# GEOLOGY AND COAL DEPOSITS OF THE BRAZIL QUADRANGLES, INDIANA

*by*

HAROLD C. HUTCHISON

Indiana Department of Conservation

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# CONTENTS

# ILLUSTRATIONS



# TABLES

# GEOLOGY AND COAL DEPOSITS OF THE BRAZIL QUADRANGLES, INDIANA

BY HAROLD C. HUTCHISON

## ABSTRACT

The Brazil Quadrangles are located in west-central Indiana and comprise an area of approximately 116 square miles. The rocks that crop out in the area belong to the Mansfield, Brazil, Staunton, and Linton Formations of the Pennsylvanian System. Glacial drift of Kansan, Illinoian, and Wisconsin age blankets the area, and Recent deposits of sand, silt, and mud cover the flood plains of the present streams.

Five unnamed thin coals and four unnamed marine zones in the Staunton Formation are described for the first time. The Perth Limestone Member in the upper part of the Brazil Formation and the Shady Lane Coal, a coal bed that occurs some 30 to 40 feet below the top of the Mansfield Formation, are herein described and formally named.

Coal reserves of the major commercially mined coals, the Lower Block, Upper Block, and Minshall of the Brazil Formation and Coal III of the Staunton Formation, are calculated according to the standard methods employed by the United States Geological Survey. Of the original 476,786,000 short tons of coal present in the area 401,403,000 short tons remain.

## INTRODUCTION

### METHODS AND PURPOSE OF STUDY

This report, covering the area of the Brazil East and Brazil West 7½-minute topographic quadrangle maps of the United States Geological Survey, is one of a series of similar studies being conducted by the Geological Survey, Indiana Department of Conservation. Field mapping was done by the author, assisted by Stanley J. Keller, during the summer of 1953. Mined areas were brought up to date in January 1960. The field mapping was done with the aid of aerial photographs and standard 1:24,000 topographic quadrangle maps. Information on mined-out areas was assembled from maps on file at the Indiana Bureau of Mines, and drilling information and data on active mines were obtained from coal companies in the area. Refraction seismic studies were carried out by the Geophysics Section, Indiana Geological Survey, and two cores were drilled by the Indiana Geological Survey as stratigraphic tests.

The purpose of this report is to show detailed areal geology and economic geology of the area, to discuss stratigraphy of the Pennsylvanian rocks, and to show the location and amount of coal reserves.

## LOCATION, TOPOGRAPHY, AND DRAINAGE

The Brazil Quadrangles comprise an area of approximately 116 square miles in parts of Clay, Parke, Putnam, and Vigo Counties (pl. 1 and fig. 1). For many years, Brazil, the county seat of Clay County, Ind., and largest town of the area, has been the shipping point for coal from the northern part of the county, and it is the center of a large clay-products industry. It is served by the Pennsylvania, Baltimore and Ohio, and Chicago and Eastern Illinois Railroads. The New York Central Railroad passes through the northern part of the quadrangles.

The land surface of the Brazil Quadrangles is a slightly rolling, somewhat dissected till plain. The nearly flat upland areas are broad and rather extensive except where dissection by present streams is somewhat more advanced, as in the eastern part of the Brazil East Quadrangle. The slopes between the uplands and valley bottoms are generally steep, particularly where the stream has encountered and cut through bedrock.

The altitude of the land surface ranges from slightly less than 520 feet above mean sea level in the valley of Raccoon Creek at the northwest margin of the Brazil West Quadrangle to more than 830 feet above mean sea level in the extreme northeast corner of the Brazil East Quadrangle. A maximum local relief of 140 feet is present in the eastern part of the Brazil East Quadrangle, but the average local relief for the area is approximately 70 feet per square mile.

The major part of the Brazil West Quadrangle and the western half of the Brazil East Quadrangle are drained westward by Otter Creek, North Branch Otter Creek, Sulphur Creek, and Raccoon Creek. Birch Creek drains a small area in the southeast corner of the Brazil West Quadrangle and the southwest corner of the Brazil East Quadrangle. Croys Creek and its tributaries drain the central and eastern parts of the Brazil East Quadrangle and flow southward to join Eel River a short distance southeast of the area. The extreme east edge of the Brazil East Quadrangle is drained by Johnson Branch, which flows into Big Walnut Creek just east of the quadrangle (pl. 1).

All the streams exhibit well-developed dendritic patterns. Flood plains in the main drainageways range from a few hundred feet to about half a mile in width. Generally the tributaries of Otter Creek and North Branch Otter Creek which enter the main valleys from the north are better developed than those entering from the

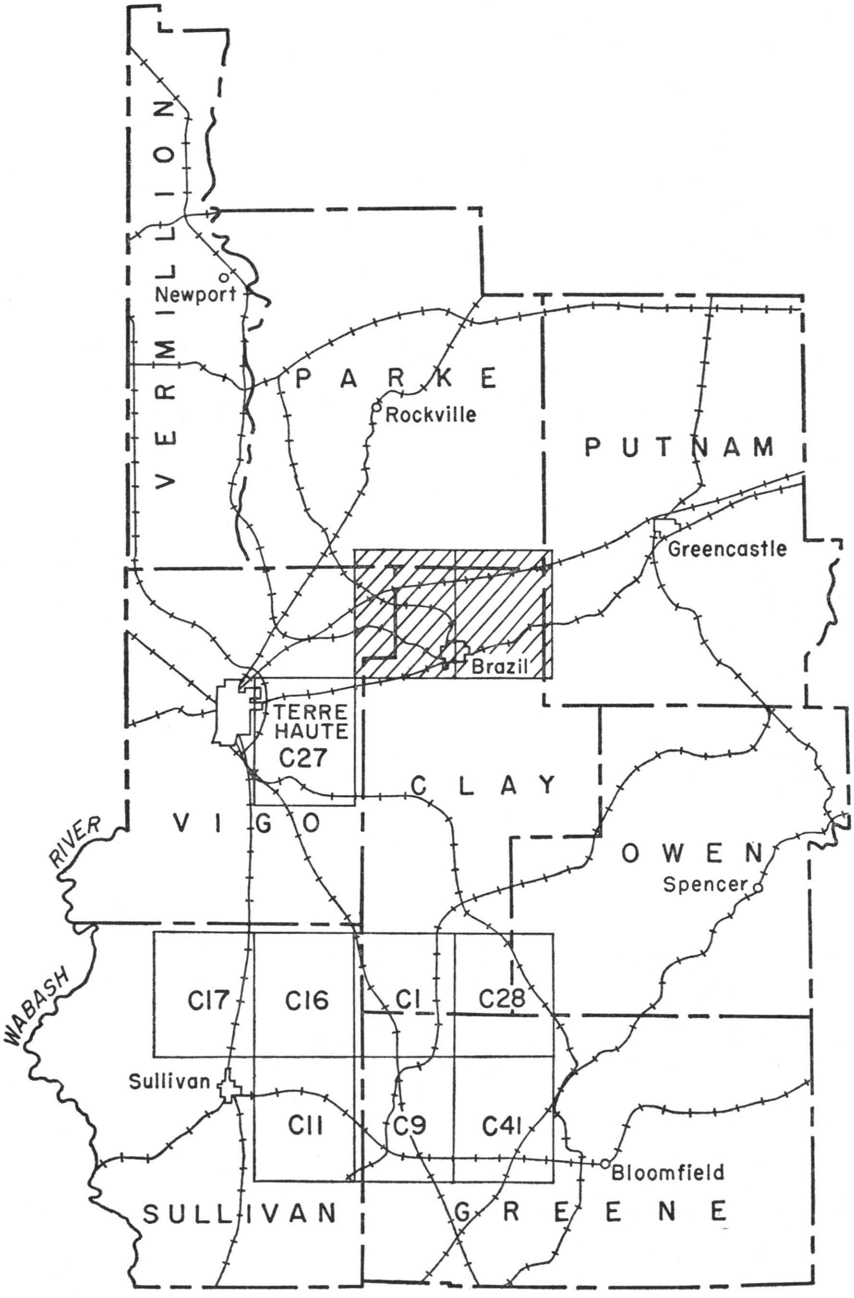


Figure 1.—Index map showing location of the Brazil Quadrangles and published maps of adjacent areas in Coal Investigations Series of the United States Geological Survey.

south. This irregular development possibly is caused by the general slope of the land surface to the south and southwest and the underlying southwestward-dipping bedrock. The present westward-flowing streams generally tend to follow the south banks of their valleys closely, a feature which possibly may also be attributed to the above-mentioned cause. Many of the tributaries of Croys Creek and Johnson Branch are narrow, gullylike streams which are cut in bedrock and have extremely narrow flood plains. The tributaries of Raccoon Creek in the northwest corner of the Brazil East Quadrangle are rather poorly developed and either lose their identity shortly after reaching the flood plain of the main valley or are ditched across the plain to the main water course.

### PREVIOUS WORK

Stratigraphy of the coal-bearing formations, extent of coal mining, and chemical and physical properties of coal in Clay, Parke, and Vigo Counties, Ind., were discussed by D. D. Owen (1859), Richard Owen (1862), E. T. Cox (1869), and G. H. Ashley (1899 and 1909). Clays of the area were discussed by W. S. Blatchley (1896), and the sandstones were reported on by T. C. Hopkins (1896). H. C. Hutchison (1956) reported the results of a coal reserve study of Clay County, Ind., in the form of a Preliminary Coal Map.

### ACKNOWLEDGMENTS

Drs. Charles E. Wier and Henry H. Gray and Mr. G. K. Guennel, all of the Coal Section, Indiana Geological Survey, made many helpful suggestions and criticisms pertaining to the stratigraphic problems of the Pennsylvanian sediments. Dr. William J. Wayne, of the Glacial Geology Section, Indiana Geological Survey, provided much information and an interpretation concerning the glacial deposits of the area. The writer also wishes to thank all coal companies, miners, drillers, and landowners who contributed much of the detailed information necessary for the completion of this investigation.

## STRATIGRAPHY

The rocks that crop out in the Brazil Quadrangles belong to the Mansfield, Brazil, Staunton, and Linton Formations of the Pennsylvanian System (pl. 1).

The Mansfield Formation crops out in the eastern part of the Brazil East Quadrangle, and the Brazil Formation crops out in the eastern part of the Brazil West Quadrangle and the western part of the Brazil East Quadrangle. These formations include shale, sandstone, underclay, coal, and limestone. The Staunton Formation and the lower part of the Linton Formation crop out in the western part of the Brazil West Quadrangle and consist of shale, sandstone, underclay, coal, and limestone. The commercially developed coal beds of the area are in the Brazil and Staunton Formations.

Glacial and alluvial deposits of Pleistocene age cover the entire area (pl. 1). The glacial deposits are (in ascending order) Kansan, Illinoian, and Wisconsin in age and include till, silt, sand and gravel, and windblown sand. Recent deposits of sand, silt, and mud as much as 15 feet thick form alluvial deposits on the flood plains of present streams.

## MANSFIELD FORMATION

The Mansfield Sandstone was named and described by T. C. Hopkins (1896, p. 199-200) from an exposure at Mansfield, Parke County, Ind. Hopkins described the Mansfield Sandstone as "that coarse-grained, gray, yellow, red, brown, or variegated, massive sandstone at the base of the Coal Measures, which lies unconformably upon the Lower Carboniferous limestone, or in the absence of the limestone on Lower Carboniferous sandstone or shale, and is overlain by a series of shales, sandstones, and coal beds"; that is, the Brazil Formation. Cumings (1922, p. 527-528) described the Mansfield Sandstone as those rocks lying unconformably upon the Mississippian rocks and below the base of the Lower Block Coal. Kottlowski (1959) proposes to call these rocks the Mansfield Formation; hence this unit of rocks will be called the Mansfield Formation in this report.

Approximately 100 feet of rocks of the Mansfield Formation crop out in the Brazil East Quadrangle. The basal contact of the Mansfield Formation and the underlying Mississippian rocks is not exposed in the area, but it may be seen at a number of localities a few miles east and north of the quadrangle.

The lowest rock of the Mansfield Formation exposed in the area is 3.0 to 4.0 feet of medium-grained dirty ferruginous shaly sandstone which appears to grade laterally and upward into dark-gray sandy carbonaceous shale. This shale locally contains a 1.0-foot bed of blue-gray hard fine-grained fossiliferous limestone. An exposure of this limestone occurs in the SW¼SE¼ sec. 19, T. 13 N., R. 5 W., at an elevation of approximately 635 feet above mean sea level (pl. 1). Between this limestone and the next stratigraphic marker above, which is also limestone, lies approximately 50 feet of yellow, brown, or red medium-grained ferruginous carbonaceous locally crossbedded sandstone interbedded with brown to gray sandy thin-bedded shales. In the NW¼SW¼ sec. 31, T. 13 N., R. 5 W., at an elevation of approximately 660 feet above mean sea level, a 1.2-foot bed of gray hard silty fossiliferous limestone crops out. Above this limestone bed is 10 feet of gray thin-bedded shale, which contains brown fine-grained sandstone lenses as much as 1.0 foot thick. A gray to light-gray shaly somewhat plastic carbonaceous underclay 2.0 feet thick overlies the shale and forms the floor of a fairly continuous coal bed.

This coal bed, which is 30 to 40 feet below the top of the Mansfield Formation, ranges from 0.5 foot to 3.0 feet in thickness, contains considerable pyrite, and is ironstained in most outcrops. In the areas where the coal has been mined it breaks into small regular cubes and is locally known as the "peacock coal" because of the iridescent colors which it shows on the fracture surfaces. The roof is generally tan to yellow ferruginous carbonaceous sandstone, but locally it is gray soft carbonaceous slightly sandy shale.

This coal is here named the Shady Lane Coal from exposures which occur along the stream valley in the SE¼ sec. 23, T. 13 N., R. 6 W. at an elevation of 630 to 650 feet above mean sea level. Shady Lane is a small community located on U. S. Route 40 2 miles northeast of Harmony, Ind.

Above the coal or overlying the shale above the coal is a prominent cliff-forming sandstone with a maximum thickness of 30 to 40 feet. This sandstone is brown to white, fairly hard, medium-grained, ferruginous, and locally crossbedded and is well exposed at many localities. An overhanging cliff of the sandstone approximately 40 feet high is exposed in the SE¼NW¼ sec. 35, T. 13 N., R. 6 W. (pl. 1), on the west bank of Croys Creek. Information derived from coal-test drill holes in the area indicates that a thick shale section underlies the Lower Block Coal at some places, but in outcrops only sandstone was observed at this stratigraphic position.

## BRAZIL FORMATION

The name Brazil Formation was given by Fuller and Ashley (1902, p. 2) to the rocks in the interval between the top of the Mansfield Sandstone and the bottom of the Petersburg coal. This interval includes rocks considered by present workers to belong in the Brazil, Staunton, and Linton Formations and in part of the Petersburg Formation. Cumings (1922, p. 525) emended the Brazil Formation to include only the shale, sandstone, underclay, coal, and limestone between the base of the Lower Block Coal and the unconformity at the base of the Staunton Formation, which occurs close above Coal II. This unconformity is difficult to identify and seems to occur only locally; hence it provides an impractical horizon for mapping in the field, and the top of Coal II is commonly used to mark the top of the Brazil Formation.

In the area of this report the Brazil Formation ranges from 40 to 90 feet in thickness and includes the commercially mined block coals, the Minshall Coal, and Coal II. A complete section of the Brazil Formation, compiled from four different measured sections along the North Branch of Otter Creek, is given below.

*Section 1. The top part of the Brazil Formation is described from a core drill hole in the SE¼SW¼ sec. 8, T. 13 N., R. 7 W., locality 41 (Appendix 1). This hole was cored to a depth of 180 feet, some 105 feet below the Perth Limestone Member, but only the top part of the Brazil Formation shown in this hole is given below.*

| | Feet |
|---|---|
| 6. Shale, dark-gray, hard, carbonaceous, soapy textured | 3.8 |
| 5. Coal, black, moderately bright, banded, hard; with pyritic lenses and 0.2 foot of bone coal at the top of bed (Coal II) | 1.6 |
| 4. Underclay, greenish-gray, sandy, carbonaceous, soapy textured | 1.5 |
| 3. Sandstone, gray, hard, fine-grained; calcareous in lower 0.2 foot | 0.5 |
| 2. Shale, dark-gray, sandy, calcareous; with tan clay nodules | 0.1 |
| 1. Limestone, gray to blue-gray, hard, fossiliferous, shaly; with light-gray limy nodules (Perth) | 1.5 |
| Total thickness of section | 9.0 |

*Section 2. Measured in the abandoned strip mine in the SW¼NE¼ sec. 3, T. 13 N., R. 7 W., locality 28 (Appendix 1).*

| | Feet |
|---|---|
| 7. Limestone, gray, hard, fossiliferous, shaly; weathers brown and contains a blue hard fossiliferous cherty vuggy medial band 2.0 feet thick (Perth) | 6.3 |
| 6. Shale, black to gray, carbonaceous, medium-bedded | 1.5 |
| 5. Shale, black, carbonaceous, fissile | 3.6 |
| 4. Shale, black, soft, blocky, carbonaceous | 3.5 |
| 3. Coal, black, moderately bright, banded, pyritiferous, semiblocky (Minshall) | 3.3 |
| 2. Underclay, gray, soft, silty, carbonaceous, plastic | 0.8 |
| 1. Sandstone, gray, fine-grained, carbonaceous, shaly | 3.5 |
| Total thickness of section | 22.5 |

*Section 3. Measured in the abandoned strip mine in the NE¼NW¼ sec. 2, T. 13 N., R. 7 W. The sandstone of Section 2, unit 1, is correlative with the sandstone of Section 3, unit 9.*

| | Feet |
|---|---|
| 9. Sandstone, gray, fine-grained, micaceous, massive | 4.5 |
| 8. Sandstone, gray, fine- to medium-grained, carbonaceous, thin-bedded to shaly | 5.1 |
| 7. Shale gray, sandy, carbonaceous | 1.3 |
| 6. Coal, black, moderately bright, banded, pyritiferous; cubic cleavage (rider of Upper Block) | 1.2 |
| 5. Coal, black, soft, shaly; contains thin lenses of vitrain | 0.6 |
| 4. Underclay, gray, soft, sandy, carbonaceous, plastic | 3.3 |
| 3. Shale, blue to gray, sandy, somewhat plastic | 5.0 |
| 2. Coal, black, moderately dull, banded, slightly pyritiferous, blocky; contains thin vitrain lenses (Upper Block) | 4.4 |
| 1. Underclay, gray, carbonaceous, slightly silty, plastic | 1.4 |
| Total thickness of section | 26.8 |

*Section 4. Measured in the active strip mine in the NW¼ sec. 32, T. 14 N., R. 6 W.*

| | Feet |
|---|---|
| 6. Coal, black, moderately dull, banded, hard, blocky; contains pyrite lenses (Upper Block) | 3.8 |
| 5. Underclay, gray, slightly silty, carbonaceous, plastic | 2.0 |
| 4. Underclay, gray, hard, slightly sandy, carbonaceous; contains light-gray hard smooth-surfaced irregularly shaped sideritic nodules | 1.4 |
| 3. Shale, gray, soft, silty, carbonaceous | 6.0 |
| 2. Shale, dark-gray, thin-bedded to flaky; contains small ovate hard ferruginous concretions and light-gray fine-grained sandstone laminae | 9.0 |
| 1. Coal, black, moderately dull, banded, hard, slightly pyritiferous, blocky; contains some vitrain lenses as much as 0.05 foot thick and 0.35 foot of bone coal at bottom of bed (Lower Block) | 3.9 |
| Total thickness of section | 26.1 |

*Lower Block Coal.*—The Lower Block Coal is moderately dull, banded, and slabby. It splits easily along the horizontal plane. Two well-developed sets of vertical joints (called slips by miners) trend approximately N. 20° W. and N. 70° E. and range from 0.3 foot up to 2.0 feet apart. These joint patterns allow the coal to be mined in blocks of regular size and shape. This coal bed, the lower of the two commercial block coals of the area, averages 3.3 feet in thickness and ranges from 0.7 foot to 5.8 feet in thickness.

