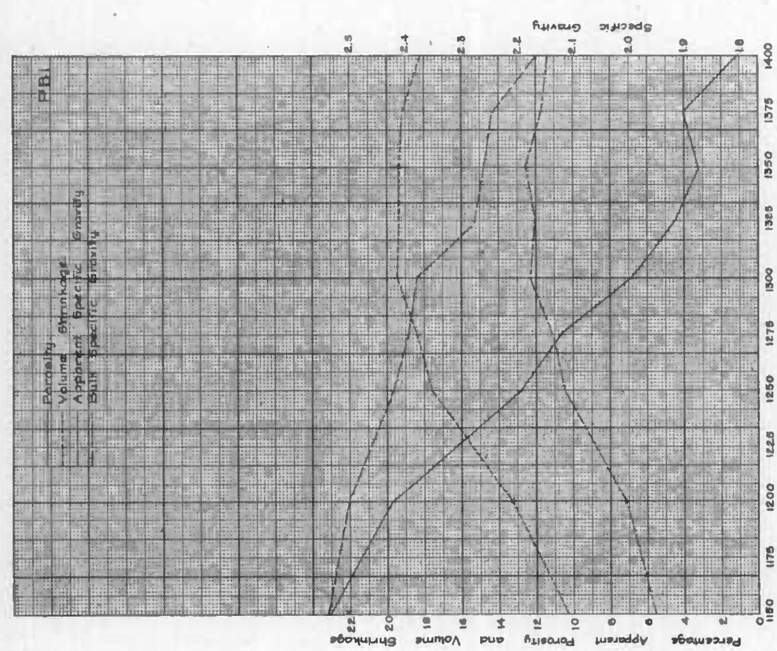

FIG. 69.—PROPERTIES OF P 81 WHEN FIRED TO DIFFERENT TEMPERATURES.

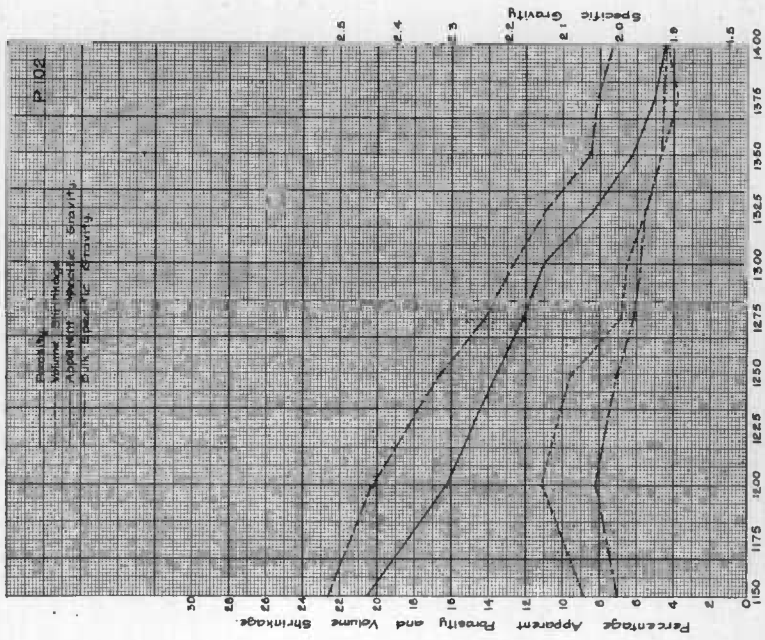

FIG. 72.—PROPERTIES OF P 102 WHEN FIRED TO DIFFERENT TEMPERATURES.

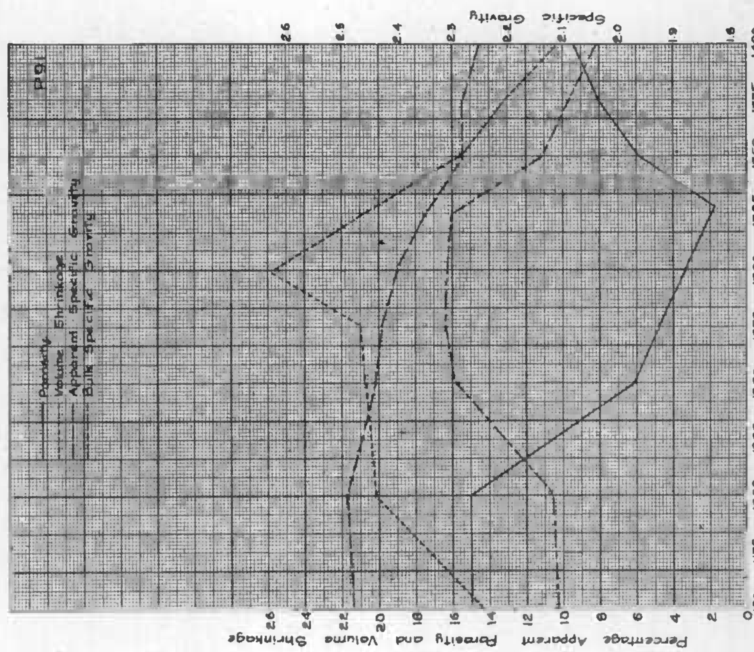

FIG. 71.—PROPERTIES OF P 91 WHEN FIRED TO DIFFERENT TEMPERATURES.

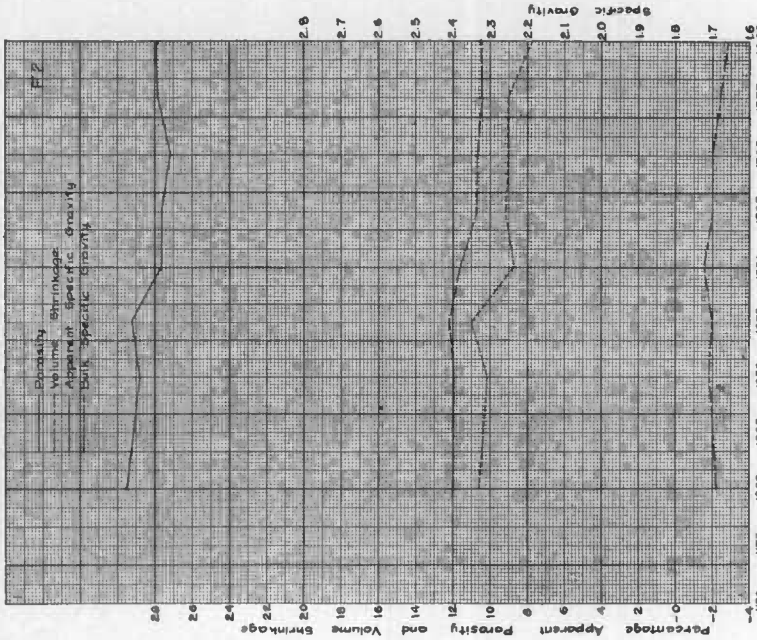

FIG. 74.—PROPERTIES OF F 2 WHEN FIRED TO DIFFERENT TEMPERATURES.

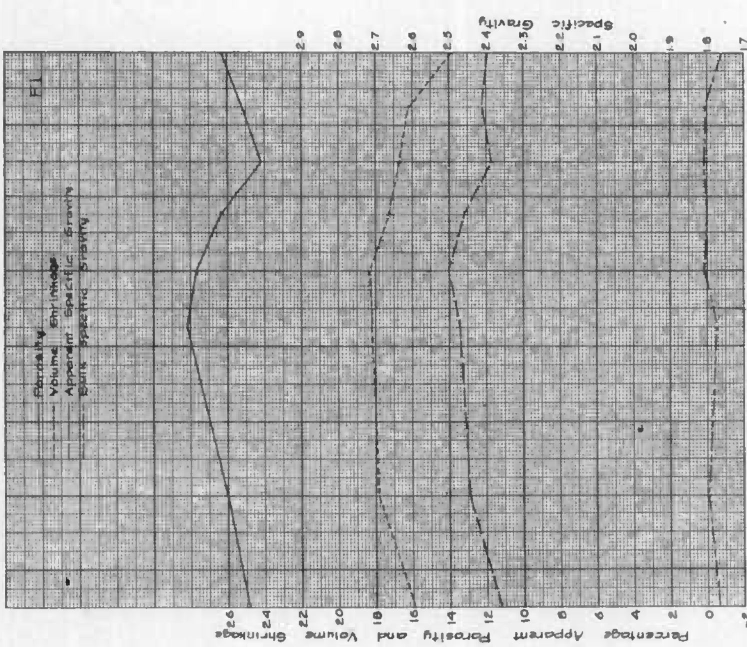

FIG. 73.—PROPERTIES OF F 1 WHEN FIRED TO DIFFERENT TEMPERATURES.

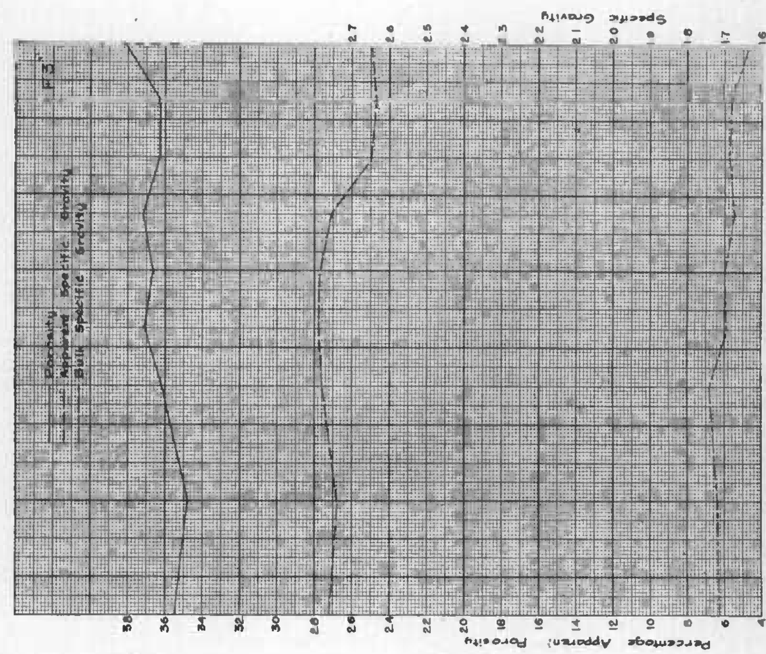

FIG. 75.—PROPERTIES OF F 3 WHEN FIRED TO DIFFERENT TEMPERATURES.

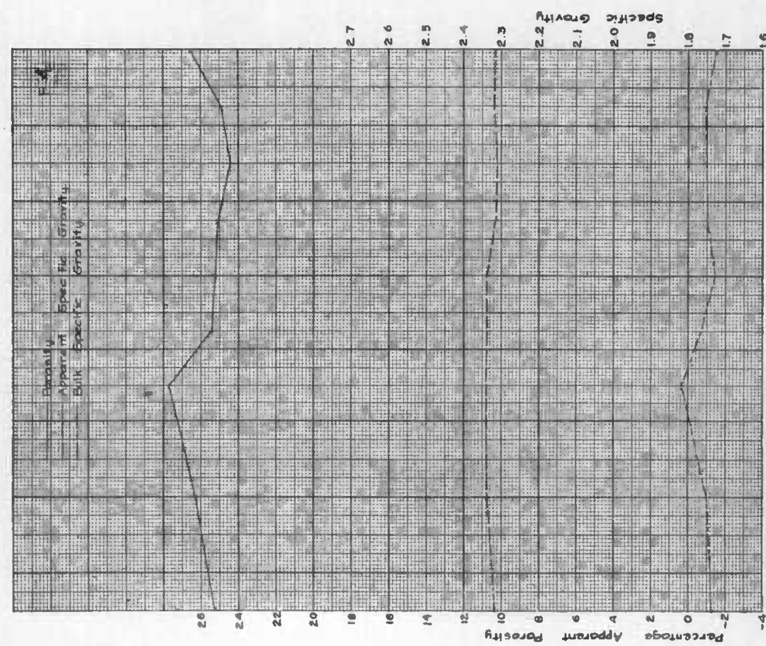

FIG. 76.—PROPERTIES OF F 4 WHEN FIRED TO DIFFERENT TEMPERATURES.

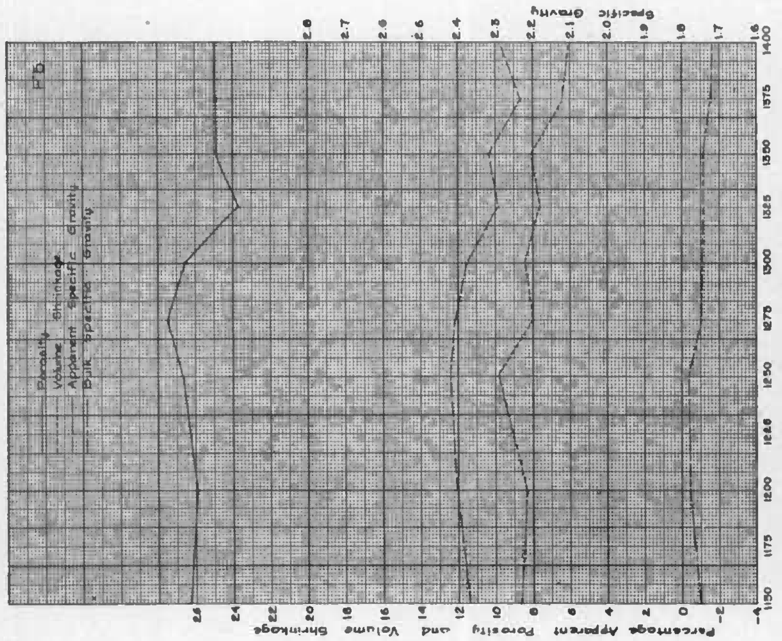

FIG. 77.—PROPERTIES OF F 5 WHEN FIRED TO DIFFERENT TEMPERATURES.

