DESCRIPTION OF THE AMITY QUADRANGLE.

By Frederick G. Clapp.

INTRODUCTION.

LOCATION AND RELATION OF THE QUADRANGLE.

The Amity quadrangle lies in the southwest corner of Pennsylvania, principally in Washington County, but it includes also a small part of Greene County. It extends from latitude 40° on the south to 40° 10' on the north, and from longitude 80° on the east to 80° 15' on the west, and therefore covers one-sixteenth of a degree of the earth's surface, comprising 228.40 square miles. It is bounded by the following quadrangles of the United States topographic map: On the north by Carnegie, on the east by Beaver, on the south by Waynesburg, and on the west by Clayville. The principal town is Washington, with a population in 1900 of 14,117.

In its physiographic and geologic relations this quadrangle forms a part of the Appalachian province, which extends from the Susquehanna Plateau to the lowlands of the Mississippi Valley, and from Canada to central Georgia.

WASHINGTON COUNTY.

Allegeny Plateaus.

The Allegheny Plateaus are drained by a series of alternating ridges and valleys, called the Great Appalachian Valley, and still farther north it is a slightly dissected upland, known as the Piedmont Plateau. West of this upland lies a series of parallel crests and valleys of the Allegheny Plateau, and this part of the province was called by Powell the Allegheny Plateau. The Allegheny quadrangle lies entirely within the Allegheny Plateau, a somewhat detailed description of the province is given below, in order to present a clear idea of the physiography and geology of the province and its relations to the surrounding country.

ALLEGHENY PLATEAU.

DESCRIPTION OF THE PLATEAU.

Drainage.—The Allegheny Plateau is drained almost entirely into Mississippi River, but the north and east drain partly into the Great Laken and partly through Susquehanna, Delaware, and Hudson rivers into the Atlantic.

Introduction. The Amity quadrangle lies in the southwest corner of Pennsylvania, principally in Washington County, but it includes also a small part of Greene County. It extends from latitude 40° on the south to 40° 10' on the north, and from longitude 80° on the east to 80° 15' on the west, and therefore covers one-sixteenth of a degree of the earth's surface, comprising 228.40 square miles. It is bounded by the following quadrangles of the United States topographic map: On the north by Carnegie, on the east by Beaver, on the south by Waynesburg, and on the west by Clayville. The principal town is Washington, with a population in 1900 of 14,117.

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Geography and Geology of the Northwestern Part of the Appalachian Province.

A line drawn along the Allegheny Front across Pennsylvania, Maryland, and West Virginia, and continuing along the eastern escarpment of the Cumberland Plateau across Virginia, Tennessee, Georgia, and Alabama, will divide the Appalachian province into two nearly equal parts. In the region lying east of this line the rocks are greatly disturbed by faulting and folding. They are very old, and in many places are so metamorphosed that their original character can be determined only with difficulty. The rocks west of this line are arched into broad, gentle folds.

The physiographic divisions of the northern part of the province are indicated in fig. 1.

In northern Pennsylvania the arrangement of the drainage is due largely to conditions that existed during the Pleistocene epoch. It is supposed that before this time all of the streams north of central Kentucky flowed northwestward and discharged their waters through the St. Lawrence system. The encroachment of the great ice sheet closed this northern outlet and new drainage lines were established along the present courses of the streams. In the same way the Allegheny Front is about 1030 feet. Sandstone is its predominant constituent, but it comprises various kinds of sandstone. The sandstone beds disappear and the formation contains the Allegheny Front formation. This is the northern boundary of the Greenbrier limestone of Virginia, and represents the upper part of the great Mississippian (Lower Carboniferous) limestone of the Mississippi Valley. The Greenbrier limestone is a thin stratum in several wells drilled in the vicinity of Blairsville in western Pennsylvania, but north of that place it is found at only a few localities. It is present in eastern Pennsylvania and western counties.

Pottsville formation.—This group of rocks derives its name from Pottsville, in the Southern Anthracite coal field. It is 1200 feet thick and is composed mainly of a coarse conglomerate, which in some parts of the field carries several workable coal seams. In the eastern part of the bituminous coal field in Pennsylvania the formation consists of at least two sandstone members, separated in the upper part by a thin shale, which at many places contains several thin coals. The upper sandstone member is known as the Humewood, the lower as the Conemaugh. In places the intervening shale contains a workable coal bed and locally also a valuable fire clay and one or more thin lignites. The sandstone and various associated beds are collectively known as the Mercer member, for the rock from which the member is named. In Pennsylvania the bones were well developed in Mercer County, Pa. Along the western border of Pennsylvania a third sandstone member occurs below the Conemaugh and is separated from it by another shale bed, which contains locally a workable coal seam. This sandstone is called the Shenandoah or Shenandoah conglomerate, and the coal bears the same name, from Shenandoah, in Mercer County, where the rock and coal are commonly exposed. In most parts of the bituminous coal field in Pennsylvania the thickness of the Pottsville runs from 125 to 200 feet. In the extreme western and in parts of west-central Pennsylvania the Pottsville lies unconformably on the Pecora formation.

Appalachian formation.—This formation takes its name from the Appalachian Mountains, and is typically developed and well exposed. In character it is rather more variable than the lower formations in the Carboniferous system. It is especially distinguished by the fact that in the northern part of the bituminous field it contains a number of workable coal seams in addition to the lower formations in this region, and on that account it is generally known as the "Lower Productive measure." Nearly all the coal mined in Pennsylvania north of Pittsburgh and east of Camb Mellville, along which it is 180 feet thick and is composed of siltstone to greenstone, and the formations contain all red shales, in the lower part of which there is a bed of limestone containing an abundance of marine fossils. This is the upper edge of the Greenbrier limestone of Virginia, and represents the upper part of the great Mississippian (Lower Carboniferous) limestone of the Mississippi Valley. The Greenbrier limestone is a thin stratum in several wells drilled in the vicinity of Blairsville in western Pennsylvania, but north of that place it is found at only a few localities. It is present in eastern Pennsylvania and western counties.
and limestones. These members are separated by strata of sandstone and shale. The clay beds form the basis of important industries at several localities.

**Conemaugh formation.**—The rocks overlying the Allegheny formation generally consist of a calcareous formation, known as the "Lower Barren measures," to distinguish it from a similar formation in the upper part of the same system. This formation overlies the Conemaugh in southwestern Pennsylvania and eastern Ohio. In some cases the side of the valley having the longest tributaries lies toward the west or northwest instead of the north, as in this region. This is not due to

![Image](image-url)
thin limestones and occasional coal beds. In southwestern Pennsylvania a number of beds will differ in thickness. Two sandstone members seem to correspond to the Homewood and Consol coal measures. The Allegheny formation is a great source of salt water, which is encountered in many wells.

<table>
<thead>
<tr>
<th>Coal Bed</th>
<th>Thickness (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Freeport coal</td>
<td>60</td>
</tr>
<tr>
<td>Allegheny formation</td>
<td>400</td>
</tr>
</tbody>
</table>

### Section of Conemaugh formation reported in the Wickenham well, borough of Deemston.

- **Pittsburgh coal**
  - Black slate | 12
  - Black limestone | 10
  - Black sandstone | 10
  - Shale | 10
  - Sand | 10
  - Lime | 15
  - Total | 60

- **Upper Freeport coal**
  - Black slate | 25
  - Black limestone | 80
  - Black sandstone | 25
  - Black sand | 12
  - Total | 180

### Allighean formation

- **Thickness**: The Allighean formation lies in the Allegheny formation. This may be defined as extending downward from the top of the Upper Freeport coal to the top of the Pittsburg sandstone. Where exposed in western Pennsylvania this formation varies in thickness from 270 to 370 feet, averaging probably about 300 feet. In the south, where the sandstone is difficult to determine, the available records seem to confirm the estimate just given.

