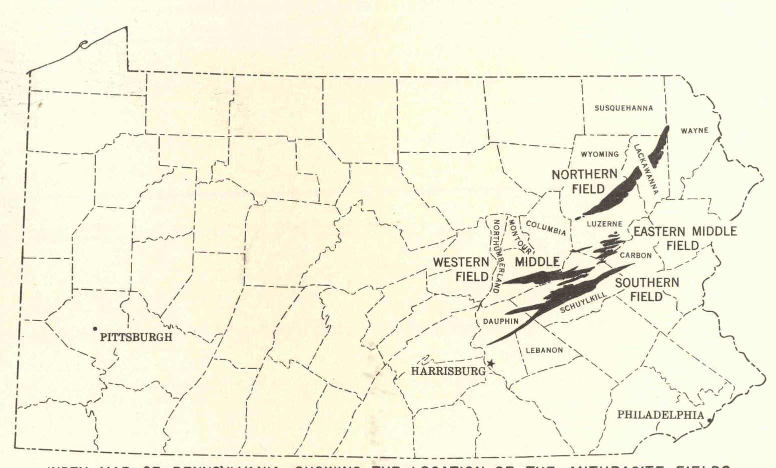
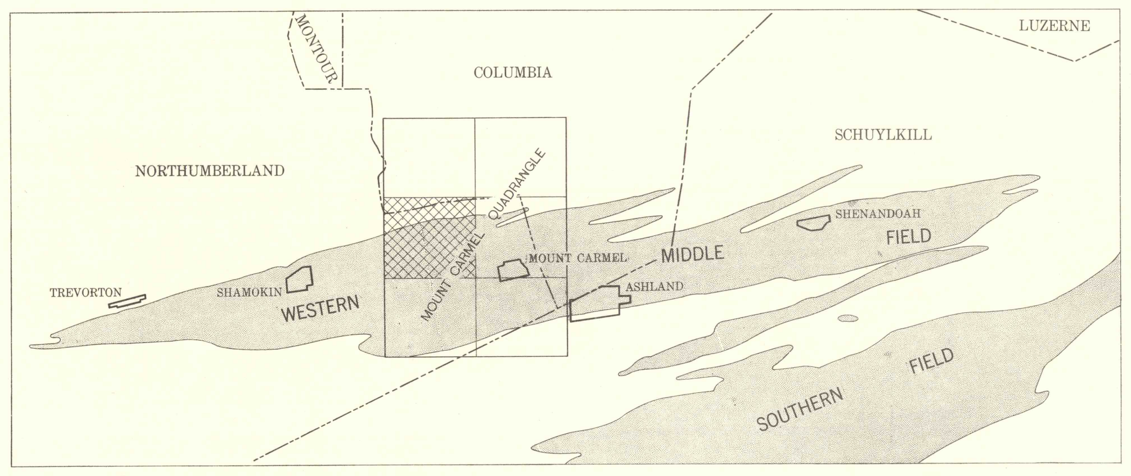