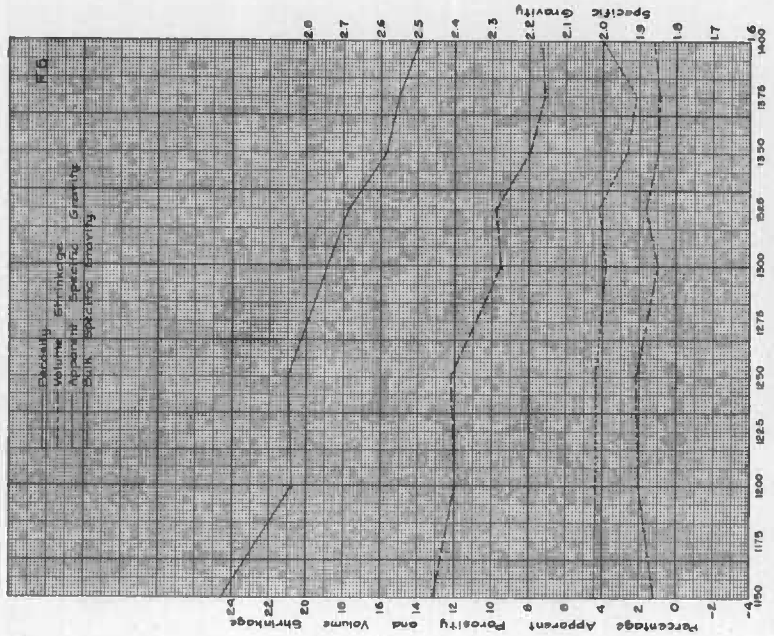

FIG. 78.—PROPERTIES OF F 6 WHEN FIRED TO DIFFERENT TEMPERATURES.

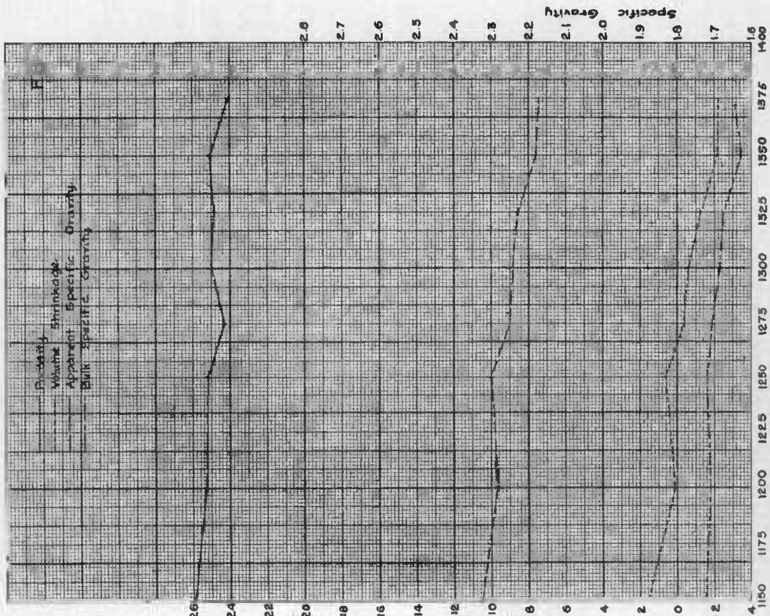

FIG. 80.—PROPERTIES OF F 8 WHEN FIRED TO DIFFERENT TEMPERATURES.

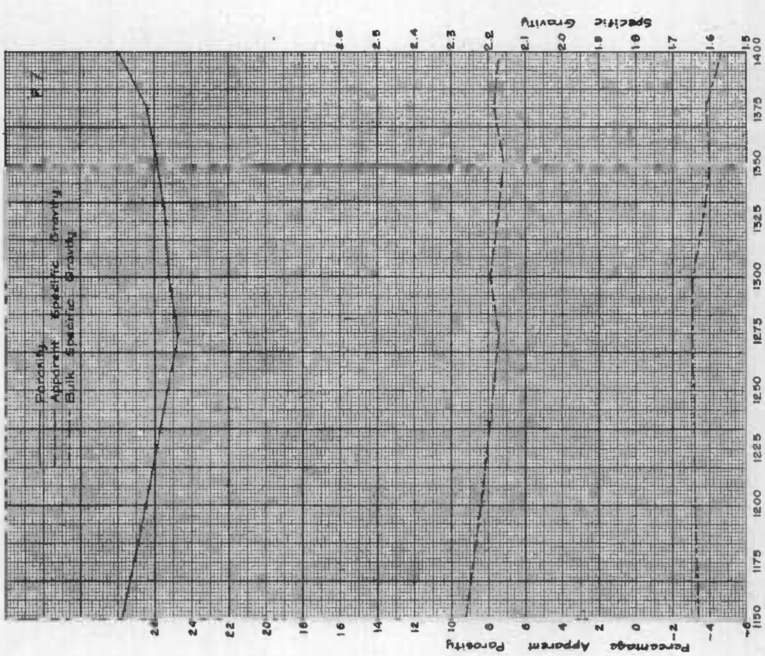

FIG. 79.—PROPERTIES OF F 7 WHEN FIRED TO DIFFERENT TEMPERATURES.

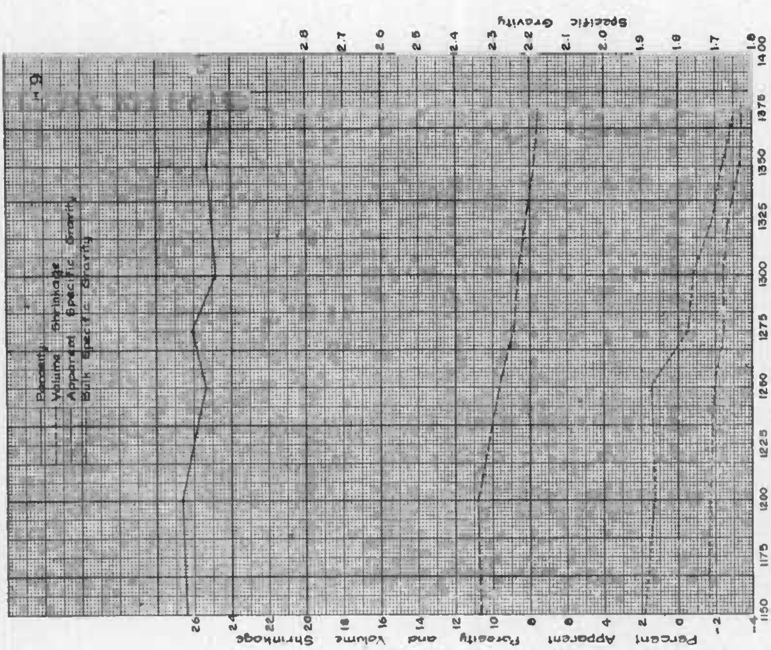

FIG. 81.—PROPERTIES OF F 9 WHEN FIRED TO DIFFERENT TEMPERATURES.

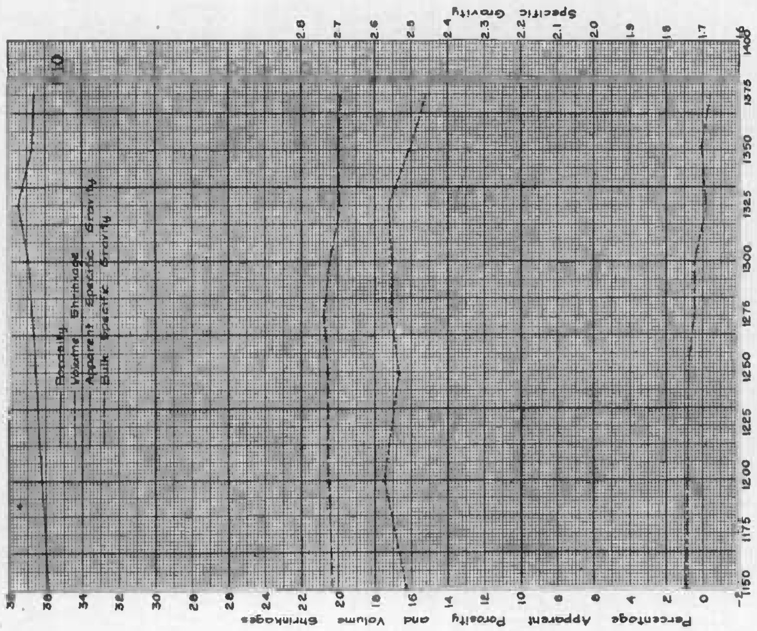

FIG. 82.—PROPERTIES OF F 10 WHEN FIRED TO DIFFERENT TEMPERATURES.

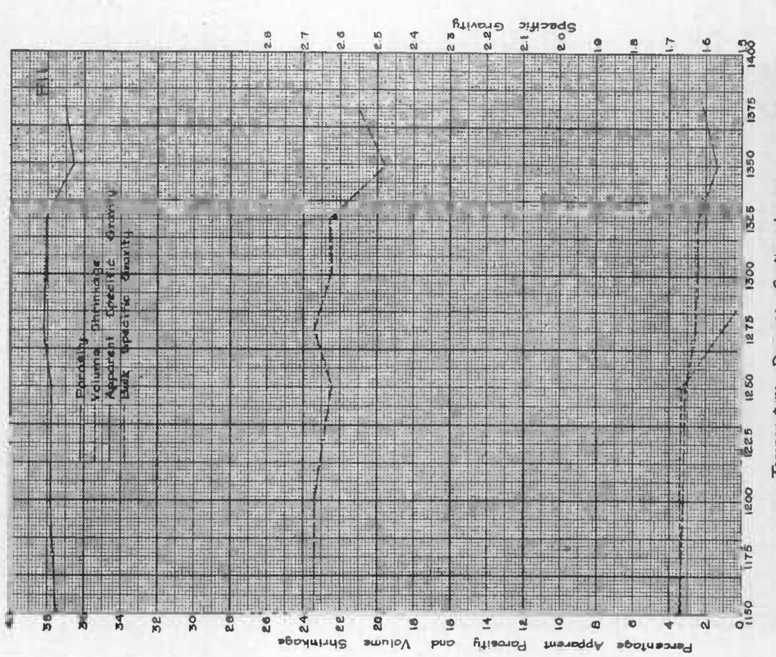

FIG. 83.—PROPERTIES OF F 11 WHEN FIRED TO DIFFERENT TEMPERATURES.

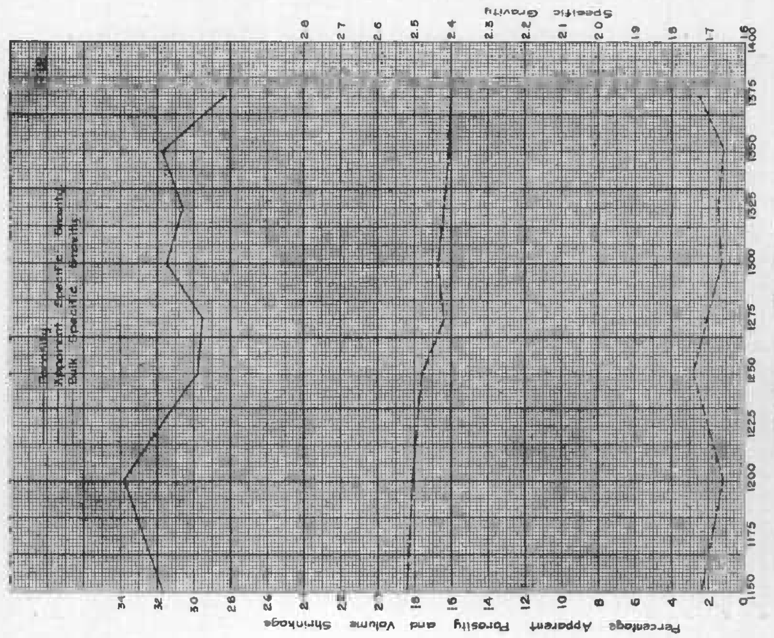

FIG. 84.—PROPERTIES OF F 12 WHEN FIRED TO DIFFERENT TEMPERATURES.