### Sandstone in the Alleghenian formation.

- **General character**: The Sandstone formation consists of sandstones, sand beds, and occasional thin limestones. At most places where the formation is exposed in Pennsylvania it contains several valuable coal beds. The general character and sequence of beds in the formation are shown by several well sections in the borough of Deemston, two of which are given below:

<table>
<thead>
<tr>
<th>Sandstone in the Alleghenian formation.</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal bed</td>
<td>60</td>
</tr>
</tbody>
</table>

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**Mississippian series.**

**Major coal formation.**

**Definition.** The Muncie coal formation may be defined as the sands included between the Potter-ville formation above and the Pocono (Big Injun) sandstone below. The lower part of the formation consists of a thick bed of limestone, known as drills or the Big Limestone. This bed is identical with the Greenbrier limestone, which outcrops on Cler-ent Ridge and Laurel Hill, farther east, and which was called by the Second Geological Survey the "Mountain limestone." It is the frontedge of the Greenbrier formation of Virginia.

**Character and thickness.** The Muncie coal formation consists of a thin bed of sandstone, known as drills or the Big Limestone. In some wells this is probably the Upper Freeport limestone. The limestones 50 to 60 feet above the base of the formation are to be regarded as the Upper Freeport limestone. In some wells the coal is recorded only in the Limestone. This bed is the Upper Freeport coal (Coalville), and is the only bed of coal occurring in the formation. It is the Upper Freeport coal (Coalville) which occurs about 40 feet below the Upper Freeport limestone. The only well in the quadrangle that shows three beds of coal is the Muncie coal formation in the Wickenham well, borough of Deemston. The section of the Muncie coal formation in this well is given below:

- **Muncie coal formation reported in the Wickenham well, borough of Deemston.**
  - **Coal beds**:
    - **Upper Muncie coal**:
      - Black slate | 25
      - Black limestone | 80
      - Black sandstone | 25
      - Black sand | 12
      - Total | 180
  - **Lower Muncie coal**:
    - Black slate | 25
    - Black limestone | 80
    - Black sandstone | 25
    - Black sand | 12
    - Total | 180

### Upper Freeport limestone

- **Thickness**: The Upper Freeport limestone is usually 10 feet thick, though it may vary from 6 to 170 feet. In certain well records there is a thickness of 60 feet. The limestone, as it occurs, is the Clarion sandstone, which is the lower part of the upper Muncie formation. It is the Clarion sandstone which occurs about 40 feet below the Upper Freeport limestone. It is the Lower Freeport coal of the Allegheny formation which occurs about 40 feet below the Upper Freeport limestone. The only well in the quadrangle that shows three beds of coal is the Muncie coal formation in the Wickenham well, borough of Deemston. The section of the Muncie coal formation in this well is given below:

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Since these sections show a fair agreement in the character of the formation, though it will be seen that there is considerable variation in occurrence of the red beds. No sections of the formation in the western and northwestern parts of the quadrangle can be given, on account of uncertainty as to its upper limit and the lack of complete records. In general the interval between the Salt and Big Injun sands is less than in that direction. The thinning is illustrated by many of the wells in the quadrangle. The Salt and Big Injun sands are of local occurrence in the northern part of the quadrangle. In the Calhoun No. 3 well, Charleroi Township, the interval from the top of the Salt sand to the top of the Big Injun is about 100 feet, but in wells in North Union Township it is in places only 100 feet. In many of these red sands are also present. In two Calhoun wells in Charleroi Township, 150 and 100 feet of black sand are reported. In certain wells in the Burgettstown quadrangle the sand is entirely missing.
Unconformity at top of Mauch Chunk formation.—The irregularity in thickness of this formation throughout western Pennsylvania is caused by an unconformity between the Pocono and the Mauch Chunk formations, due to erosion after the deposition of the Mauch Chunk and before that of the Pocono. This unconformity was first determined from evidence afforded by small faults. The Mauch Chunk is absent in the northern part of the State, where the massive sandstone of the Pocono formation appears.

General statement.—The Pocono is the lowest formation in the Pennsylvania series. It is in most instances conformable with the top of the Big Injun sand of the drill, a bed that corresponds with the Burgess sandstone of the Ordovician System. In the Allegheny Valley it extends down 300 to 600 feet, according to different authors. The top of the Pocono is characterized by the presence of the Little lime, which is at the top of the first red shale below the Little lime, and tends to cave after the removal of the drill.

Bad character and thickness.—Assuming the boundary defined above to be correct, the average thickness of the Pocono formation in western Pennsylvania is 130 feet. In some places it may be 150 feet or more, and in others as little as 100 feet. The average thickness of the Pocono in Indiana and Armstrong counties is about 120 feet. The thickness of the Pocono in the Allegheny Valley is about 140 feet. In the Kittanning and neighboring quadrangles it is about 150 feet. In the Latrobe quadrangle it is about 160 feet. In the North Franklin quadrangle it is about 170 feet. In the South Franklin quadrangle it is about 180 feet. In the Hackett quadrangle it is about 190 feet. In the Zollarsville field it is about 200 feet. In the North and South Franklin townships it is about 210 feet. In the West Pike Run Township it is about 220 feet. In the Seaman Township it is about 230 feet. In the Nottingham Township it is about 240 feet. In the Harbor Township it is about 250 feet. In the General average it is about 260 feet.

In its interval to the top of the Big Injun sand the Gants varies from 374 to 753 feet, the extremes being respectively, the well on the Mound at Latrobe and the well near Newwauken in Armstrong County. In single instances considerably greater intervals occur, but there are believed to be due either to the presence of salt domes or to a mistaken correlation of the sands.

The thickness of the interval between the top of the Mauch Chunk formation and the bottom of the Pocono varies from 375 to 500 feet, the extremes being respectively, the well on the Mound at Latrobe and the well near Newwauken in Armstrong County. In single instances considerably greater intervals occur, but there are believed to be due either to the presence of salt domes or to a mistaken correlation of the sands.

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</tr>
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<td>Zollarsville field</td>
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On comparing these groups of intervals, the most noticeable feature is the second group, unlike the first, does not show any general thickening toward the southeast. This fact is in harmony with the thickening of the strata is due largely to the unconformity at the top of the Mauch Chunk formation. The thickness of the Gantz sand varies from 10 to 60 feet and that of the Fifty-foot sand from 0 to 100 feet. Where they are developed separately they may occur as much as 80 feet apart, the break being due to a fault or a syncline. The interval from the Pittsburg coal to the Fifty-foot sand varies from 1065 feet at the Matthew Line well near Washington to 2007 feet in the Burgettstown well in the borough of Deinnton, as shown in the following table:

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The Gantz and Fifty-foot sands form a very prominent oil horizon, made famous by many huge gas-holds in the Washington field. These sands are rather persistent and are recognizable in most of the well records. Toward the southwest they taper and are known as the Hundred-foot sand. In position the Gants and range from 80 to 180 feet below the top of the Thirty-foot sand. The Fifty-foot sands are accumulated to be equivalent to the First sand of Oil Creek. The condensation of the Gants sand to the Thirty-foot sand is more variable than that between any two persistent sands. Within the interval it varies from the Rose well in Washington county to the first sand of Oil Creek to 185 in one of the J. L. Thompson wells in the Zollarsville field. As with the upper sands, there is a gradual thickening of the interval from the northeast toward the southeast, as shown by figures in the various districts. The variation probably results from the movement of the Potawkee and the consequent increase in thickness of the Mauch Chunk formation toward the southeast. The limiting average thicknesses are given in the following table:

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sand is therefore probably the lowest sand in the Carboniferous system.