INDEX MAP OF PENNSYLVANIA SHOWING THE LOCATION OF THE ANTHRACITE FIELDS

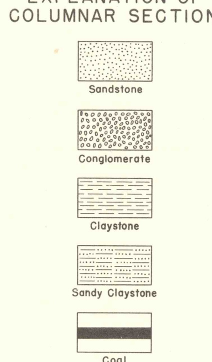
0 50 100 Miles
SCALE

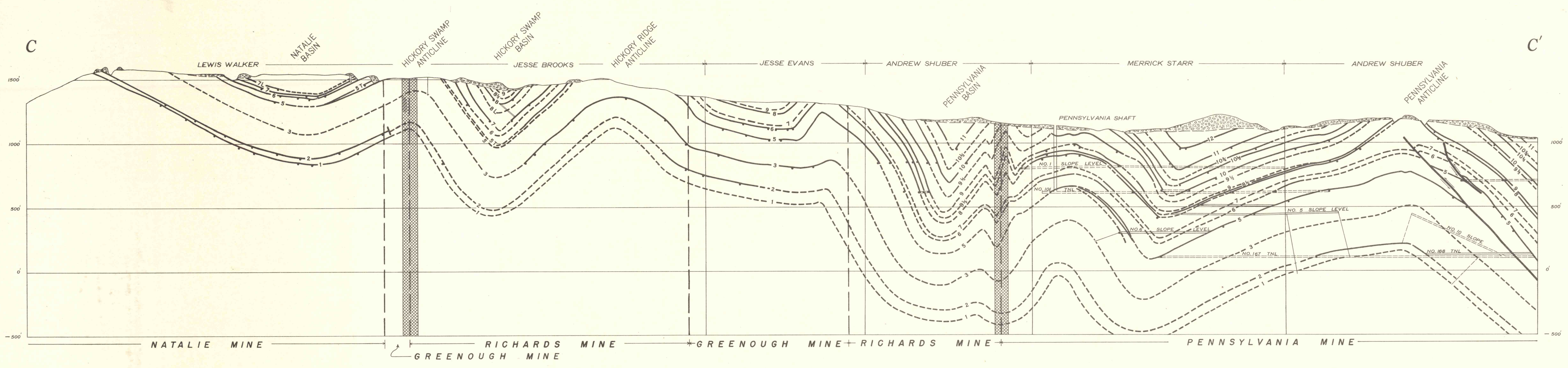


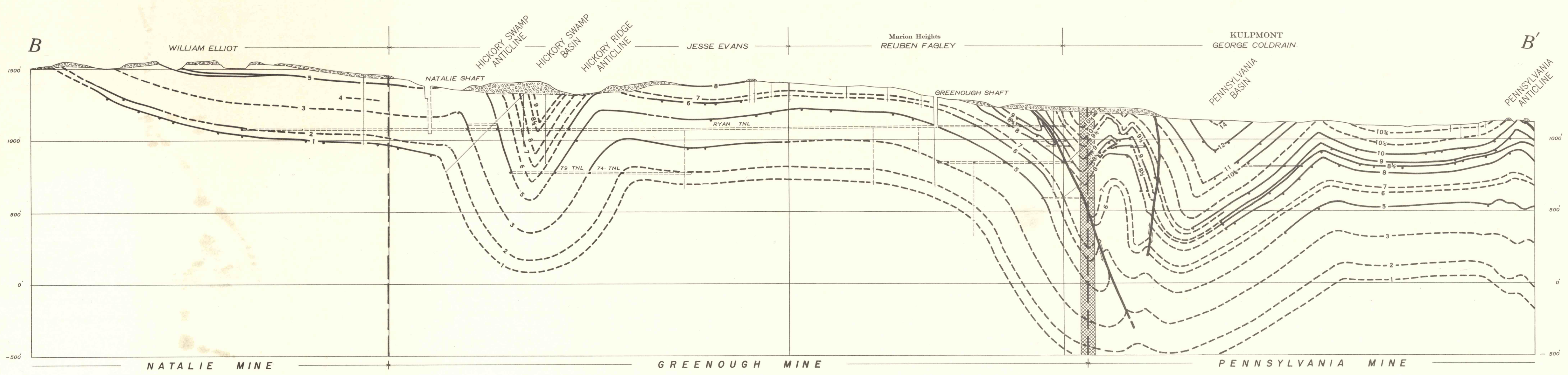
INDEX MAP OF THE WESTERN MIDDLE FIELD SHOWING THE LOCATION OF THE MAPPED AREA

0 5 10 Miles
SCALE

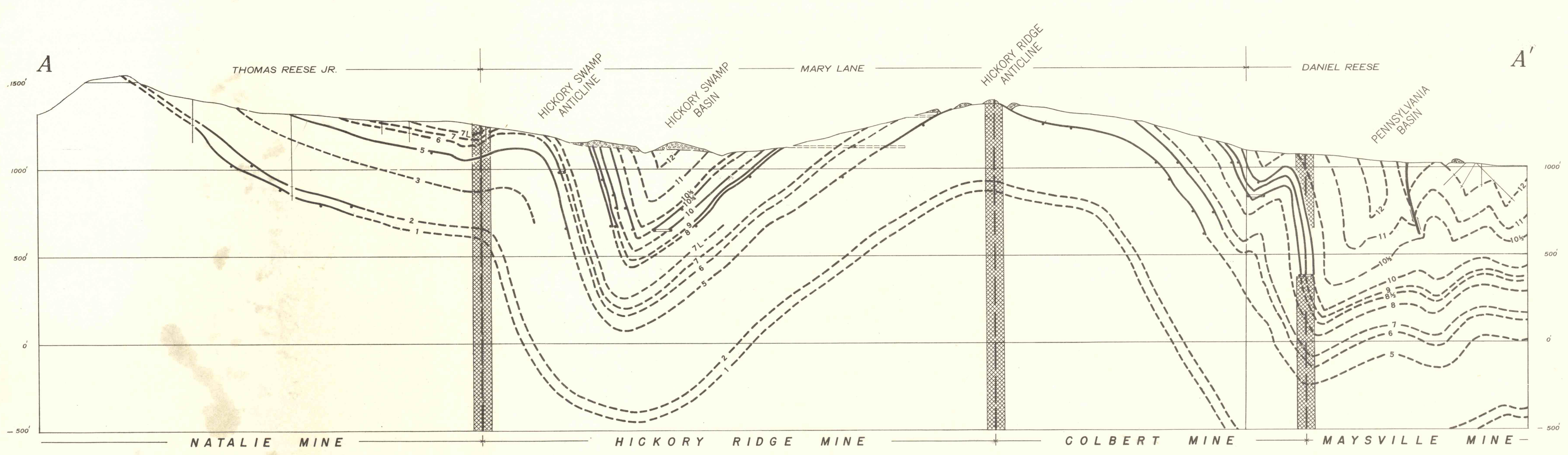
EXPLANATION OF COLUMNAR SECTION







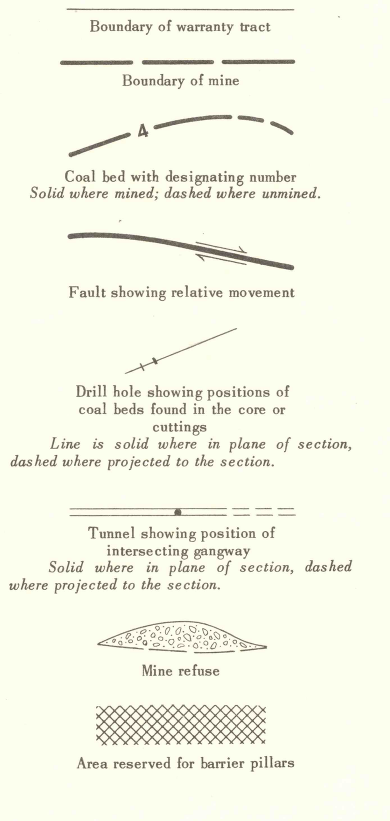
Prepared in 1948 from data supplied by the Natalie Coal Corporation, Lehigh Valley Coal Company, and Susquehanna Collieries Company with modifications by the Geological Survey, United States Department of the Interior.



CROSS SECTIONS SHOWING THE STRUCTURE OF THE COAL BEDS

500 0 500 1000 1500 2000 Feet
VERTICAL AND HORIZONTAL SCALE

EXPLANATION OF CROSS SECTION



Boundary of warranty tract

Boundary of mine

Coal bed with designating number
Solid where mined; dashed where unmined.

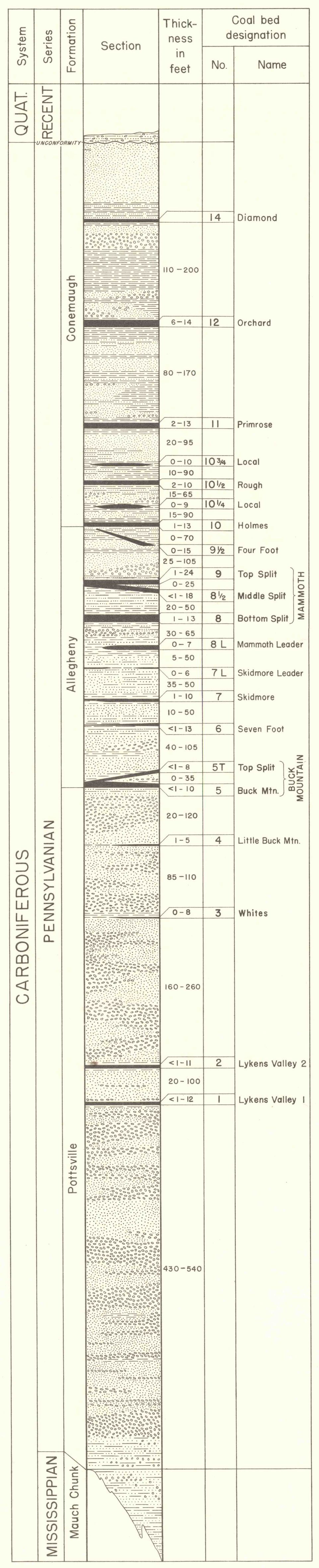
Fault showing relative movement

Drill hole showing positions of coal beds found in the core or cuttings
Line is solid where in plane of section, dashed where projected to the section.