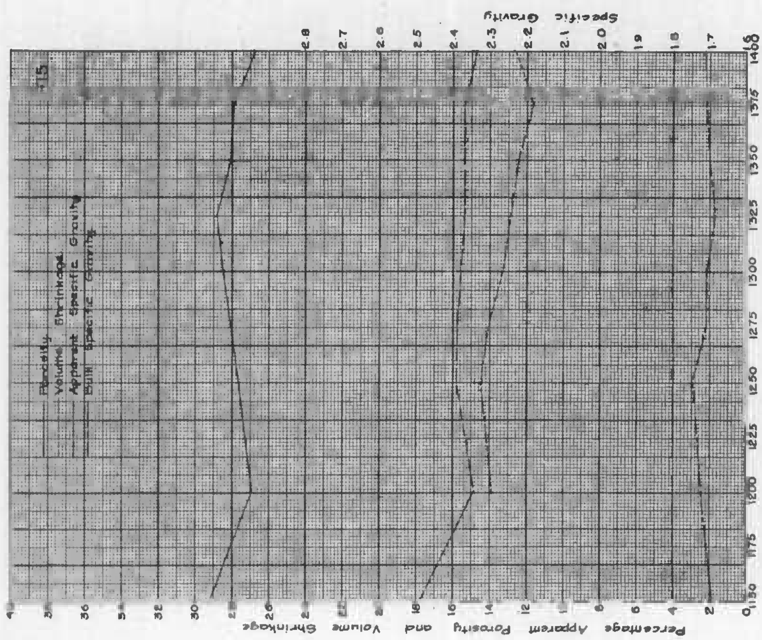

FIG. 86.—PROPERTIES OF F 15 WHEN FIRED TO DIFFERENT TEMPERATURES.

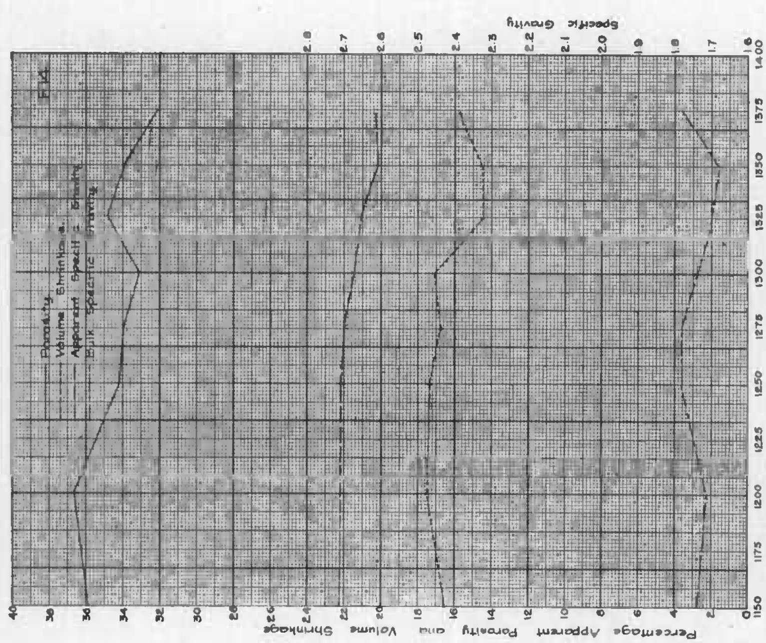

FIG. 85.—PROPERTIES OF F 14 WHEN FIRED TO DIFFERENT TEMPERATURES.

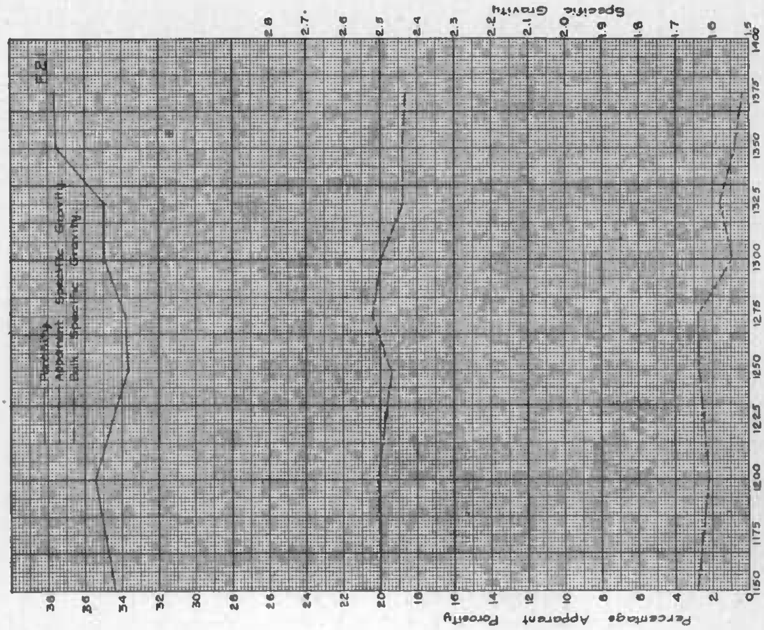

FIG. 88.—PROPERTIES OF F 21 WHEN FIRED TO DIFFERENT TEMPERATURES.

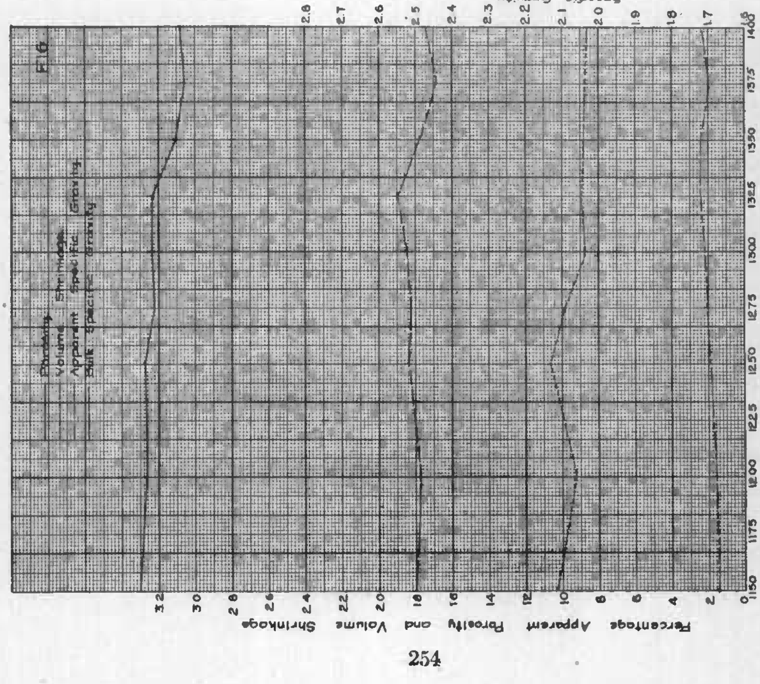

FIG. 87.—PROPERTIES OF F 16 WHEN FIRED TO DIFFERENT TEMPERATURES.

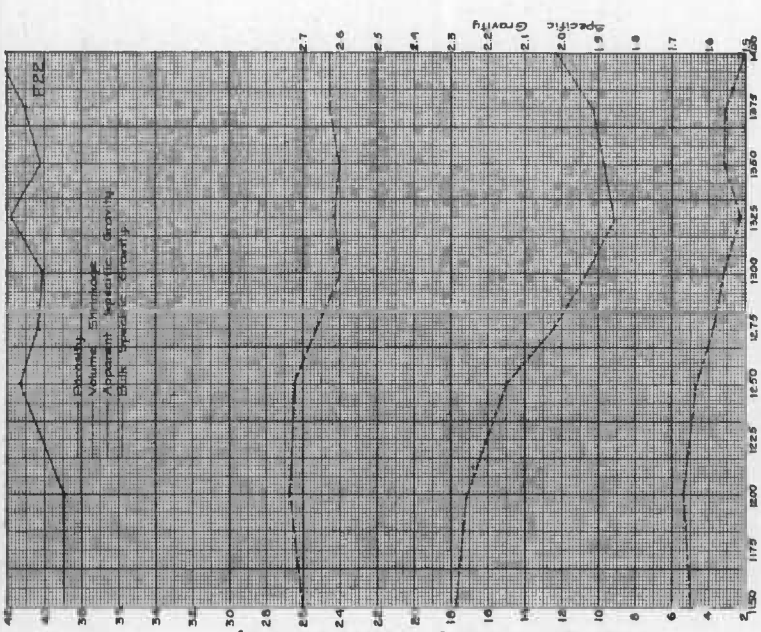

FIG. 89.—PROPERTIES OF F 22 WHEN FIRED TO DIFFERENT TEMPERATURES.

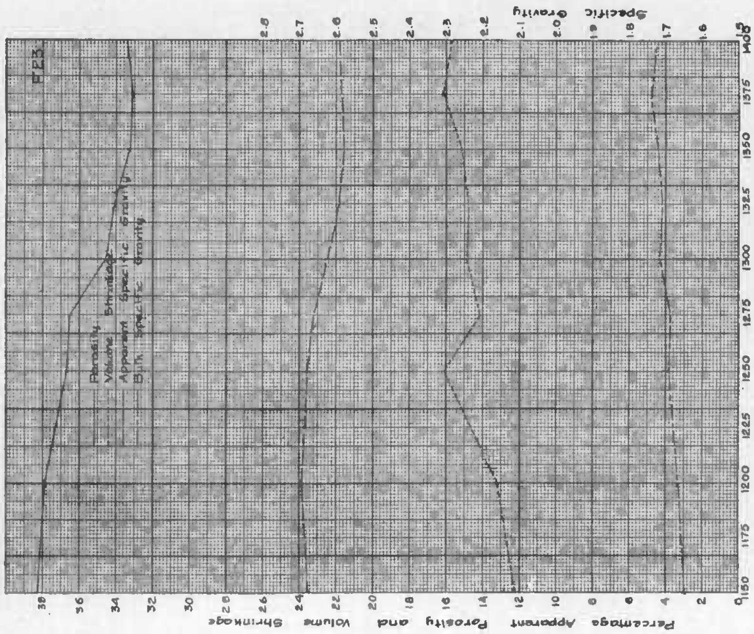

FIG. 90.—PROPERTIES OF F 23 WHEN FIRED TO DIFFERENT TEMPERATURES.

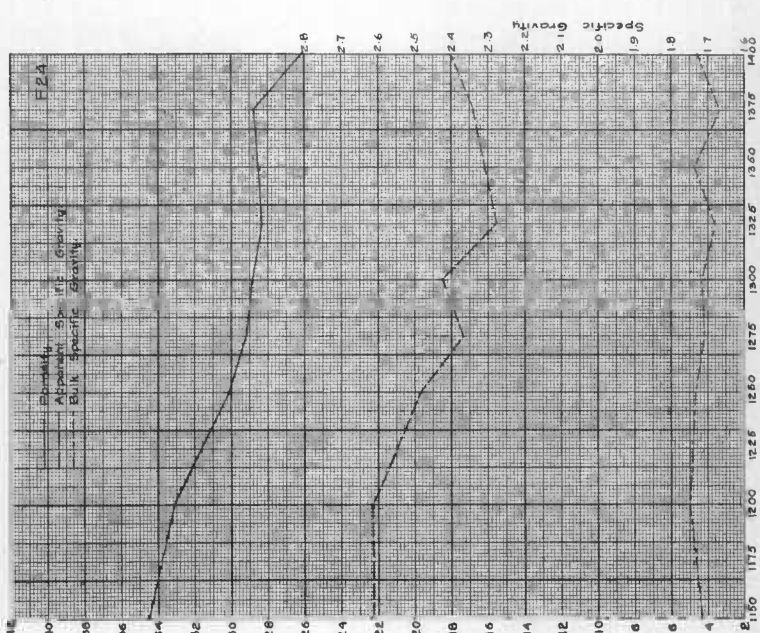

FIG. 91.—PROPERTIES OF F 24 WHEN FIRED TO DIFFERENT TEMPERATURES.

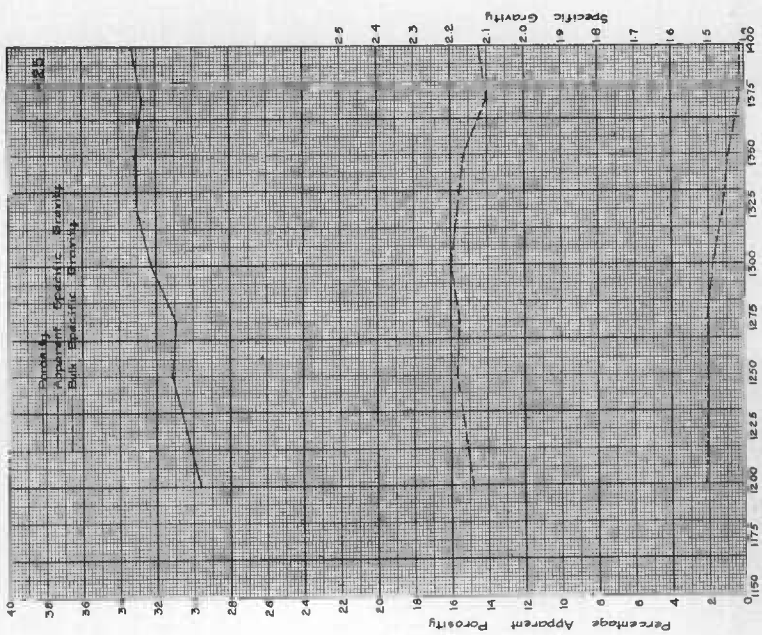

FIG. 92.—PROPERTIES OF F 25 WHEN FIRED TO DIFFERENT TEMPERATURES.