In the mapped area only two outcrops and a core of this coal were observed. Much information about the characteristics and mined areas of this bed was recorded by Ashley (1899, p. 522-596). Many sections of the Lower Block Coal in Ashley's report indicate that a bone coal which is commonly underlain by a soft vitrainous coal and bone coal as much as 3.0 feet thick occurs at the base of the main bed. Generally the main part of the coal rests directly on the bone coal, but locally this coal is separated from the main body of the coal bed by as much as 12 feet of gray shale. Basin structure is particularly apparent in this bed. In the center of the basin the coal generally reaches its maximum thickness and has an underclay or sandy shale floor which is underlain by the lower bone coal. Near the margin of the basin, the underclay thins or is entirely absent, and the main part of the seam rests on the bone coal.

Two measured sections of the Lower Block Coal are shown below.

*Locality 6. Active strip mine of S. L. Turner Coal Co., in the NE¼NW¼ sec. 32, T. 14 N., R. 6 W. (Appendix 1).*

| | Feet |
|---|---|
| 4. Coal, black, moderately bright, banded, slightly pyritiferous; cubic cleavage | 0.70 |
| 3. Coal, black, moderately dull, banded, hard, slightly pyritiferous, blocky; contains some vitrain lenses as much as 0.05 foot thick | 2.60 |
| 2. Bone coal, black, dull, hard, shaly | 0.35 |
| 1. Coal, black, bright, soft | 0.25 |
| Total thickness | 3.90 |

*Locality 80. Indiana Geological Survey core hole, in the NW¼NW¼ sec. 21, T. 13 N., R. 6 W. (Appendix 1).*

| | Feet |
|---|---|
| 3. Coal, black, dull, banded, bony; cubic cleavage | 0.90 |
| 2. Coal, black, predominantly dull, banded, hard, pyritiferous; contains thin vitrain bands | 4.60 |
| 1. Bone coal, black, dull, pyritiferous, shaly | 0.30 |
| Total thickness | 5.80 |

The Lower Block Coal also crops out in an abandoned strip mine, locality 78, in the SE¼NW¼ sec. 19, T. 13 N., R. 6 W. (Appendix 1). The lower coal and bone coal were not exposed at this place.

In mining this seam considerable trouble was experienced with irregularities in thickness and sandy or shaly inclusions in the seam. In deep mining the bone coal generally is left as the floor of the mine. In strip mining the bone coal is not taken; hence a clean, ready-to-use, mine-run product is derived directly from the pit. Two analyses of the Lower Block Coal are included in table 1.

The interval between the Lower Block and Upper Block Coals averages about 25 feet in thickness; it ranges from 13 feet (locality 74, Appendix 1) to 46 feet (locality 7, Appendix 2) and includes shale, sandstone, and underclay. Generally gray hard sandy thin-bedded to massive shale with interbedded light-gray fine-grained sandstone laminae forms the roof of the Lower Block Coal. An exposure of this unit occurs at locality 78 (Appendix 1). Locally the roof is gray to reddish-brown fine-grained shaly sandstone, as in the NE¼NE¼ sec. 32, T. 14 N., R. 6 W., where Otter Creek has broken through into the workings of Lower Block Coal in the old Crawford No. 1 Mine. Although the coal is not visible, the sandstone appears to form the roof.

In the core hole at locality 80 (Appendix 1), 18 feet of dark-gray sandy carbonaceous shale with a few light-gray fine-grained sandy laminae lies above the Lower Block Coal. This combination of sandy shale and fine-grained sandy laminae is known in miners' terms as "fake."

The underclay which forms the floor of the Upper Block Coal is gray to light gray, hard, slightly sandy, and carbonaceous and becomes plastic when moist. This fireclay is mined in conjunction with the Upper Block Coal and is used in the ceramic industry of the Brazil area. Murray and Riely (1954) found three recognizable zones in this underclay; namely, in ascending order, a basal clay-shale zone, a middle nodular zone, and an upper leached zone. The basal clay-shale zone, which locally is white hard fine-grained ganisterlike sandstone, is gradational between the underlying sandy beds and the true underclay.

In the production of a rough grade of structural tile or sewer pipe the basal clay-shale is used. The middle nodular zone, which generally occurs 2.0 feet below the top of the underclay, contains irregular light-gray hard fine-grained pyritic smooth-surfaced siderite nodules and disseminated grains of limonite, magnetite, tourmaline, garnet, and rutile (Murray and Riely, 1954). Because this part of the underclay causes much difficulty when burned, efforts are made at the mine to eliminate this zone before it reaches the factory.

The upper leached zone provides the structural tile industries with high-grade raw material. This part burns to a tan or buff colored, smooth-surfaced, strong building material. Several strip mine operators are now concentrating on clay production and are taking only that coal which is made available in gaining access to the underclay. Some areas from which the coal has been mined are being stripped over to recover the underclay.

The total thickness of the underclay ranges from 2.5 to 14 feet. At the S. L. Turner Coal Co. strip mine in the SW¼NW¼ sec. 32, T. 14 N., R. 6 W., 14 feet of underclay is mined; in the core hole at locality 80 (Appendix 1) only 2.5 feet of underclay was present below the Upper Block Coal.

*Upper Block Coal.*—The Upper Block Coal is a moderately dull, banded, hard, and semisplint coal which exhibits the same structural joint pattern that is observed in the Lower Block Coal. Reddish-orange plant megaspores are present in both the Upper and Lower Block Coals. From field examination it appears that megaspores are more abundant in the Upper Block than in the Lower Block Coal. The Upper Block Coal is the upper of the two commercial block coal beds of the area, averages 3.2 feet in thickness, and ranges from 1.5 to 5.0 feet in thickness. Two distinct benches can be observed in this seam in most places where it is found, and locally a third may be present. About 1.5 feet above the base of the coal bed is a zone of soft flaky coal (fusain) 0.01 to 0.03 foot thick. In mining terms this zone is called the "bench mining" or "bearing-in band"; it divides the coal bed into two benches of unequal thickness.

The lower bench is a moderately dull, banded, and hard coal which tends to break out in small cubes. In most places a joint pattern similar to that described for the Lower Block Coal is present in this bench.

The upper bench is a moderately dull, banded, hard, and blocky coal which displays a vertical joint pattern which may be offset slightly from that of the underlying bench at the "bearing-in band." The coal splits easily along the horizontal bedding planes but is hard to cut along the vertical face. Locally the top few inches of this bench may be a bone coal, but rarely does the bone reach a thickness which causes difficulty in handling the coal.

At the core hole (locality 80, Appendix 1) the Upper Block Coal has a gray carbonaceous shale parting 0.45 foot thick; this parting occurs 0.80 foot from the top of the bed. This is the only locality where this parting was observed. In deep mining, the top bench is usually undercut at the "bearing-in band" and wedged down by the miner. The lower bench is taken up from the floor. Three analyses of the Upper Block Coal are included in table 1.

Basin structure is present in this bed as in the Lower Block Coal. The thickness is more regular, and inclusions of sandstone and shale are not as common as in the Lower Block Coal. The following is a section of the Upper Block Coal from the core hole at locality 80 (Appendix 1).

| | | Feet |
|---|---|---|
| 4. | Coal, black, dull, soft, shaly | 0.80 |
| 3. | Shale, gray, soft, carbonaceous, soapy textured | 0.45 |
| 2. | Bone coal, black, dull, pyritiferous, shaly | 0.25 |
| 1. | Coal, black, moderately dull, banded, pyritiferous | 3.35 |
| | Total thickness of section | 4.85 |

A good exposure of the Upper Block Coal occurs in the S. L. Turner Coal Co. strip mine at locality 7 (Appendix 1).

| | | Feet |
|---|---|---|
| 3. | Coal, black, moderately dull, banded, blocky; contains pyrite lenses | 2.80 |
| 2. | Coal, black, dull, soft, flaky fusainitic | 0.02 |
| 1. | Coal, black, moderately dull, banded, hard; cubic cleavage | 1.00 |
| | Total thickness of section | 3.82 |

The interval between the Upper Block Coal and the Minshall Coal ranges in thickness from 8 feet (locality 27, Appendix 1) to 50 feet (locality 49, Appendix 2) and averages 22 feet in thickness. It includes shale, sandstone, coal, and underclay. The roof of the Upper Block Coal is generally gray hard silty thick-bedded shale as much as 15.0 feet thick, but locally it may be a few inches of gray soft flaky shale overlain by brown or gray hard medium-grained massive sandstone. Locally this sandstone forms the roof of the coal.

Locally a rider of the Upper Block Coal is present from 5.0 to 21.0 feet above the Upper Block Coal. This coal bed ranges from a few inches to 3.0 feet in thickness; is black, moderately bright, banded, and fairly hard; breaks out in small blocks; and contains considerable sulphur. It has been mined extensively in secs. 1 and 2, T. 13 N., R. 7 W. The floor of the coal is a light-gray yellow-stained sandy somewhat plastic underclay 1.5 feet thick. Generally the coal has a brown or gray medium-grained shaly to thin-bedded sandstone roof which grades upward into a gray sandy shale. Locally a gray sandy carbonaceous shale forms the roof. An analysis of the rider of the Upper Block Coal is included in table 1.

The floor of the Minshall Coal is generally 2.5 to 4.0 feet of gray soft plastic carbonaceous underclay. In former years this underclay was mined for making fine ceramic and pottery ware. Locally the underclay is thin and grades downward into a fine-grained shaly carbonaceous sandstone. A pronounced nodular zone such as occurs in the underclay of the Upper Block Coal is not apparent in this bed.

*Minshall Coal.*—The Minshall Coal is moderately bright, banded, and semiblocky and varies considerably in thickness and quality within short distances. Most of the outcrops of this coal observed in the area were badly stained by iron and sulphur. This coal averages 2.7 feet in thickness and ranges from 0.5 foot to 5.7 feet in thickness. Because of the irregular thickness and extent of this bed, particularly along the outcrop zone in the northwestern part of Clay County, only small pockets of the coal have been worked. Large areas of the Minshall Coal have been worked in the northeastern part of Vigo County where the coal ranges from 100 to 200 feet below the surface of the ground. It is reported that in local areas considerable bone coal is present, particularly in the top part of the Minshall Coal bed.

No exposed sections or drill holes have been found in which the Minshall Coal has been actually observed to lie above the rider of the Upper Block Coal. If the Perth Limestone Member is not present, it is difficult to distinguish the Minshall Coal from this rider in the field. Miospore analyses, however, indicate a distinct difference in spore assemblages between these two coal beds and also between the rider and the Upper Block (Guennel, 1958). Because the problem of differentiation still exists in the field and because there is such a small difference stratigraphically between the rider of the Upper Block Coal and the Minshall, areas underlain by the rider coal are included within the coal-extent line bearing the Minshall Coal symbol. An analysis of the Minshall Coal is included in table 1.

*Perth Limestone Member.*—A limestone bed locally forms the roof of the Minshall Coal, but more commonly the limestone is separated from the coal either by blue-gray smooth carbonaceous thin-bedded shale, which in some places is calcareous and fossiliferous, or by black carbonaceous thin-bedded shale. Ashley (1899 and 1909) made numerous references to this limestone, and Wanless (1939) referred to this limestone as the Minshall Limestone and correlated the unit with the Seville Limestone of Illinois and the Curlew Limestone of western Kentucky.

The term Minshall Limestone has been used informally for many years, but it is herein proposed to abandon that name because the stratigraphy at the type locality, the old mining town of

Minshall, Parke County, Ind., has not been well understood and because many miscorrelations have been made in tracing this limestone along its outcrop. The limestone that crops out at Minshall is not the limestone that closely overlies the Minshall Coal, as previously thought, but is a well-developed marine zone in the Staunton Formation approximately 50 feet above the Minshall Coal, as shown by core holes drilled in the vicinity by the Indiana Geological Survey. The name Minshall Coal has priority and has been widely used in northern Clay County and southern Parke County. Only confusion could result from redefinition of the Minshall Limestone, and it is therefore proposed to abandon that name and to name the marine unit that closely overlies the Minshall Coal the Perth Limestone Member of the Brazil Formation. Exposures of the limestone which occur in the now abandoned strip mine of the G. & F. Corp. in the SW¼NE¼ sec. 3, T. 13 N., R. 7 W., Clay County, Ind. (locality 28, Appendix 1), half a mile northwest of the town of Perth, Ind., are herein designated as the type section for this unit. Here the limestone is gray, hard, argillaceous, and fossiliferous; weathers brown; and is 6.3 feet thick. The unit contains a 2.0-foot medial band of blue hard fossiliferous vuggy chert. Crinoid stems make up the bulk of the fossil content. Brachiopods, bryozoans, fusulines, and pelecypods also are present.

The Perth Limestone Member lies 0.2 foot to 15.0 feet above the Minshall Coal and 3.0 to 15.0 feet below Coal II, which lies near the top of the Brazil Formation. The limestone is commonly overlain by gray shale or sandstone and underlain by dark-gray or black shale. This limestone ranges from 0.5 foot to 19.0 feet in thickness, but it is locally absent. This absence is due in some places to nondeposition and in others to erosion. Gray soft locally calcareous and fossiliferous shale at the stratigraphic position of the Perth Limestone Member indicates that the limestone probably is missing owing to nondeposition; gray or brown fine- to medium-grained sandstone, which is calcareous in some places, indicates that the limestone is absent owing to erosion.

Although numerous miscorrelations of the Perth Limestone Member with the stratigraphically higher limestones of the Staunton Formation appear to have been made, either the Perth Limestone Member or a limestone occupying about the same stratigraphic position has been recognized from central Warren County southward through Fountain County (Alexander, 1943), Parke and Clay Counties (Ashley, 1899), into Owen County (Kottlowski, 1959). In southern Indiana, in southeastern Daviess County and southern Spencer County (Schweers, 1940), a limestone bed which occupies approximately the same stratigraphic position as the Perth Limestone Member of the northern part of the coal field has been recognized. In Spencer County the probable correlative to the Perth is the limestone which overlies the Buffaloville Coal (of local usage only) (Franklin and Wanless, 1944, and Hutchison, 1959).

*Coal II.*—Coal II is a black, moderately bright, banded, hard, and pyritiferous coal which ranges from 0.5 foot to 1.6 feet in thickness and is irregularly distributed. The roof is dark-gray carbonaceous shale or brown to gray fine-grained sandstone, and the floor is gray to greenish-gray sandy carbonaceous underclay. Coal II has not been mined commercially in the area.

### STAUNTON FORMATION

The Staunton Formation, proposed by Cumings (1922, p. 525), was named for the town of Staunton, Clay County, Ind., and originally included the rocks between the erosional disconformity above Coal II and the stratigraphic break above Coal IV. Wier (1950) restricted the Staunton Formation to include the rocks between the disconformity above Coal II and the disconformity above Coal III.

In the Brazil Quadrangles the Staunton Formation ranges from 74 to 104 feet in thickness and consists of shale, sandstone, underclay, coal, and limestone. With the exception of approximately the lower 15 feet, the entire formation crops out along Little Creek in secs. 9 and 17, T. 13 N., R. 7 W. The following measured sections indicate the stratigraphy of most of the Staunton Formation.