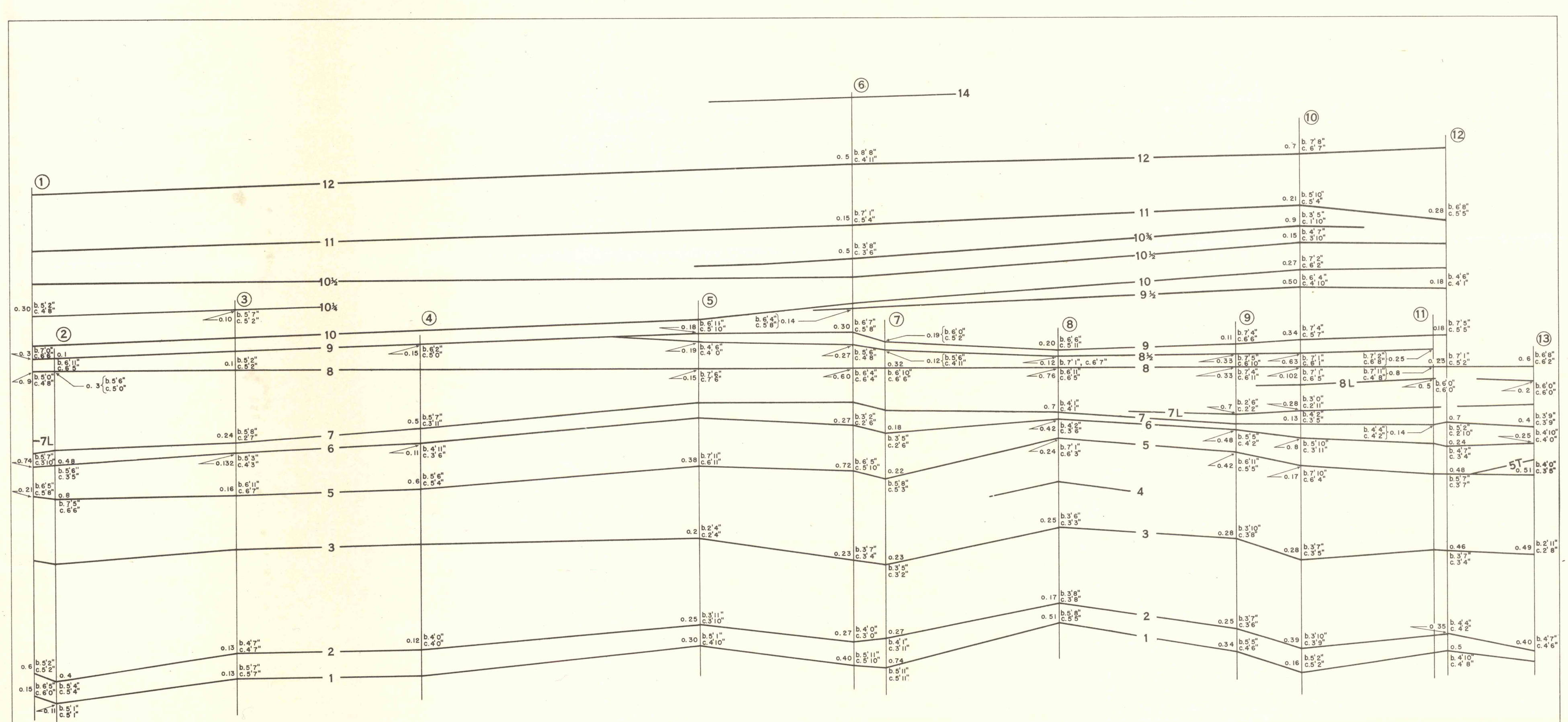
Tunnel showing position of intersecting gangway
Solid where in plane of section, dashed where projected to the section.

Mine refuse

Area reserved for barrier pillars



COLUMNAR SECTION



CORRELATION CHART SHOWING THE EAST-WEST LATERAL VARIATION IN THE INTERVALS BETWEEN THE COAL BEDS

(Numbered columns show the intervals that are representative of the corresponding structural cross sections shown on the index map)

1000 0 1000 2000 3000 FEET
HORIZONTAL SCALE

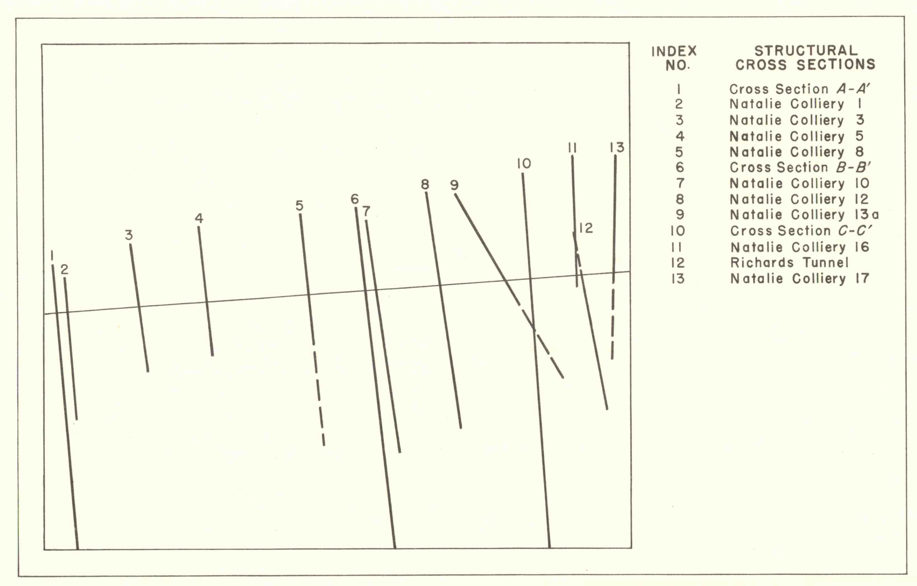
200 0 200 400 600 800 1000 FEET
VERTICAL SCALE