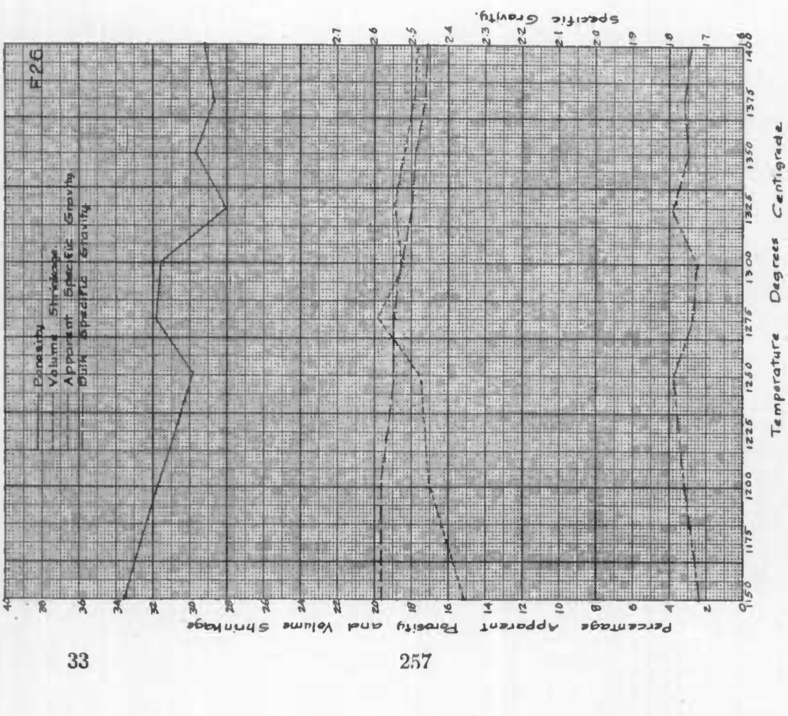

FIG. 93.—PROPERTIES OF F 26 WHEN FIRED TO DIFFERENT TEMPERATURES.

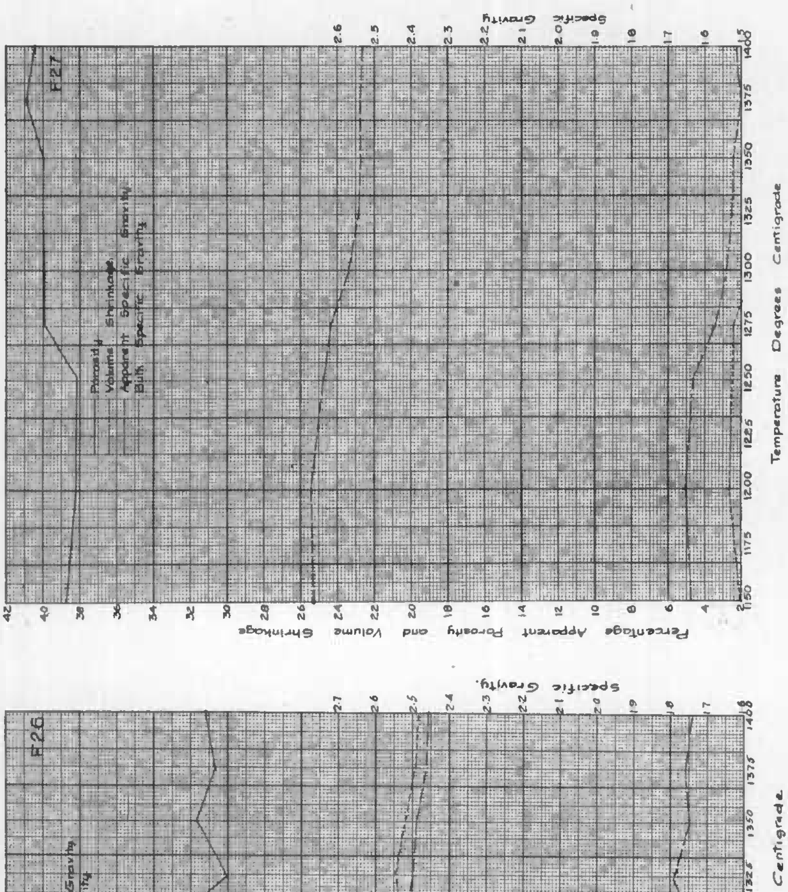

FIG. 94.—PROPERTIES OF F 27 WHEN FIRED TO DIFFERENT TEMPERATURES.

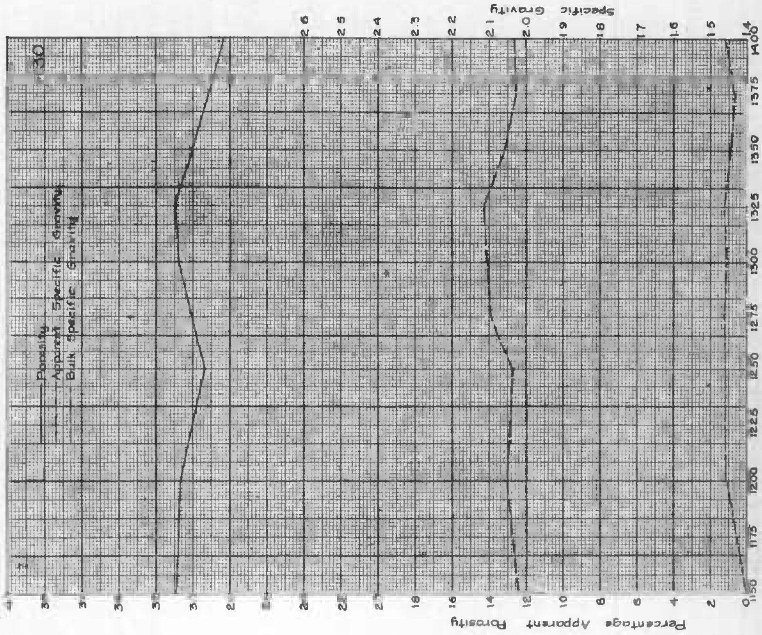

FIG. 96.—PROPERTIES OF F 30 WHEN FIRED TO DIFFERENT TEMPERATURES.

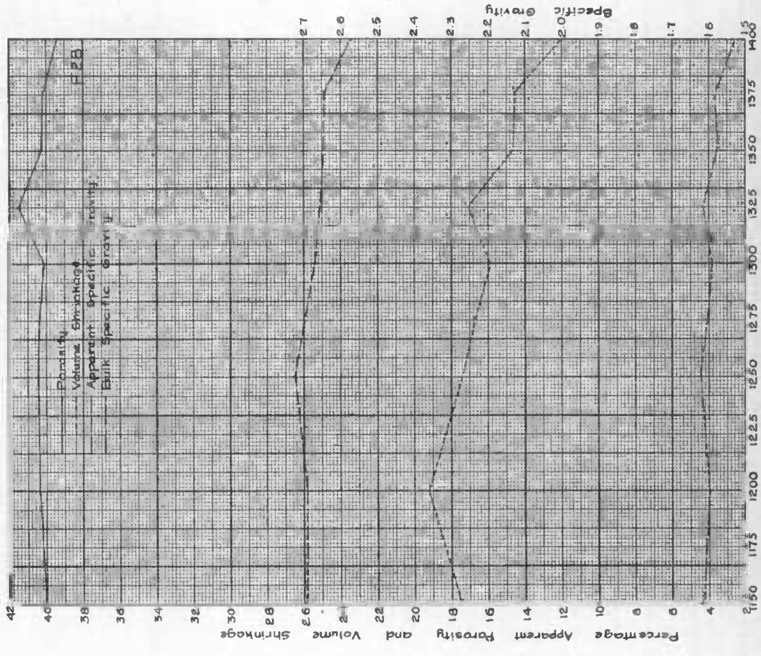

FIG. 95.—PROPERTIES OF F 28 WHEN FIRED TO DIFFERENT TEMPERATURES.

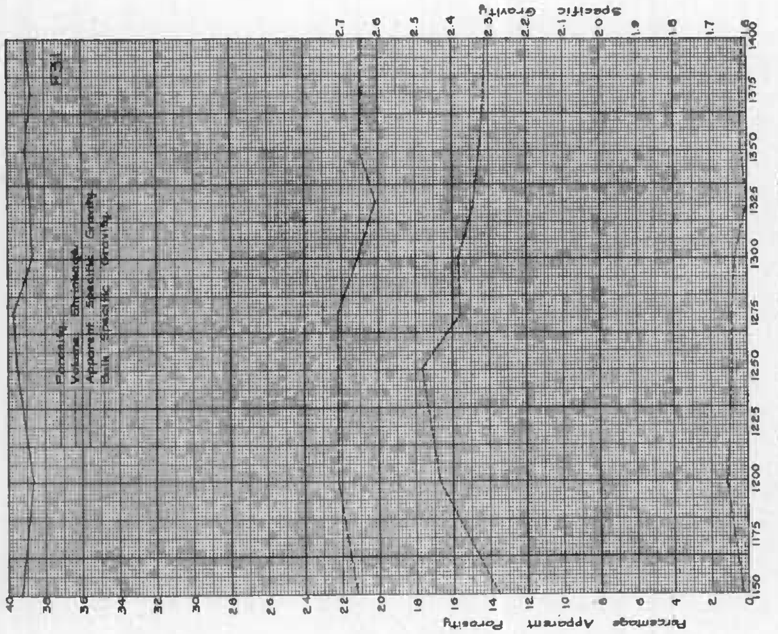

FIG. 97.—PROPERTIES OF F 31 WHEN FIRED TO DIFFERENT TEMPERATURES.

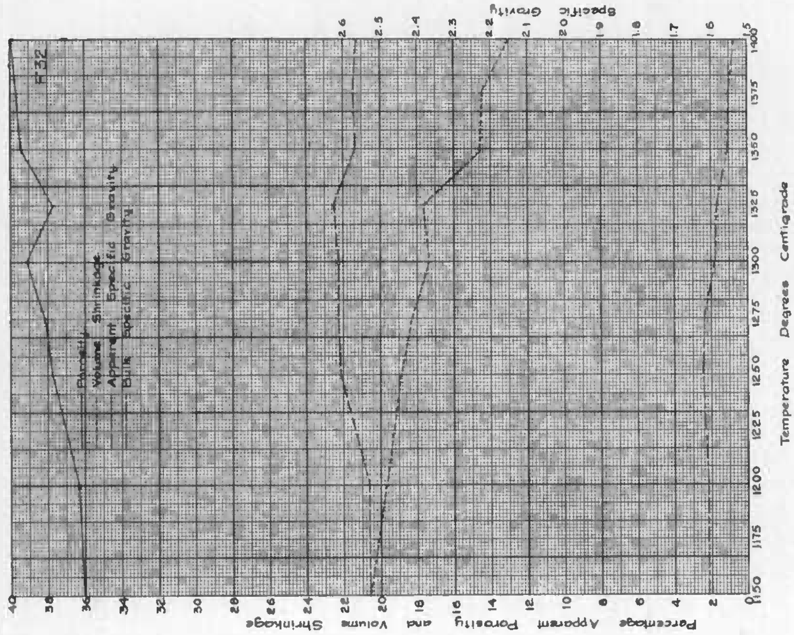

FIG. 98.—PROPERTIES OF F 32 WHEN FIRED TO DIFFERENT TEMPERATURES.

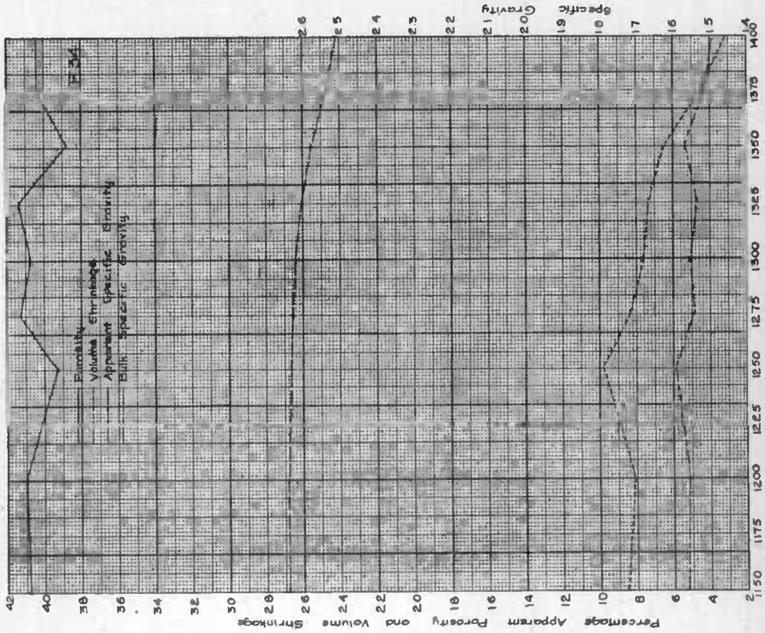

FIG. 100.—PROPERTIES OF F 34 WHEN FIRED TO DIFFERENT TEMPERATURES.