Red shale (Bucks).—The red shale already mentioned as occurring between the Thirty-foot and Gantz sands and probably representing the Bedford shale has also been reported in the Burgettstown quadrangle, but it is given in only five wells in the Amity quadrangle. This may be due to the absence of the red shale, but it seems more likely to be due to the scarcity of complete records. In one well in the J. L. Thompson No. 3 well, in West Pike Run Township, it is 5 feet thick; in the Lens well, near Beadlesville, it is 20 feet thick; and in the J. L. Thompson wells No. 1 and 2 it is 10 feet thick. In the Gantz well it is present as 8 feet of reddish sand. In some wells it occurs directly below the Thirty-foot sand.

This red shale deserves more attention than it has hitherto received from geologists. As has been said, it is generally present beneath the Burgettstown quadrangle and has been noted in Beaver County. Toward the southeast, however, it is not known. Mr. John F. Curll (Rept. 1st, Second Geol. Survey Pennsylvania, 1868, pp. 90-96, Pl. V) has published a map showing the distribution of this bed, and has traced it by means of well records under the name of the Collins or Southern Venango County, and western Butler County in Pennsylvania, and in eastern Ohio as far west as its occurrence along the Cincinnati anticline. Curll's report was published considerable drilling has been done in the Amity and Burgettstown quadrangles and it is evident the red shale has been found in some distance outside its southeastern boundary as mapped by him. It is possible that in the Amity quadrangle it may occur only in pockets.

In eastern Greene County it is not present, but in western Greene it is generally present. The red shale is best developed in western Pennsylvania its thickness runs from 80 to 130 feet. The application of the name Bedford shale to this horizon is questionable on account of the uncertainty in correlation with surface outcrops, but it is believed to represent the Bedford shale.

DEVOINIAN SYSTEM.

CHERNIC FORMATION.

General character.—Throughout the Amity quadrangle the Devonian rocks extend a short distance above the surface. As has been seen, the top of this system is very indistinct, but is probably 1000 feet above the surface. The rocks are extensively faulted and the occurrence of the red sand above the surface in a number of wells in the Zollarsville field raises the question of its occurrence in that area.

The general character of the group containing the red beds can be seen from the following table:

<table>
<thead>
<tr>
<th>Location</th>
<th>Bed</th>
<th>Thickness of interval from top of Pittsburg coal to top of Gantz sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zollarsville</td>
<td>Fourth sand</td>
<td>90 to 140 feet</td>
</tr>
<tr>
<td>Morris Township, Greene County</td>
<td>Fifth sand</td>
<td>20 to 60 feet</td>
</tr>
<tr>
<td>Somerset Township</td>
<td>Zollarsville</td>
<td>20 to 180 feet</td>
</tr>
<tr>
<td>North Franklin Township</td>
<td>Fourth sand</td>
<td>60 to 120 feet</td>
</tr>
<tr>
<td>Washington Township</td>
<td>Fifth sand</td>
<td>10 to 30 feet</td>
</tr>
</tbody>
</table>

Partial section of these formations in the J. L. Thompson No. 3 well, in West Pike Run Township.

The top of the Chernic formation is well enough defined to be used in drilling, but the lower part is more difficult to define. The red sand has been known as the Bedford shale, but it is probable that the red shale is the equivalent of the Bedford shale. The red sand is probably the lowest sand in the system.

The red sand lies within the limits of the Catskill beds, but it is more persistent than the Catskill sand. It is more persistent than the Catskill sand in the Zollarsville field, where the beds are very persistent. The red sand is more persistent than the Catskill sand in the Morris Township, where the beds are not persistent. The red sand is more persistent than the Catskill sand in the Washington Township, where the beds are not persistent.

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miles on Little Tenmile Creek near Lone Pine. In the northwest corner of the quadrangle it occurs along the Main coal area west of Farmington, but except small tracts along the main valley, where it has formed a coal seam, it is not well developed. In the southeast corner of the quadrangle it occurs as a strip over a mile wide on the hillside parallel to the creek. In the valley of Little Tenmile Creek it extends from the edge of the quadrangle as far south as Wyalusing, cropping up on the side valleys for a distance of 2 to 3 miles along the north side of the town of West Brownsville, but there it is only 2 or 3 feet thick. In the area north of the Williamsport Pike and east of a line drawn northward along Shipps Run it is covered by rocks of this formation. A small area along Peters Creek consists of Conemaugh rocks. The Monongahela formation occurs on the several branches of Pigeon Creek as far up as Emery and Vanover, and nearly to Three and Four. It also includes the greater portion of the area southeast of Zollarsville and Spring Hill.

**General character.**—This formation consists of shales, limestones, and occasional sandstones, and contains at least three valuable coal beds. The best recorded section in Washington County was measured by Dr. J. C. White (Bull. U. S. Geol. Surv. No. 65, p. 45) near West Brownsville, and is as follows. It is best developed in the northwestern part of the quadrangle, and there is a bed of limestone which originally was named by Stevenson (Rept. K, Second Geol. Survey Pa., 1876, p. 67) the Fitch Run limestone, from Fitch Run, in the southeast corner of Washington County, where it occurs. The term Swick­ ley has generally been applied to this limestone, but it has been observed under the curve on Fitch Run and Mingo Creek.

By comparison of these records it will be seen that while the lower intervals occur in a general way more abundantly in the western portion of the quadrangle, there are also points in West Pittsburg, Wheeling, and West Bethel townships, where the beds are more than 600 feet thick. In addition, it is not rare to see the beds 300 feet thick near the town of Wheeling.

**Lithologic characteristics.**—The Monongahela formation is well exposed at a number of points in the Amity quadrangle, where it occurs at an interval ranging from 20 to 80 feet above the Pittsburg coal bed. It is also present at a few places in other parts of the quadrangle, but it is believed to be cut out in some localities by the Pittsburg coal mine. It is of some value, but it has been little prospected. Its thickness reaches 4 or 5 feet at some places.

**Pittsburg limestone**.—The Swickley coal lies on a bed of limestone which originally was named by Stevenson (Rept. K, Second Geol. Survey Pa., 1876, p. 67) the Fitch Run limestone, from Fitch Run, in the southeast corner of Washington County, where it occurs. The term Swick­ ley has generally been applied to this limestone, but it has been observed under the curve on Fitch Run and Mingo Creek.

**Sandstone.**—This stone consists of a lower and an upper division, both being in turn divided by a thin shale. The lower part is generally a hard, pure sandstone, while the upper division is more clayey and argillaceous. The lower part is generally a hard, pure sandstone, while the upper division is more clayey and argillaceous.

**Shales.**—There are very few points in the northeastern part of the quadrangle where the Shales can be seen at several points on Chartiers Creek, Wheeling, and its base is from 100 to 130 feet above the Pittsburg coal bed. It is at many places several feet thick and has been opened at a few places on the map of Mingo Creek.

**Waynesburg coal.**—In the Amity quadrangle, its horizon being from 90 to 150 feet above the Pittsburg coal bed. It is at many places several feet thick and has been opened at a few places on the map of Mingo Creek.

**Limestone.**—In the south side of the quadrangle, its horizon being from 90 to 150 feet above the Pittsburg coal bed. It is at many places several feet thick and has been opened at a few places on the map of Mingo Creek.

**Leptophytes.**—The chief pecopterids of the large lepidophytes are waning, the genus Sigillaria appears to be characterized by a great abundance of brachysicylops, the genus *Lepidodendron* by a great abundance of brachysicylops, and the genus *Lepidodendron* by a great abundance of brachysicylops.
about 750 feet, is in Morris Township, Greene County, in the extreme southwestern corner of the quadrangle. The rocks dip toward the southeast and the maximum thickness is about 60 feet. In some regions it is the top of the Upper Washington sandstone. In that region the thickness of the beds is least. In most of the area the beds are not exposed. In Greene County the Dunkard carries many beds of red shale. These increase in importance toward the southeast and are most prominent in West Virginia, but toward Washington County they disappear, giving way to the ordinary shaly or yellowish shales. Traces of the red shales can be seen on some of the highest hills in the southwestern part of the quadrangle.