EXPLANATION OF CORRELATION CHART

4
Coal bed with designating number

②
Index number designating structural cross section used to determine the intervals between coal beds

b.5'6"
c.4'3"
o.46
Coal bed data representative of the area traversed by a cross section
(b. =*average total thickness of the coal bed*
c. =*average total thickness of the coal in the bed*
o. =*number of observations from which the thickness of the coal was derived)*



INDEX NO.	STRUCTURAL CROSS SECTIONS
1	Cross Section A-A′
2	Natalie Colliery 1
3	Natalie Colliery 3
4	Natalie Colliery 5
5	Natalie Colliery 8
6	Cross Section B-B′
7	Natalie Colliery 10
8	Natalie Colliery 12
9	Natalie Colliery 13a
10	Cross Section C-C′
11	Natalie Colliery 16
12	Richards Tunnel
13	Natalie Colliery 17

DIAGRAM OF THE MAPPED AREA SHOWING THE LOCATION OF THE CROSS SECTIONS REPRESENTED ON THE CORRELATION CHART

GEOLOGY OF ANTHRACITE IN THE WEST-CENTRAL PART OF THE MOUNT CARMEL QUADRANGLE, PENNSYLVANIA

INTRODUCTION

LOCATION

The Pennsylvania anthracite fields, consisting of the Northern, Western-middle, Eastern-middle, and Southern fields, are in the eastern part of the Commonwealth of Pennsylvania (index map of Pennsylvania, sheet 3). The margins of the fields are generally delineated by the outcrops of the oldest coal bed in them, which is in a sequence of coal beds called the Lykens Valley zone. Because the form or structure of the coal-bearing rocks is basin-like, the outcrops of this oldest coal bed generally circumscribe each of the fields, except the Eastern-middle field. The Eastern-middle field consists of several closely spaced but disconnected areas of coal-bearing rocks and so is not bounded by a single circumscribing coal bed.

The mapped area here described is near the middle of the Western-middle field and consists of the west-central part of the area included in the Geological Survey's Mount Carmel topographic quadrangle. This part of the quadrangle is between latitudes 40°47'30" and 40°50'00" north, a distance of 2.87 miles, and longitudes 76°26'15" and 76°30'00" west, a distance of 3.26 miles, and is chiefly in Northumberland County but also extends into Columbia County. The town of Marion Heights is near the center of the mapped area.

PURPOSE

The chief purpose of the project is to aid in prolonging mining operations in the anthracite fields by publishing general information about the extent and structural relationships of the fields, and specific information about (1) the location of coal outcrops and the surface workings in them (sheet 1); (2) the depth, pitch, and other structural features of representative coal beds (sheets 2 and 3); and (3) the correlation of the beds, the stratigraphic intervals between them, and the thicknesses, continuity, and other physical characteristics of the coal (sheet 3).

The set of maps that constitutes this report is the first unit of a series of publications about the Pennsylvania anthracite fields. Each unit will be equivalent in area to 1/6 of a 7-1/2 minute topographic quadrangle. Other units will be issued as they are completed.

METHODS OF WORK

The base map upon which the geology is shown was made from the U. S. Geological Survey's Mount Carmel topographic quadrangle, mapped in 1944 from aerial photographs flown in 1942. This map, first compiled on a scale of 1:10,000, was published at a scale of 1:24,000, and prepared to be of standard accuracy at that scale. It was enlarged to a scale of 1:6,000 for use as a base.

The outcrop and structural data were assembled from mine maps and structural cross sections prepared by the operating companies from carefully controlled engineering data. Most of these maps and cross sections are drawn at a scale of 1 inch = 100 feet (1:1,200) and the compilations made for the Geological Survey's project were prepared at the same scale. These compilations were reduced photographically to the scale of 1:6,000 and were registered on the topographic base by means of the culture, political boundaries, and prominent topographic features. The complete assembly was checked in the field by observation or where necessary by plane table survey.

The property lines, taken from company surveys, represent the boundaries of the tracts for which warranty titles or patents were given by the Commonwealth of Pennsylvania. They are shown on the maps as a means of orientation and identification, and are not located with reference to mine workings or coal outcrops with a sufficient degree of accuracy to be a basis for claims of ownership.

The outcrop map shows the positions that the coal beds would occupy if they were projected to the surface of the ground. Only rarely do the beds crop out in this manner because they are generally covered by a mantle of soil, and where they appear in the soil as weathered coal or bloom, they occur down the slope at various distances from their original positions because of creep of the weathered soil. Exploration for the unweathered outcrop, therefore, should be started at the position shown on the map and extended in the direction of the dip.

ACKNOWLEDGMENTS

The foregoing description of the methods used in compiling the data for this report reveals the importance to the project of contributions of technical data by various organizations and individuals. Acknowledgment of this assistance is gratefully made to the engineering personnel in offices of the Glen Burn Colliery of the Susquehanna Collieries Company, the Natalie Colliery of the Natalie Coal Corporation, and the Wilkes-Barre and Hazleton Divisions of the Lehigh Valley Coal Company. Thanks are also due to the officials of these companies for granting permission to release the information required for the report. The project was endorsed by the Bureau of Topographic and Geologic Survey of the Commonwealth of Pennsylvania and was greatly aided by the cooperation of the Mine Inspectors of the Department of Mines of the Commonwealth. Many others have given freely of their experience and data.

GEOLOGY

STRATIGRAPHY

The rocks that crop out in the mapped area belong to the Carboniferous and Quaternary Systems and include in ascending order the upper part of the Pottsville, all of the Allegheny, and the lower part of the Conemaugh formations of Pennsylvanian (Carboniferous) age, and alluvial deposits of Recent (Quaternary) age (columnar section, sheet 3). The boundaries between these formations are considered to be the Buck Mountain coal bed at the base of the Allegheny and the Holmes coal bed at the base of the Conemaugh. (Lohman, 1937, p. 46.) The areal distribution of the upper part of the Pottsville, Allegheny, and Conemaugh formations is indicated on sheet 1 by the outcrops of these coal beds.

PENNSYLVANIAN ROCKS

The Pennsylvanian rocks are of continental origin and consist of lenticular deposits of conglomerate, sandstone, siltstone, claystone (generally called "slate" by the miners), and coal. The beds of coal are the most persistent of these rock types. The others show great lateral variation.