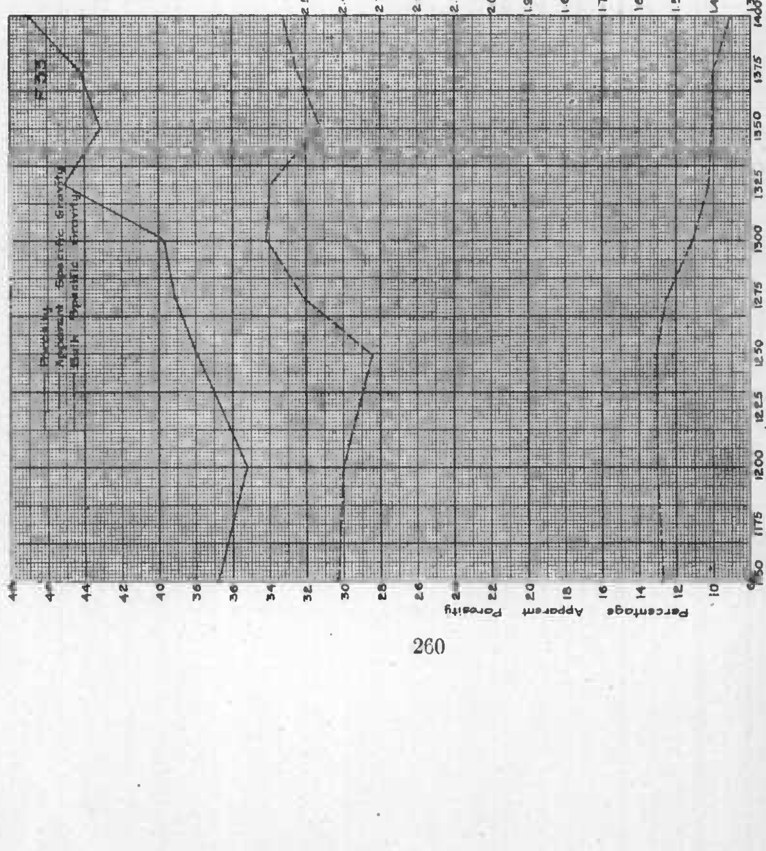

FIG. 99.—PROPERTIES OF F 33 WHEN FIRED TO DIFFERENT TEMPERATURES.

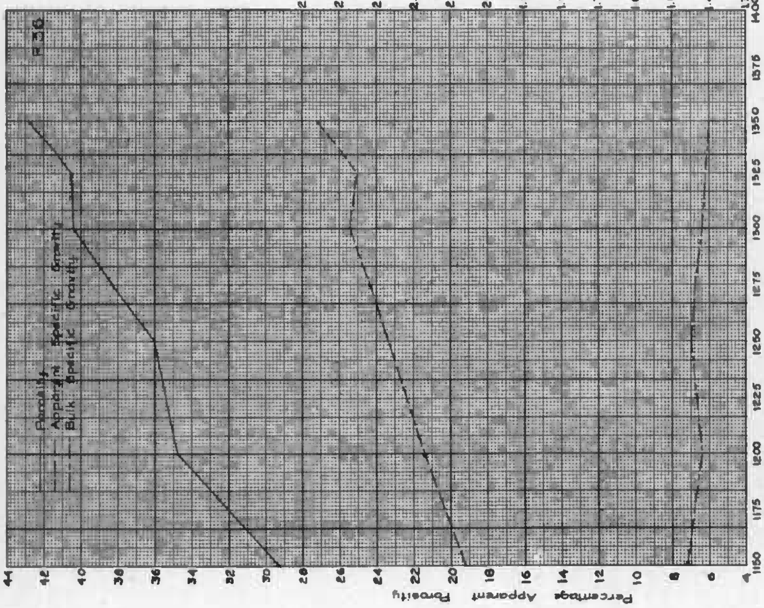

FIG. 101.—PROPERTIES OF F 36 WHEN FIRED TO DIFFERENT TEMPERATURES.

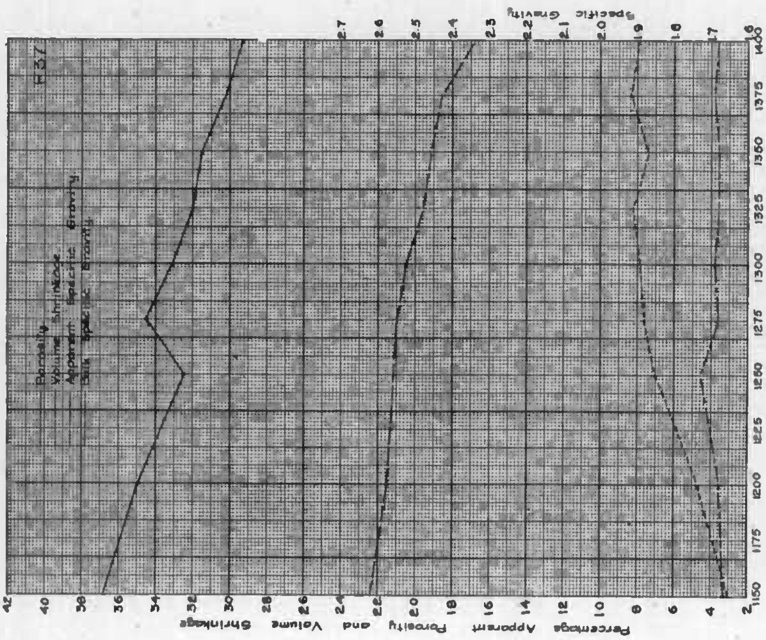

FIG. 102.—PROPERTIES OF F 37 WHEN FIRED TO DIFFERENT TEMPERATURES.

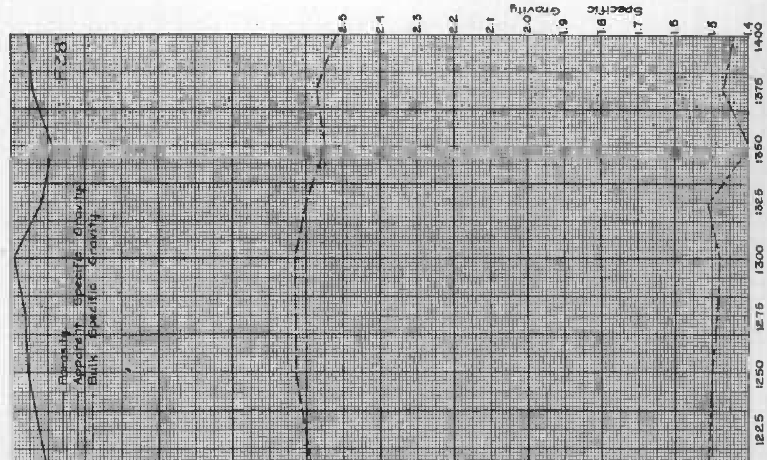

FIG. 103.—PROPERTIES OF F 38 WHEN FIRED TO DIFFERENT TEMPERATURES.

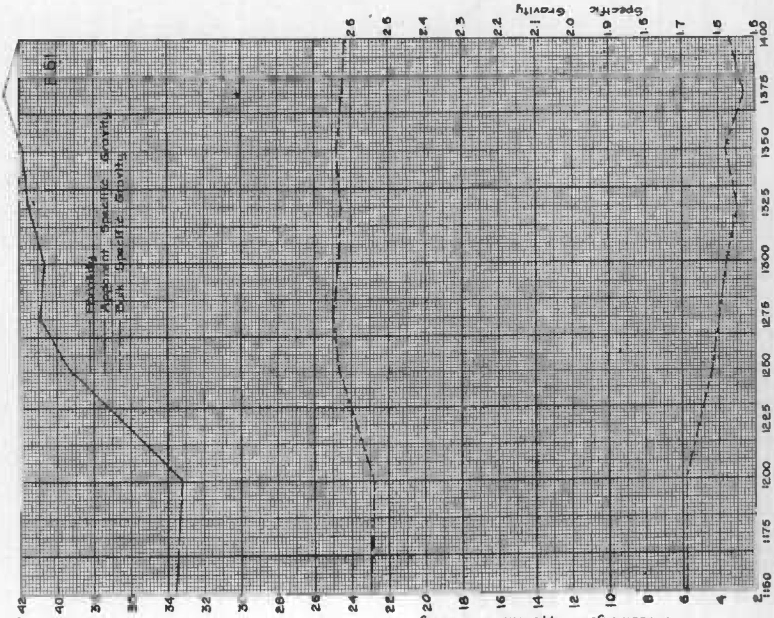

FIG. 104.—PROPERTIES OF F 51 WHEN FIRED TO DIFFERENT TEMPERATURES.

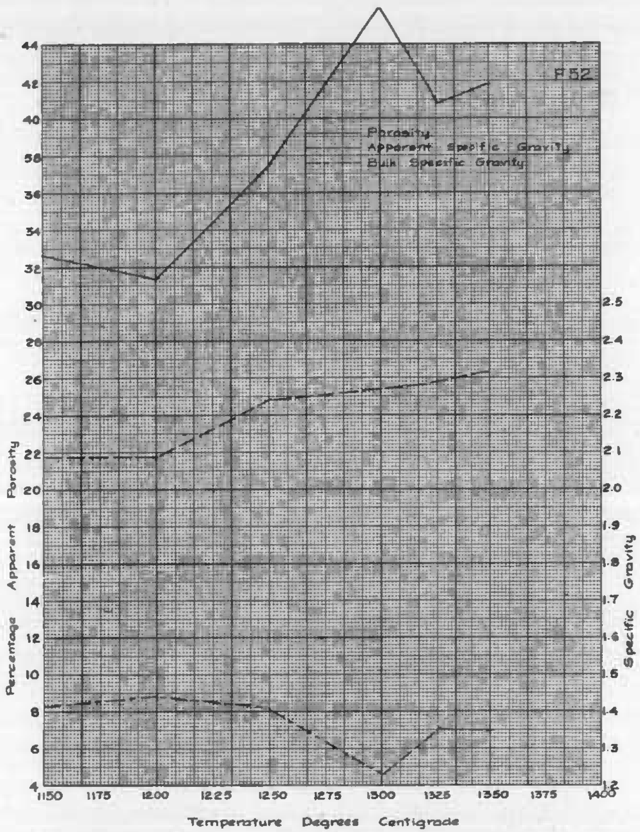

FIG. 105.—PROPERTIES OF F 52 WHEN FIRED TO DIFFERENT TEMPERATURES.

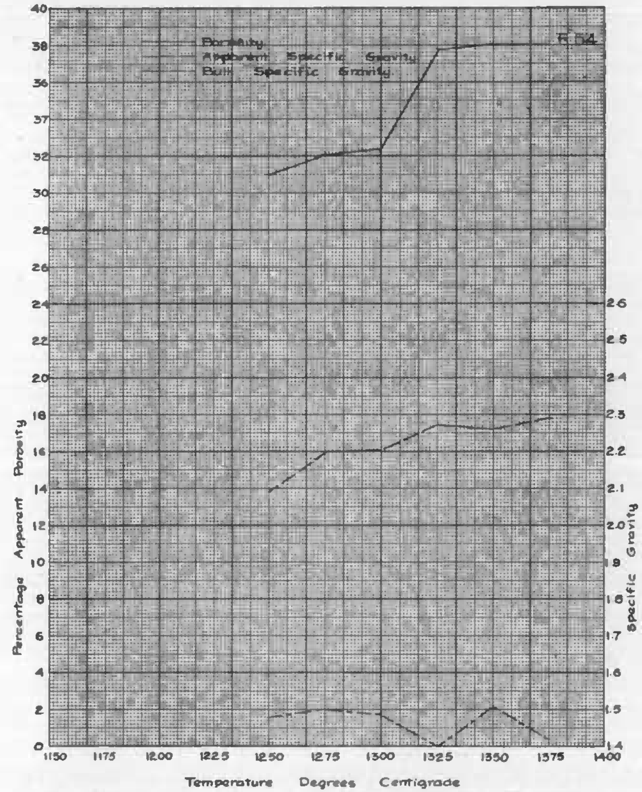

FIG. 106.—PROPERTIES OF F 54 WHEN FIRED TO DIFFERENT TEMPERATURES.

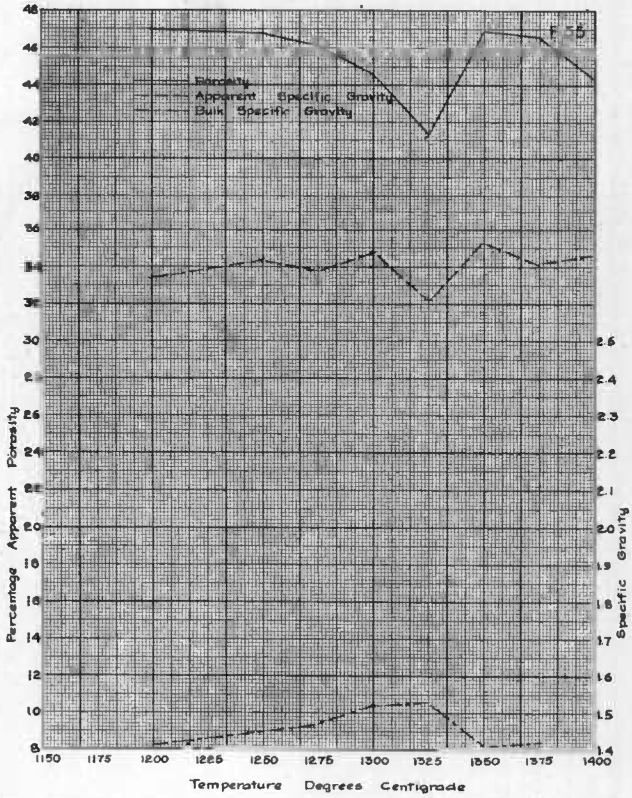

FIG. 107.—PROPERTIES OF F 55 WHEN FIRED TO DIFFERENT TEMPERATURES.