The oldest of the Dunkard—The Dunkard group was formerly considered a formation, like the Conococheague and Monongahela, but in some regions it is now considered as the Union and Marietta formations of that region. This formation is characterized by the abundant occurrence of such genera as Callipteris, Neuropteris, Pecopteris, Sphenopteris, and Odontopteris obtusiloba Nauru.

The most accurate detailed section of these rocks within the quadrangle is given by Maass Smith in his diamond-drill hole near Russell. This record, however, includes only the lower 143 feet of the formation. The principal fault-bounding bed of the Dunkard group is the Caswille shale, which is at some places present between the Waynesburg coal and the Upper Washington sandstone, and with which has been included, palynologically, the upper shale parting of the coal. Other important fossiliferous beds are a sandstone below the Upper Washington sandstone, a black carbonaceous shale just above the Washington coal, parts of the Upper Washington sandstone, and the roof of the Jollytown coal.

**Washington Formation.**

**Definition and thickness.**—As stated above, the Washington Formation includes all strata between the top of the Waynesburg coal and the top of the Upper Washington limestone, being bounded below by the Monongahela and above by the Caswille shale. This thickness varies, but in this quadrangle is generally 600 to 400 feet.

**Distribution.**—This formation occurs in a large area in this quadrangle than any other formation. It occurs in the surface of nearly all the central part, the exceptions being patches of the Dunkard group or the Caswille shale, which has a light bluish to bluish-gray color and usually contains blackish or bluish shale, which is in this region is in the vicinity of Washington is in the Baltimore and Ohio Railroad cut in the western part of town, where it can be seen outcropping below the Upper Washington sandstone.

**Lower Washington limestone.**—The lowest of the three principal limestones occurring near Washington. The limestone is at some places one and a half feet thick near the coal and the lime. The Lower Washington limestone occurs from 130 to 230 feet below the top of the Upper Washington sandstone. Washington County is the region of its best development, and here it sometimes attains a thickness of 30 feet. It is generally interstratified with shales, as shown in the following section:

<table>
<thead>
<tr>
<th>Section of Lower Washington limestone and associated shale</th>
<th>Thickness</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Black slate, dark</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Black slate, white</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Shale</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Black slate, white</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Silicious sandstone</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>155</td>
<td></td>
</tr>
</tbody>
</table>

The Lower Washington is at most places a hard, red to yellowish sandstone, commonly called the "Washington red" sandstone in association with gray or grayish sandstone, which in this region is in the vicinity of Washington is the region of its best development. The sandstone is also said to be rich in carbonaceous matter, and is often light blue in color and contains black or bluish shale, which is in this region is in the vicinity of Washington is in the Baltimore and Ohio Railroad cut in the western part of town, where it can be seen outcropping below the Upper Washington sandstone.
feet in thickness. On the uplands in the vicinity of Zollarsville, the thickness is much greater, at some places amounting to as much as 800 feet.

One of the most continuous exposures of the limestones in the quadrangle is on a long ridge on which a road runs in a northwest-southwest direction through the town and in a quarry on the hill southeast of the town.

The Upper Washington limestone is easily recognized by its weathered surface, which is sharply broken, with a slight tinge of blue. It varies in thickness from 4 to 50 feet.

The best exposures of this limestone are in the vicinity of Washington, where it reaches a thickness of nearly 30 feet. The tunnel of the Baltimore and Ohio Railroad 1 mile east of town can be seen through the bed, exposing at its western end the section given below. The limestone is quarried at this place.

### Section of Upper Washington limestone and associated rocks at tunnel 1 mile east of "Washington"

<table>
<thead>
<tr>
<th>Strata, dark gray</th>
<th>10</th>
<th>Shale, black</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale, hard, clay</td>
<td>30</td>
<td>Sandstone, hard, gray</td>
<td>10</td>
</tr>
<tr>
<td>Shale, gray, mud</td>
<td>10</td>
<td>Shale, clay, black</td>
<td>30</td>
</tr>
<tr>
<td>Shale, gray, clay</td>
<td>10</td>
<td>Greenstone, black</td>
<td>5</td>
</tr>
<tr>
<td>Shale, black</td>
<td>10</td>
<td>Greenstone, black, medium</td>
<td>30</td>
</tr>
<tr>
<td>Shale, black, fine</td>
<td>30</td>
<td>Greenstone, black, tough</td>
<td>10</td>
</tr>
<tr>
<td>Shale, black, fine</td>
<td>10</td>
<td>Greenstone, black, very</td>
<td>10</td>
</tr>
<tr>
<td>Shale, black, gray, very</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total thickness of Upper Washington limestone**

14 feet

### On Cemetery Hill, in the southwestern part of Washington

Just off the quadrangle, between Houston and Greensburg, there is a narrow terrace of these deposits on the east side of the creek at an elevation of 800 feet. At this place the gravels and silts are exposed in a quarry. As much of the upper silt being exposed at a brickyard, where it is utilized for brickmaking.

The underlying gravel is poorly exposed and the clay below can not be seen. The pebbles in the gravel have a maximum diameter of 2 inches, though most of them are smaller. They are mostly sandstones, but quartz pebbles up to five-eights inch in diameter were found. Most of the pebbles are deeply weathered, and have a very old appearance. The presence of a few quartz pebbles seems to indicate that the deposits were in part derived from material brought in from the north, so as to pebbles even approximating their size are known to have been exposed in any of the sandstones that overtop the Carmichaels coal or in the Shale formation.

The silt forming the top of the deposits deserves special mention. Where seen in the clay pit it is a very tough, buff-colored deposit, lightly banded between the faces, strongly resembling portions of the loess of the Mississippi Valley. Silt of this type is a constituent of all the Carmichaels deposits in the Allegheny quadrangle and of Carmichaels deposits in general. It is so coarse a fact that sites of these deposits have been noted on similar terraces a short distance outside the glacial boundary of Beaver River, on Ohio River in the vicinity of Wheeling, and at several other localities.

### Originals

There is still some doubt as to the exact mode of origin of the Carmichaels deposits. They were never doubt laid aside at a time when the water was at a higher level than the present and had probably little current, and the subsequent trenching of the old valley floor has left the gravels and silts on the lower bench. There are, however, different theories for account to the deposits. The first theory was formulated in 1874 by B. F. Schorger (Phil. Soc. Sci., vol. 17, 1879, pp. 269-316), and accepted by T. C. Chamberlin (Amer. Geol. Mag., vol. 18, Dec. 1896, pp. 368-379), who assumes that the sediments were deposited in an open lake occupying the entire Monongahela Valley. The third theory is that of E. R. Campbell, proposed in the Missoulian, is the theory that the sediments were held in the drainage basin of the stream, the Ohio, which flows in the vicinity of the Amity quadrangle. The theory that the sediments were deposited in an open lake occupying the entire Monongahela Valley is the theory that has been followed.
ntheastward into Lake Erie. The advent of the pre-Kasans or first, ice sheet is supposed to have blocked this outlet, and the water and sand to have overflowed through a pass in the southern southeastern watershed of Monongahela River. According to Mr. Campbell's recent theory, the waters were distributed locally by temporary ice dams at various points along the ancient rivers, and the main body of these waters was deposited in the smallest ponds, while gravels and sands may have been deposited at higher levels in such a lake as that postulated by I. C. White.

The theory of ice dams accounts for the absence of the old channels and explains the occurrence of the deposits in many of the tributary valleys, like Charlestown, Tennesse Creek, and certain conditions that exist over broad localities outside the glacial boundary along Ohio, Allegheny, and Beaver rivers, capping rock benches up to 1070 feet.