Pottsville formation.--The Pottsville formation, the average thickness of which is approximately 910 feet in this area, is above the Mauch Chunk shale of Mississippian (Carboniferous) age and below the Allegheny formation of Pennsylvanian age. The base of the Pottsville is well exposed in the mapped area only along the highway cut in Big Mountain northwest of Natalie. At this locality the basal strata are gradational with the Mauch Chunk and the boundary between the two formations is considered to be the place above which the weathered beds are predominantly brown and the fresh surfaces predominantly gray, and below which the weathered beds are predominantly brownish-red and fresh surfaces are predominantly reddish-gray. Although conglomerates occur both above and below this horizon they are much more numerous and thicker above it and are preponderant in the upper part of the Pottsville formation. The conglomerates vary greatly in thickness and are composed chiefly of well-rounded ovoid quartz pebbles in a matrix of silica-cemented sand. The pebbles generally range from a few millimeters to two or three centimeters in length. They consist chiefly of quartzite and milky quartz but there are some pebbles of silica-cemented siltstone and dark chert. Coarse- to medium-grained sandstones, locally cross bedded, and a few claystones are interbedded with the conglomerates.

The coal beds in the Pottsville formation are in its upper half. The oldest of the coals belongs to the Lykens Valley zone of coal beds which is 430 feet above the Mauch Chunk shale in a diamond drill hole west of the area and 540 feet above the Mauch Chunk in a bore hole in the Reliance Colliery south of the mapped area. The Lykens Valley zone in the mapped area consists of two beds called in ascending order No. 1 and No. 2 coal beds, but in other areas the zone includes from 1 to 6 beds (Lohman, 1937, p. 48 and Griffith, 1913). No. 1 and No. 2 coal beds are separated by a sandstone, 20 to 100 feet thick, that is conglomeratic in places. Above the Lykens zones the Pottsville formation consists of massive conglomerate interbedded with lenticular sandstone, a lesser amount of carbonaceous shale, and local coal beds. The average thickness of this sequence is 485 feet, but it ranges from 430 to 540 feet. The most persistent of the local coal beds, called the Whites or No. 3 bed, is near the middle of this part of the Pottsville formation. A coal bed of local distribution, called the Little Buck Mountain (No. 4) bed in this report, occurs at distances ranging from 20 to 120 feet below the top of the Pottsville. The lithology of the Pottsville formation, shown in the columnar section (sheet 3), was determined from field observations and from 14 core drill holes drilled in the Natalie mine, one of which reached the Mauch Chunk shale. The intervals between the coal beds in the Pottsville, and also in the overlying formations, were obtained chiefly from operators' cross sections drawn transverse to the longitudinal axes of the folds in the beds at intervals of 1,000 feet or less.

Allegheny formation.--The Allegheny formation, which overlies the Pottsville and underlies the Conemaugh formations, includes the Buck Mountain (No. 5) coal as its basal bed and extends to the Holmes (No. 10) coal, the basal bed of the Conemaugh. The Allegheny formation consists chiefly of sandstone and sandy claystone with intercalated coal beds. Claystone, which is a minor constituent in the lower part of the formation becomes more common in its upper part. Conglomerate or conglomeratic sandstone commonly occurs above the Buck Mountain coal, above and below the coal beds of the Mammoth zone, and in the strata near the top of the formation. All of the strata show lateral gradation into related rock types. The majority of the coal beds found in the mapped area, including the most important ones, occur in the Allegheny formation. Best known of these are the Buck Mountain beds at the base of the formation and the group of beds called the Mammoth coal zone near its middle. The general sequence of rock types in the Allegheny formation in the mapped area is shown by the columnar section (sheet 3) which was made from field measurements, cross sections through the mine workings, and the records of 24 drill holes.

Conemaugh formation.--Only the lower 400 feet of the Conemaugh formation is exposed in the mapped area. The basal bed of the formation is the Holmes coal, which rests on the Allegheny formation. The eroded upper part of the formation is covered by Quaternary soil and alluvium. The formation consists of carbonaceous claystone, sandstone, some of which is conglomeratic, five persistent coal beds, and three local ones. The claystones and sandstones are generally lenticular but a coarse-grained micaceous sandstone a few feet above the Holmes coal is sufficiently persistent to be useful in determining the location of this coal bed.

RECENT DEPOSITS

Deposits of Recent (Quaternary) age consist of silt, sand, gravel, boulders, and water-borne, or alluvial, mine refuse. These materials occur chiefly in the lower valleys where alluvial mine refuse generally forms the top layer of the deposit. As the mapped area was probably covered by ice during the Pleistocene period of the Quaternary era (Ashley, 1931), it is possible that some of the alluvium is of Pleistocene age. No attempt was made, however, to differentiate such deposits.

STRUCTURE

The Western-middle anthracite field is a composite syncline consisting of a group of roughly parallel folds that strike approximately N. 75° E (sheet 2). The mapped area is on the north limb, called the south pitch by miners, of the composite syncline; hence the folds that comprise it extend to progressively lower levels from north to south. The larger folds, the average width of which is about 4,000 feet, persist across the mapped area; the smaller ones tend to overlap. The axes of the folds are slightly undulating both in plan and cross section.

The anticlinal folds in the composite syncline tend to be broad or open arches such as the Hickory Ridge and Pennsylvania anticlines (sheet 3). Subsidiary anticlines such as the Hickory Swamp anticline, are developed in the limbs of some of the folds.

The synclines, which are more closely folded and more complex than the anticlines, plunge westward and are slightly asymmetric. Their axial planes dip northward, a characteristic that is clearly shown by the Hickory Swamp syncline whose limbs generally dip about 60° south and 35° north. The Pennsylvania syncline is the largest and most complex in the area. Synclinal areas, particularly those that are mined as units, are called "basins" in the anthracite fields, a practice that is generally followed in this report.

The rocks are cut by many faults most of which are longitudinal, or parallel with the long axes of the folds. The dips of the faults at the surface, computed in a few places (sheet 1), appear to be generally at angles of from 65° to 90°. A longitudinal fault near the middle of the east margin of the area, however, flattens noticeably underground, ranging from 65° at the surface (sheet 2) to 25° 300 feet underground where it cuts the Buck Mountain coal bed (sheet 2). Another exception is the longitudinal fault, shown near the southeast corner of sheet 2, on which one segment of the Buck Mountain bed has been thrust over another along a plane that dips 45° southward. All of these faults are probably the result of compression or thrusting and are generally reverse faults. Most of the faults in this area occur on the north limb (south pitch) of the synclines.