*Section 5. Measured along Little Creek in secs. 9 and 17, T. 13 N., R. 7 W.*

| | Feet |
|---|---|
| 20. Coal, black, moderately bright, banded, hard, pyritiferous; divided into three benches by a thin pyrite parting 2.0 feet above base of bed and a shaly carbonaceous parting 3.2 feet from base of bed (Coal III) | 5.2 |
| 19. Underclay, gray, sandy, carbonaceous, plastic to shaly | 3.2 |
| 18. Shale, gray, carbonaceous, sandy; interbedded with gray to brown fine- to medium-grained sandstone | 15.0 (approx.) |
| 17. Limestone gray, hard, fine-grained to silty, slightly fossiliferous | 1.0 |
| 16. Shale, black, carbonaceous, fissile | 2.0 |
| 15. Coal, black, moderately bright, banded, hard, pyritiferous | 1.6 |
| 14. Underclay, gray, hard, sandy, carbonaceous | 1.0 |
| 13. Shale, gray, soft, sandy, carbonaceous | 5.5 |
| 12. Limestone, gray, soft, fine-grained, fossiliferous, shaly | 0.3 |

| | | |
|---|---|---|
| 11. | Shale, black, carbonaceous, fissile | 2.0 |
| 10. | Coal, black, moderately bright, banded, pyritiferous | 1.4 |
| 9. | Underclay, gray, sandy, carbonaceous, shaly | 1.5 |
| 8. | Shale, gray, soft, sandy, carbonaceous; contains thin lenses of sandstone | 6.5 |
| 7. | Shale, black, carbonaceous, fissile | 2.2 |
| 6. | Coal, black, moderately bright, banded, pyritiferous; cubic cleavage | 1.3 |
| 5. | Underclay, gray, soft, carbonaceous | 2.0 |
| 4. | Shale, gray, soft, carbonaceous, thin-bedded | 7.0 |
| 3. | Coal, black, moderately bright, banded, pyritiferous; cubic cleavage | 0.2 |
| 2. | Underclay, white, soft, plastic | 0.9 |
| 1. | Limestone, gray, hard, silty, slightly fossiliferous | 0.4 |
| | Total thickness of section | 60.2 |

*Section 6. Measured in the abandoned strip mine in the SE¼SW¼ sec. 4, T. 13 N., R. 7 W., locality 30 (Appendix 1). The limestone of Section 5, unit 1, probably is correlative with the limestone of Section 6, unit 4.*

| | | *Feet* |
|---|---|---|
| 15. | Limestone, gray to blue, hard, silty, slightly fossiliferous; weathers brown | 1.2 |
| 14. | Shale, black, soft, carbonaceous, blocky | 1.0 |
| 13. | Shale, black, hard, carbonaceous, fissile | 1.2 |
| 12. | Shale, gray, soft, sandy, carbonaceous | 0.6 |
| 11. | Coal, black, moderately bright, banded, hard, pyritiferous | 1.1 |
| 10. | Shale, gray, carbonaceous, sandy | 0.5 |
| 9. | Shale, gray, soft, carbonaceous, plastic | 4.0 |
| 8. | Shale, gray, sandy, carbonaceous, thin-bedded | 1.2 |
| 7. | Shale, black, carbonaceous, blocky to fissile | 1.6 |
| 6. | Coal, black, moderately bright, banded, hard, pyritiferous, slightly blocky | 1.8 |
| 5. | Underclay, gray, somewhat sandy, carbonaceous, shaly | 2.0 |
| 4. | Limestone, gray, hard, silty, conglomeratic | 0.3 |
| 3. | Shale, dark-gray, clayey, carbonaceous, thin-bedded | 0.8 |
| 2. | Shale, light-gray, sandy, thin-bedded; contains limey concretions; becomes carbonaceous toward bottom | 5.5 |
| 1. | Coal, only top surface of coal exposed in pit floor | — |
| | Total thickness of section | 22.8 |

It is estimated that Coal II occurs 10 to 15 feet below the lowest coal in the above section. In the core drill hole at locality 41 (Appendix 1) the interval between Coal II and the next coal above is 15.0 feet and consists of shale, clay-shale, and underclay. Locally this interval is composed of interbedded shale and sandstone.

The coal beds and limestones of the lower part of the Staunton Formation are very irregular both in thickness and extent. Some mining, by both strip- and deep-mining methods, has been carried on along the outcrops of these coals. Drill-hole records throughout the western part of the Brazil West Quadrangle show the presence of these coal beds, but nowhere was a bed more than 2.0 feet thick indicated. An analysis of one of these coals is included in table 1.

The underclay of Coal III is gray, sandy, plastic, and locally shaly. In many places it averages 5.0 feet in thickness. It is not used commercially in this area.

Coal III, the uppermost coal bed of the Staunton Formation, is black, bright to moderately bright, banded, hard, and pyritiferous and averages 5.2 feet in thickness in the Brazil West Quadrangle. Locally it reaches a maximum thickness of 7.9 feet (locality 63, Appendix 1). The coal is made up of alternating shiny and dull bands and contains considerable pyrite, both as disseminated grains and lenses and as persistent bands. In mining the seam breaks out in small cubes.

The bed is divided into three benches by a thin pyrite parting about 2.0 feet above the base of the coal and by another carbonaceous pyritiferous shale parting approximately 1.5 to 2.0 feet below the top of the coal. An analysis of a channel sample of Coal III is given in table 1.

The roof of Coal III is generally a gray flaky to thin-bedded slightly sandy carbonaceous shale ranging from a few inches to 8.0 feet in thickness. Locally, depending upon the position of the erosional unconformity that marks the top of the Staunton Formation, the roof of Coal III is a sandstone which lies at the base of the overlying Linton Formation. In this area the shale roof holds up well, but the sandstone, although it provides a good roof when fresh, tends to break up and cave when exposed to the atmosphere.

### LINTON FORMATION

The Linton Formation was named by Wier (1950) from exposures of shale, sandstone, underclay, coal, and limestone along Lattas Creek 4 miles north of Linton, Greene County, Ind. The formation includes the rocks in the interval between the disconformity above Coal III and the disconformity above Coal IV. The formation averages 65 feet in thickness at the type locality, but in the Brazil West Quadrangle the Linton Formation is represented only by approximately 30 feet of rocks; the upper part has been eroded.

*Section 7. Lower part of the Linton Formation, measured in the SE¼SE¼ sec. 7, T. 13 N., R. 7 W. (locality 35, Appendix 1).*

| | | Feet |
|---|---|---|
| 8. | Shale, gray, slaty; weathers to a soft reddish shale | 3.7 |
| 7. | Shale, black, carbonaceous, fissile; contains dark-gray hard silty carbonaceous oval-shaped concretions at the base | 2.0 |
| 6. | Coal, black, bright, banded; contains gray clayey carbonaceous medial parting, 0.05 foot thick (Coal IIIa) | 1.1 |
| 5. | Underclay, gray, soft, slightly sandy, carbonaceous | 4.0 |
| 4. | Shale, gray, soft, sandy; contains brown soft sandstone lenses | 7.1 |
| 3. | Sandstone, brown, soft, friable, micaceous, ferruginous, shaly | 4.0 |
| 2. | Shale, gray, soft; contains sandy lenses and carbonized plant remains | 2.0 |
| 1. | Coal III, only top 0.6 foot exposed above creek level | — |
| | Total thickness of section | 23.9 |

A gray to brown friable fine- to medium-grained micaceous massive sandstone with a maximum thickness of 15.0 feet lies at the base of the Linton Formation generally overlying the shale of the Staunton Formation which forms the roof of Coal III. Locally the sandstone forms the roof of Coal III. This sandstone grades upward into about 8.0 feet of gray sandy shale interbedded with gray to brown soft carbonaceous sandstone. Above this unit is a gray to light-gray slightly sandy carbonaceous plastic underclay which forms the floor of Coal IIIa.

Coal IIIa is a thin bright banded pyritiferous coal bed which contains a medial parting of light-gray carbonaceous clay-shale. Coal IIIa averages 1.0 foot in thickness, and it ranges from 0.5 foot to 2.0 feet in thickness. It is not mined commercially in the area.

Overlying the coal bed is a black carbonaceous somewhat fissile shale which locally contains dark-gray hard silty ferruginous carbonaceous concretions at its base. These concretions, commonly called coal balls, reach a maximum diameter of 3.0 feet. They tend to be flattened along a horizontal plane. The shale ranges from 2.0 to 4.0 feet in thickness and has a badly weathered reddish-brown fossiliferous limestone 0.4 foot thick overlying it. An outcrop of the limestone occurs in the NW¼SW¼ sec. 8, T. 13 N., R. 7 W. (locality 39, Appendix 1), where it is represented by a highly weathered reddish-brown soft clayey slightly calcareous fossiliferous zone 0.5 foot thick.

The remainder of the Linton Formation in the Brazil West Quadrangle is approximately 10.0 feet of gray somewhat sandy soft shale interbedded with brown soft carbonaceous sandstone.

An exposure of this unit occurs in the gully beside the bridge across Otter Creek in the NE¼SE¼NE¼ sec. 25, T. 13 N., R. 8 W.

## PLEISTOCENE SERIES

The Brazil Quadrangles are almost entirely covered by unconsolidated surficial deposits of Pleistocene age; Kansan, Illinoian, and Wisconsin Stages of glaciation and the Recent Stage are represented. The sediments consist of till, silt, sand and gravel, and windblown sand and range from a few feet to 110 feet in thickness (Appendix 3).

The Kansan deposits are the oldest Pleistocene deposits exposed in the area (pl. 1). Approximately 1 foot of pinkish-gray silty to sandy pebbly Kansan till occurs in the west bank of the small tributary of North Branch Otter Creek in the SW¼SE¼ sec. 5, T. 13 N., R. 7 W. In the active strip mine in the NE¼NW¼ sec. 2, T. 13 N., R. 7 W., several feet of Kansan till is exposed in the highwall. In the south bank of Otter Creek in the NW¼SW¼ sec. 27, T. 13 N., R. 7 W., approximately 7.0 feet of Kansan till is exposed. Another outcrop of possible Kansan age is exposed in the abandoned strip-mine highwall in the NW¼SE¼ sec. 5, T. 13 N., R. 6 W., but the overlying sand and gravel deposits make positive identification impossible.

Till of the Illinoian Stage covers most of the area and averages 30 feet in thickness. A rather extensive outwash plain of Illinoian age is present in secs. 11, 12, 13, 14, 15, 16, 21, 22, and 23, T. 13 N., R. 7 W., and in secs. 7 and 8, T. 13 N., R. 6 W. Because the boundary of this outwash is diffuse and obscure, it is not shown on the map. Two well-developed boulder pavements, indicating two possible local recessions and readvancements of the ice during Illinoian time, are present in the highwall of the abandoned strip mine of the Lone Star Coal Co. in the NW¼NE¼ sec. 20, T. 13 N., R. 7 W.

Although the ice did not cover the Brazil Quadrangles during the Wisconsin Stage, outwash sand and gravel of the Wisconsin Stage was deposited by melt water as a valley train in Raccoon Creek valley. As much as 17.0 feet of windblown sand and silt mantle the hills adjacent to the valley on the southeast.

Water-laid sand, silt, and mud of the Recent Stage, derived mostly from the Illinoian till, form a thin veneer of alluvium on the surface of most creek valleys in the area. These deposits rarely exceed 15 feet in thickness, and in the upper reaches of the smaller tributaries are too thin to be readily identified and mapped.

## THE BEDROCK SURFACE

The bedrock surface, now almost completely covered by surficial materials of Pleistocene age, is one of rugged topography caused by erosional processes of pre-Pleistocene age. Little or no surface expression of this underlying topography is visible; hence coal drillings, water wells, and seismic shots (Appendixes 1 and 3) are the main sources of information concerning this topography.

An extensive bedrock-valley system (fig. 2) commencing in the northwestern part of the Brazil East Quadrangle, flowing southwestward through the Brazil West Quadrangle, and passing out of the area in the southwestern part of that quadrangle is filled with glacial deposits of Kansan and Illinoian age as much as 110 feet thick. The Illinoian outwash plain mentioned above (p. 25) tends to follow the outline of this buried valley. The main channel of the buried Montclair Valley (Wayne, 1956, p. 43-44) passes through the extreme northwest corner of the Brazil West Quadrangle, and major tributaries of this valley are present along the west and north edges of the mapped area. The headwater area of another buried valley which flowed southward is present in the southwestern part of the Brazil East Quadrangle.

As can be seen on plate 2 these buried-valley systems affected to a considerable degree the mineable areas of coal. The coal-extent lines of the Lower Block, Upper Block, Minshall, and Coal III beds also indicate the size, shape, and course of these valleys.

## STRUCTURAL GEOLOGY

### REGIONAL STRUCTURAL GEOLOGY

The Brazil Quadrangles lie on the northeast edge of the Eastern Interior Coal Basin, the center of which lies 120 miles to the southwest. The regional dip of the Pennsylvanian rocks is southwest at an average rate of 35 to 45 feet per mile. The surface of any given stratigraphic unit is an irregular one characterized by anticlinal noses, synclinal troughs, and closed basin and domal structures with a maximum relief of 50 feet. This is particularly apparent in the Mansfield and Brazil Formations.

Faults with vertical displacements as much as 40 feet have been reported in the area (Ashley, 1899), but lack of information has prevented detailed mapping of these features. In the Brazil Block coal field any irregularity or absence of a coal bed, whether structural, erosional, or depositional in origin, is termed a "fault" by the miner.

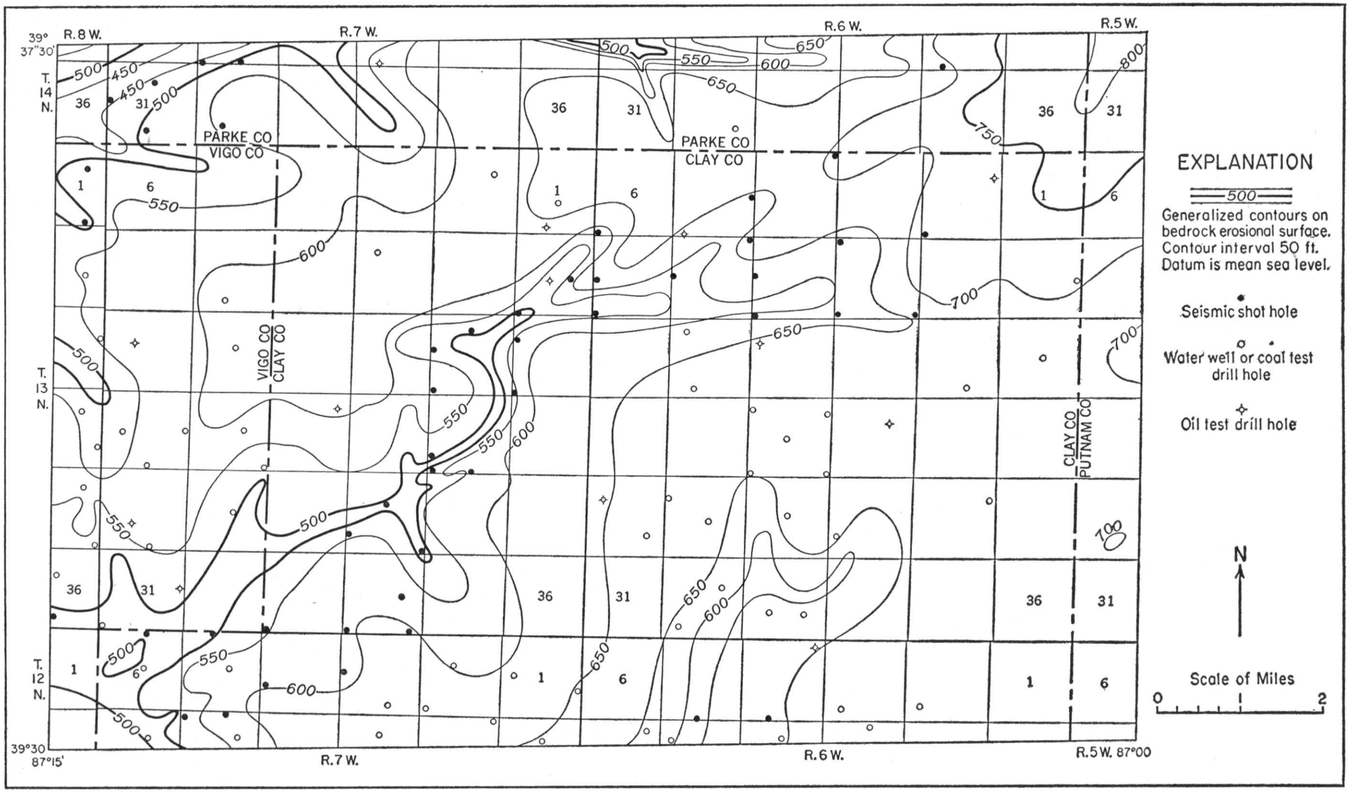


Figure 2.—Bedrock topographic map of the Brazil Quadrangles.

## LOCAL STRUCTURAL GEOLOGY

The top of the Upper Block Coal is contoured on the economic geology map (pl. 2). The Upper Block Coal has two westward-plunging synclinal troughs with local relief of 40 feet superimposed on the general westerly dip of the beds. The intervening anticlinal ridge is broad and gentle and has several minor flexures including closed domes and basins.

Most of the shaft mines of the area were sunk in the lower parts of troughs, and thus in most mines the added expense of pumping water away from the working faces was eliminated. Two of the shaft mines, the Delacci (locality 20, Appendix 2) and the Nickel Plate No. 1 (locality 67, Appendix 2), were sunk in the center of completely closed basins. A 40-foot reversal of dip is present on the Upper Block Coal in sec. 21, T. 13 N., R. 6 W., and a number of mines were sunk to both the Upper and Lower Block Coals in that section (pl. 2). Another broad and more shallow basin structure is present in secs. 5 and 6, T. 13 N., R. 6 W., into which several mines were sunk.

Most of these structural features are reflections of somewhat similar structures in the immediately underlying beds, and in many places these features are reflected into the overlying beds. For example, the Lower Block Coal generally is deformed similarly to the Upper Block Coal but in many areas shows even greater irregularities. The notable flexures of the Upper and Lower Block Coals probably are not reflections of deeper lying structures in the Mississippian or Devonian rocks but are merely the result of differential compaction over the underlying sandstone and shale of the Mansfield Formation.