The top or bottom of some persistent and easily recognizable structure is selected as datum surface, and its elevation above sea level is determined at many points as possible. In the Amity quadrangle, the horizon selected is the bottom of the Pittsburg coal bed, this being the best known and most persistent bed in the region. The structure is shown on the structure map by means of red contour lines. These are drawn at uniform intervals above sea level, and all points on a given contour have the same elevation. In other words, a given structure contour may be considered as the line of intersection of the datum surface with a plane, all points of which have the same elevation above sea level. Another objection to the use of the cross-section method in this district is that the dips are so gentle that nowhere in efficiency is substan
gually exaggerating the vertical scales. In this report, therefore, the structure is represented by a line parallel to the 700-foot contour and the 1000-foot contour.

Gravel deposits were observed in widespread localities outside the glacial boundary along Ohio, Allegheny, and Beaver rivers, capping rock benches and having the general character and relations of the Carmichaels formation. On Allegheny and Beaver rivers they grade toward the north into gravels supposed to be of pre-Kasans but possibly of Kasan age, capping rock terraces at elevations of 900 to 1000 feet. Furthermore, in the survey of the Rogersville quadrangle, in western Greene County, small patches of gravel and silt in every respect like the Carmichaels deposits were found up to an elevation of 970 feet covering rock terraces on Dunker Fork of Wheeling Creek near Durbin.

Sumsinuki, we find that the upper limit of the deposits classed as Carmichaels in all the valleys of southwestern Pennsylvania has a vertical range of but little over 100 feet. This fact seems to indicate that part of them, at least, were formed in standing waters ponded throughout southwestern Pennsylvania and parts of adjacent States. This ponding was probably due to the advance of the first or pre-Kasans ice sheet and the consequent damming of the northward-flowing rivers. After the water fell below the general level, owing to retreat of the ice or to creation of a new outlet, local ice dam may have been formed at Carmichaels and elsewhere, making possible the deposition of sediments at varying levels below the upper limit of ponding. Some of the differences in upper level, especially toward the southeast, may be due to erosion and slight tilting. The weathered and aged appearance of the gravels in the Carmichaels deposits and their occurrence on the rock terraces on which the rivers flowed at the beginning of the Quarternary period corroborees their probable deposition in earliest Pleistocene time.

Recent deposits.

The valleys of most of the streams in the quadrangle are so narrow that many of the flood plains are not a hundred yards wide—too small to map. Only the larger areas of alluvium are therefore indicated on the geological map. The best development of flood plains is along Charleroi, Lith
town, and Tennesse Creek. At a few points in these valleys flood plains locally are as much as one-fourth of a mile wide.

Geologic structure.

Structure in general.

Method of representing structure.—Geologic structure can be graphically represented in two ways. One method—still commonly used—is that of cross sections, which show the strata as if cut through along a given vertical plane. In difficulty arises from the fact that only a limited number of sections can be given on the map, and between them lie considerable areas concerning whose structure little or no information is given. Another objection to the use of the cross section method in this district is that the dips are so gentle that nowhere is an exact measurement possible. As can be seen by the map, the elevation of the valley at this point is about 800 feet, and the strike of the 500-foot structure contour; therefore the Pittsburg coal is here calculated to be about 800 minus 500 feet below the surface.

Degree of accuracy.—Should the belief be maintained that it is impossible to make structure contours strictly accurate in all parts of the field, and allowance for possible errors should therefore be made in using them. Over large areas there are no mines or wells by which the exact depth of the coal below the surface can be determined. In each area it is necessary to depend upon estimated intervals between the coal and the bed which show them in outcrop, and as the intervals are never constant over any considerable area, an error may be intro

duced which will affect the drawing of the struc
ture contours. In this quadrangle, however, the accuracy is probably never very great. By reference to the map it will be noticed that in cer
tain localities the contours have many waves and turns, while in other parts of the quadrangle they run for miles in long, regular curves. This differ
cence is partly due to the fact that in certain parts, as in the Ellsworth, Peters Creek, and Charleroi Creek mining districts, the contours are based on mine maps showing the elevations of the coal in the areas that have been worked. In regions where a great many well records have been avail
able, the structure is likewise more accurately shown than in other por
tions of the quadrangle. The Survey is endeavoring to get more and better maps, which will have generally furnished their well records, and to the various coal companies which have allowed the use of their mine levels.

Limits of error.—In general the structure-contour interval in a given area is decided by two factors—(1) the steepness of the dip, and (2) the accuracy with which the available data enable contours to be drawn. In a region like this, where the dips are all fairly gentle, only the second factor has to be considered. Obviously it is useless to make the intervals less than the "limit of error" (20 feet of error). For example, if over a given area the elevation of the datum horizon was determined within 50 feet, it would be unsafe to draw contours with a 25-foot interval. Moreover, such a representation would be misleading to the reader, who would be led to believe that the elevation at any given point was accurate to within 25 feet, which would not be the case. In general, then, the "limit of error" for an area should not be greater than the contour interval.

The detailed structure of the Amity quadrangle in its relations to the geology and geography is best exhibited by the structure and economic geol
ogy map. The principal structural features shown on this are three anticlines and two synclines, trending in a general way in a northeast-southwest direction. These will be described in order from east to west.

Bellevue anticline.—What is here called the Bellevue anticline was called the Waynesburg anticline by J. A. Stevenson in a report published in 1876, in which the same name was used to the anticline lying west of the anticline. When the Bellevue anticline was surveyed, in 1901, there was some doubt whether the anticline crossing Monongahela River near Bellevue was continuous with the one running near Waynesburg, named by Stevenson. On account of this uncer
tainty and on account of the fact that the term Waynesburg had been applied to two structural features, this axis in the Bellevue quadrangle was named by M. K. Campbell (folio No. 94) the Bellevue anticline, and this name was employed by R. W. Stone in the Waynesburg folio (folio No. 121) a year later.

The Bellevue anticline crosses the Amity quadrangle in its extreme southeast corner. That part of the axis lying within this quadrangle has a length of about 1.5 miles. It trends N. 29° E., and the elevation of the Pittsburg coal on its crest is 800 to 840 feet.
course, averaging about 8° 40' W., to the southern edge of the quadrangle. From Butlerville it follows the valley of Pigeon Creek to Three and Four, where it turns southeastward toward the southwest, then at the Greene County line runs east and passes half a mile, and east of Seven Mile Hill, winding across West Allegheny Township and running directly through Jessville, south of which it leaves the quadrangle.

Where the axis of the trough enters the quadrangle from the east it is at an elevation of about 750 feet above tide, and from this it descends gradually toward the southeast until, at the Greene County line its elevation is below 400 feet. Throughout the basin the dips are gentle, averaging less than 100 feet per mile, except on the eastern flank between Zellbiller and Beallsville, where they are as much as 150 feet per mile for short distances. In this section the structure is largely interpreted from well records, and shows several rather peculiar nose-like projections from the flank of the anticline. These are presumably about as represented, as the well records seem to be mostly good, but in many cases due allowance should be made for the possibility of errors in the records. In the center of the trough, between Jessville and Runnaway Valley, it is possible, owing to the near data obtained, that the basin is somehow deeper to place than shown.

Anticline anticline.—From the Wytheburg syncline the rocks rise gently northeastward to the crest of the anticline. This was called the "Pine Island" by Stevenson and White in their reports, the term being taken from a farm, now used to the south of this stratum. The designations being from the village of Amity, seemed more suitable, Stone described it as such in the Wytheburg folio.

