DESCRIPTION OF THE BEAVER QUADRANGLE.

By Lester H. Woolsey.

INTRODUCTION.

PHYSIOGRAPHIC RELATIONS.

The Beaver quadrangle is located in western Pennsylvania, its western boundary being about 4 miles from the Ohio State line. Its whole area lies in Beaver County, except a triangular portion in the southeast corner, which is in Allegheny County. Ohio River flows through the middle of the quadrangle in a general westerly direction, and near the town of Beaver, which gives its name to the quadrangle, receives from the north its chief tributary, Beaver River. The quadrangle lies between latitudes 40° 30' on the south and 40° 45' on the north, and between longitude 80° 15' on the east and 80° 30' on the west, including one-sixth of a degree of the earth's surface with an area of about 227 square miles.

PHYSIOGRAPHIC AND GEOLOGIC RELATIONS.

In its physiographic and geologic relations this quadrangle forms a part of the Appalachian province, which extends from the Atlantic Coastal Plain on the east to the Mississippi lowlands on the west, and from central Alabama to Canada.

The Allegheny Plateaus.

With respect to the topography and the altitude of the rocks, the Appalachian province may be divided into two nearly equal parts by a line which follows the Allegheny Front through New York, Pennsylvania, Maryland, and West Virginia (see fig. 1 and the eastern escarpment of the Cumberland Plateau across Virginia, Tennessee, Georgia, and Alabama. East of this line the rocks are greatly thinned by faults, and the uplands are less dissected and the nearly flat, the few folds which break the regularity of the structure being too broad that they are scarcely appreciable. West of it are the Great Appalachian Valley, and still farther east stretches a slightly dissected upland known as the Piedmont Plateau. West of the line extend the Greater Appalachian Valley, and still farther east stretches the slightly dissected upland known as the Piedmont Plateau.

The Allegheny Plateaus are characterized by irregular hills and the upper and lower plateaus are divided into two nearly equal parts by a line which follows the Allegheny Front through New York, Pennsylvania, Maryland, and West Virginia (see fig. 1 and the eastern escarpment of the Cumberland Plateau across Virginia, Tennessee, Georgia, and Alabama. East of this line the rocks are greatly thinned by faults, and the uplands are less dissected and the nearly flat, the few folds which break the regularity of the structure being too broad that they are scarcely appreciable.

The Allegheny Plains.

The Allegheny Plains are characterized by distinct types of drainage, surface features, and geologic structure, which are described below.

RESOURCES.

The Allegheny Plains are drained almost entirely into the Mississippi River, but the northeastern part of the region drains either into the Great Lakes or through the Susquehanna, Delaware, and Hudson into the Atlantic Ocean.

In the northeastern part of the province the arrangement of the drainage is largely due to former glaciation. Before the Glacial epoch all the streams north of central Kentucky probably flowed northwest and discharged their waters through the St. Lawrence system (see fig. 2). The escarpment of the great ice sheet closed this northern outlet and new drainage lines were established along the present courses of the streams.

In the southern half of the province not only do the streams flow generally in a southeasterly direction, but the effects of the ice have not been as marked as in the north. The Allegheny Plains, in fact, were not affected by the ice to as great an extent as the surrounding region.

Belief—The surface of this division of the Appalachian province is composed of a number of plateaus, the highest and most extensive of which lies along the southeastern margin of the province. This feature is so old and continuous that its plateau character is not always apparent. It was discovered in southwestern New Jersey by the Pennsyltania surveys divided both series into a number of separate formations. Of the Pennsylvania series the Monongahela, Connestoga, and Allegheny formations, and a portion of the Potomac are exposed in the Beaver quadrangle, while the lower part of the Potomac and beds of the Mississippi series, supposed to represent the Potomac and Mauch Chunk formations, are found in deep wells.

MINERALIZATION.

Pocono formation.—This name is derived from the Pocono Mountains in eastern Pennsylvania, where the formation is well exposed, resting conformably upon the Cottrell red beds (uppermost Devonian). It contains thin clays and fossil plants, and was, therefore, easily assigned to the Carboniferous system. In the type region it measures over 5000 feet in thickness and consists largely of gray sandstones. On the Allegheny Front this point is commonly marked by a belt of red and greenish rocks, so that the two terms are nearly synonymous. To the west, however, distinction is less certain for the reason that red shales of Cottrell character interfingers with those of Pocono type.

The Casselman formation.—This formation overlies the "silicious limestones" of the Pocono.

The rocks of the Allegheny province belong to two general classes—crystalline rocks, such as granite and gneiss, and sedimentary rocks, chiefly sandstone, limestone, and shale, and occasionally conglomerates. The crystalline rocks, which outcrop along the northern and eastern borders of the province, probably underlie the sedimentary rocks and are, therefore, presumably the oldest rocks in the region. The great mass of younger sedimentary rocks which covers the rest of the province is probably at least 3000 feet thick, and comprises several systems. The lower systems are the Carboniferous series. In the Potomac and Allegheny quadrangles these beds are well exposed in deep wells.