In the south-central part of the Brazil West Quadrangle the structure contours on the Upper Block Coal are based on drilling and mining information on the Minshall Coal. These projected contours fit nicely with the information on the Upper Block Coal to the east and north; this fact indicates that the Minshall Coal may be deformed similarly to the Upper Block Coal. Coal III is contoured in the western part of the Brazil West Quadrangle.

### LOCAL GEOLOGIC STRUCTURES

Extremely local irregularities of the coal beds and associated strata are found in the highwalls of many of the strip mines in the area. These structural features can be attributed, for the most part, to thrusting by glacial ice, differential compaction, and slumping and flowing of the sediments while yet unlithified.

Thrusting action by glacial ice generally affects only the top few feet of the bedrock. Pressures from flowing ice may cause gouged-out places in an otherwise fairly regular bedrock surface. Thrust faulting in beds immediately underlying the glacial cover is in some places due to ice thrusting. This action may result in a repetition of beds and can be ascertained in most places by the inclusion of glacial materials between the beds along the plane of thrusting (fig. 3a). Chatter marks or glacial striae on the top surface of the more resistant strata are common.

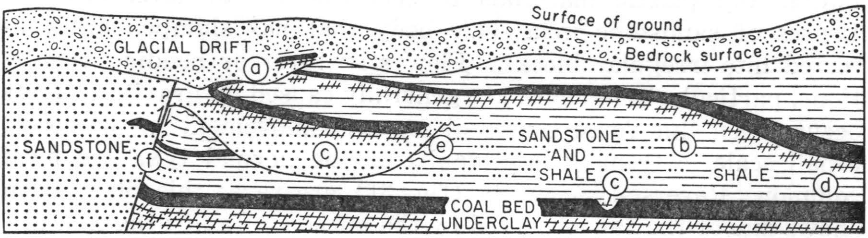


Figure 3.—Sketch of local geologic structures associated with coal beds. Based on observations in the Log Cabin Coal Co. strip mine 1 mile north of Brazil. (Not to scale)

(a) Thrust faulting and gouged-out depression caused by glacial-ice movement.
(b) Lateral gradation from sandstone and shale to shale.
(c) Postdepositional channeling with subsequent filling of sand and shale.
(d) Thinning of bed and a minor local flexure due to differential compaction.
(e) Bedding contortions in shale caused by slumping and flowing.
(f) Fault showing bedding drag along fault plane.

Local lateral variation in character of sediments is one of the major causes of structural irregularities that are developed by differential compaction or by slumping and flowing of unconsolidated sediments. Lateral gradation (fig. 3b) from shale to sandy shale to sandstone is common and may be seen in the highwalls of many strip pits. More abrupt lithologic variation is the result of penecontemporaneous cut-and-fill action or postdepositional channeling and filling with a different sediment (fig. 3c). Because of the difference in compaction of different sediments, local lateral variations such as these influence the structure of overlying beds.

Differential compaction is a complex phenomenon which involves many forces and results in a variety of structural irregularities. Among the most important of the factors controlling differential compaction are the weight load applied from above by subsequent deposition, the lithology of the beds being compacted, and the irregular surface and different lithologies of the underlying beds. It is difficult, if not impossible, to determine, in any given place, which of the above conditions is the main cause of the results obtained. In most places a combination of conditions is evident. Some of the results of differential compaction are domal and basinal structures, thinning of beds due to squeezing action, faulting, and variously shaped minor and generally local flexures in otherwise almost flat-lying beds (fig. 3d). The latter is particularly common in the area studied.

Slumping and flowing appear to have occurred while the sediments were yet unlithified (fig. 3e). These conditions are almost entirely the result of gravity; that is, a tendency of all liquid, semiliquid, and plastic materials to seek the lowest level possible. Lenses of sandstone in a shale body that has slumped are contorted into irregular blocks. Flow structures or bedding contortions, particularly in shale, are generally caused by gravity. Faults occur when this force causes differential movement in the rocks. Small scale, extremely local faults of the normal type are most common. Reverse-type faults (fig. 3f) are rare; this illustration shows one of the few observed by the author. Fault drag and distortion of the normal bedding planes of the rocks adjacent to the fault plane in most places accompany both normal and reverse-type faulting.

## HISTORY OF COAL MINING

Ashley (1899, p. 3) stated that the Block coals of Clay County were first discovered in 1851 in a well on the Huff place in sec. 16, T. 11 N., R. 6 W., about 10 miles southeast of Brazil, Ind. At about the same time Block coal was discovered in the bed of Otter Creek just north of Brazil. Coal was first produced and shipped from that point in 1852. Richard Owen (1862, p. 169) located and described the Brazil shaft mine which was near the site of the present Pennsylvania Railroad station in Brazil. By 1869 (Cox, 1869, p. 36-71) numerous mines were operating in the Block coals, particularly along Otter Creek and its tributaries. It has been reported that during that year the Brazil Block Coal Co. opened the Gart No. 1 shaft mine, which operated for about 25 years in the Upper and Lower Block Coals.

By 1900 many of the smaller mines had been worked out and abandoned, but large mines in the Block coals dotted the area north of Brazil. Strip mining, particularly in the stream valleys where the coal is shallow and has soft, easily removed overburden above it, was employed in the Block coal field at about this time.

During the 1890's the Block coals around Carbon, Ind., in the northwestern part of the Brazil East Quadrangle, were being explored and developed. Also the coals in the Diamond area of south-central Parke County were being mined by the Zeller-McClelland Co., the Brazil Block Coal Co., and the Standard Block Coal Co.

As these mines were worked out and abandoned during the early 1900's, the deeper Block coal to the west was explored and developed by such companies as the Diamond Block Coal Co., the McClelland Block Coal Co., the Crawford Coal Co., and the Coal Bluff Mining Co. During this period the Block coals of northeastern Vigo County, which are as much as 250 feet deep, were being mined by the Otter Creek Coal Co. and the Coal Bluff Mining Co.

In 1907 the Coal Bluff Mining Co. opened the Minshall Mine in sec. 7, T. 13 N., R. 7 W. (locality 31, Appendix 2) ; in the following 14 years this mine produced almost a million and a half tons of coal. The Monkey Mine (locality 51, Appendix 2) and the Crawford No. 1 Mine (locality 52, Appendix 2), both in sec. 7, T. 13 N., R. 7 W., were worked for several years in the Minshall seam.

Coal III has been mined in the Coal Bluff area for many years. The Coal Bluff Mining Co. opened the Peerless Mine (locality 32, Appendix 2) in 1892, operated it for 14 years, and produced more than half a million tons of Coal III. During this time the Victor and Star Mines also were producing considerable tonnages of Coal III.

Farther south along the west edge of the Brazil West Quadrangle many small diggings in Coal III were operated, and in 1901 the Miami Coal Co. began operation in this seam. Along the south edge of the Brazil West Quadrangle, Coal III was being worked in the Turner field. The Vandalia Coal Co. and the Brazil District Mining Co. were two of the larger companies of this field.

Since 1920 a gradual decline in the employment of the deep-mining method of coal production in this area has been noted. Production of the Lower Block Coal by deep-mining methods ceased in 1934 with the abandonment of the Price Mine (locality 62, Appendix 2). Deep mining of the Upper Block Coal stopped with the abandonment of the Winn Mine (locality 46, Appendix 2) in 1951. Deep mining in the Minshall Coal ceased with the abandonment of the Rio Grande No. 2 Mine (locality 57, Appendix 2) in 1947. Deep-mine production of Coal III ended with the closing of the

Nickel Plate No. 2 Mine (locality 92, Appendix 2) in 1924. At the present time no deep mines are operating in the area.

Strip mining has been the most prominent method of mining since the late 1920's and is today the only method employed. The Campbell Coal Co., G. & F. Coal Corp., Log Cabin Coal Co., Lone Star Coal Co., Ren Coal Co., and the S. L. Turner Coal Co. are presently engaged in strip mining coal in this area.

## COAL SAMPLING AND ANALYSES

All coal samples shown in table 1, except for the Minshall Coal sample from the Monkey Mine, were collected by the author, and the analyses were made by the Indiana Geological Survey. Carefully controlled channel samples were collected in the strip mines as soon as possible after the coal was broken at the working face. The cored samples were split and stored immediately after measurements had been completed. Dirty bands three-eighths inch or more in thickness were not included in the samples. The samples of coal were placed in 5-gallon airtight aluminum containers, which were not opened again until the analysis was to be run. Hence the underground characteristics of the coal were preserved as much as possible.

Proximate analyses, percentages of sulphur, and heat determinations were run on all samples according to standard methods. These analyses are not average for each seam listed but are merely the analyses of the coals at the specific locations.

## COAL RESERVES

The coal reserves of the Brazil Quadrangles were calculated by standard methods. County boundaries were used to divide the quadrangles into three parts, and reserves were estimated for the Lower Block Coal, Upper Block Coal, Minshall Coal, and Coal III for each of the counties. An average thickness of each of the coal beds was obtained from thicknesses at outcrops, in drill holes, and in deep mines of the area. An average specific gravity of 1.32 was assumed for the coals of the area, and the following formula was used to calculate reserves: Area (acres) x average thickness (feet) x 1,800 (tons per acre-foot) = reserves (tons).

The coal reserves are further divided according to amount of overburden. Coal III is divided into two categories: (1) coal which is less than 90 feet deep and which is considered available for strip mining under present economic conditions and (2) coal which lies more than 90 feet below the surface. Because of irregularities in

Table 1.—*Analyses of samples from coal beds in the Brazil Quadrangles*
(as received basis)

| Coal bed | Source of sample | Location | | | Moisture | Ash | Volatile matter | Fixed carbon | Sulphur | B.t.u. | Kind of sample |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sec. | T. (N.) | R. (W.) | | | | | | | |
| III | Lone Star Coal Co. | 20 | 13 | 7 | 14.5 | 18.6 | 33.7 | 33.3 | 6.2 | 9,537 | channel |
| * | Indiana Geological Survey Drill hole 17 (Appendix 1, locality 41) | 8 | 13 | 7 | 9.9 | 17.4 | 38.7 | 34.0 | 4.4 | 10,420 | 2-inch core |
| Minshall[1] | Vandalia Coal Co. Monkey Mine (Appendix 3, locality 51) | 17 | 13 | 7 | 13.1 | 8.3 | 36.8 | 41.8 | 2.6 | 11,480 | channel |
| rider of Upper Block | Indiana Geological Survey Drill hole 18 (Appendix 1, locality 80) | 21 | 13 | 6 | 11.3 | 14.6 | 35.5 | 38.7 | 4.6 | 10,761 | 2-inch core |
| Upper Block | Indiana Geological Survey Drill hole 18 (Appendix 1, locality 80) | 21 | 13 | 6 | 16.4 | 7.5 | 32.5 | 43.6 | 1.4 | 11,144 | 2-inch core |
| Lower Block | Indiana Geological Survey Drill hole 18 (Appendix 1, locality 80) | 21 | 13 | 6 | 11.2 | 15.1 | 34.4 | 39.3 | 2.3 | 10,511 | 2-inch core |
| Upper Block | G. & F. Coal Corp. Hickory No. 2 Mine (Appendix 1, locality 2) | 35 | 14 | 7 | 14.0 | 4.7 | 30.3 | 51.1 | 1.5 | 10,657 | channel |
| Upper Block | S. L. Turner Coal Co. (Appendix 1, locality 7) | 32 | 14 | 6 | 14.2 | 6.4 | 33.0 | 46.4 | 2.3 | 11,551 | channel |
| Lower Block | S. L. Turner Coal Co. (Appendix 1, locality 6) | 32 | 14 | 6 | 15.6 | 4.4 | 30.8 | 49.2 | 0.9 | 11,440 | channel |

* Unnamed coal 28.0 feet below Coal III in the Staunton Formation.

[1] The analysis of the Minshall Coal is taken from U. S. Bur. Mines Tech. Paper 417, 1927, Analyses of Indiana Coal, p. 28, Lab. No. 26124. The remaining analyses are from samples collected and analyzed by the Indiana Geological Survey. Analyst, Louis V. Miller.

Table 2.—*Coal reserves of the Brazil Quadrangles as of January 1960*
(in thousands of short tons)

| Coal bed | Part of county | Original reserves | | Average thickness (feet) | Over-burden (feet) | Mined and lost in mining as of January 1960 | | | | | Remaining reserves | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Strip mines | | Deep mines | | Total tons | Measured | | Indicated | | Inferred | | Total tons |
| | | Acres | Tons | | | Acres | Tons | Acres | Tons | | Acres | Tons | Acres | Tons | Acres | Tons | |
| III | Vigo | 4,567 | 42,747 | 5.2 | 0-90 | 463 | 4,334 | 870 | 8,143 | 12,477 | 1,941 | 18,168 | 359 | 3,360 | 368 | 3,444 | 24,972 |
| | | | | | 90-105 | — | — | 284 | 2,658 | 2,658 | 282 | 2,640 | — | — | — | — | 2,640 |
| III | Clay | 597 | 5,587 | 5.2 | 0-90 | 39 | 365 | 302 | 2,845 | 3,210 | 254 | 2,377 | — | — | — | — | 2,377 |
| Minshall | Vigo | 6,478 | 31,483 | 2.7 | 60-200 | — | — | 918 | 4,461 | 4,461 | 1,510 | 7,339 | 1,118 | 5,433 | 2,932 | 14,250 | 27,022 |
| Minshall | Clay | 13,746 | 66,806 | 2.7 | 0-60 | 244 | 1,186 | 117 | 569 | 1,755 | 2,123 | 10,318 | 1,171 | 5,691 | 2,667 | 12,962 | 28,971 |
| | | | | | 60-150 | — | — | 451 | 2,192 | 2,192 | 1,854 | 9,010 | 1,692 | 8,223 | 3,427 | 16,655 | 33,888 |
| Minshall | Parke | 1,156 | 5,618 | 2.7 | 0-60 | 42 | 204 | 21 | 102 | 306 | 318 | 1,545 | 251 | 1,220 | 107 | 520 | 3,285 |
| | | | | | 60-140 | — | — | — | — | — | — | — | — | — | 417 | 2,027 | 2,027 |
| Upper Block | Vigo | 5,253 | 30,258 | 3.2 | 60-215 | — | — | 476 | 2,742 | 2,742 | 695 | 4,003 | 656 | 3,779 | 3,426 | 19,734 | 27,516 |
| Upper Block | Clay | 20,373 | 117,348 | 3.2 | 0-60 | 752 | 4,332 | 1,144 | 6,589 | 10,921 | 3,646 | 21,001 | 2,184 | 12,580 | 445 | 2,563 | 36,144 |
| | | | | | 60-190 | — | — | 1,475 | 8,496 | 8,496 | 3,054 | 17,591 | 2,448 | 14,100 | 5,225 | 30,096 | 61,787 |
| Upper Block | Parke | 4,143 | 23,864 | 3.2 | 0-60 | 162 | 933 | 239 | 1,377 | 2,310 | 673 | 3,876 | 406 | 2,339 | 1,255 | 7,229 | 13,444 |
| | | | | | 60-160 | — | — | 267 | 1,538 | 1,538 | 293 | 1,688 | 325 | 1,872 | 523 | 3,012 | 6,572 |
| Lower Block | Vigo | 1,337 | 7,942 | 3.3 | 60-240 | — | — | 18 | 107 | 107 | 25 | 149 | 26 | 154 | 1,268 | 7,532 | 7,835 |
| Lower Block | Clay | 20,479 | 121,646 | 3.3 | 0-60 | 106 | 630 | 637 | 3,784 | 4,414 | 1,390 | 8,257 | 768 | 4,562 | 1,357 | 8,061 | 20,880 |
| | | | | | 60-210 | — | — | 2,028 | 12,046 | 12,046 | 4,926 | 29,260 | 2,672 | 15,872 | 6,595 | 39,174 | 84,306 |
| Lower Block | Parke | 3,954 | 23,487 | 3.3 | 0-60 | 19 | 113 | 267 | 1,586 | 1,699 | 445 | 2,643 | 482 | 2,863 | 534 | 3,172 | 8,678 |
| | | | | | 60-180 | — | — | 682 | 4,051 | 4,051 | 482 | 2,863 | 505 | 3,000 | 538 | 3,196 | 9,059 |
| Total | | 82,083 | 476,786 | | | 1,827 | 12,097 | 10,198 | 63,286 | 75,383 | 23,911 | 142,728 | 15,063 | 85,048 | 31,084 | 173,627 | 401,403 |

thickness, which limit somewhat the depth of economical strip mining, the Minshall, Upper Block, and Lower Block coals were divided into coal less than 60 feet deep and coal more than 60 feet below the surface.

The coal reserves are further divided into three parts: measured, indicated, and inferred. Measured reserves are those reserves which lie within a radius of one-eighth mile of any observation point. Indicated reserves are those reserves which lie between radii of one-eighth and a quarter of a mile of any observation point. Inferred reserves are those reserves which lie between radii of a quarter of a mile and half a mile. Because of the irregular nature of the coals of the area, that coal which lies beyond a radius of half a mile from observation points was not included in the reserve calculations.

Table 2 presents in thousands of short tons the reserve categories mentioned above and also lists the tons of coal that have been mined and lost in mining to January 1960. Tonnage figures of mined areas do not agree with actual production figures of the abandoned mines in Appendix 2 because recovery of deep-mined coal is about 50 percent. In strip mining about 15 percent of the available coal is lost in mining.

## OTHER RESOURCES

In addition to coal and underclay, the Brazil Quadrangles have other mineral resources of economic importance. These are limestone, sandstone, shale, sand and gravel, water, and possibly oil and gas.

### LIMESTONE

The Perth Limestone Member has been quarried and crushed for use as road metal in the NW¼NW¼ and in the SW¼SW¼ sec. 10, T. 13 N., R. 7 W. (pl. 2). This limestone crops out at a number of places in the Brazil West Quadrangle and lies close to the surface at a minable depth over a considerable area. At most places where observed it contains chert as scattered irregular masses throughout the bed and at some localities as a medial parting 1.0 foot or more thick. From information available this limestone does not contain a sufficient percentage of lime to meet the specifications required for agricultural lime, but it is excellent road-metal material.