Beginning at the south, this anticline crosses the Greene County line, forming the boundary between Morris and Washington townships. As it enters the quadrangle it takes a slight bend or offset to the east, thus continuing in an average course about N. 30° E., passing just east of Amity, through Lone Pine, and crossing the National Pike 4 miles southwest of Oil City. This formation is rather broad and flat, and the coal ranges in elevation from 900 feet at the south to 1100 feet at the northern end. Beyond this point the axis descends rather steeply toward the Nineveh syncline. This feature of the structure is interesting in view of the fact that the famous Washington oil field is situated along the strike of this flank. The numerous well records in the vicinity show the intermittence of the structure continues in the vicinity.

North of the axis about the quadrangle all the folds plunge to the southwest, in conformity with the general dip, into the deepest part of the Appalachian coal field. The dips are about 60° from north to south, and 80° from west to east.

Lock of parallelism between beds.—In using the contours represented on the map it should be remembered that few beds are exactly parallel, and hence allowance must be made for increases and decreases of thickness in various directions. For instance, the interval between the Upper Washington limestone, one of the most persistent outcropping beds in the Pittsburgh coal, varies from 630 to 710 feet, and the interval between the Wytheburg coal and the Pittsburgh varies from 250 to 350 feet. Some of the intervals between formations below the surface vary even more, as shown in the uplifted and mantled beds. The causes of these variations are two-fold, (1) slight changes in the thickness of various beds, and (2) the changes in thickness of sedimentary beds, due largely to the indication of the structure contours in the vicinity.

GEOLOGIC HISTORY.

FAIRMOUNT ERIAL.

As has been said, the Amity quadrangle is situated near the center of the great Appalachian synclinal basin, in which the pre-Divonian rocks are basied as deeply below the surface that they have not been penetrated by the drill. The oldest rocks exposed at the surface belong high in the Pennsylvania series of the Conemaugh system, but the extensive exploitation of oil and gas in this part of the state has made it possible to study the underlying Mississippian and Devonian rocks, and the sequence of events has been determined with considerable accuracy.

SEVIERIAN PERIOD.

CRUSHED EROM.

As shown in the section of the strata of the quadrangle, the oldest rocks penetrated by the drill in this quadrangle are Mississippian rocks, and the oldest rocks lying below any part of the structure are the Mississippian rocks. At the time those rocks were formed a large part of what is now the county of Greene was under the ocean. There was a great inland sea, which was bounded on the north by the Archean highlands of Canada and on the south and west by the Allegheny highlands of the Appalachian plateau. It probably lay somewhere along the Atlantic slope and probably crossed New England near its western end as far extended to the south and west, and it seems likely that it reached outward considerably beyond the present Atlantic shore line. The great expense of salt water in central United States had not then started, as it did later, and it is believed that the salt water in the open ocean was too cold to have any great effect on the growth of coal.
The land in southwestern Pennsylvania and Ohio subsided and deposition was resumed in this part of the province. The Conococheague sandstone was deposited at this time. This period was followed by one in which the basin was covered with vegetation, the remains of which formed the Morris coal, its remaining plants having been accompanied by a varying amount of mud, forming shales, and of calcareous matter, which formed limy shales. The deposition of the Homewood sandstone was deposited over most of the field, and this episode closed the Poorville epoch.

SUBMERSIVE EPOCH.

After the material composing the poorville sandstone of the Poorville epoch had been deposited there came a time in which the bed now forming the slates, sandstones, limestones, and coal seams of the Allegheny formation were laid down. The great variations in the material of this formation indicate that it was deposited during periods in which large amounts of coarse sediments were swept into the basin and alternated with periods in which little or no material was supplied except the abundant growth of plants whose remains now make up the coal beds. The origin of the coal and the method of its accumulation in seams covering great areas are not well understood. That it was deposited by a single period is almost universally acknowledged, but there is great difference of opinion as to the method by which the vegetable matter was transported to the deposit. It seems safe to assume that the coal seams of the Appalachian province were in the main formed near sea level in normal periods, which often extended over thousands of square miles.

The well records in Greene and Washington counties do not give evidence of any interesting epoch, but in general the sequence of events during the period of deposition of the Allegheny formation is as follows:

The deposition of the Homewood sandstone was followed by a slight submergence and the accumulation of a few feet of cherty sediments. Then the sea was filled or its bottom rose approximately to sea level and mamal conditions prevailed. Different parts of this sea were overlying this area. This is the Homewood epoch.

The formation of a few feet of clayey sediments. Then the sea was filled or its bottom rose approximately to sea level and mamal conditions prevailed. Different parts of this sea were overlying this area. This is the Homewood epoch.

After the great long and comparatively quiet period the region was again gradually submersed and alternate periods in which little or no deposition took place. When marshes prevailed the material of which coal was accumulated the remains of many generations of plants. Different parts of this marsh were overlying this area. This is the Homewood epoch.

The Homewood sandstone, which covered the area, was overridden by another great period of submergence, the Homewood epoch. During this period the sea occupied nearly the entire area. This is the Homewood epoch.

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During the Homewood epoch conditions were evidently normal, with the result that sediments were deposited, the surface being gently peneplaned. Then, the sea, after filling the basin, receded and left the surface in a state of submergence, which caused the deposition of the coarse sandy and marly sediments. The deposition of the Homewood sandstone was followed by a slight submergence and the accumulation of a few feet of cherty sediments. Then the sea was filled or its bottom rose approximately to sea level and mamal conditions prevailed. Different parts of this sea were overlying this area. This is the Homewood epoch.

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MINERAL RESOURCES

COAL

Coal is destined to become the most important mineral resource of the Amity quadrangle. Owing to the depth of the Pittsburg coal below the surface it is mined at only a few places at the present time, but the demand for coal is increasing with its exhaustion near the surface, and more shafts will doubtless soon be sunk to this coal in this quadrangle.

The principal coal outcropping in the quadrangle is the Pittsburg, Redstone, Waynesburg, Waynesburg “A,” and Washington coals. The Pittsburg coal is the only one now mined for shipment, but the Washington is worked at many country banks, and the Redstone and Swiktley have been opened locally; the Waynesburg “A” probably is worthless, and the coal mined for shipment. In the center of this area, of no value under existing conditions. Several seams below the Washington have been penetrated by the drill in search for oil and gas. The Pittsburg coal is the most valuable seam in southwestern Pennsylvania. From all the evidence available it seems to be everywhere of workable thickness and of good quality.

The Pittsburg coal lies at the base of the Monongahela formation. In the Amity quadrangle the outcrop of the bed is only about 15 miles long, but the coal is believed to underlie the entire district except in two small patches, where it is cut by Charities and Peters creeks, so that it comprises an area of about 320 square miles.

The outcrop of the Pittsburg coal follows both sides of Peters Creek below Venetia and of Charities Creek below McGovern. It also reaches the surface at Meadowlands and extends nearly a mile up several tributary valleys west of Charities Creek. Well records show that the bed is present in all parts of the quadrangle. At Washington its average depth is about 450 feet below the valley; at Linden, 250 feet; at Wylandville, 350 feet; at Sollivania, 300 feet; at Susqueh, 300 feet; and at Tennent, 410 feet. The variation in level of the Pittsburg coal in this quadrangle is shown on the structure map, and the method by which its approximate depth at any point can be determined is explained under the heading “Stratigraphic,” on page 19.

For mining operations are yet in progress in the Amity quadrangle, but the coal is reached by drifts and slopes at a number of places along Charities and Peters creeks, and has been shafted at to the Mindfield mine, at Ellsworth, and at Three and Four. The thickness of the Pittsburg coal bed is rather variable, but its structure is fairly constant throughout this region. The arrangement of the benches is shown in the following section:

The uppermost part of the seam is known as the “roof division,” below which lie the “main clay” and the “lower division” or the latter being the part of the coal mined for shipment. In the center of the lower division are two very persistent “slate” partings separated by a thin layer of coal, the group being known to the miners as the “hearing-in coal.” This bench is generally chosen by the miners as the best layer on which to work in preparing the overlying coal. The bands separate the lower division of the coal into the “brust coal” lying above the “breasting coal,” and the “brick coal” and “bottom coal,” lying below the bands. In most regions the “brick coal” and “bottom coal” are distinct and are separated by a thin binder, but in this quadrangle they can be distinguished in a few instances only.