INDEX OF SAMPLES OF FLINT CLAYS TESTED

INDEX OF SAMPLES OF PLASTIC CLAYS TESTED

Sample Number	Locality	Age	Page
P54	Montell Tunnel	Clay above Lower Bakerstown coal	89, 181
P55	One and a quarter mile southeast of Grantsville	"	97, 181
P56	Big Shade Run, 1 mile northwest of Grantsville	Clay above Upper Bakerstown coal	99, 184
P57	Three miles southwest of Grantsville	Ellerslie or Lower Kittanning	98, 182, 237
P58	West of Ridgely Hill	Parting in Davis or Upper Freeport coal	98, 183, 237
P59	"	Clay below Davis or Upper Freeport coal (Bolivar clay of Pa.)	98, 184
P60	Frostburg Mine No. 6	Mt. Savage or Clarion?	85, 176, 238
P61	"	"	85, 176, 238
P62	"	"	85, 176
P63	"	"	84, 177, 239
P64	"	"	85, 177, 239
P65	Union Mine No. 6	"	81, 150, 240
P66	"	"	81, 150, 240
P67	One-half mile northeast of Piedmont Dam	Ellerslie or Lower Kittanning	95, 185, 241
P68	Westernport (Miller and Greene mine)	Clay below Montell coal	90, 186
P69	Clarysville	Clay above the Barton coal	88, 187
P70	Piedmont, W. Va.	Mt. Savage or Clarion?	92, 200, 241
P71	"	"	93, 202, 242
P72	East of Bond	Clay below Upper Freeport or Barrelville coal	94, 187
P73	"	Ellerslie or Lower Kittanning	95, 188, 242
P74	150 feet west of Luke bridge	Luke	94, 203, 243
P75	Opposite paper mill near Luke	"	94, 203
P76	Westernport, Md.	86 feet below Montell coal	93, 189, 243
P77	Corinth, W. Va.	Thornton	99, 204, 244
P78	"	"	99, 204
P79	Sines P. O.	Clay above Lower Kittanning coal	102, 190
P80	114 feet north of Swallow Falls	Ellerslie or Lower Kittanning	102, 190, 244
P81	Near Swallow Falls	Hardman	102, 191, 245
P83	Oak Shoals	Clay in split of Lower Bakerstown coal	101, 192
P84	Crellin	Clay below Davis or Upper Freeport coal (Bolivar of Pa.)	100, 193
P85	"	Probably Thornton	100, 193
P90	Maryland Coal Co.	Ellerslie or Lower Kittanning	86, 194, 245
P91	"	"	86, 195, 246
P101	Gleason Run, W. Va.	Clay below Davis or Upper Freeport coal	205
P102	North American Mine	Ellerslie?	96, 195, 246
P103	One-half mile east of Barrelville	Mt. Savage or Clarion?	88, 159

GENERAL INDEX

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No. on Map	Operator	Mine	Location	Location on Map	Seam: Name in this Report	Seam: Name in Earlier Reports
	GEORGES CREEK BASIN					
1	Allegany Coal Co.	Tacoma	¼ mi. N. of Westernport	D-11	Piedmont	Lower Kittanning
2	Chapman Coal Mining Co.	Swanton	Barton	C-10	Barton	Bakerstown
3	Chapman Coal Mining Co.	Swanton	Barton	C-10	Barton	Little Pittsburg
4	Consolidation Coal Co.	Consolidation No. 1	Ocean Station	C-7	Pittsburg	Pittsburg
5	Consolidation Coal Co.	Consolidation No. 3	Hoffman	D-5	Pittsburg	Pittsburg
6	Consolidation Coal Co.	Consolidation No. 7	½ mi. W. of Lord	C-7	Pittsburg	Pittsburg
7	Consolidation Coal Co.	Consolidation No. 12	Borden Shaft	C-6	Pittsburg	Pittsburg
8	Consolidation Coal Co.	Consolidation No. 9	1½ mi. N. E. of Frostburg	C-4	Lower Sewickley, (Tyson)	Tyson
9	Georges Creek Coal Co.	Test opening	¾ mi. N. E. of Lonaconing	D-8	Franklin	Franklin
10	Georges Creek Coal Co.	No. 3	½ mi. N. of Lonaconing	D-8	Lower Sewickley, (Tyson)	Tyson
11	Georges Creek-Parker Coal Co.	Bond	Barrelville	C-2	Upper Kittanning (Montell)	Bluebaugh
12	Georges Creek-Parker Coal Co.	Parker	Barrelville	C-2	Lower Freeport (Barrelville)	Parker
13	Hampshire Big Vein Coal Co.	Hampshire No. 2	Reynolds	D-11	Barton	Lower Freeport
14	Maryland Coal Co.	New opening	3 mi. N. W. of Lonaconing	B-7	Upper Bakerstown (Maynadier)	Upper Freeport
15	Maryland Coal Co.	Kingsley	Near Lonaconing, W. side of Koontz Run	C-8	Waynesburg	Waynesburg
22	McKee Coal Co.	Koontz	2 mi. N. W. of Lonaconing	C-8	Lower Sewickley, (Tyson)	Tyson
18	Miller & Greene Coal Co.	No. 1	Franklin	D-11	Upper Kittanning (Montell)	Clarion
19	Moscow-Georges Creek Mining Co.	Moscow No. 3	¾ mi. N. of Barton	C-9	Barton	Bakerstown
20	Mt. Savage-Georges Creek Coal Co.	Mt. Savage No. 1	½ mi. S. W. Barrelville	C-2	Upper Kittanning (Montell)	Bluebaugh
21	Henry Mullaney	Fuel Mine	¾ mi. E. of Mt. Savage	C-3	Lower Bakerstown (Thomas)	Lower Freeport
23	New York Mining Co.	Union No. 1	½ mi. N. E. of Allegany	B, C-4	Pittsburg	Pittsburg
24	New York Mining Co.	Tyson No. 3	1¼ mi. N. E. of Allegany	B, C-4	Lower Sewickley, (Tyson)	Tyson
16	North Maryland Coal Mining Co.	Montell Tunnel	Loarville (Mertins Station)	D-5	Upper Kittanning (Montell)	Bluebaugh
17	North Maryland Coal Mining Co.	Montell Tunnel	Loarville (Mertins Station)	D-5	Upper Freeport (Davis)	Lower Kittanning
25	Piedmont & Georges Creek Coal Co.	Washington No. 1	Near Gannon's Station	C-11	Upper Freeport (Davis)	Split-Six
26	Piedmont & Georges Creek Coal Co.	Washington No. 2	Near Eckhart	C-5	Lower Sewickley, (Tyson)	Tyson
27	Piedmont & Georges Creek Coal Co.	Washington No. 5	Opposite Gannon's Station	C-11	Barton	Bakerstown
28	Henry Pratt	Fuel Mine	1 mi. S. W. Barrelville	C-3	Harlem	Brush Creek
29	The Andrew Ramsay Co.	Ellerslie clay mines	2 mi. W. of Ellerslie	D-1	Upper Mt. Savage	Quakerstown
30	The Andrew Ramsay Co.	Ellerslie clay mines	2 mi. W. of Ellerslie	D-1	Lower Kittanning (Ellerslie)	Mercer
31	Stanton-Georges Creek Coal Co.	No. 1	1 mi. S. of Clarysville	D-3, 4	Upper Kittanning (Montell)	Bluebaugh
32	Union Mining Co.	No. 6 (fire clay mine)	2½ mi. N. W. Mt. Savage	B-3	Upper Mt. Savage	Mercer
33	West Virginia Pulp & Paper Co.	Devon	¼ mi. N. of Luke	D-12	Piedmont	Lower Kittanning
	UPPER POTOMAC BASIN					
35	Bloomington Coal Co.	No. 7	¾ mi. S. W. of Bloomington	C-12	Piedmont	Lower Kittanning
36	Chaffee Coal Co.	Chaffee	2 mi. N. W. of Chaffee	A, B-16, 17	Upper Freeport (Davis)	Lower Kittanning
37	Davis Coal & Coke Co.	Kempton, or No. 42	Kempton, ¾ mi. N. of Beechwood Station	Z-27	Upper Freeport (Davis)	Lower Kittanning
37a	Davis Coal & Coke Co.	Henry, or No. 22	Henry	Z, A-25, 27	Lower Bakerstown (Thomas)	Upper Freeport
38	Garrett County Coal & Mining Co.	No. 3 Dodson	1 mi. S. W. of Harrison, W. Va.	A,B,C-17, 18	Upper Freeport (Davis)	Lower Kittanning
39	Garrett County Coal & Mining Co.	No. 5 Dodson	1 mi. S. W. of Harrison, W. Va.	A,B,C-17, 18	Piedmont	Upper Kittanning
40	Hamill Coal & Coke Co.	No. 2	¾ mi. N. of Blaine	B, C-16	Upper Freeport (Davis)	Lower Kittanning
34	Hubbard Coal Mining Co.	No. 1	Opposite Hubbard	B-18, 19	Upper Freeport (Davis)	Lower Kittanning
42	McKanwig Coal Co.	Nethkin	⅛ mi. E. of Bayard Station	A, B-22, 23	Lower Bakerstown (Thomas)	Upper Freeport
43	Monroe Coal Mining Co.	Elk Run No. 1	Barnum	B-14	Upper Freeport (Davis)	Lower Kittanning
44	Monroe Coal Mining Co.	Elk Run No. 2	Barnum	B, C-13, 14	Barton	Bakerstown
45	Potomac Valley Coal Co.	Peerless No. 3	1 mi. N. of Blaine	B, C-15, 16	Lower Bakerstown (Thomas)	Upper Freeport
46	Strathmore Coal Mining Co.	Strathmore	1½ mi. N. E. of Gorman	A, B-21, 22	Lower Bakerstown (Thomas)	Upper Freeport
	UPPER YOUGHIOGHENY BASIN					
47	J. W. Beeghley	Fuel mine	2 mi. S. W. of Swallow Falls		Piedmont	Lower Kittanning
48	J. F. & A. S. Chisholm	Chisholm	4 mi. N. E. of Oakland		Loarville (Upper Kittanning)	Lower Kittanning
49	Lance Bros.	Guthrie	2 mi. S. W. of Crellin		Upper Freeport (Davis)	Lower Kittanning
50	O. R. Leighton	Fuel mine	6 mi. N. W. of Oakland		Piedmont	Lower Kittanning
51	L. G. Shaeffer	Fuel mine	1 mi. E. of Swallow Falls		Upper Kittanning (Montell)	Lower Kittanning
52	John Sines	Fuel mine	8 mi. N. of Oakland		Lower Kittanning (Ellerslie)	Mercer
53	Taylor Sines	Fuel mine	6½ mi. N. W. of Oakland		Upper Kittanning (Montell)	Upper Freeport
54	E. Z. Tower	Fuel mine	3½ mi. N. of Oakland		Piedmont	Lower Kittanning
55	Wills Coal Co.	Wills No. 3			Upper Freeport (Davis)	Lower Kittanning
					CASTLEMAN BASIN	
56	Aaron Beachey	Fuel mine			Upper Freeport (Davis)	Grantsville
					LOWER YOUGHIOGHENY	
57	David Fike	McCulloh			Lower Kittanning	Lower Kittanning