The limestones of the Staunton Formation and the Mansfield Formation are for the most part extremely silty and break down easily. They are thin and only locally developed and therefore have little, if any, economic importance.

### SANDSTONE

Sandstone of the Mansfield Formation has been quarried on a small scale at a number of locations in the eastern half of the Brazil East Quadrangle for use in bridge- and building-foundation construction. This sandstone crops out in stream valleys and road cuts in the area, and thus easy and inexpensive prospecting and sampling are possible. Sandstone has been quarried 1 mile northeast of Lena, Ind., in the northeast corner of the Brazil East Quadrangle, for use as a glass sand. In the eastern half of sec. 31, T. 13 N., R. 5 W. (pl. 2) a small amount of this sandstone was quarried.

### SHALE

Some of the shale beds of Pennsylvanian age in the Brazil Quadrangles are suited for a variety of uses; among these are rock-wool insulation material, rough tile and face-brick material, and a raw material for manufacturing cement.

The shales occur in outcrops and near-surface deposits in the area, and thus easy and inexpensive prospecting and sampling are possible. About 1 mile southwest of Brazil the shale overlying the Minshall Coal was produced from a small strip mine for use in rock-wool production. A few miles south of Brazil this same shale bed is being mined for use in the cement industry.

### SAND AND GRAVEL

Abandoned sand and gravel pits are found in secs. 10 and 11, T. 13 N., R. 6 W., and in secs. 12, 35, and 36, T. 13 N., R. 7 W. (pl. 2). Recently a small amount of sand was removed from a hill in the SW¼NW¼ sec. 32, T. 14 N., R. 6 W., for fill material in roadway construction. The sand and gravel occur both as limited lenses of poorly sorted material incorporated in the glacial drift and as broad, thick, well-sorted outwash-plain and valley-train materials. Both pits that have been opened are in an outwash plain, and the gravel is reported to be at least 60 feet thick.

### WATER

Water resources are divided into two categories, surface and ground water, on the basis of their occurrence in nature. Surface water is that water which is present in surface reservoirs such as ponds, lakes, abandoned strip-mine areas, and streams and rivers. Ground water is that water which is present in the surficial materials and the underlying bedrock. This is the larger and more important source of water.

The occurrence of surface water is readily ascertained from the topographic base map included with this report. The most easily acquired ground water is obtained from the surficial deposits, particularly the sand and gravel deposits described above. Hand-dug and drilled wells into these generally shallow-lying deposits are comparatively inexpensive, and most of these wells provide a satisfactory domestic water supply. The bedrock strata underlying these surficial materials, particularly the porous sandstone beds, contain ground water which can be used for domestic purposes, although commonly such water contains a noticeable iron content. The sandstone beds of Pennsylvanian age and the sandstone and limestone beds of late Mississippian (Chester) age are producing water for domestic purposes in the area.

### OIL AND GAS

Nineteen oil and gas test wells (Appendix 4) have been drilled in the Brazil Quadrangles. All these tests have been dry holes. In general, deep-lying possible oil-containing structures will be reflected on the shallow-lying coal beds of the Pennsylvanian, but all structures noted on the coal beds may not be reflections of deeper structures. Several oil-producing horizons in Vigo and Sullivan Counties to the west and south of the quadrangles also are present in this area. These are, in descending order, sandstones in the Mansfield Formation, certain beds of the Chester Series, the Ste. Genevieve Limestone, the Salem Limestone, and the oil-producing zones in limestones of Devonian and Ordovician age. The Staunton oilfield, about 1 mile south of the Brazil West Quadrangle, is producing oil from limestone of Devonian age. Considerable geophysical prospecting has been conducted in the quadrangles by several oil companies, but to date no oil has been found.

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# APPENDIX 1. THICKNESS AND ELEVATION OF COAL BEDS

| No. | Location | | | Surface elevation | Elevation and thickness of coal beds (feet) | | | | | | Source of information |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sec. | T. (N.) | R. (W.) | | IIIa | III | Coals in lower Staunton | Minshall (rider of Upper Block) | Upper Block | Lower Block | |
| 1 | 34 | 14 | 7 | | | | | | 568-4.6 | | Outcrop |
| 2 | 35 | 14 | 7 | | | | | 582-3.9 | 563-4.3 | | Outcrop |
| 3 | 36 | 14 | 7 | | | | | 625-0.8 | | | Outcrop |
| 4 | 36 | 14 | 7 | | | | | 627-1.1 | | | Outcrop |
| 5 | 31 | 14 | 6 | | | | | | 635-1.2 | | Outcrop |
| 6 | 32 | 14 | 6 | | | | | | | 619-3.9 | Outcrop |
| 7 | 32 | 14 | 6 | | | | | | 652-3.8 | | Outcrop |
| 8 | 32 | 14 | 6 | | | | | | 676-3.6 | | Outcrop |
| 9 | 32 | 14 | 6 | 692 | | | | | 656-4.2 | | Drill hole |
| 10 | 33 | 14 | 6 | | | | | | | 659-1.0 | Outcrop |
| | | | | | | | | | | 728-2.3 | Outcrop |
| 11 | 35 | 14 | 6 | | | | | | | | |
| 12 | 4 | 13 | 6 | | | | | | | 680-0.8 | Outcrop |
| 13 | 4 | 13 | 6 | 688 | | | | | 673-4.5 | | Drill hole |
| 14 | 4 | 13 | 6 | 690 | | | | | | 650-4.3 | Drill hole |
| 15 | 5 | 13 | 6 | | | | | | 647-1.7 | | Outcrop |
| 16 | 5 | 13 | 6 | 685 | | | | | 660-4.5 | | Drill hole |
| 17 | 5 | 13 | 6 | 689 | | | | | 629-4.5 | | Drill hole |
| 18 | 5 | 13 | 6 | 691 | | | | | 649-3.8 | 618-2.8 | Drill hole |
| 19 | 6 | 13 | 6 | | | | | [1] 656-3.9 | | | Outcrop |
| 20 | 6 | 13 | 6 | | | | | | 638-2.2 | | Outcrop |
| 21 | 6 | 13 | 6 | 672 | | | | 657-4.5 | | | Drill hole |
| 22 | 1 | 13 | 7 | | | | | 625-0.7 | 612-2.3 | | Outcrop |
| 23 | 1 | 13 | 7 | | | | | [1] 636-2.2 | | | Outcrop |
| 24 | 1 | 13 | 7 | 660 | | | | | | 609-2.1 | Drill hole |
| 25 | 2 | 13 | 7 | | | | | [1] 604-2.1 | | | Outcrop |
| 26 | 2 | 13 | 7 | | | | | [1] 580-1.0 | | | Outcrop |
| 27 | 2 | 13 | 7 | 642 | | | | [1] 607-1.0 | 599-4.7 | | Drill hole |

## APPENDIX 1. THICKNESS AND ELEVATION OF COAL BEDS—Continued

| No. | Location | | | Surface elevation | Elevation and thickness of coal beds (feet) | | | | | | Source of information |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sec. | T. (N.) | R. (W.) | | IIIa | III | Coals in lower Staunton | Minshall (rider of Upper Block) | Upper Block | Lower Block | |
| 28 | 3 | 13 | 7 | | | | | 586-3.3 | | | Outcrop |
| 29 | 3 | 13 | 7 | 641 | | | | 571-3.5 | 550-2.7 | | Drill hole |
| 30 | 4 | 13 | 7 | | | | 577-1.1, 569-1.8, 559-1.3 | | | | Outcrop |
| 31 | 5 | 13 | 7 | 620 | | 554-— | | | | | Drill hole |
| 32 | 12 | 13 | 8 | 610 | | 506-5.6 | 480-1.0, 465-1.5, 418-1.0 | | | | Drill hole |
| 33 | 12 | 13 | 8 | 580 | | 515-5.3 | 489-2.0, 478-1.2, 437-1.0 | | | | Drill hole |
| 34 | 12 | 13 | 8 | 615 | | 512-3.3 | 451-1.0, 438-0.5 | | | | Drill hole |
| 35 | 7 | 13 | 7 | | 558-1.1 | | | | | | Outcrop |
| 36 | 7 | 13 | 7 | 600 | | 553-7.0 | | | | | Drill hole |
| 37 | 7 | 13 | 7 | 600 | | 542-6.1 | | | | | Drill hole |
| 38 | 7 | 13 | 7 | 559 | | 515-7.0 | 498-0.8, 486-2.0, 473-0.9 | | | | Drill hole |
| 39 | 8 | 13 | 7 | | 571-1.0 | | | | | | Outcrop |
| 40 | 8 | 13 | 7 | | | 555-4.0 | | | | | Outcrop |
| 41 | 8 | 13 | 7 | 572 | | | 550-2.0, 540-1.5, 530-1.5 | 498-0.8 | | | Drill hole |
| 42 | 9 | 13 | 7 | | | | 570-1.9, 557-2.3 | | | | Outcrop |
| 43 | 9 | 13 | 7 | | | | | 565.0.7 | | | Outcrop |
| 44 | 10 | 13 | 7 | | | | | 575-0.7 | | | Outcrop |
| 45 | 10 | 13 | 7 | 615 | | | | 549-— | 525-— | 498-— | Drill hole |
| 46 | 10 | 13 | 7 | 635 | | | | | 545-4.6 | | Drill hole |
| 47 | 11 | 13 | 7 | 640 | | | | 579-1.5 | 540-3.0 | | Drill hole |
| 48 | 11 | 13 | 7 | 655 | | | | | | 589-5.5 | Drill hole |
| 49 | 11 | 13 | 7 | 655 | | | | | 600-3.4 | | Drill hole |
| 50 | 8 | 13 | 6 | 691 | | | | 660-4.5 | | | Drill hole |
| 51 | 17 | 13 | 6 | 650 | | | | | | 643-2.0 | Drill hole |
| 52 | 17 | 13 | 6 | 670 | | | | | | 655-2.0 | Drill hole |
| 53 | 17 | 13 | 6 | 676 | | | | | | 650-2.0 | Drill hole |
| 54 | 17 | 13 | 6 | | | | | | 664-0.8 | | Outcrop |
| 55 | 18 | 13 | 6 | | | | | | | 611-2.7 | Outcrop |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 56 | 18 | 13 | 6 | | | | | | 657-3.4 | | Outcrop |
| 57 | 13 | 13 | 7 | 675 | | | | | 624-3.0 | 601-4.0 | Drill hole |
| 58 | 14 | 13 | 7 | 660 | | | | | | 577-1.0 | Drill hole |
| 59 | 15 | 13 | 7 | 600 | | | | 547-2.8 | 523-2.2 | | Drill hole |
| 60 | 16 | 13 | 7 | 610 | | | | | 473-1.0 | | Drill hole |
| 61 | 17 | 13 | 7 | | | | 564-2.0, 554-2.0 | | | | Outcrop |
| 62 | 17 | 13 | 7 | | 563-1.7 | | | | | | Outcrop |
| 63 | 17 | 13 | 7 | 612 | | 573-7.9 | | | | | Drill hole |
| 64 | 17 | 13 | 7 | 612 | | 558-4.0 | | | | | Drill hole |
| 65 | 18 | 13 | 7 | 594 | | 545-3.7 | | | | | Drill hole |
| 66 | 18 | 13 | 7 | | 550-1.2 | 537-3.9 | | | | | Outcrop |
| 67 | 13 | 13 | 8 | 560 | | 506-6.2 | 479-1.5, 472-1.0, 422-0.8 | | | | Drill hole |
| 68 | 24 | 13 | 8 | 592 | | 504-5.4 | | | | | Drill hole |
| 69 | 24 | 13 | 8 | 591 | | 500-6.0 | | | | | Drill hole |
| 70 | 24 | 13 | 8 | | 544-1.0 | | | | | | Outcrop |
| 71 | 19 | 13 | 7 | 591 | | 524-6.6 | | | | | Drill hole |
| 72 | 20 | 13 | 7 | 618 | | | | | 440-3.2 | | Drill hole |
| 73 | 21 | 13 | 7 | 622 | | | | 522-2.6 | 501-2.4 | | Drill hole |
| 74 | 21 | 13 | 7 | 590 | | | | | 510-3.8 | 497-3.9 | Drill hole |
| 75 | 22 | 13 | 7 | 639 | | | | 522-0.6 | 513-1.0 | | Drill hole |
| 76 | 22 | 13 | 7 | 635 | | | | | 511-3.1 | | Drill hole |
| 77 | 24 | 13 | 7 | | | | | | 593-3.8 | | Outcrop |
| 78 | 19 | 13 | 6 | | | | | | 631-3.1 | 602-2.9 | Outcrop |
| 79 | 21 | 13 | 6 | 703 | | | | 671-3.7 | 649-2.3 | | Drill hole |
| 80 | 21 | 13 | 6 | 731 | | | | [1] 690-3.0 | 666-4.9 | 640-5.8 | Drill hole |
| 81 | 27 | 13 | 6 | 675 | | | | | | 655-1.1 | Drill hole |
| 82 | 28 | 13 | 6 | 699 | | | | 661-3.0 | 644-4.0 | | Drill hole |
| 83 | 28 | 13 | 6 | 680 | | | | | | 625-3.0 | Drill hole |
| 84 | 29 | 13 | 6 | 701 | | | | 667-0.4 | [2] 648-OW | | Drill hole |
| 85 | 29 | 13 | 6 | 688 | | | | 659-2.0 | 614-3.8 | | Drill hole |
| 86 | 29 | 13 | 6 | 689 | | | | 660-3.0 | 641-3.0 | | Drill hole |
| 87 | 30 | 13 | 6 | | | | | 624-1.1 | 612-3.5 | | Outcrop |
| 88 | 30 | 13 | 6 | 670 | | | | | [2] 622-OW | | Drill hole |
| 89 | 30 | 13 | 6 | 675 | | | | 627-0.5 | [2] 621-OW | | Drill hole |
| 90 | 25 | 13 | 7 | | | | | 618-1.2 | | | Outcrop |
| 91 | 29 | 13 | 7 | | | | 541-1.7 | | | | Outcrop |
| 92 | 30 | 13 | 7 | 590 | | 560-6.1 | | | | | Drill hole |
| 93 | 30 | 13 | 7 | 602 | | 576-7.5 | | | | | Drill hole |
| 94 | 36 | 13 | 8 | 590 | | 515-7.0 | | | | | Drill hole |

# APPENDIX 1. THICKNESS AND ELEVATION OF COAL BEDS—Continued

| No. | Location | | | Surface elevation | Elevation and thickness of coal beds (feet) | | | | | | Source of information |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sec. | T. (N.) | R. (W.) | | IIIa | III | Coals in lower Staunton | Minshall (rider of Upper Block) | Upper Block | Lower Block | |
| 95 | 31 | 13 | 7 | 596 | | 533-5.0 | | | | | Drill hole |
| 96 | 35 | 13 | 7 | 615 | | | | | 542-2.5 | | Drill hole |
| 97 | 36 | 13 | 7 | 620 | | | | | 526-3.8 | | Drill hole |
| 98 | 32 | 13 | 6 | 675 | | | | | 632-3.1 | | Drill hole |
| 99 | 32 | 13 | 6 | 676 | | | | | 627-3.7 | | Drill hole |
| 100 | 33 | 13 | 6 | 661 | | | | | 633-2.1 | | Drill hole |
| 101 | 3 | 12 | 6 | 662 | | | | | 646-1.9 | | Drill hole |
| 102 | 4 | 12 | 7 | 632 | | | | 549-3.8 | | | Drill hole |
| 103 | 4 | 12 | 7 | 610 | | | | 534-— | | | Drill hole |
| 104 | 6 | 12 | 7 | 560 | | 520-6.8 | | | | | Drill hole |
| 105 | 9 | 12 | 7 | 609 | | | | 514-3.1 | | | Drill hole |
| 106 | 7 | 12 | 6 | 663 | | | | | 622-1.0 | 603-3.3 | Drill hole |
| 107 | 8 | 12 | 6 | 656 | | | | | | 600-1.0 | Drill hole |
| 108 | 9 | 12 | 6 | 665 | | | | | 635-1.7 | | Drill hole |
| 109 | 10 | 12 | 6 | 645 | | | | | | 613-3.0 | Drill hole |

[1] Determined to be rider of Upper Block Coal by miospore analysis.
[2] OW indicates mined area in coal designated.