The principal coal beds outcropping in the quadrangle are the Pittsburg, Redstone, Swiktley, Waynesburg, Waynesburg “A,” and Washington coals. The Pittsburg coal is the only one now mined for shipment, but the Washington is worked at many country banks, and the Redstone and Swiktley have been opened locally; the Waynesburg “A” probably is worthless, and the coal mined for shipment. In the center of this area, of no value under existing conditions. Several seams below the Washington have been penetrated by the drill in search for oil and gas.

PITTSBURGH COAL

In quality the Pittsburg coal in Washington County is fair for a bituminous coal. Several analyses have been made and the following average of analyses have been calculated for this quadrangle. The average is computed from the composition of 8 samples. In taking these samples a section 2 inches wide was cut from roof to floor in the seam as is mined for shipment, and all partings not included by the miner were thrown out. The sample was then thoroughly mixed and quartered to the bulk desired, sealed in an air tight jar, and mailed to the chemical laboratory of the United States Geological Survey's coaling plant at St. Louis.

In the Pittsburg coal in Washington County is fair for a bituminous coal. Several analyses have been made and the following average of analyses have been calculated for this quadrangle. The average is computed from the composition of 8 samples. In taking these samples a section 2 inches wide was cut from roof to floor in the seam as is mined for shipment, and all partings not included by the miner were thrown out. The sample was then thoroughly mixed and quartered to the bulk desired, sealed in an air tight jar, and mailed to the chemical laboratory of the United States Geological Survey's coaling plant at St. Louis.

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The proportion of fixed carbon in the coal of the quadrangle is only moderate, but the ash is rather high. This coal, however, is known as the “brust coal,” lying above the “breasting coal,” and the “brick coal” and “bottom coal,” lying below the bands. In most regions the “brick coal” and “bottom coal” are distinct and are separated by a thin binder, but in this quadrangle they can be distinguished in a few instances only.

The principal coal beds outcropping in the quadrangle are the Pittsburg, Redstone, Swiktley, Waynesburg, Waynesburg “A,” and Washington coals. The Pittsburg coal is the only one now mined for shipment, but the Washington is worked at many country banks, and the Redstone and Swiktley have been opened locally; the Waynesburg “A” probably is worthless, and the coal mined for shipment. In the center of this area, of no value under existing conditions. Several seams below the Washington have been penetrated by the drill in search for oil and gas.

For mining operations are yet in progress in the Amity quadrangle, but the coal is reached by drifts and slopes at a number of places along Charities and Peters creeks, and has been shafted at to the Mindfield mine, at Ellsworth, and at Three and Four. The thickness of the Pittsburg coal bed is rather variable, but its structure is fairly constant throughout this region. The arrangement of the benches is shown in the following section:

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PITTSBURGH COAL

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of sulphur, as indicated by the following analyses of the coal at Zollarsville. The analyses show the compositions of both the upper and main benches.

**Analyses of Waynesburg and Amity, Pa.**

<table>
<thead>
<tr>
<th></th>
<th>Coal (Wash.)</th>
<th>Coal (N. Wash.)</th>
<th>Lignite</th>
<th>Clay</th>
<th>Coal and shale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Moisture</td>
<td>5.90</td>
<td>9.20</td>
<td>10.30</td>
<td>6.90</td>
<td>4.70</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>31.40</td>
<td>36.50</td>
<td>38.70</td>
<td>31.40</td>
<td>28.30</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>43.70</td>
<td>43.10</td>
<td>43.60</td>
<td>40.60</td>
<td>41.30</td>
</tr>
<tr>
<td>Ash</td>
<td>14.66</td>
<td>16.10</td>
<td>15.10</td>
<td>14.10</td>
<td>14.60</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
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</tr>
</tbody>
</table>

The upper bench is generally of poor quality, and when the roof consists of shale is sometimes left in by the miners for support. The Waynesburg coal is used principally by farmers and is considered a fair fuel in sections where no better coal is obtainable.

**WaterShed “A” Coal.**

The Waynesburg “A” coal is very persistent throughout the county and can usually be recognized by the characteristic vein of coal which it produces. The Waynesburg sandstone is also associated with the Waynesville coal. The only measurements of the Waynesburg “A” coal known in this area amount to 20 inches, 27 inches, and 37 inches, including pinnings. A section on North Bridge of Pigeon Creek in Somerset Township measures as follows:

<table>
<thead>
<tr>
<th></th>
<th>Coal (Wash.)</th>
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The Waynesburg “A” coal has often been opened as an opening of one or two points, but is not mined.

**WaterShed “B” and “C” Washington Coal.**

The Washington coal is known from the locality of its typical occurrence. It lies from 110 to 100 feet above the Waynesburg coal and directly below the Lower Washington sandstone. It is much more persistent than any other coal of the Dunkard group and at many places reaches a thickness of several feet, although it is of little value commercially on account of the numerous shale partings. At no point in the Amity quadrangle is the coal bed worked. The coal is a known at a number of points along Little Charity Creek, on the ridge between North Strabane and Nottingham townships, and in West Bethel Township, and in the vicinity of West Amity and Dunns station it is reported in a number of oil and gas wells.

One of the best exposures of the Washington coal is in the East and Ohio River townships, just west of Washington, where it is 7 feet 1 inch thick and overlies the Lower Washington sandstone. This coal is represented in fig. 7.

**Amity Coal.**

In western Pennsylvania the oil and gas occur in beds of sandstone, or “sand,” as they are called by the drillers. The sands have been named and their names have come into common use. In order to show their relations in the Amity quadrangle the following table has been prepared, giving the drillers’ names for the sand and key rock, its depth above the Pittsburgh coal, and the geologic formation to which it belongs.

<table>
<thead>
<tr>
<th>Sand Name</th>
<th>Depth Above Pittsburgh Coal</th>
<th>Formation</th>
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</thead>
<tbody>
<tr>
<td>Big Injun</td>
<td>670 to 840 feet below Pittsburgh coal</td>
<td>Maugh formation</td>
</tr>
<tr>
<td>plains sand</td>
<td>7 feet 1 inch below Conemaugh sandstone</td>
<td>Conemaugh formation</td>
</tr>
<tr>
<td>Dinkard sand</td>
<td>100 feet below Conemaugh formation</td>
<td>Conemaugh formation</td>
</tr>
<tr>
<td>Thirty-foot sand</td>
<td>270 feet below Conemaugh formation</td>
<td>Conemaugh formation</td>
</tr>
<tr>
<td>sand</td>
<td>340 to 400 feet below Pittsburgh coal</td>
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**Geological Correlation of Oil and Gas Basins.**

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**Shale occurrence of oil and gas basins.**

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**Gas fields in southwestern Pennsylvania.**

In the Amity quadrangle the gas fields are near its eastern border. The Amity quadrangle is near the eastern border of the field, and hence the only oil fields are near the western side of the quadrangle, but gas fields are widely scattered through it. As shown by the figure, the gas field is the southeastern part of the quadrangle, a nearly continuous with prominent fields in Greene County.
this county. The great majority of wells in the Washington field have not yet by been completed, and in the early days of the field it was the source of many good stories. In most cases, the sand is very thin, only one inch or two.

**Fiftyninefoot sand.**—Where it is distinct from the Gants sand, the Fiftynine-foot is separated by a thin, almost imperceptible, layer of shale, but where it is thick and continuous, it is a distinct sand, often 250 to 300 feet thick. It is frequently designated Nineveh Thirty-foot, or simply Nineveh, or Thirty.