Two types of deformation that result from longitudinal or strike faulting are represented in this area. In one type, the fault cuts the beds at a relatively low angle with the bedding and produces overlap in the rock segments, as illustrated by the fault shown in the southeast corner of sheet 2 and in the south end of cross section C-C', sheet 3. Such faults are common. They may lie extensively within one coal bed, which acted as a lubricant for the moving masses, and may die out in the adjoining competent rocks without cutting adjacent coal beds. The second type of deformation, which is much less common than the first, produces closely spaced faults that bound uplifted wedge-shaped blocks, called horsts, as shown 1,000 feet south of Greenough shaft (sheet 2 and cross section B-B', sheet 3).

A kind of fault also due to thrusting cuts the beds obliquely to or parallel with their dip, and on the basis of its position may be called an oblique or dip fault. One of the largest of these faults branches northward from a long strike fault in the southwestern part of the area and is associated for most of its length with a shear zone in the Buck Mountain coal bed but dies out in an expanded part of the shear zone at its northern end (sheet 2).

Shear zones in which coal, claystone, or other incompetent rock is deformed with no apparent fracturing of the adjoining competent rock, occur frequently. The coal in these shear zones is reduced to thin lenticular fragments bounded by slickensided faces and is described by the miners as "shelly". The shear zones may be associated with rolls (small local flexures) in which the coal is either "shelly", thinned, or pinched out entirely. Areas of this kind, that are large enough to be mapped, are shown on sheet 2. Most of them are oblique to the longitudinal axes of the structures.

Open fractures, encrusted or filled with quartz crystals, represent a late stage of deformation in which tension appears to have been the predominant force. The largest of these that has come to the attention of the writer extends from the unbroken roof of the No. 3 coal bed in the Greenough mine downward in an undulating plane for at least 300 feet.

COAL BEDS

NOMENCLATURE AND CORRELATION OF THE COAL BEDS

In the Western-middle anthracite field the coal beds are generally known as veins, following very early usage. As the term "vein" generally refers to tabular mineral deposits that are foreign to, and younger than the rocks in which they occur, it is not applicable to deposits of coal. In this report the coal deposits are called coal "beds".

The nomenclature of the coal beds has not been completely standardized, but great progress has been made from the early periods of mining when names were given to beds in isolated mines before correlation could be made. Other factors contributing to this lack of uniformity are the complexity of structure and lithology, and the scarcity of outcrops. Moreover, misnomers persist in some mines because of common usage and the difficulty of changing the records. The bed names used in this report were chosen to conform, so far as possible, to the consensus of usage in the eastern half of the Western-middle field. They are offered tentatively as a standard of nomenclature that, it is hoped, will also apply to other areas of the anthracite fields. These names, however, do not necessarily agree with those used in the anthracite reports of the Second Geological Survey of Pennsylvania, because those reports followed local usage only (Ashburner, 1883, p. 84).

DESCRIPTION OF THE COAL BEDS

THICKNESSES OF COAL

The coal thicknesses shown in this report were obtained chiefly from underground measurements made by the operators. These measurements, selected from a great many such observations, were chosen so as to reflect the normal thickness of the bed and its included coal in unit areas 1,000 feet square. Measurements that were considered to be abnormally affected by structural deformation, such as faulting, pinching or swelling, were not used; hence, the measurements do not include the most extreme dimensions of the bed. Wherever possible at least four measurements per unit area were averaged. In the following descriptions and in the correlation chart, sheet 3, two thickness figures are generally given, the first indicating the total thickness of the bed that contains the coal, and the second the aggregate thickness of the layers of coal in the bed (sheet 3).

The ranges in thickness that are given in the text may be less than the ranges shown on the columnar section, because those in the text represent thicknesses in mined areas, whereas those in the columnar section represent thicknesses throughout the mapped area.

LYKENS VALLEY COAL ZONE

The Lykens Valley zone contains two coal beds in the mapped area. They are differentiated in this report by designating them in ascending order as No. 1 and No. 2 beds. Both beds have been mined extensively for various distances southward from their outcrops on the north slope of Big Mountain.

No. 1 bed of the Lykens Valley coal zone.--The No. 1 bed, the oldest coal in the area, was mined under most of the area known as the Natalie mine and in the northern part of the Greenough mine (sheet 2). In these areas the bed averaged 5'8" thick, of which 5'4" was coal. The range in thickness of the bed was from 12 to 2 feet. The bed thins southward from its outcrop, where it averaged about 7 feet, to the north line of the Greenough mine, where it was about 4 feet thick.

No. 2 bed of the Lykens Valley coal zone.--The No. 2 bed, which is from 20 to 100 feet stratigraphically above No. 1 bed, has been mined extensively in the Natalie mine and in the northwestern part of the Richards mine. It has also been mined in the northern and eastern parts of the Greenough mine, in the southeastern part of the Pennsylvania mine, and possibly elsewhere in the area. In the mined areas the average thicknesses of the bed and its included coal were 4'1" and 3'10", respectively, but the bed ranged from 11'0" to 0'10" thick and the coal from 9'3" to 0'6" thick. The No. 2 bed is very irregular in thickness but shows an over-all thinning southward from its outcrop.

WHITES (NO. 3) COAL BED

A coal bed, which is designated as the No. 3 on the maps of the Natalie Coal Corp., and is sometimes called the Whites coal, occurs from 150 to 200 feet above the Lykens (No. 2) bed. The horizon of the bed is at the surface on the north side of Big Mountain, but no outcrops of coal were found. The approximate location of its outcrop, however, is shown on sheet 1, where underground workings indicate its presence.

The Whites (No. 3) coal was mined in parts of the Natalie, Greenough, and Richards mines, and possibly elsewhere. The workings are generally limited on the north by a pinch near the crest of the Hickory Swamp anticline and on the south by the steeply-dipping north limb of the Pennsylvania basin.

The bed is a lenticular body with an east-west elongation and an average thickness of 3'9", but it varied greatly in thickness throughout the mined area, ranging from 8'4" to 0'5". The bed generally contains partings or lenses of bone which reduced the included coal to an average thickness of 3'1" with a range of 7'4" to 0'5".

LITTLE BUCK MOUNTAIN (NO. 4) COAL BED

In the Natalie mine a local bed was found in core drill holes and in some of the tunnels at a stratigraphic position 80 feet above the Whites bed and from 20 to 120 feet below the Buck Mountain coal. It is correlated in this report with coal bed No. 4 in the Sioux mine found in a similar position, and with a bed elsewhere in the Mount Carmel quadrangle known as the Little Buck Mountain bed, and is called in this report the Little Buck Mountain (No. 4) coal bed.