COAL—AIR-DRIED

No. on Map	Proximate: Moisture	Proximate: Volatile Matter	Proximate: Fixed Carbon	Proximate: Ash	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Ultimate: Sulphur	Ultimate: Ash	Fuel Value Determined: Calories	Fuel Value Determined: B. T. U.
1	.75	15.80	73.37	10.08	4.16	79.64	1.40	3.12	1.60	10.08	7689	13840
2	.60	16.65	71.60	11.15	4.13	78.37	1.58	2.79	1.98	11.15	7590	13662
3	.58	20.71	70.81	7.90	4.48	79.61	1.61	5.23	1.17	7.90	7920	14256
4	.80	19.10	71.15	8.95	4.72	79.17	1.91	4.24	1.01	8.95	7851	14132
5	.88	19.32	72.32	7.48	4.31	81.06	1.94	4.15	1.06	7.48	7950	14310
6	.78	20.82	71.22	7.18	4.62	82.34	1.96	2.93	.97	7.18	8022	14440
7	.85	19.14	72.56	7.45	4.57	82.10	1.98	2.87	1.03	7.45	7981	14366
8	1.10	18.55	72.02	8.33	4.40	80.65	1.66	3.94	1.02	8.33	7867	14161
9	.88	18.57	72.15	8.40	4.55	80.42	1.61	3.67	1.35	8.40	7788	14018
10	.95	20.28	73.57	5.20	4.58	83.99	1.73	3.44	1.06	5.20	8176	14717
11	.65	15.98	72.82	10.55	4.03	78.93	1.19	2.74	2.56	10.55	7625	13725
12	1.03	17.13	76.79	5.05	4.36	84.18	1.44	3.81	1.16	5.05	8144	14659
13	.70	15.68	72.97	10.65	4.09	78.93	1.45	2.75	2.13	10.65	7626	13727
14	.60	17.63	59.19	22.58	3.64	66.57	1.18	2.84	3.19	22.58	6499	11698
15	.52	20.15	65.65	13.68	4.28	75.21	1.60	2.66	2.57	13.68	7404	13327
22	.85	21.70	71.55	5.90	4.54	82.30	1.66	4.43	1.17	5.90	8106	14591
18	.68	20.05	65.24	14.03	4.08	74.62	1.19	2.44	3.64	14.03	7334	13201
19	.70	17.72	71.48	10.10	4.22	79.14	1.73	2.55	2.26	10.10	7702	13864
20	.75	15.45	70.55	13.25	4.04	74.66	1.30	5.92	.83	13.25	7439	13390
21	1.00	15.90	62.80	20.30	3.72	67.62	1.20	3.09	4.07	20.30	6637	11947
23	.85	22.29	68.91	7.95	4.59	80.54	1.84	3.68	1.40	7.95	7914	14245
24	.93	20.27	72.70	6.10	4.42	82.05	1.81	4.62	1.00	6.10	8057	14503
16	.80	16.70	66.62	15.88	4.03	73.88	1.25	3.52	1.44	15.88	7119	12814
17	.53	20.37	70.57	8.53	4.68	80.78	1.31	3.31	1.39	8.53	7915	14247
25	.58	15.72	71.35	12.35	3.96	77.25	1.24	2.66	2.54	12.35	7506	13511
26	.75	19.75	73.77	5.73	4.62	83.47	1.76	3.52	.90	5.73	8133	14639
27	.78	17.13	72.09	10.00	4.18	78.34	1.61	4.41	1.46	10.00	7745	13941
28	.68	16.43	73.34	9.55	4.38	80.55	1.63	2.64	1.25	9.55	7790	14022
29	.48	21.69	60.88	16.95	4.27	68.71	1.16	6.00	2.91	16.95	6968	12542
30	.53	21.37	60.07	18.03	4.14	68.11	1.09	4.76	3.87	18.03	6932	12478
31	.73	16.62	72.77	9.88	4.32	80.20	1.35	2.86	1.39	9.88	7722	13900
32	.58	19.22	64.15	16.05	4.18	74.07	1.05	3.34	1.31	16.05	7171	12908
33	.88	15.62	72.55	10.95	4.24	78.26	1.41	3.63	1.51	10.95	7643	13757
35	.83	15.02	72.17	11.98	4.01	77.93	1.30	2.68	2.10	11.98	7522	13540
36	.80	16.68	72.99	9.53	4.26	79.82	1.31	3.04	2.04	9.53	7739	13930
37	.78	21.52	72.20	5.50	4.64	82.23	1.37	4.44	.82	5.50	8189	14740
37a	.58	23.12	70.17	6.13	4.83	83.05	1.50	2.53	1.96	6.13	8128	14630
38	.83	15.71	74.01	9.45	4.32	80.63	1.29	2.49	1.82	9.45	7745	13941
39	.80	16.76	73.79	8.65	4.19	81.40	1.47	3.61	.68	8.65	7849	14128
40	.63	16.70	72.57	10.10	4.21	79.66	1.30	2.24	2.49	10.10	7729	13912
34	.78	17.97	67.62	13.63	4.22	76.56	1.26	2.01	2.32	13.63	7388	13298
42	.95	19.64	69.21	10.20	4.25	78.87	1.23	3.91	1.54	10.20	7652	13774
43	.63	18.69	70.65	10.03	4.22	79.20	1.08	3.84	1.63	10.03	7748	13946
44	.68	16.02	74.25	9.05	4.09	81.08	1.53	3.63	.62	9.05	7851	14132
45	.65	18.28	73.24	7.83	4.26	81.68	1.38	3.03	1.82	7.83	7973	14351
46	.72	16.98	65.60	16.70	3.87	73.21	1.21	3.60	1.41	16.70	7090	12762
47	1.20	26.45	61.55	10.80	4.49	75.71	1.50	5.02	2.48	10.80	7500	13500
48	1.30	20.83	69.97	7.90	4.58	80.33	1.35	4.37	1.47	7.90	7825	14085
49	.68	23.46	64.91	10.95	4.63	77.28	1.44	3.60	2.10	10.95	7601	13682
50	.58	25.87	58.50	15.05	4.55	72.00	1.32	2.20	4.88	15.05	7230	13014
51	.93	28.38	58.94	11.75	4.70	75.23	1.26	3.25	3.81	11.75	7446	13403
52	.90	25.28	53.87	19.95	4.03	65.41	1.31	4.72	4.58	19.95	6642	11956
53	1.15	26.40	63.92	8.53	4.59	78.07	1.42	3.51	3.88	8.53	7794	14029
54	1.10	22.05	66.57	10.28	4.47	77.74	1.47	3.50	2.54	10.28	7619	13714
55	1.00	24.51	65.04	9.45	4.72	78.09	1.37	3.26	3.11	9.45	7710	13878
56	.93	22.42	68.50	8.15	4.45	80.26	1.47	4.46	1.21	8.15	7844	14119
57	.90	23.56	63.81	11.73	4.57	75.26	1.34	3.03	4.07	11.73	7503	13505

COAL—AS RECEIVED

No. on Map	Proximate: Moisture	Proximate: Volatile Matter	Proximate: Fixed Carbon	Proximate: Ash	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Ultimate: Sulphur	Ultimate: Ash	Fuel Value Determined: Calories	Fuel Value Determined: B. T. U.	Fuel Value Calculated: Calories	Fuel Value Calculated: B. T. U.
1	1.94	15.61	72.49	9.96	4.24	78.68	1.38	4.16	1.58	9.96	7597	13675	7675	13815
2	2.90	16.27	69.94	10.89	4.29	76.56	1.54	4.79	1.93	10.89	7415	13347	7501	13502
3	2.34	20.34	69.56	7.76	4.60	78.20	1.58	6.71	1.15	7.76	7780	14004	7640	13752
4	2.92	18.69	69.63	8.76	4.86	77.48	1.87	6.04	.99	8.76	7683	13829	7696	13853
5	2.43	19.02	71.19	7.36	4.41	79.80	1.91	5.48	1.04	7.36	7826	14087	7757	13963
6	2.21	20.52	70.19	7.08	4.71	81.14	1.93	4.18	.96	7.08	7906	14231	8022	14440
7	2.17	18.89	71.59	7.35	4.66	81.01	1.95	4.01	1.02	7.35	7875	14175	8002	14404
8	3.15	18.17	70.52	8.16	4.54	78.98	1.63	5.69	1.00	8.16	7704	13867	7724	13903
9	3.75	18.03	70.06	8.16	4.74	78.09	1.56	6.14	1.31	8.16	7562	13612	7707	13873
10	2.56	19.95	72.37	5.12	4.69	82.62	1.70	4.83	1.04	5.12	8043	14477	8109	14596
11	3.06	15.59	71.06	10.29	4.20	77.01	1.16	4.84	2.50	10.29	7440	13392	7519	13534
12	3.75	16.66	74.68	4.91	4.55	81.87	1.40	6.14	1.13	4.91	7920	14256	7943	14297
13	1.27	15.59	72.55	10.59	4.13	78.48	1.44	3.24	2.12	10.59	7583	13649	7674	13813
14	1.40	17.49	58.71	22.40	3.70	66.04	1.17	3.53	3.16	22.40	6447	11605	6531	11756
15	3.13	19.62	63.93	13.32	4.46	73.24	1.56	4.92	2.50	13.32	7210	12978	7297	13135
22	3.30	21.16	69.79	5.75	4.70	80.27	1.62	6.52	1.14	5.75	7906	14231	7849	14128
18	1.87	19.81	64.46	13.86	4.16	73.72	1.18	3.48	3.60	13.86	7246	13043	7319	13174
19	2.30	17.43	70.33	9.94	4.33	77.86	1.70	3.95	2.22	9.94	7578	13640	7664	13795
20	2.34	15.20	69.42	13.04	4.16	73.47	1.28	7.23	.82	13.04	7320	13176	7078	12740
21	3.15	15.55	61.44	19.86	3.88	66.15	1.17	4.96	3.98	19.86	6493	11687	6558	11804
23	2.34	21.96	67.87	7.83	4.69	79.33	1.81	4.96	1.38	7.83	7795	14031	7843	14117
24	2.74	19.90	71.37	5.99	4.54	80.55	1.78	6.16	.98	5.99	7910	14238	7830	14094
16	3.18	16.30	65.02	15.50	4.20	72.11	1.22	5.56	1.41	15.50	6948	12506	7064	12715
17	2.88	19.89	68.90	8.33	4.83	78.87	1.28	5.33	1.36	8.33	7728	13910	7837	14107
25	2.90	15.35	69.68	12.07	4.13	75.45	1.21	4.66	2.48	12.07	7331	13196	7375	13275
26	2.22	19.46	72.67	5.65	4.71	82.23	1.73	4.79	.89	5.65	8013	14423	8081	14546
27	2.77	16.79	70.64	9.80	4.32	76.77	1.58	6.10	1.43	9.80	7589	13660	7462	13432
28	3.77	15.92	71.06	9.25	4.59	78.04	1.58	5.33	1.21	9.25	7548	13586	7684	13831
29	3.05	21.13	59.31	16.51	4.45	66.94	1.13	8.14	2.83	16.51	6788	12218	6654	11977
30	2.91	20.86	58.63	17.60	4.31	66.48	1.06	6.77	3.78	17.60	6766	12179	6649	11968
31	3.30	16.19	70.89	9.62	4.50	78.12	1.32	5.09	1.35	9.62	7522	13540	7673	13811
32	2.76	18.80	62.74	15.70	4.33	72.45	1.03	5.21	1.28	15.70	7014	12625	7151	12872
33	2.36	15.39	71.46	10.79	4.35	77.09	1.39	4.89	1.49	10.79	7529	13552	7551	13592
35	3.12	14.67	70.51	11.70	4.18	76.13	1.27	4.67	2.05	11.70	7348	13226	7438	13388
36	2.39	16.41	71.82	9.38	4.37	78.54	1.29	4.41	2.01	9.38	7615	13707	7708	13874
37	4.09	20.80	69.79	5.32	4.86	80.45	1.32	7.26	.79	5.32	7915	14247	7879	14182
37a	4.18	22.28	67.63	5.91	5.06	80.04	1.45	5.65	1.89	5.91	7834	14101	8009	14416
38	2.53	15.44	72.74	9.29	4.44	79.25	1.27	3.96	1.79	9.29	7613	13703	7801	14042
39	3.57	16.29	71.73	8.41	4.38	79.13	1.43	5.99	.66	8.41	7630	13734	7659	13786
40	1.83	16.50	71.69	9.98	4.29	78.70	1.28	3.29	2.46	9.98	7635	13743	7751	13952
34	3.80	17.42	65.56	13.22	4.43	74.23	1.22	4.65	2.25	13.22	7163	12893	7375	13275
42	3.18	19.20	67.65	9.97	4.40	77.10	1.20	5.82	1.51	9.97	7480	13464	7528	13550
43	1.71	18.49	69.88	9.92	4.29	78.34	1.07	4.77	1.61	9.92	7664	13795	7638	13748
44	2.26	15.77	73.06	8.91	4.20	79.79	1.51	4.98	.61	8.91	7726	13907	7694	13849
45	1.76	18.08	72.42	7.74	4.33	80.77	1.36	4.00	1.80	7.74	7884	14191	7887	14197
46	2.62	16.66	64.34	16.38	4.01	71.81	1.19	5.23	1.38	16.38	6955	12519	6991	12584
47	3.92	25.72	59.86	10.50	4.68	73.63	1.46	7.32	2.41	10.50	7294	13129	7299	13138
48	4.47	20.16	67.72	7.65	4.79	77.75	1.31	7.08	1.42	7.65	7574	13633	7662	13792
49	2.66	22.99	63.62	10.73	4.76	75.74	1.41	5.30	2.06	10.73	7450	13410	7579	13642
50	2.23	25.44	57.53	14.80	4.65	70.81	1.30	3.64	4.80	14.80	7110	12798	7273	13091
51	3.03	27.78	57.69	11.50	4.84	73.64	1.23	5.06	3.73	11.50	7288	13118	7485	13473
52	2.77	24.80	52.86	19.57	4.16	64.17	1.29	6.32	4.49	19.57	6516	11729	6447	11605
53	3.48	25.78	62.41	8.33	4.74	76.23	1.39	5.52	3.79	8.33	7610	13698	7640	13752
54	4.32	21.33	64.41	9.94	4.68	75.21	1.42	6.29	2.46	9.94	7371	13268	7473	13451
55	3.36	23.93	63.48	9.23	4.87	76.23	1.34	5.29	3.04	9.23	7527	13549	7679	13822
56	3.30	21.88	66.86	7.96	4.61	78.34	1.43	6.48	1.18	7.96	7657	13783	7666	13799
57	3.63	22.91	62.05	11.41	4.75	73.19	1.30	5.39	3.96	11.41	7297	13135	7409	13336