# APPENDIX 2. UNDERGROUND MINES

| No. | Name of mine | Operator | County | Location Sec. | T. (N.) | R. (W.) | Surface elevation | Coal bed | Elevation of coal (feet) | Thickness of coal (feet) | Kind of mine | Years operated | Tons shipped |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Superior No. 6 | Zeller-McClelland & Co. | Parke | 25 | 14 | 7 | 661 | Lower Block | 571 | 3.0 | Shaft | 1911 - 1921 | [1] 299,995 |
| 2 | Superior No. 5 | Zeller-McClelland & Co. | Parke | 26 | 14 | 7 | 645 | Lower Block | 495? | 3.3 | Shaft | 1906 - 1913 | [1] 379,651 |
| 3 | Brazil Block No. 9 (McClelland No. 9) (Schrepferman) | Brazil Block Coal Co. (McClelland Block Coal Co.) (Schrepferman Coal Co.) | Parke | 34 | 14 | 7 | 630 | Upper Block | 525 | 4.2 | Shaft | 1901 - 1913 | [1] 322,536 |
| 4 | Brazil Block No. 12 | Brazil Block Coal Co. | Parke | 34 | 14 | 7 | 635 | Minshall | — | — | Shaft | 1898 - 1910 | [1] 427,247 |
| | | | | | | | | Upper Block | 537 | — | | | |
| 5 | McIntosh No. 1 | J. McIntosh Coal Co. | Parke | 35 | 14 | 7 | 640 | Upper Block | 540 | — | Shaft | 1893 - 1899 | [1] 262,701 |
| | | | | | | | | Lower Block | 515 | — | | | |
| 6 | McIntosh No. 3 | J. McIntosh Coal Co. | Parke | 35 | 14 | 7 | 641 | Lower Block | 551? | 3.3 | Shaft | 1898 - 1904 | [1] 180,079 |
| 7 | Standard | Standard Block Coal Co. | Parke | 35 | 14 | 7 | 642 | Upper Block | 564 | 4.5 | Shaft | 1896 - 1902 | [1] 254,456 |
| | | | | | | | | Lower Block | 518 | 3.7 | | | |
| 8 | Superior No. 1 | Zeller-McClelland & Co. | Parke | 35 | 14 | 7 | 647 | Upper Block | 555 | 5.0 | Shaft | 1893 - 1908 | [1] 767,354 |
| | | | | | | | | Lower Blohk | 518 | 3.9 | | | |
| 9 | Superior No. 2 | Zeller-McClelland & Co. | Parke | 35 | 14 | 7 | 635 | Upper Block | 550 | 4.3 | Shaft | 1895 - 1912 | [1] 795,029 |
| | | | | | | | | Lower Block | 512 | 3.5 | | | |
| 10 | Superior No. 3 | Zeller-McClelland & Co. | Parke | 35 | 14 | 7 | 610 | Upper Block | 555 | 4.3 | Shaft | 1902 - 1912 | [1] 327,193 |
| | | | | | | | | Lower Block | 525 | 3.2 | | | |
| 11 | Blain Hill | Brazil Block Coal Co. | Parke | 32 | 14 | 6 | — | Upper Block | — | — | Slope | —— - 1892 | ——— |
| | | | | | | | | Lower Block | — | | Shaft | | |
| 12 | Crawford | Crawford Coal Co. | Parke | 32 | 14 | 6 | — | Upper Block | — | 4.9 | Drift | 1894 - 1901 | [1] 252,254 |
| | | | | | | | | Lower Block | — | 4.2 | Shaft | | |
| 13 | Otter Creek (New Otter Creek) | Brazil Block Coal Co. | Parke | 32 | 14 | 6 | — | Upper Block | — | | Drift | 1892 - 1901 | [1] 210,247 |
| | | | | | | | | Lower Block | — | 4.0 | Shaft | | |
| 14 | Pan American | Plymouth Block Coal Co. | Parke | 32 | 14 | 6 | 655 | Lower Block | — | 4.0 | Shaft | 1901 - 1906 | [1] 248,491 |
| 15 | Eureka No. 3 | Eureka Block Coal Co. | Clay | 3 | 13 | 6 | 735 | Lower Block | 695 | 3.2 | Shaft | 1898 - 1904 | [1] 155,187 |
| 16 | Eureka No. 1 (Banner) | Eureka Block Coal Co. | Clay | 5 | 13 | 6 | 691 | Upper Block | — | — | Shaft | 1891 - 1895 | 299,000 |
| | | | | | | | | Lower Block | 606 | — | | | |

## APPENDIX 2. UNDERGROUND MINES—Continued

| No. | Name of mine | Operator | County | Location | | | Surface elevation | Coal bed | Elevation of coal (feet) | Thickness of coal (feet) | Kind of mine | Years operated | Tons shipped |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sec. | T. (N.) | R. (W.) | | | | | | | |
| 17 | Eureka No. 2 | Eureka Block Coal Co. | Clay | 5 | 13 | 6 | 691 | Upper Block | 630 | 4.0 | Shaft | 1893 - 1903 | [1] 399,233 |
| | | | | | | | | Lower Block | 595 | 3.8 | | | |
| 18 | Chicago | Brazil Block Coal Co. | Clay | 6 | 13 | 6 | 675 | rider of Upper Block? | 650 | 4.5 | Shaft | —— - 1893 | 346,000 |
| | | | | | | | | Upper Block | — | 4.0 | | | |
| 19 | Old Carbon | Indianapolis & St. Louis Railroad Co. | Clay | 6 | 13 | 6 | 691 | rider of Upper Block? | 664 | 4.5 | Shaft | —— - —— | 223,000 |
| | | | | | | | | Upper Block | 634 | 3.0 | | | |
| | | | | | | | | Lower Block | 615 | 4.0 | | | |
| 20 | Delacci | Delacci Bros. Coal Co. | Clay | 2 | 13 | 7 | 585 | Upper Block | 520 | 3.5 | Shaft | 1935 - 1942 | 12,000 |
| 21 | Brazil Block No. 8 (Schrepferman No. 3) | Brazil Block Coal Co. (Schrepferman Coal Co.) | Clay | 3 | 13 | 7 | 595 | Upper Block | 551 | 4.5 | Shaft | —— - 1912 | 814,000 |
| | | | | | | | | Lower Block | 509 | 3.3 | | | |
| 22 | Brazil Block No. 10 | Brazil Block Coal Co. | Clay | 3 | 13 | 7 | 620 | Upper Block | 542 | 1.5 | | | |
| | | | | | | | | Lower Block | 499 | 4.2 | Shaft | —— - 1905 | 328,000 |
| 23 | Brazil Block No. 11 | Brazil Block Coal Co. | Clay | 3 | 13 | 7 | 620 | Upper Block | 546 | 4.0 | Shaft | 1896 - 1903 | 290,000 |
| | | | | | | | | Lower Block | — | — | | | |
| 24 | Swamp Angel (Excelsior No. 1) | Hoosier Coal Co. (C. Ehrlich Coal Co.) | Clay | 3 | 13 | 7 | 577 | Upper Block | — | 3.2 | Shaft | 1891 - 1898 | [1] 195,459 |
| | | | | | | | | Lower Block | 517 | 3.2 | | | |
| 25 | Excelsior No. 2 (Brazil Block No. 11½) | C. Ehrlich Coal Co. (Brazil Block Coal Co.) | Clay | 3 | 13 | 7 | 585 | Minshall | 575 | 3.3 | Drift | 1892 - 1894 | 16,000 |
| 26 | Gladstone (Big Four) | Brazil Mining Co. (Clay County Coal Co.) | Clay | 4 | 13 | 7 | 570 | Lower Block | 438 | 4.5 | Shaft | 1893 - 1902 | 410,000 |
| 27 | Glenn No. 1 | Coal Bluff Mining Co. | Clay | 4 | 13 | 7 | 580 | Lower Block? | 465 | 4.5 | Shaft | 1900 - 1908 | 194,000 |
| 28 | Glenn No. 2 (Plymouth No. 2) | Coal Bluff Mining Co. | Clay | 4 | 13 | 7 | 575 | Lower Block? | 494 | 3.0 | Shaft | 1904 - 1922 | 177,000 |
| 29 | Mary No. 2 | Otter Creek Coal Co. | Vigo | 1 | 13 | 8 | 595 | Upper Block | 350 | 4.0 | Shaft | 1908 - 1924 | 572,000 |
| 30 | Mary No. 3 | Otter Creek Coal Co. | Vigo | 1 | 13 | 8 | 595 | Minshall | 397 | 5.7 | Shaft | 1916 - 1924 | 580,000 |
| 31 | Minshall | Coal Bluff Mining Co. (Western Indiana Mining Co.) | Vigo | 7 | 13 | 7 | 558 | Minshall | 383? | 5.0 | Shaft | 1907 - 1921 | 1,435,000 |
| 32 | Peerless (Old Moses) | Coal Bluff Mining Co. (Western Indiana Mining Co.) | Vigo | 7 | 13 | 7 | 590 | III | 504 | 7.0 | Shaft | 1892 - 1906 | 583,000 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | Plymouth No. 1 | Coal Bluff Mining Co. (Western Indiana Mining Co.) | Vigo | 7 | 13 | 7 | 560 | Upper Block? | 345 | 3.8 | Shaft | 1906 - 1923 | 374,000 |
| 34 | Victor (Blue Goose) | Coal Bluff Mining Co. | Vigo | 7 | 13 | 7 | 555 | III | 505 | 6.5 | Shaft | 1906 - 1909 | [1] 244,719 |
| 35 | State No. 1 | State Coal & Mining Co. | Vigo | 7 | 13 | 7 | 575 | III | 539 | 6.5 | Shaft | 1919 - 1920 | 12,000 |
| 36 | Pratt | Coal Bluff Mining Co. | Clay | 9 | 13 | 7 | 575 | Lower Block? | 470 | 2.2 | Shaft | 1888 - 1903 | 301,000 |
| 37 | Brazil No. 4 (McClelland No. 4) (DeCamp) | Brazil Block Coal Co. (McClelland Block Coal Co.) (DeCamp Mining Co.) | Clay | 10 | 13 | 7 | 635 | Upper Block<br>Lower Block | 489?<br>475? | 3.3<br>3.8 | Shaft | 1904 - 1916 | 646,000 |
| 38 | Diamond No. 3 | Diamond Block Coal Co. | Clay | 10 | 13 | 7 | 595 | Upper Block<br>Lower Block | 518<br>488 | 4.3<br>3.5 | Shaft | 1895 - 1902 | 399,000 |
| 39 | Diamond No. 5 | Diamond Block Coal Co. | Clay | 10 | 13 | 7 | 632 | Upper Block<br>Lower Block | 542<br>— | 2.5<br>— | Shaft | 1899 - 1904 | 284,000 |
| 40 | Eureka No. 5 | Eureka Block Coal Co. | Clay | 10 | 13 | 7 | 635 | Lower Block | 519 | 3.5 | Shaft | 1904 - 1916 | 341,000 |
| 41 | Fairview | Otter Creek Coal Co. | Clay | 11 | 13 | 7 | 641 | Upper Block<br>Lower Block | 560<br>540 | 4.0<br>3.5 | Shaft | 1892 - 1899 | [1] 140,099 |
| 42 | Chicago | Jackson Coal & Mining Co. (Nickle Plate Coal & Mining Co.) | Clay | 17 | 13 | 6 | 704 | Upper Block | 664 | — | Shaft | — - 1893 | 95,000 |
| 43 | Gart No. 5 (Redbird) | Brazil Block Coal Co. | Clay | 17 | 13 | 6 | 690 | Upper Block<br>Lower Block | 665<br>638 | 4.1<br>3.0 | Shaft | 1894 - 1903 | [1] 567,786 |
| 44 | Dewey | Jackson Coal & Mining Co. | Clay | 18 | 13 | 6 | 681 | Lower Block | 617 | 3.5 | Shaft | 1898 - 1902 | 55,000 |
| 45 | Gart No. 7 | Brazil Block Coal Co. | Clay | 18 | 13 | 6 | 665 | Upper Block<br>Lower Block | —<br>— | 4.0<br>— | Shaft | — - 1902? | 239,000 |
| 46 | Winn | Winn Coal Co. | Clay | 18 | 13 | 6 | 685 | Upper Block | 643 | 4.0 | Shaft | 1948 - 1951 | 6,000 |
| 47 | Gart No. 6 (old) (Brazil Block No. 6) | Brazil Block Coal Co. | Clay | 13 | 13 | 7 | 671 | Upper Block<br>Lower Block | 619<br>597 | 3.5<br>4.0 | Shaft | — - 1894 | 309,000 |
| 48 | Gart No. 6 (new) | Brazil Block Coal Co. | Clay | 13 | 13 | 7 | 680 | Lower Block | — | 4.0 | Shaft | 1893 - 1896 | 103,000 |
| 49 | James | James Coal Co. | Clay | 16 | 13 | 7 | 620 | Minshall<br>Upper Block | 515<br>465 | —<br>4.3 | Shaft | — - — | 158,000 |
| 50 | Mershon No. 1 | Rio Grande Coal Co. | Clay | 16 | 13 | 7 | 610 | Minshall | — | — | Shaft | — - — | 143,000 |
| 51 | Monkey (Clay Co. No. 1) (Vandalia No. 74) | Clay County Block Coal Co. (Vandalia Coal Co.) | Vigo | 17 | 13 | 7 | 560 | Minshall | 454 | 4.5 | Shaft | 1911 - 1923 | 857,000 |
| 52 | Crawford No. 1 | Crawford Coal Co. | Vigo | 17 | 13 | 7 | 585 | Minshall | 476 | 4.5 | Shaft | 1919 - 1929 | 170,000 |
| 53 | Diamond | Coal Bluff Mining Co. | Vigo | 17 | 13 | 7 | 600 | III | 546 | 6.0 | Shaft | — - 1895 | 84,000 |
| 54 | Victor | Coal Bluff Mining Co. | Vigo | 18 | 13 | 7 | 560 | III | — | — | Shaft | 1892 - 1897 | — |
| 55 | Star | Coal Bluff Mining Co. | Vigo | 13 | 13 | 8 | 560 | III | 515 | 4.9 | Shaft | — - 1897 | — |
| 56 | Otter Valley | Otter Valley Coal Co. | Vigo | 24 | 13 | 8 | 540? | III | — | 7.0 | Slope | 1916 - 1923 | 54,000 |
| 57 | Rio Grande No. 2 | Rio Grande Coal Co. | Vigo | 20 | 13 | 7 | 617 | Minshall | 457 | 4.3 | Shaft | 1937 - 1947 | 413,000 |