The thickness of this bed in the Natalie mine ranges from 4'10" to 1'1" but it contains waste which may constitute as much as 40 percent of the bed. The bed is worked a short distance east of the mapped area in the Sioux mine where it contains less waste and is more uniform in thickness, ranging from 3'0" to 4'9".

BUCK MOUNTAIN (No. 5 AND 5T) COAL BED

The Buck Mountain coal bed, from 350 to 400 feet above the Lykens (No. 2) bed, crops out near the top of Big Mountain and in places along the axes of the Hickory Swamp and Hickory Ridge anticlines.

The coal bed has been mined extensively throughout the mapped area, except in the deeper parts of the Hickory Swamp and Pennsylvania basins. The mined areas are approximately equivalent to those on sheet 2 in which the contour lines are solid.

The bed generally contains a parting which in some areas becomes as much as much as 35 feet thick and divides the bed into a bottom split, called No. 5 bed in this report, and top split, called No. 5T. The parting is chiefly carbonaceous claystone and fine-grained sandstone which locally contains lenses of pebble conglomerate. The Buck Mountain bed overlies the thick conglomerate sequence of the Pottsville formation. The rocks between the Buck Mountain coal and the overlying Seven-foot bed are chiefly sandstone but in some places include a bed of conglomerate that is useful in designating the position of the Buck Mountain coal.

The total thickness of the two splits of the Buck Mountain coal bed in the eastern two-thirds of the mapped area ranged from 18'4" to 0'6" with the included coal ranging from 12'0" to 0'4". The average thicknesses of the bed and coal, however, were 6'11" and 5'9", respectively.

SEVEN-FOOT (NO. 6) COAL BED

The Seven-foot (No. 6) coal bed, which is from 40 to 105 feet above the Buck Mountain bed, is known as the No. 5 coal in most of the mines in the mapped area. It is called the Seven-foot bed in this report because that is the name by which it is commonly known elsewhere in the Mount Carmel quadrangle.

The rocks between the Seven-foot bed and underlying Buck Mountain bed consist chiefly of sandstone, which in some places is conglomeratic. The coal bed crops out along the anticlines north of the Pennsylvania basin, and has been mined in parts of the Sioux, Richards, Greenough, Natalie, Hickory Ridge, Scott, and Pennsylvania mines. In these areas the average thicknesses of the bed and its included coal were 4'7" and 3'4", respectively, but the bed ranged in thickness from 10'3" to 1'5" and the coal from 6'5" to 1'5".

SKIDMORE (NO. 7) COAL BED

The Skidmore (No. 7) coal bed in this area is defined as the first persistent coal below the Mammoth that can be correlated with the bed commonly known as the Skidmore elsewhere in the quadrangle.

In the northwestern part of the mapped area it is 170 feet below the Mammoth and no other coal occurs between the two beds. In the northeastern part of the area, however, this interval decreases to 80 feet and in some places contains two local beds, the Skidmore leader and the Mammoth leader.

The Skidmore bed crops out north of the Pennsylvania basin and has been worked most extensively in that area. Average thicknesses of the bed in the unit areas were generally from 4 to 6 feet but southeastward the thickness decreased to 2 or 3 feet. The maximum range recorded was from 9'11" to 1'6". Coal constituted about 82 percent of bed.

SKIDMORE LEADER (NO. 7L) COAL BED

The Skidmore leader (No. 7L) is a local coal bed that occurs only in the northeastern part of the mapped area, where it is known as the No. 6-½ coal of the Natalie mine. It crops out on the Hickory Swamp anticline and has been mined in the Natalie mine on the limbs of the anticline. The thickness of the bed ranged from a few inches to 3'3". Its average thickness was 2'10", of which 2'5" was coal.

SKIDMORE (NO. 7) COAL BED

The Skidmore (No. 7) coal bed, an important source of coal in adjoining areas, is poorly represented in the mapped area. It is exposed only in the northeastern part of the area, where it has been mined. In the southern part of the area it is not recognized. Elsewhere its presence is inferred from scattered showings in core drill holes and mine workings.

The stratigraphic interval from the Skidmore to the underlying coal beds is quite variable but the interval from the Skidmore to the overlying Mammoth coal is more regular, ranging from 35 to 60 feet. In some places a conglomerate that occurs above the Skidmore coal is an aid in locating its outcrop.

In the mined area the Skidmore bed was from 4 to 6-½ feet thick.

MAMMOTH COAL ZONE

The Mammoth coal zone, the most famous of the anthracite deposits, consists of three principal members throughout most of the mapped area, but in some places, as in the northwestern part, only a top and a bottom member is recognized. The principal members of the zone are called the bottom, middle, and top splits and are designated in this report as No. 8, No. 8-½, and No. 9, respectively. In addition to these principal members a leader bed, called the No. 8L in this report, occurs locally in the northeastern part of the area. The bottom split (No. 8) is generally a distinct bed separated from the upper splits by claystone and siltstone from 20 to 50 feet thick, but in some localities south of the mapped area the bottom and middle splits form a single bed. The middle (No. 8-½) and top (No. 9) splits may comprise a single bed in some localities but elsewhere may be separated by as much as 25 feet of claystone, siltstone, or sandstone. In some areas the partings between the members may be so thin that they are almost unrecognizable. In such areas the coal may be of considerable thickness.

Mammoth leader (No. 8L) bed of the Mammoth coal zone.--The Mammoth leader coal bed occurs locally in the northeastern part of the mapped area where it is known as the No. 7 bed of the Natalie mine. It is included with the Mammoth coal zone in this report because it is so close to the principal bottom member of that zone that the two were mined as a single bed in some places, and because the stratigraphy suggests that it is not the Skidmore bed.

The Mammoth leader bed crops out in the Hickory Swamp and Natalie basins. (See sheet 1.) Its thickness in the workings ranged from 6'7" to 3'0" and averaged nearly 6'0", all of which was coal.