In the vicinity of Houston and Canonsburg. The great majority of wells which produced gas from it. Beds at about this horizon are also productive in the vicinity of Canonsburg. *Fifty-foot sand.*—The Fifty-foot sand is a thin sand, generally from 20 to 30 feet thick, and is generally the best sand in the Amity quadrangle.

Washington field. This field extends from a point near Claysville, in western Washington, on the eastern flank of the Washington anticline through South and North Strabane townships nearly to Linsen. The principal productive oil of this field was the same immediately following its discovery, in 1855. The oil has been obtained nearly entirely from the Gants and the Fifty-foot sand, but there are a few wells found oil in the Gordon and the Fifty-foot sands. The deeper sands have not yet been prospected. An estimated 100,000,000 barrels of oil a day has been produced from this sand in considerable quantities. Many productive gas wells are also located on the flat-topped ridge of the Washington anticline in the vicinity of Houston and Canonsburg.

**Fifth sand.**—The Fifth sand is a thin sand, producing about 30 barrels of oil a day from the Gants and Fifty-foot sands. Some gas is also produced from this field.

Gordon sand. In general, the sandstones of the Amity quadrangle are best developed in the eastern part of the quadrangle, as the gas pay is much thinner in the western part. The greatest majority of wells which produced gas from it have now been abandoned. It has also produced some gas from the Bayard sand. The Gantz and Fifty-foot sands are the most important of the Amity sandstones.

For example, Washington field has obtained its oil from the Gants and Fifty-foot sands, and in the vicinity of Houston and Canonsburg. The great majority of wells which produced gas from it have now been abandoned. It has also produced some gas from the Bayard sand. The Gantz and Fifty-foot sands are the most important of the Amity sandstones.

The most commonly productive are, however, the Gantz, Fifty-foot, Fourth, and Fifth.

Geological relations of oil and gas. General conditions. A more or less definite relation of oil and gas to geologic structure in the Appalachian field has long been recognized. It has been observed that nearly all the productive gas pools are situated near the crests of the anticlinal folds, while oil occurs partly down the anticlinal slope or in the bottom of the syncline. More frequently salt water occurs in the lowest part of the syncline and the oil is found only above the salt water level.

The "anticlinal theory" was definitely formulated by L. C. White in a paper on the mapping of Pennsylvania (Bass, Geol. Soc. Amer. vol. 3, April 14, 1892, pp. 21-30). The view is that the anticline deforms the strata, the rocks are gently tilted to the east, and water contained in them escapes out in the order of their formation. The gas first escapes, then the oil next follows, and part way up the slope; and gas nearest the axis of the anticlines. In western Pennsylvania, and in the Gantz and Fifty-foot sands, the deposits lie in beds that round in a general northeast-southwest direction, intersecting limestone, and still farther around the crest of the anticline, the gas and oil are associated with the geologic axes. Considerable doubt has been thrown on the validity of the anticlinal theory by the discovery of various apparent contradictions, and it is now accepted with qualified reservations, until it has been definitely established that the general relations of oil and gas hold good with respect to all the fields.

Washington oil field. The geologic map of the Amity quadrangle affords a basis for certain statements with reference to the distribution of oil and gas. The Washington oil field, for example, is located on the eastern flank of the Washington anticline, which follows in this quadrangle for a distance of 5 miles. A large part of the field is in a syncline, and a portion of the structural axis of the syncline is exceptional, as gas is more often found on the crests of anticlinal folds.

Washington field. The geological relations of oil and gas reservoirs of the Amity quadrangle to geologic structure. The Washington field. The geological relations of oil and gas reservoirs of the Amity quadrangle to geologic structure. The Washington field. The geological relations of oil and gas reservoirs of the Amity quadrangle to geologic structure.
National Pike and the railroad tunnel east of Washington. The bed of sandstones quarried at this place lies about 130 feet above the Upper Washington limestone, which outcrops at the entrance to the tunnel. The rock in this quarry is a good, hard, massive sandstone, and is used for curbing and bridge construction.

CLAY AND SHALE.

Two classes of material suitable for brickmaking are found in this territory. They are clay and shale, the former being a surface deposit and the latter composing a large proportion of the hard rocks.

Clay.—Local clay deposits occur in stream valleys in this quadrangle, but so far as could be learned none of these have been used. Similar deposits, however, have been used at a small brickyard just off the northern border of the quadrangle, at a point between Houston and Canonsburg. The clay is a tough, buff, silty layer that caps a rock terrace and is part of the Carmichaels formation. The material is somewhat gritty to the teeth, but contains no pebbles. Below the clay lies 6 inches to 3 feet of gravel, overlaying 8 feet of hard clay. The lower bed is not known to have been utilized. The top clay is said to make very good bricks, but so far as could be learned none of these have been used. Similar deposits, however, have been used at a small brickyard just off the northern border of the quadrangle, at a point between Houston and Canonsburg.

Shale.—Shale of fine texture is abundant in the Dunkard group and occurs over wide areas. In other parts of the country some of these shales have been used, and they have produced bricks of good quality. They might also be used in connection with limestone for making cement. At only two points in the quadrangle is shale known to have been utilized. One of these is in the southern part of the town of Washington, near the Baltimore and Ohio Railroad; the other is near Vance station on the same railroad, a few miles northeast of Washington. Both these plants make a great number of red bricks.

WATER.

The Amity quadrangle contains no large streams, but its entire area is cut up by a fine network of small streams that run in rather deep valleys. All except a few of the large creeks generally run dry in the summer months, and even those which contain water the year round consist for several months of a series of mud holes.

The grade of most of the streams is too slight to make them serviceable for the production of power, but some of the creeks are used as a source of water power, as Bane Creek, at Chambers dam. There are small reservoirs on South Branch of Pigeon Creek, just above Three and Four, and on Center Branch near Elksworth. On Clarion Creek a few miles southwest of Washington there are several reservoirs owned by the Citizens Water Company and used for supplying the town of Washington with water. The water is collected in four reservoirs, which have a total capacity of 725,000,000 gallons, and is passed through sand filters and pumped to a high-service reservoir that stands 285 feet above the lowest point in the town.

The water seems to be of good quality and is well guarded against danger of contamination. Although, like other surface waters, it sometimes has a disagreeable odor and taste during the summer months. Many of the villages of the quadrangle obtain their water supply from wells, nearly all of which are considerably less than 100 feet in depth, the majority being only a few feet deep. The farming communities use both springs and wells. The latter are more numerous, the former are abundant and most of them furnish plenty of water. In the valley bottoms and on the flatter ridges and hilltops wells are more numerous, but in general it is not necessary to go very deep for water. A number of wells drilled for oil or gas have been nonproductive, and the upper part of the latter are subsequently been utilized as water wells.

For data are at hand regarding water-bearing strata, for the water wells in this quadrangle are in most connection with the underlying rock, and the records of only a few of the oil and gas wells show water horizons. In general, the water at any great depth is salty, and is thus not suitable for ordinary purposes.

Soil.

The soil of Washington County is much better adapted to farming than that of Greene, Beaver, or Allegheny counties. In general it is best in the eastern and northern parts of the quadrangle, where the Beaver limestone and the limestones of the Washington formation are well exposed. These form a thick, strong soil, which makes Washington County one of the best farming counties in this part of the State. The greater regularity of the surface also assists in making Washington County better for agricultural purposes than Greene. On account of the great abundance of limestones the large amount of lime in the soil little fertilizer is used. Corn, grain, and grass are raised in abundance and in parts of the county productive fruit orchards have been planted. Sheep are raised, though not so many as in Greene County, and the best days of this industry are past. Some of the frost cuts lie on the alluvial fans in the valleys of Tenmile and other creeks, and these are often planted with corn. The forests of the area were long ago removed.

March, 1906.