## APPENDIX 2. UNDERGROUND MINES—Continued

| No. | Name of mine | Operator | County | Location | | | Surface elevation | Coal bed | Elevation of coal (feet) | Thickness of coal (feet) | Kind of mine | Years operated | Tons shipped |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sec. | T. (N.) | R. (W.) | | | | | | | |
| 58 | Crawford No. 10 | Crawford Coal Co. | Clay | 21 | 13 | 7 | 622 | Upper Block | 492 | 4.5 | Shaft | 1907 - 1914 | 310,000 |
| 59 | Crawford No. 12 | Crawford Coal Co. | Clay | 21 | 13 | 7 | 622 | Upper Block | 470 | 4.0 | Shaft | 1913 - 1921 | 246,000 |
| 60 | Rebstock (Crawford No. 9) | I. McIntosh Coal Co. (Crawford No. 9) | Clay | 21 | 13 | 7 | 590 | Upper Block | 490 | 4.5 | Shaft | 1903 - 1910 | 150,000 |
| 61 | Crawford No. 4 | Crawford Coal Co. | Clay | 22 | 13 | 7 | 633 | Upper Block | 510 | 3.6 | Shaft | 1915 - 1919 | 238,000 |
| 62 | Price | George Price Coal Co. | Clay | 19 | 13 | 6 | 665 | Lower Block | — | — | Shaft | —— - 1934 | 36,000 |
| 63 | Wizard No. 1 | Hall-Zimmerman Coal Co. | Clay | 19 | 13 | 6 | 610 | Lower Block | 568 | 3.5 | Shaft | 1907 - 1912 | [1] 163,456 |
| 64 | Buckeye | ———— | Clay | 20 | 13 | 6 | 698 | Upper Block | 638 | 4.0 | Shaft | —— - —— | ———— |
| 65 | Cornwall | Watson Coal Co. (Jackson Coal & Mining Co.) | Clay | 20 | 13 | 6 | 718 | Upper Block<br>Lower Block | 668<br>632 | 3.4<br>3.5 | Shaft | 1900 - 1905 | [1] 123,375 |
| 66 | Jackson | Jackson Coal & Mining Co. | Clay | 20 | 13 | 6 | 702 | Upper Block<br>Lower Block | —<br>— | —<br>— | Shaft | —— - —— | ———— |
| 67 | Nickle Plate No. 1 | Jackson Coal & Mining Co. | Clay | 20 | 13 | 6 | 708 | Upper Block<br>Lower Block | 618<br>— | 4.0<br>— | Shaft | —— - 1892 | ———— |
| 68 | Nickle Plate No. 2 | Jackson Coal & Mining Co. | Clay | 20 | 13 | 6 | 705 | Upper Block<br>Lower Block | 652<br>618 | 4.0<br>3.3 | Shaft | 1892 - 1898 | [1] 377,174 |
| 69 | Clark | ———— | Clay | 21 | 13 | 6 | 725 | rider of Upper Block? | 672 | 2.5 | Shaft | —— - —— | 3,000 |
| 70 | Cornwall (Benwood) | Jackson Coal & Mining Co. | Clay | 21 | 13 | 6 | 725 | rider of Upper Block | 687 | 3.7 | Shaft | —— - —— | 40,000 |
| 71 | Diamond | ———— | Clay | 21 | 13 | 6 | 705 | Upper Block<br>Lower Block | 645<br>630 | 3.7<br>3.7 | Shaft | —— - —— | 115,000 |
| 72 | Gart No. 1 | Brazil Block Coal Co. | Clay | 21 | 13 | 6 | 712 | Upper Block<br>Lower Block | —<br>— | 4.0<br>4.0 | Shaft | 1869?- 1893 | ———— |
| 73 | Gart No. 2 | Brazil Block Coal Co. | Clay | 21 | 13 | 6 | 715 | Upper Block<br>Lower Block | —<br>— | 4.0<br>3.4 | Shaft | —— - 1893 | ———— |
| 74 | Gart No. 3 | Brazil Block Coal Co. | Clay | 21 | 13 | 6 | 715 | Upper Block<br>Lower Block | 632<br>598 | 4.2<br>3.4 | Shaft | —— - 1901 | ———— |
| 75 | Jack Oak | Jackson Coal & Mining Co. | Clay | 21 | 13 | 6 | 728 | rider of Upper Block<br>Upper block | 682<br>663 | 4.0<br>3.2 | Shaft | —— - —— | 102,000 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | Star No. 1 | Indianapolis Rolling Mill Co. | Clay | 21 | 13 | 6 | 697 | Upper Block | 662 | 4.7 | Shaft | 1860 ? - —— | 36,000 |
| 79 | Star No. 2 | Indianapolis Rolling Mill Co. | Clay | 21 | 13 | 6 | 695 | rider of Upper Block | 670 | — | Shaft | —— - —— | 62,000 |
| 81 | | | | | | | | Upper Block | 656 | 5.0 | | | |
| 78 | Briar Hill | Zellers Coal Co. | Clay | 28 | 13 | 6 | 690 | Lower Block | 628 | 4.0 | Shaft | —— - —— | ——— |
| 76 | Crawford No. 1 | Crawford Coal Co. | Clay | 28 | 13 | 6 | 701 | Lower Block | 632 | 4.0 | Shaft | —— - —— | ——— |
| 77 | Crawford No. 2 | Crawford Coal Co. | Clay | 28 | 13 | 6 | 686 | Lower Block | 611 | 3.5 | Shaft | —— - 1893 ? | ——— |
| | Gart No. 4 | Brazil Block Coal Co. | Clay | 28 | 13 | 6 | 690 | Lower Block | — | — | Shaft | 1891 - 1895 | ——— |
| 82 | Handcock | ———— | Clay | 28 | 13 | 6 | 701 | Lower Block | — | 4.0 | Shaft | —— - —— | ——— |
| 83 | Andrews | Andrews Coal & Mining Co. | Clay | 29 | 13 | 6 | 687 | Lower Block | 600 | 3.3 | Shaft | 1898 - 1903 | [1] 65,278 |
| | (Lancaster No. 5) | (Lancaster Block Coal Co.) | | | | | | | | | | | |
| | (Rob Roy) | (United Coal Co.) | | | | | | | | | | | |
| 84 | Brazil | Jackson Coal & Mining Co. | Clay | 29 | 13 | 6 | 678 | Minshall | 620 | 3.1 | Shaft | 1893 - 1899 | 240,000 |
| | | | | | | | | Upper Block | 610 | 4.0 | | | |
| | | | | | | | | Lower Block | 587 | 3.3 | | | |
| 85 | Jumbo | Watson, Little & Co. | Clay | 29 | 13 | 6 | 692 | Upper Block | — | — | Shaft | —— - 1895 | 363,000 |
| | (Gartside) | | | | | | | Lower Block | | | | | |
| 86 | Worlds Fair | Davis Coal Co. | Clay | 29 | 13 | 6 | 685 | Upper Block | 636 | 3.5 | Shaft | 1892 - 1899 | [1] 222,396 |
| 87 | Treager No. 1 | Treager Bros. Coal Co. | Clay | 30 | 13 | 6 | 692 | Upper Block | 632 | 4.0 | Shaft | 1905 ? - 1910 | 48,000 |
| 88 | Hydraulic Press Brick No. 1 | Hydraulic Press Brick Co. | Clay | 25 | 13 | 7 | 659 | Upper Block | 624 | 3.5 | Shaft | 1922 - 1938 ? | [1] 21,000 |
| 89 | American Vitrified No. 31 | American Vitrified Products, Inc. | Clay | 25 | 13 | 7 | 655 | Upper Block | 575 | 3.8 | Shaft | 1896 - 1926 | 75,000 |
| | (Monarch) | (Monarch Sewer Pipe Co.) | | | | | | | | | | | |
| 90 | Domestic Block No. 1 | Domestic Block Coal Co. | Vigo | 29 | 13 | 7 | 555 | Upper Block | 445 | 4.0 | Shaft | 1905 - 1921 | 566,000 |
| | (Kokomo, Sterling) | (Inland Coal & Mining Co.) | | | | | | | | | | | |
| 91 | Vigo | Vigo Coal Co. | Vigo | 30 | 13 | 7 | 560 | III | — | 6.3 | Slope | 1895 - 1903 | ——— |
| 92 | Nickle Plate | Ehrman Coal Co. | Vigo | 25 | 13 | 8 | 550 | III | — | 6.5 | Shaft | 1894 - 1924 | 260,000 |
| | (Nickle Plate No. 2) | (Brazil Mining Co.) | | | | | | | | | | | |
| 93 | Miami No. 2 | Miami Coal Co. | Vigo | 36 | 13 | 8 | 580 | III | 520 | 6.0 | Shaft | 1903 - 1910 | 652,000 |
| 94 | Collieries No. 1 | Brazil Collieries Co. | Clay | 33 | 13 | 7 | 622 | Minshall | 472 | 4.0 | Shaft | 1913 - 1919 | 391,000 |
| 95 | Gifford No. 2 | Collins Coal Co. | | | | | | | | | | | |
| | | (O. S. Richardson Coal Co.) | Clay | 33 | 13 | 7 | 575 | Minshall | 503 | 4.5 | Shaft | 1901 - 1910 | 196,000 |
| 96 | Bea Ridge | Bea Ridge Block Coal Co. | Clay | 34 | 13 | 7 | 575 | Minshall | 545 | 4.0 | Shaft | 1910 - 1912 | 7,000 |
| | | (Peavine Coal Co.) | | | | | | | | | | | |
| 97 | Brazil Clay No. 2 | Brazil Coal Co. | Clay | 34 | 13 | 7 | 632 | Minshall | 532 | 2.0 | Shaft | 1925 - 1936 | 11,602 |
| 98 | Brazil Clay No. 1 | Brazil Clay Co. | Clay | 35 | 13 | 7 | 630 | Upper Block | 520 | 1.5 | Shaft | 1912 - 1935 | 34,000 |
| 99 | West Side No. 1 | Chas. Zeller Coal Co. | Clay | 35 | 13 | 7 | 641 | Upper Block | 571 | 3.7 | Shaft | 1913 - 1918 | 73,000 |
| 100 | Brazil Block No. 1 | Brazil Block Coal Co. | Clay | 36 | 13 | 7 | 655 | Upper Block | 555 | 3.3 | Shaft | 1895 - 1910 | 740,000 |
| 101 | Crawford No. 9 | Crawford Coal Co. | Clay | 36 | 13 | 7 | 618 | Upper Block | 534 | 4.0 | Shaft | 1903 - 1910 | 186,000 |

# APPENDIX 2. UNDERGROUND MINES—Continued

| No. | Name of mine | Operator | County | Location | | | Surface elevation | Coal bed | Elevation of coal (feet) | Thickness of coal (feet) | Kind of mine | Years operated | Tons shipped |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sec. | T. (N.) | R. (W.) | | | | | | | |
| 102 | Ashley | ——— | Clay | 31 | 13 | 6 | 692 | Upper Block | 618 | 3.8 | Shaft | — - — | 43,000 |
| 103 | Black Cat | Schlatter Coal Co. | Clay | 32 | 13 | 6 | 675 | Lower Block | 591 | 3.9 | Shaft | 1922 - 1931 | [1] 95,541 |
| 104 | McIntosh No. 2 | I. McIntosh Coal Co. | Clay | 32 | 13 | 6 | 680 | Lower Block | 600 | 4.0 | Shaft | 1894 ?- 1897 | 55,000 |
| 105 | Brazil Block No. 7 (Tohay) | Brazil Block Coal Co. | Clay | 33 | 13 | 6 | 670 | Lower Block | 595 | 3.5 | Shaft | 1903 - 1908 | 152,000 |
| 106 | Brown | Indiana Block Coal Co. | Clay | 33 | 13 | 6 | 670 | Lower Block | 620 | 4.3 | Shaft | 1937 - 1940 ? | 19,000 |
| 107 | Schrepferman No. 1 | Schepferman Coal Co. | Clay | 4 | 12 | 6 | 671 | Lower Block | 607 | 4.2 | Shaft | 1907 - 1919 | 130,000 |
| 108 | Columbia | Zeller & Sigler Coal Co. | Clay | 5 | 12 | 6 | 652 | Upper Block | — | — | Shaft | — - 1895 | 334,000 |
| | | | | | | | | Lower Block | — | — | | | |
| 109 | German No. 1 | German Coal Co. | Clay | 5 | 12 | 6 | 671 | Upper Block | 609 | 4.0 | Shaft | 1909 - 1914 | [1] 28,000 |
| 110 | Nellie | Otter Creek Coal Co. | Clay | 6 | 12 | 6 | 681 | Upper Block | — | — | Shaft | — - 1897 | 372,000 |
| 111 | Progressive | Progressive Coal & Mining Co. (Heiliger-Stoot Coal Co.) | Clay | 6 | 12 | 6 | 672 | Lower Block | 567 | 3.8 | Shaft | 1907 - 1912 | [1] 172,430 |
| 112 | Schrepferman No. 2 | Schrepferman Coal Co. | Clay | 6 | 12 | 6 | 675 | Upper Block | 612 | 3.8 | Shaft | 1910 - 1912 | 33,000 |
| 113 | Gifford No. 1 (Billtown) | Collins Coal Co. (Deep Vein Block Coal Co.) | Clay | 4 | 12 | 7 | 612 | Minshall | 502 | 4.0 | Shaft | — - — | 318,000 |
| 114 | Miami No. 1 | Miami Coal Co. | Vigo | 12 | 12 | 8 | 555 | III | 500 | 6.0 | Shaft | 1901 - 1909 | 942,000 |
| 115 | Collieries No. 2 | Brazil Collieries Co. | Clay | 9 | 12 | 7 | 622 | Minshall | 522 | 4.3 | Shaft | 1918 - 1924 | [1] 397,192 |
| 116 | Vandalia No. 60 (Fairview) | Vandalia Coal Co. (Indiana Bituminous Coal Co.) | Clay | 10 | 12 | 7 | 692 | III | 660 | 7.0 | Shaft | 1905 - — | ——— |
| 117 | West Side No. 2 (Cleveland) (Hamlin & Heck No. 1) | West Side Coal Co. (Cleveland Coal Co.) (Hamlin & Heck Coal Co.) (Brazil District Mining Co.) | Clay | 11 | 12 | 7 | 682 | III | — | 7.0 | Slope | 1916 - 1923 | ——— |
| 118 | Watson No. 2 | Gartsherrie Coal & Mining Co.) | Clay | 7 | 12 | 6 | 664 ? | Upper Block | — | — | Shaft | — - 1892 ? | 75,000 |

[1] Production figures taken from Annual Reports of the Indiana State Mine Inspector's office.
Other figures derived from measurements of areas of reported mining assuming 50 percent recovery.

# APPENDIX 3. REFRACTION SEISMIC DATA

| No. | Location | | | Surface elevation | Elevation of bedrock (feet) |
|---|---|---|---|---|---|
| | Sec. | T. (N.) | R. (W.) | | |
| 110 | 26 | 14 | 6 | 745 | 670 |
| 111 | 29 | 14 | 7 | 545 | 474 |
| 112 | 36 | 14 | 8 | 534 | 448 |
| 113 | 32 | 14 | 7 | 620 | 577 |
| 114 | 6 | 13 | 6 | 680 | 558 |
| 115 | 12 | 13 | 7 | 665 | 590 |
| 116 | 7 | 13 | 6 | 675 | 583 |
| 117 | 7 | 13 | 6 | 671 | 630 |
| 118 | 7 | 13 | 6 | 671 | 536 |
| 119 | 8 | 13 | 6 | 699 | 655 |
| 120 | 8 | 13 | 6 | 670 | 632 |
| 121 | 8 | 13 | 6 | 698 | 621 |
| 122 | 9 | 13 | 6 | 709 | 649 |
| 123 | 10 | 13 | 6 | 693 | 624 |
| 124 | 11 | 13 | 6 | 681 | 653 |
| 125 | 13 | 13 | 7 | 662 | 532 |
| 126 | 14 | 13 | 7 | 665 | 590 |
| 127 | 14 | 13 | 7 | 653 | 523 |
| 128 | 15 | 13 | 7 | 632 | 525 |
| 129 | 15 | 13 | 7 | 636 | 588 |
| 130 | 22 | 13 | 7 | 635 | 515 |
| 131 | 22 | 13 | 7 | 585 | 550 |
| 132 | 23 | 13 | 7 | 668 | 505 |
| 133 | 23 | 13 | 7 | 572 | 548 |
| 134 | 26 | 13 | 7 | 630 | 500 |
| 135 | 27 | 13 | 7 | 567 | 497 |
| 136 | 28 | 13 | 7 | 554 | 520 |
| 137 | 28 | 13 | 7 | 558 | 488 |
| 138 | 32 | 13 | 7 | 628 | 481 |
| 139 | 33 | 13 | 7 | 609 | 545 |
| 140 | 34 | 13 | 7 | 630 | 576 |
| 141 | 4 | 12 | 6 | 664 | 627 |
| 142 | 5 | 12 | 6 | 652 | 586 |
| 143 | 3 | 12 | 7 | 641 | 615 |
| 144 | 6 | 12 | 7 | 602 | 490 |

# APPENDIX 4. OIL AND GAS TEST WELLS

| No. | Name of well | Company | Location | | | Surface elevation | Elevation top of Devonian limestone (feet) | Total depth (feet) |
|---|---|---|---|---|---|---|---|---|
| | | | Sec. | T. (N.) | R. (W.) | | | |
| 145 | A. Kibbe No. 1 | —————— | 25 | 14 | 7 | 655 | 545 | 1,200 |
| 146 | Biggens No. 1 | Carter Oil Co. | 34 | 14 | 7 | 641 | 616 | 1,442 |
| 147 | Downes No. 1 | —————— | 2 | 13 | 6 | 741 | — | 420 |
| 148 | PG-8 | Carter Oil Co. | 5 | 13 | 6 | 689 | -552 | 1,408 |
| 149 | Wells PG-2 | Carter Oil Co. | 6 | 13 | 6 | 674 | -566 | 1,289 |
| 150 | Moyer, Aydelotte, and Wells No. 1 | —————— | 1 | 13 | 7 | 672 | -558 | 1,361 |
| 151 | Archer No. 1 | Carter Oil Co. | 3 | 13 | 7 | 569 | -651 | 1,912 |
| 152 | Condron PG-9 | Carter Oil Co. | 3 | 13 | 7 | 635 | -616 | 1,411 |
| 153 | Mooney PG-11 | Carter Oil Co. | 3 | 13 | 7 | 593 | -605 | 1,213 |
| 154 | Miller PG-5 | Carter Oil Co. | 10 | 13 | 7 | 623 | -685 | 1,363 |
| 155 | Merchon | —————— | 12 | 13 | 7 | 646 | — | 1,242 |
| 156 | Danhauer No. 1 | Dome-Minnick Oil Co. | 16 | 13 | 6 | 693 | -551 | 1,404 |
| 157 | Knott No. 1 | Schafer and Granholm Oil Co. | 18 | 13 | 7 | 600 | -768 | 1,428 |
| 158 | St. Louis Joint Stock Land Bank No. 1 | Ohio Oil Co. | 21 | 13 | 7 | 623 | — | 2,785 |
| 159 | Girton No. 1 | Dome-Minnick Oil Co. | 22 | 13 | 6 | 685 | -570 | 1,357 |
| 160 | Excelsior Clay Co. No. 1 | Business Men's Oil and Gas Co. | 30 | 13 | 6 | 649 | — | 1,685 |
| 161 | Figg No. 1 | Carter Oil Co. | 30 | 13 | 7 | 602 | -856 | 1,843 |
| 162 | Nevin No. 1 | Carter Oil Co. | 31 | 13 | 7 | 606 | -853 | 1,497 |
| 163 | Longshore No. 1 | Carter Oil Co. | 4 | 12 | 6 | 668 | -638 | 1,962 |

GEOLOGICAL SURVEY
JOHN B. PATTON, State Geologist

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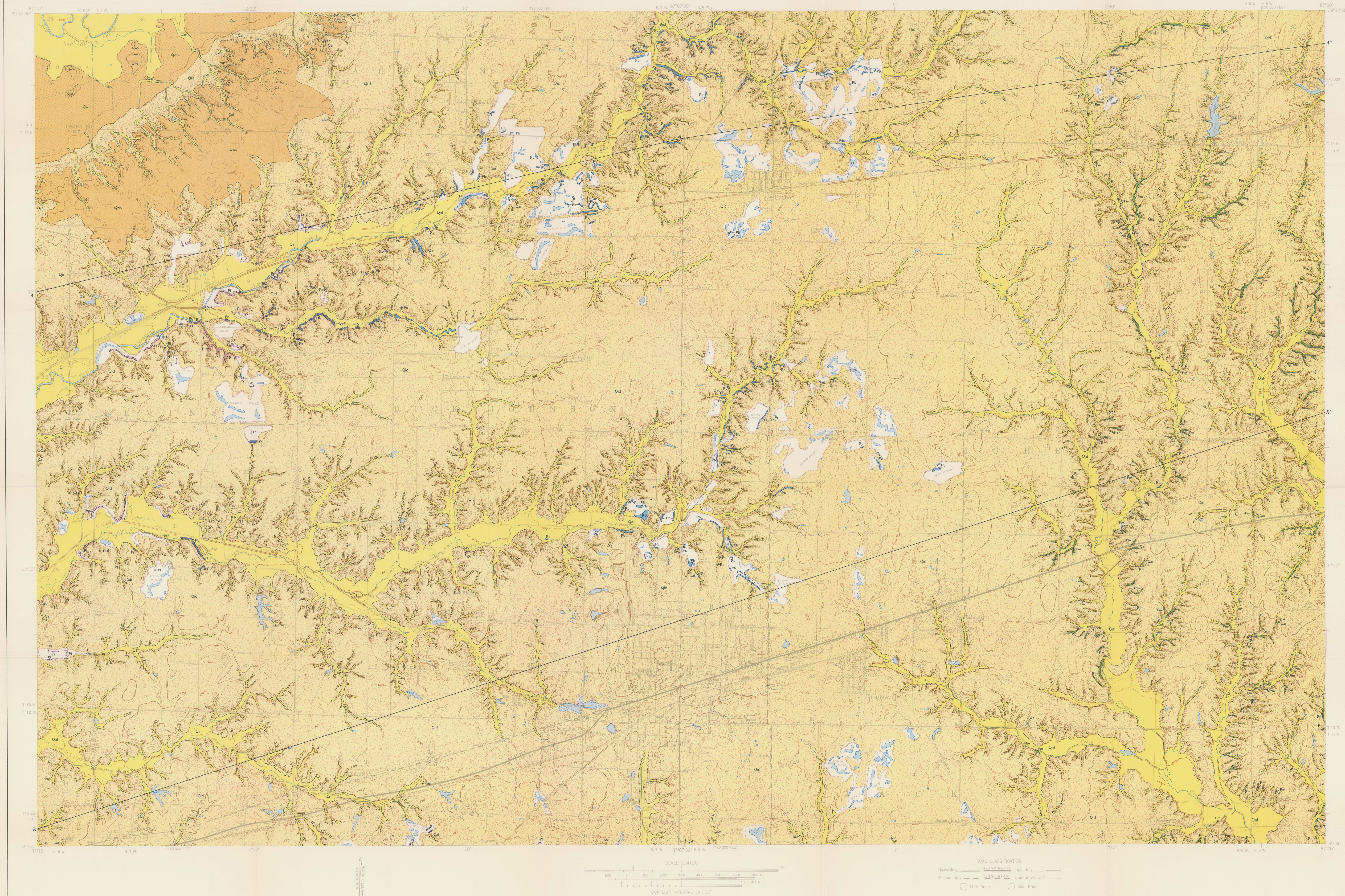
BULLETIN 16, PLATE 1