Bottom split (No. 8) of the Mammoth coal zone.--The No. 8 bed, or bottom split of the Mammoth coal, crops out in many places in the area and has been mined in all of the mines. It is a persistent bed and is generally easily recognized. For these reasons it is often used as a reference datum or key bed in determining the stratigraphic positions of other beds or the structure of the rocks. The bed thickened irregularly eastward, having average thicknesses of from 3 to 6 feet in the western part of the area and from 4 to 9 feet in the eastern part. The maximum and minimum thicknesses of the bed, however, exclusive of areas that were faulted or closely folded, were 13'0" and 1'0", respectively. The average thickness of the bed in the mined areas was 6'0" of which 5'3" was coal.

Middle split (No. 8-½) of the Mammoth coal zone.--The middle split (No. 8-½) of the Mammoth coal is present throughout the mapped area except in the northwestern part where it merges with the overlying top split of the Mammoth. The middle split crops out in the eastern half of the Hickory Swamp basin, on the north limb (south pitch) of the Pennsylvania basin, and along the crest of the Pennsylvania anticline.

Extensive workings have been made in this coal, the average thickness of which varied from 4 to 6 feet in the western part of the area and from 5 to 8 feet in the eastern part. The maximum variation in thickness, however, was much more than this, ranging from 18'0" to 2'4". Measurements of the coal in place indicate that it contained an average of about 8 percent of refuse.

Top split (No. 9) of the Mammoth coal zone.--The top split (No. 9) of the Mammoth coal crops out in many places south of the Hickory Swamp anticline. It was mined in all of the mines except the Natalie.

The bed had a wider range of thickness in the workings than older beds, its maximum and minimum being 23'6" and 1'2", respectively. Average thicknesses of the bed in the unit areas, however, displayed a tendency to thicken eastward from a range of 3 to 8 feet in the western part of the mined area to a range of from 4 to 11 in the eastern part. The bed in place contained an average of 20 percent of waste.

FOUR-FOOT (NO. 9½) COAL BED

The Four-foot (No. 9½) coal bed has been mined in the southeastern part of the mapped area. In the eastern part of the mined area it is about 60 feet below the Holmes (No. 10) coal, but westward near the boundary between the Pennsylvania and Scott mines, this interval decreases so much that the Four-foot and Holmes beds are not differentiated in the mine workings. A short distance northeast of the common corner of the Scott, Greenough, and Pennsylvania mines, however, the Holmes and the Four-foot are separate beds with about 65 feet of sandy claystone between them.

The average thicknesses of the Four-foot bed in the northern part of the area of occurrence were from 4 to 11 feet. The bed thinned southward until in the southeastern part of the mapped area it was about 3 feet thick. The maximum and minimum thicknesses, however, were 14'6" and 2'0", respectively. The bed generally contained about 20 percent of waste.

HOLMES (NO. 10) COAL BED

The Holmes coal bed, which is at the base of the Conemaugh formation, is notable for its widespread occurrence and relatively uniform thickness. It occurs in all of the mines within the mapped area except the Natalie mine. It crops out in the western or deeper end of the Hickory Swamp anticline, on both flanks of the Pennsylvania basin, and at various positions along the broad top of the Pennsylvania anticline.

The strata between the Holmes bed and the underlying Mammoth coal zone form an eastward thickening wedge which in the western part of the mapped area is only 30 feet thick. This increase in thickness is gradual through the Hickory Ridge and Scott mines but east of these mines the thickness of the wedge increases rapidly until a maximum of about 150 feet is reached at the east side of the area. This increase is partly due to the presence of the Four-foot coal and the strata which intervene between it and the Holmes bed (see correlation chart, sheet 3).

The Holmes bed is remarkably uniform in thickness, generally averaging from 4 to 6 feet, but extremes, exclusive of closely folded and faulted areas, of 12'7" and 1'0" were recorded. It contains less waste than most of the coal beds in the area, the average proportion being about 16 percent.

LOCAL (NO. 10-¼) COAL BED

In the Hickory Ridge mine a coal bed, called the Hickory Ridge No. 9-¾, occurs about 25 feet above the Hickory Ridge No. 9-½, which is called the Holmes (No. 10) coal bed in this report. The Hickory Ridge No. 9-¾ does not appear to correlate with any of the coal beds in the Greenough mine to the east and is considered in this report to be a local bed which is designated the No. 10-¼.

In the mined area the average thickness of the bed was from about 4-½ to 6-½ feet and its maximum and minimum thicknesses were 8'8" and 3'2", respectively.

Measurements of the bed in place indicate that it contained about 7 percent of waste, which is an unusually small percentage.

ROUGH (NO. 10-½) COAL BED

The Rough (No. 10-½) coal bed, which is about 55 feet above the Holmes coal, crops out on the north limb (south pitch) of the Pennsylvania basin and in the area south of the synclinal axis. It has been mined only in the southern part of the area of occurrence where its average thickness in the unit areas ranged from 3 to 6 feet. Its maximum and minimum thicknesses were 10'2" and 1'10", respectively. About 27 percent of the bed in place was waste.

LOCAL (NO. 10-¾) COAL BED

A coal, called the No. 10-¾, is locally present in the southeastern part of the mapped area. It occurs in the Pennsylvania mine about 25 feet above the Rough coal. The average thickness of the bed ranged from about 3 to 6 feet, of which approximately 24 percent was waste. Maximum and minimum thicknesses of 10'2" and 1'4" have been recorded.

PRIMROSE (NO. 11) COAL BED

The position of the Primrose (No. 11) bed is more accurately determined by the stratigraphic interval above the Holmes coal than by measuring from either the Rough (No. 10-½) or the local (No. 10-¾) coal beds. This interval between the Holmes and the Primrose coals thins eastward from about 200 feet in the western part of the area to about 110 feet in the eastern part.

The Primrose coal generally crops out in the synclines in the southern part of the area. It was mined in the Pennsylvania and Richards mines where it had a relatively uniform thickness of about 7 feet, but had a maximum variation of from 12'7" to 1'7". The proportion of waste in the bed was about 22 percent.

ORCHARD (NO. 12) COAL BED

The Orchard (No. 12) coal bed is from 80 to 170 feet stratigraphically above the Primrose coal. It crops out along the more deeply folded synclines in the southern part of the area where it has been mined at scattered localities, and along the Hickory Swamp basin in the western part. The thickness of the bed in the workings in the southeastern part of the area was generally about 9 feet, but it ranged from 13'8" to 6'0". The proportion of waste in the bed was approximately 10 percent.

DIAMOND (NO. 14) COAL BED

The Diamond (No. 14) coal bed crops out only in the southern part of the area. No record of workings in it was seen but a core drill that cut the bed showed it to be 3'8" thick of which 1'8" was coal.

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