COAL—MOISTURE-FREE

No. on Map	Proximate: Volatile Matter	Proximate: Fixed Carbon	Proximate: Ash	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Ultimate: Sulphur	Ultimate: Ash	Fuel Value Determined: Calories	Fuel Value Determined: B. T. U.
1	15.92	73.92	10.16	4.10	80.24	1.41	2.48	1.61	10.16	7747	13945
2	16.76	72.02	11.22	4.09	78.85	1.59	2.26	1.99	11.22	7637	13447
3	20.83	71.22	7.95	4.44	80.08	1.62	4.73	1.18	7.95	7967	14341
4	19.25	71.73	9.02	4.68	79.81	1.93	3.54	1.02	9.02	7914	14245
5	19.49	72.97	7.54	4.24	81.79	1.96	3.40	1.07	7.54	8021	14438
6	20.98	71.78	7.24	4.57	82.97	1.97	2.27	.98	7.24	8085	14553
7	19.31	73.18	7.51	4.52	82.80	1.99	2.14	1.04	7.51	8049	14488
8	18.76	72.81	8.43	4.33	81.55	1.68	2.98	1.03	8.43	7954	14317
9	18.73	72.79	8.48	4.49	81.14	1.62	2.91	1.36	8.48	7857	14143
10	20.47	74.28	5.25	4.53	84.79	1.74	2.62	1.07	5.25	8255	14859
11	16.08	73.30	10.62	3.98	79.44	1.20	2.18	2.58	10.62	7675	13815
12	17.31	77.59	5.10	4.29	85.06	1.45	2.93	1.17	5.10	8229	14812
13	15.79	73.48	10.73	4.04	79.49	1.46	2.13	2.15	10.73	7681	13826
14	17.74	59.54	22.72	3.59	66.98	1.19	2.32	3.20	22.72	6539	11770
15	20.25	66.00	13.75	4.24	75.61	1.61	2.21	2.58	13.75	7443	13397
22	21.88	72.17	5.95	4.48	83.01	1.68	3.70	1.18	5.95	8176	14717
18	20.19	65.69	14.12	4.03	75.13	1.20	1.85	3.67	14.12	7384	13291
19	17.84	71.99	10.17	4.17	79.69	1.74	1.96	2.27	10.17	7756	13961
20	15.56	71.09	13.35	3.99	75.23	1.31	5.28	.84	13.35	7496	13493
21	16.06	63.43	20.51	364	68.30	1.21	2.23	4.11	20.51	6704	12067
23	22.49	69.49	8.02	4.54	81.23	1.85	2.95	1.41	8.02	7982	14368
24	20.46	73.38	6.16	4.36	82.82	1.83	3.82	1.01	6.16	8133	14639
16	16.83	67.16	16.01	3.98	74.48	1.26	2.81	1.46	16.01	7176	12917
17	20.48	70.94	8.58	4.64	81.21	1.32	2.85	1.40	8.58	7958	14324
25	15.81	71.76	12.43	3.92	77.71	1.25	2.14	2.55	12.43	7550	13590
26	19.90	74.32	5.78	4.56	84.10	1.77	2.88	.91	5.78	8195	14751
27	17.27	72.65	10.08	4.12	78.96	1.63	3.74	1.47	10.08	7805	14049
28	16.54	73.85	9.61	4.33	81.10	1.64	2.06	1.26	9.61	7844	14119
29	21.80	61.17	17.03	4.24	69.05	1.17	5.59	2.92	17.03	7002	12604
30	21.49	60.38	18.13	4.11	68.47	1.09	4.31	3.89	18.13	6969	12544
31	16.74	73.31	9.95	4.27	80.78	1.37	2.23	1.40	9.95	7779	14002
32	19.33	64.52	16.15	4.13	74.51	1.06	2.83	1.32	16.15	7213	12983
33	15.76	73.19	11.05	4.19	78.96	1.42	2.85	1.53	11.05	7711	-3880
35	15.14	72.78	12.08	3.95	78.58	1.31	1.96	2.12	12.08	7585	13653
36	16.81	73.58	9.61	4.20	80.46	1.32	2.35	2.06	9.61	7802	14044
37	21.69	72.76	5.55	4.60	83.88	1.38	3.77	.82	5.55	8252	14854
37a	23.25	70.58	6.17	4.80	83.53	1.51	2.02	1.97	6.17	8176	14717
38	15.84	74.63	9.53	4.27	81.31	1.30	1.75	1.84	9.53	7811	14060
39	16.89	74.39	8.72	4.13	82.06	1.48	2.93	.68	8.72	7912	14242
40	16.81	73.02	10.17	4.17	80.16	1.30	1.69	2.51	10.17	7777	13999
34	18.11	68.15	13.74	4.17	77.16	1.27	1.32	2.34	13.74	7446	13403
42	19.83	69.87	10.30	4.18	79.63	1.24	3.09	1.56	10.30	7725	13905
43	18.81	71.10	10.09	4.17	79.70	1.09	3.31	1.64	10.09	7797	14035
44	16.13	74.75	9.12	4.04	81.63	1.54	3.05	.62	9.12	7904	14227
45	18.40	73.72	7.88	4.20	82.22	1.38	2.49	1.83	7.88	8025	14445
46	17.11	66.07	16.82	3.82	73.74	1.22	2.98	1.42	16.82	7142	12856
47	26.77	62.30	10.93	4.41	76.63	1.52	4.00	2.51	10.93	7592	13666
48	21.10	70.89	8.01	4.49	81.39	1.37	3.25	1.49	8.01	7928	14270
49	23.62	65.36	11.02	4.58	77.81	1.45	3.02	2.12	11.02	7653	13775
50	26.02	58.84	15.14	4.50	72.42	1.33	1.70	4.91	15.14	7272	13090
51	28.65	59.49	11.86	4.64	75.94	1.27	2.44	3.85	11.86	7515	13527
52	25.51	54.36	20.13	3.96	66.00	1.33	3.96	4.62	20.13	6702	12064
53	26.71	64.66	8.63	4.51	78.98	1.44	2.51	3.93	8.63	7885	14193
54	22.29	67.32	10.39	4.39	78.61	1.48	2.56	2.57	10.39	7704	13867
55	24.76	65.69	9.55	4.66	78.88	1.39	2.37	3.15	9.55	7789	14020
56	22.63	69.14	8.23	4.38	81.01	1.48	3.68	1.22	8.23	7918	14252
57	23.77	64.39	11.84	4.51	75.95	1.35	2.24	4.11	11.84	7572	13630

COAL—MOISTURE AND ASH-FREE

No. on Map	Proximate: Volatile Matter	Proximate: Fixed Carbon	Ultimate: Hydrogen	Ultimate: Carbon	Ultimate: Nitrogen	Ultimate: Oxygen	Ultimate: Sulphur	Fuel Value Determined: Calories	Fuel Value Determined: B. T. U.	Remarks
1	17.72	82.28	4.56	89.32	1.57	2.76	1.79	8623	15521	Room No. 8 off first right heading.
2	18.88	81.12	4.61	88.82	1.79	2.54	2.24	8604	15484	Right rib at face of sixth right heading. 1700 ft. from entry.
3	22.63	77.37	4.82	87.00	1.76	5.14	1.28	8655	15579	Second right butt off main entry, about 150 ft. in.
4	21.16	78.84	5.14	87.72	2.12	3.90	1.12	8698	15656	Spitzman's heading.
5	21.08	78.92	4.59	88.46	2.12	3.67	1.16	8675	15615	North side main heading.
6	22.62	77.38	4.93	89.44	2.12	2.45	1.06	8716	15689	Upper section of the Midway.
7	20.88	79.12	4.89	89.52	2.15	2.32	1.12	8703	15665	Room broken off on left of empty slant. Also called Klondike heading.
8	20.49	79.51	4.73	89.06	1.83	3.26	1.12	8687	15637	Manway, first room off second right heading.
9	20.47	79.53	4.91	88.66	1.77	3.17	1.49	8585	15453	About 100 ft. S. 55° E. from opening.
10	21.60	78.40	4.78	89.49	1.84	2.76	1.13	8712	15682	Broadback's room off third right heading. Vertical depth from surface to point of sampling about 340-350 ft.
11	17.99	82.01	4.45	88.88	1.34	2.44	2.89	8587	15457	Rib of straight heading, 180 ft. northeast of first.
12	18.24	81.76	4.52	89.63	1.53	3.09	1.23	8671	15608	Second room on right at top of Dip heading.
13	17.69	82.31	4.53	89.04	1.64	2.38	2.41	8604	15487	Main heading right.
14	22.96	77.04	4.65	86.67	1.54	3.00	4.14	8461	15230	Face of main heading, 350 ft. inside from opening.
15	23.48	76.52	4.92	87.66	1.87	2.56	2.99	8629	15532	Rib right main heading at face—600 ft. from entry.
22	23.27	76.73	4.76	88.26	1.79	3.94	1.25	8694	15649	Face of main heading over 1¼ miles in.
18	23.51	76.49	4.69	87.48	1.40	2.16	4.27	8598	15476	Butt off main heading.
19	19.86	80.14	4.64	88.71	1.94	2.18	2.53	8634	15541	Room No. 4 off second left heading.
20	17.96	82.04	4.60	86.82	1.51	6.10	.97	8651	15572	Face of main heading—2100 ft. in.
21	20.20	79.80	4.58	85.92	1.52	2.81	5.17	8434	15181	Face of main heading—120 ft. in.
23	24.45	75.55	4.94	88.31	2.01	3.21	1.53	8678	15620	Fifth room off fourth left heading—vertical depth from surface to point of sampling, 185 ft.
24	21.80	78.20	4.65	88.25	1.95	4.07	1.08	8667	15601	Room No. 3—second right heading.
16	20.04	79.96	4.74	88.68	1.50	3.34	1.74	8544	15379	First left heading in south side.
17	22.40	77.60	5.08	88.84	1.44	3.11	1.53	8705	15669	Frederick heading—4600 ft. southeast from mouth of tunnel.
25	18.05	81.95	4.48	88.74	1.43	2.44	2.91	8621	15518	Fourth right air course—2200 ft. west of entry.
26	21.12	78.88	4.84	89.26	1.88	3.05	.97	8697	15655	Room No. 6 off fourth left heading.
27	19.21	80.79	4.58	87.81	1.81	4.17	1.63	8680	15624	Second south heading.
28	18.30	81.70	4.79	89.72	1.81	2.29	1.39	8678	15620	Face of main heading 80 ft. in.
29	26.28	73.72	5.11	83.23	1.40	6.74	3.52	8440	15192	Right rib of second right heading, 20 ft. from main heading—1200 ft. from entry.
30	26.25	73.75	5.02	83.63	1.33	5.27	4.75	8512	15322	First right butt off first right heading—1000 ft. from entry.
31	18.59	81.41	4.74	89.71	1.52	2.48	1.55	8639	15550	Room No. 3 off fourth right heading.
32	23.05	76.95	4.93	88.86	1.26	3.38	1.57	8602	15484	Butt opening off main heading, about 600 ft. from entry.
33	17.72	82.28	4.71	88.77	1.60	3.20	1.72	8669	15604	Main heading—3000 ft. in.
35	17.22	82.78	4.49	89.38	1.49	2.23	2.41	8627	15539	Room No. 6 third left heading.
36	18.60	81.40	4.65	89.01	1.46	2.60	2.28	8631	15536	Face of main heading over a mile from opening.
37	22.97	77.03	4.87	88.81	1.46	3.99	.87	8737	15727	Face of main heading—3500 ft. from shaft bottom.
37a	24.78	75.22	5.12	89.03	1.61	2.14	2.10	8714	15685	Third left butt heading off the Webster heading, about 4800 ft. from shaft bottom in Garrett County.
38	17.51	82.49	4.72	89.87	1.44	1.94	2.03	8633	15539	Fourth butt off the first left heading.
39	18.50	81.50	4.52	89.90	1.62	3.22	.74	8668	15602	Room No. 2 off the first right heading.
40	18.71	81.29	4.64	89.23	1.45	1.89	2.79	8657	15583	Air course off second right heading at boundary line—1600 ft. northwest of opening.
34	20.99	79.01	4.83	89.45	1.47	1.54	2.71	8632	15538	Third room off first right heading.
42	22.11	77.89	4.66	88.77	1.38	3.45	1.74	8612	15502	Face of second left heading.
43	20.92	29.08	4.64	88.64	1.21	3.69	1.82	8672	15610	Right rib of sixth left heading, (50 ft. from main heading) 1500 ft. west of entry.
44	17.75	82.25	4.45	89.83	1.69	3.35	.68	8698	15656	Face of seventh right heading—1200 ft. northwest from entry.
45	19.97	80.03	4.56	89.25	1.50	2.70	1.99	8711	15680	Room No. 1 off fifth left heading—1000 ft. from entry.
46	20.57	79.43	4.59	88.65	1.47	3.58	1.71	8586	15455	Room No. 7 second right heading.
47	30.05	69.95	4.95	86.03	1.71	4.49	2.82	8524	15343	Second room first left heading.
48	22.94	77.06	4.88	88.48	1.49	3.53	1.62	8619	15514	Room No. 1 off first left heading.
49	26.54	73.46	5.15	87.44	1.63	3.40	2.38	8600	15480	Face of eighteenth left room off main heading—850 ft. northwest from opening.
50	30.66	69.34	5.30	85.34	1.57	2.00	5.79	8569	15424	Face of heading in new opening—60 ft. in from entry.
51	32.51	67.49	5.26	86.16	1.44	2.77	4.37	8527	15349	Second room off third right heading.
52	31.94	68.06	4.96	82.63	1.67	4.96	5.78	8391	15104	Main heading—70 ft. in.
53	29.23	70.77	4.94	86.44	1.58	2.74	4.30	8630	15534	Left rib of main heading west of first left heading.
54	24.87	75.13	4.90	87.72	1.65	2.86	2.87	8597	15475	Face of main heading.
55	27.37	72.63	5.15	87.21	1.54	2.62	3.48	8612	15502	No. 1 room in first right heading.
56	24.66	75.34	4.77	88.28	1.61	4.01	1.33	8628	15530	Sixth room off second right heading.
57	26.96	73.04	5.12	86.15	1.53	2.54	4.66	8589	15460	Face of new heading—50 ft. above old heading.

Envelope in back
vol. XI