EXPLANATION

QUATERNARY

Pleistocene — Recent Stage

Qal — **Alluvium** — *Sand and silt*

Pleistocene — Wisconsin Stage

Qws — **Windblown sand** — *Unconsolidated*

Qwo — **Outwash** — *Sand and gravel*

Pleistocene — Illinoian Stage

Qid — **Drift** — *Unconsolidated till, silt, sand, and gravel*

Pleistocene — Kansan Stage

Qkd — **Drift** — *Unconsolidated till, sand, and gravel*

PENNSYLVANIAN

Middle Pennsylvanian

Pl — **Linton Formation** — *Shale, sandstone, underclay, coal, and limestone*

Ps — **Staunton Formation** — *Shale, sandstone, underclay, coal, and limestone*

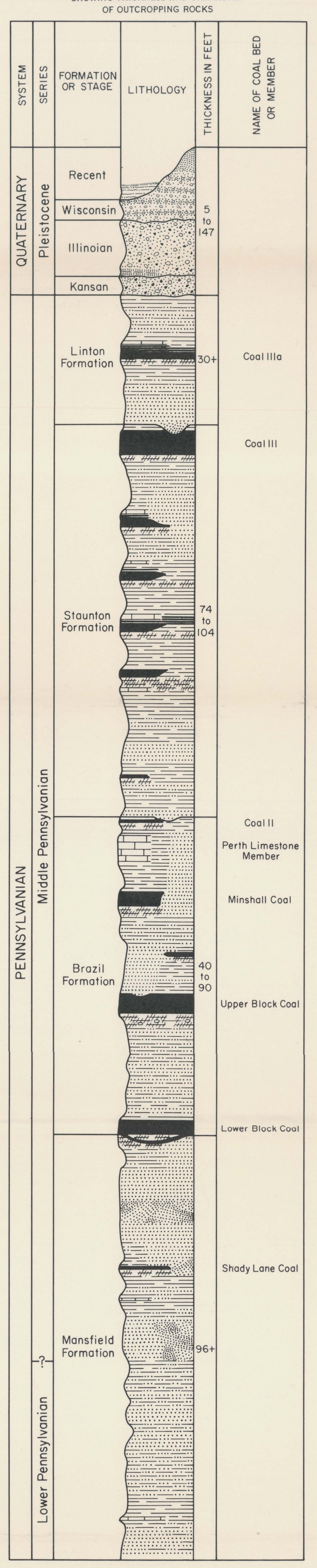
Pb — **Brazil Formation** — *Shale, sandstone, underclay, coal, and limestone*

Lower and middle Pennsylvanian

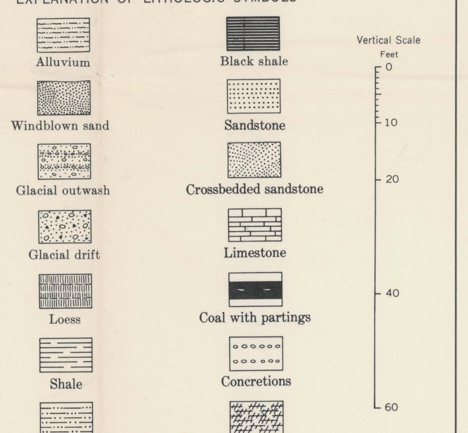
Pm — **Mansfield Formation** — *Shale, sandstone, underclay, coal, and limestone*

**Contact** — *Dashed where approximately located*

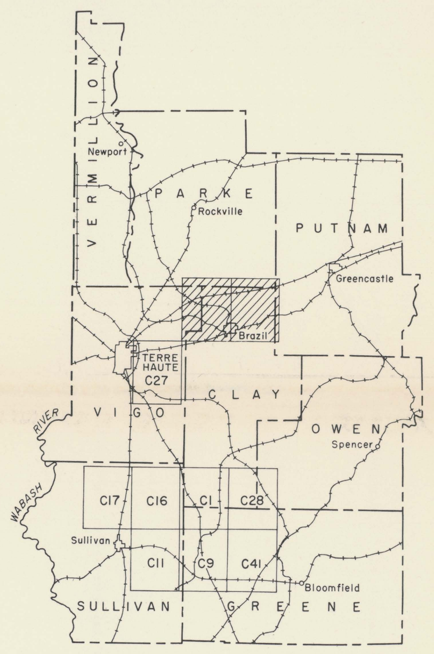
GENERALIZED COLUMNAR SECTION
SHOWING THICKNESS AND CHARACTER OF OUTCROPPING ROCKS



EXPLANATION OF LITHOLOGIC SYMBOLS



INDEX MAP SHOWING LOCATION OF BRAZIL QUADRANGLES



INDEX MAP SHOWING LOCATION OF BRAZIL QUADRANGLES AND COAL INVESTIGATIONS MAPS PREPARED IN COOPERATION WITH U.S. GEOLOGICAL SURVEY

COAL INVESTIGATIONS MAPS PREPARED IN COOPERATION WITH U.S. GEOLOGICAL SURVEY

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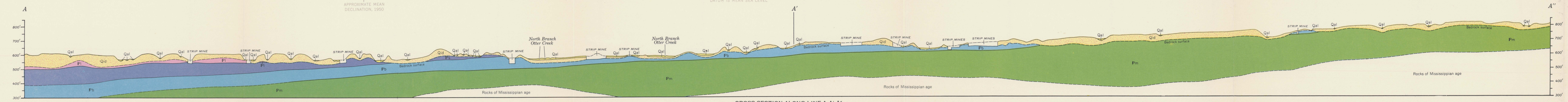
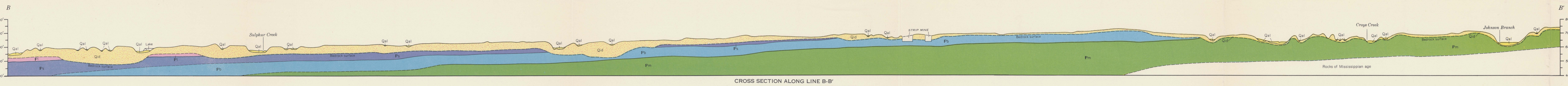


CROSS SECTION ALONG LINE A-A'-A''
SHOWING LAND SURFACE AND POSITION OF FORMATIONS



CROSS SECTION ALONG LINE B-B'
SHOWING LAND SURFACE AND POSITION OF FORMATIONS

Base from U.S. Geological Survey topographic quadrangle maps

# GEOLOGIC MAP OF BRAZIL QUADRANGLES, INDIANA

By Harold C. Hutchison

1960

Williams & Heintz Map Corporation, Washington 27, D.C.

Geologic mapping 1953. Mined areas revised 1960. Drafted by John E. Peace

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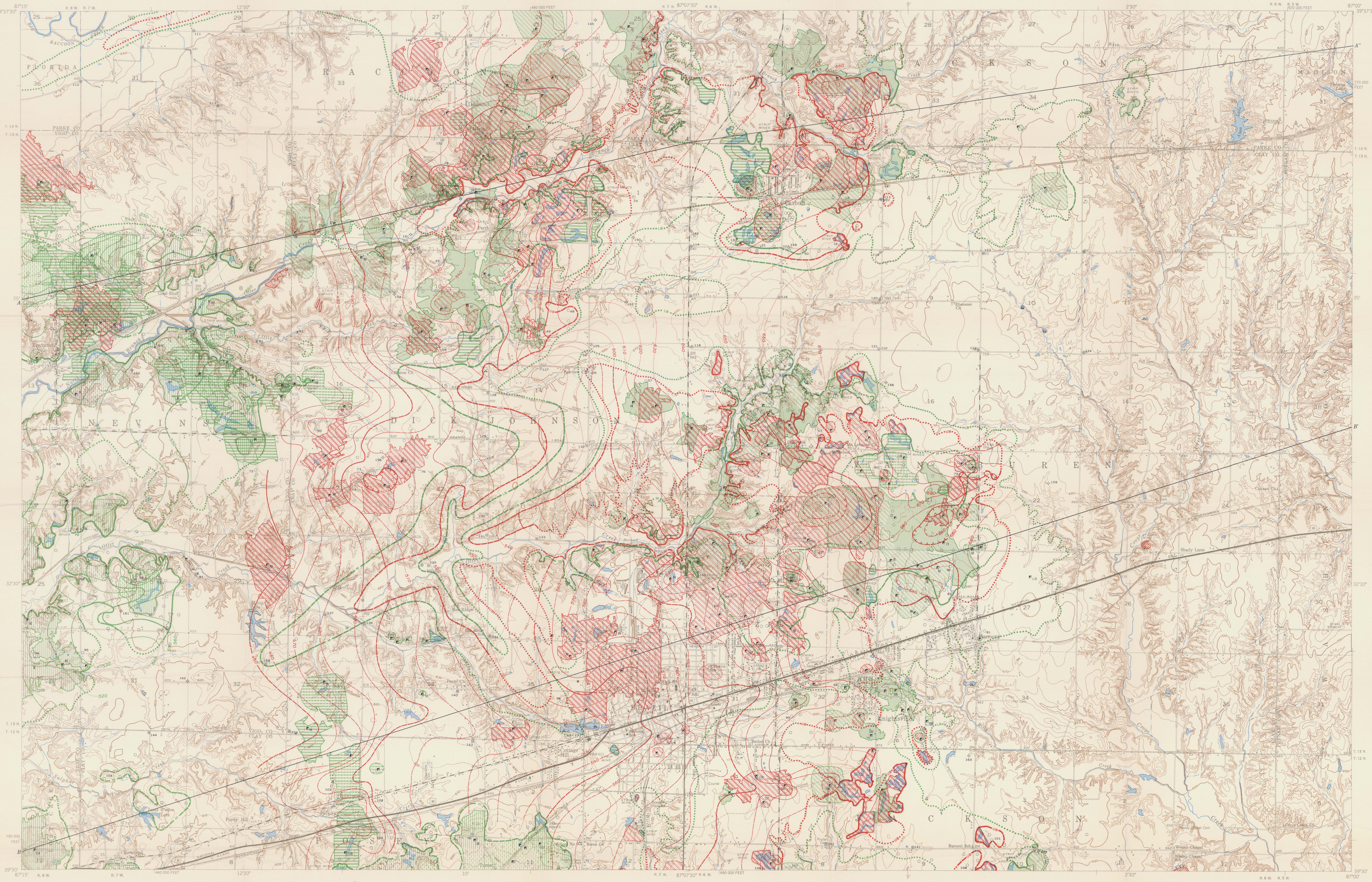


## EXPLANATION

Mined area of Coal III

Mined area of coals in lower part of Staunton Formation

Mined area of Minshall Coal or rider of Upper Block Coal

Mined area of Upper Block Coal

Mined area of Lower Block Coal

Mined area of coal in Mansfield Formation

*Solid lines show accurately located mined areas; dashed lines show approximately located boundaries of reported mining. Shaft, slope, or strip mine symbol with letter designating coal shown for mined areas of less than one acre*

Boundary of Coal III

Boundary of Minshall coal or rider of Upper Block Coal

Boundary of Upper Block Coal

Boundary of Lower Block Coal

*Line shows coal bed outcrop or extent of coal bed beneath surficial deposits. Solid line shows boundary located accurately from outcrop or drill-hole data; dashes show approximately located boundary; dots show inferred boundary. Coal may be absent locally where thickness of surficial deposits is not known.*

Structure contours on top of Coal III

Structure contours on top of Upper Block Coal

*Contours solid where accurately located; dashed where approximate; dotted where coal is absent and altitude is inferred. Contour interval 10 feet; datum is mean sea level*

Shallow drill hole
*Numbers refer to appendix 1*

Refraction seismic shot hole
*Numbers refer to appendix 2*

Dry hole
*Deep test for oil and gas. Numbers refer to appendix 7*

Outcrop of coal
*Numbers refer to appendix 1*

Shaft mine
*Numbers refer to appendix 3*

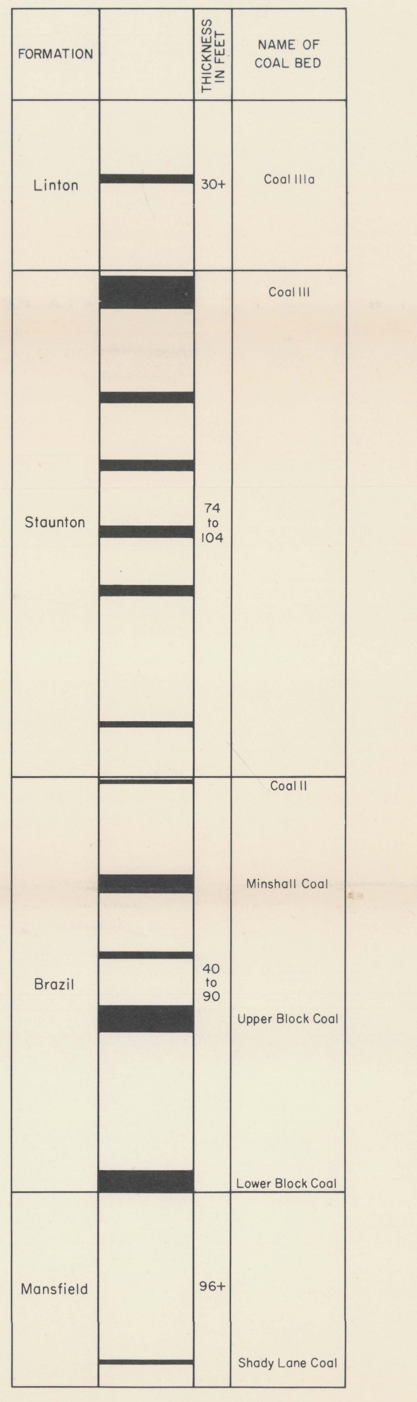
Slope mine
*Numbers refer to appendix 3*

Strip mine
*Larger areas outlined; areas less than one acre shown by small symbol only.*

Limestone quarry

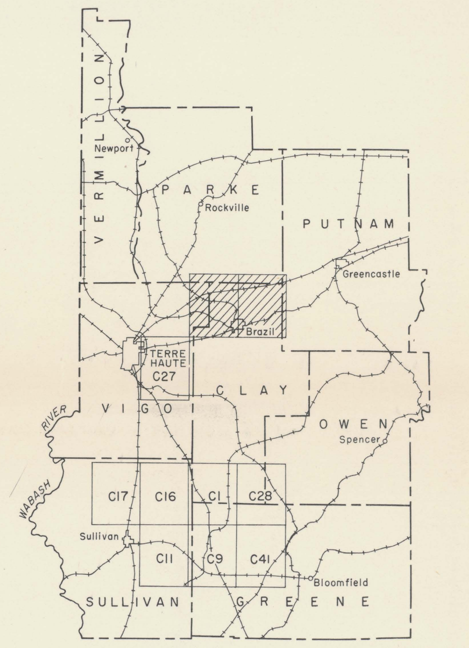
Gravel pit

GENERALIZED COLUMNAR SECTION
SHOWING THICKNESS AND RELATIVE POSITION OF COAL BEDS





INDEX MAP SHOWING LOCATION OF BRAZIL QUADRANGLES

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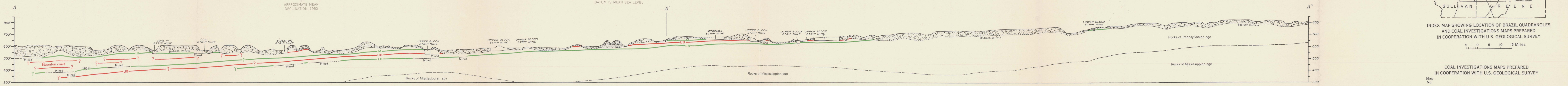
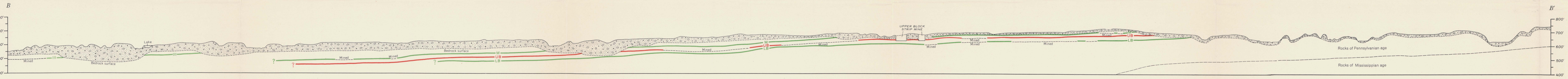


CROSS SECTION ALONG LINE A-A'-A''
SHOWING LAND SURFACE AND PRINCIPAL COAL BEDS



CROSS SECTION ALONG LINE B-B'
SHOWING LAND SURFACE AND PRINCIPAL COAL BEDS

Base from U.S. Geological Survey topographic quadrangle maps.

# MAP OF BRAZIL QUADRANGLES, INDIANA, SHOWING DISTRIBUTION, STRUCTURE, AND MINED AREAS OF COALS

By Harold C. Hutchison

1960

Williams & Heintz Map Corporation, Washington 27, D.C.

Geologic mapping 1953. Mined areas revised 1960. Drafted by John E. Peace