The Carboniferous series is divided into two principal series below and the Pennsylvanian above. The former is best developed in the Mississippi Valley. In general it is not coal bearing, but in certain parts of the Allegheny region it includes not only limited beds of workable coal, especially in its upper portion, but also strata bearing petroleum and natural gas. The Pennsylvania series, on the other hand, includes the coal-bearing beds, or Coal Measures, of the Appalachian coal fields, and is typically developed in Pennsylvania. Both series, therefore, are of eminent importance in western Pennsylvania, and in the Beaver quadrangle both afford valuable economic resources. For purposes of economic as well as scientific study, the geologists of earlier Pennsyltania surveys divided both series into a number of separate formations. Of the Pennsylvania series the Monongahela, Connestoga, and Allegheny formations, and a portion of the Potomac are exposed in the Beaver quadrangle, while the lower part of the Potomac and beds of the Mississippi series, supposed to represent the Pocono and Mauch Chunk formations, are found in deep wells.
and has been named the Mercer group; the lower coal is designated Shawne coal because of its good development at Shanon, Mercer County. Some members have been named by the Second Geologic Survey of Pennsylvania the Homerwood, Connoquenessing, and Oak Creek, respectively. In the Beaver quadrangle the formation, averaging about 200 feet in thickness, has been divided into two, but sometimes three sandstones, with intermediate clays or shales comparable to the above-mentioned horizons.

Physiography. The Allegheny overlies the Pottsville conformably. From the fact that most of the workable coal beds in the lower part of the Pennsylvanian series occur within this formation, it was formerly called the Lower Productive measures. More recently it has been referred to as the Allegheny River series, but in this folio it will be spoken of as the Allegheny formation. The name is taken from the river along which it outcrops typically.

In addition to coal seams it contains valuable beds of fire clay and some limestone. It was for the purpose of including the beds of economic importance in one group of rocks, in contradistinction to a barren group above, that the boundary of this formation was set as the top of the Upper Freepoit coal. These economic beds usually occur in groups which are separated by shales and lens-like sandstones of greatly varying character. The Allegheny formation is thus essentially the same as the thickness on the Allegheny Front as in the Beaver quadrangle.

Conococheague formation. This formation conformably overlies the Allegheny group, and was named by Rogers from Conococheague, on the upper Potomac River, a short distance below Hagerstown, Maryland. It contains the same beds as the Alleghanian, but is generally developed, except on Allegheny and rasp-leader sandstones, in which it is exposed in typical form. This name has been recently revived and applied to this formation in the same sense in which it was used by Rogers.

I. C. White called it the Elk River series, from a locality in western Virginia, and as it occurs generally distinct from workable coal it was formerly known as the Lower Barren measures in contradistinction to the Lower Productive measures. In some parts of Pennsylvania, however, it contains coal of a workable thickness. The formation is composed almost wholly of shales and some overlying sandstones, and in order to include only such barren beds, the boundaries of the formation have been arbitrarily set as the top of the Upper Freepoit coal and the base of the Pittsburg coal. Between Monongah and West Virginia it is called the Oak Creek formation.

The three sandstone members have been named by logtown, elk-horn, and mons, the rivers above. Between Monongah and Georges Creek it enters the other streams which drain this region—Big Run, Poohocum Run, Bacoocum Creek and its tributaries; the Rockville, and Mill Creek, named in order from east to west. Of these Bacoocum Creek is the largest, and along two-thirds of that part of the quadrangle south of Ohio River. The drainage of the northern part is carried by logtown, elk-horn, and mons rivers into the Ohio above Monongah. Between Monongah and Georges Creek it enters the other streams which drain this region. The main tributary of Ohio within the Beaver quadrangle has its sources on the northern slope of a region which would normally drain into Lake Erie. Its headwaters, in fact, are only a mile or two distant from the lake, yet they lead directly away from it and take little part in the drainage of the Erie basin. This fact is in general true of Allegheny River. It may be further noticed that from the valleys of Bacoocum Creek to Allegheny River about one-third of the drainage of the Allegheny basin is carried by a nearly straight line, and that from this line the Ohio below Beaver takes an almost perpendicular course to the west. This unusual relation of main to lateral streams was recognized many years ago, and showed a close relation to the Allegheny basin. The valleys of the principal streams were therefore developed along the line of least resistance, as shown by gentle slopes leading up by easy stages to the main stream upland farther back. Below the 1000-2000 feet above sea level the valleys are so cut steep beaks 150 to 200 feet high.

The streams of this quadrangle, as will be seen from the topographic map, have in general rather narrow, precipitous valleys, displaying but a small exposure of flood plain. But recent flood plains, a unique feature of the surface relief, are still preserved as terraces along the larger streams. On the streams, the bottom of the intermediate slope is marked by remnants of rock shelves along Allegheny and Ohio rivers to the Beaver quadrangle.

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shown at Monaca and Beaver and along the east bank of Beaver River. Between Beaver and Georgetown they are less conspicuous though terrace remnants may be seen at intervals. Just west of Georgetown, however, in the Wallville quadrangle, there is a more prominent terrace. Between Mill and Little Mill creeks these terraces lie between 900 and 1000 feet above tide. The terrace sequence in elevation may be due to the different stages of erosion but it is more probably the result of local inequalities of the old valley bottom. Between Rochester and McDaniells a small rock terrace was observed at 840 feet above sea. From this single shelf not much can be deduced; it represents perhaps a valley floor that had been eroded below the level of the present terrace, and probably indicates a hilly or undulating region in the present valley subsequent to the formation of the quadrangle.

On Racecoon Creek similar terrace remnants occur, with a rock floor at an elevation of about 900 feet. The full width of the ancient valley is best shown near New Sheffields, where for a short distance the whole floor is still preserved, free from incisions of modern streams. Remnants of this terrace occur in the north of Independence but they are less conspicuous though the whole floor is still preserved, free from facies of modern streams. Remnants of this terrace may also be seen at intervals. Just below the main terrace remnants, a rock floor of about 125 feet is preserved near Stockport.

In the quadrangle the width of the Parker strath also varies greatly. From 2 miles at Monaca, 14 miles at Beaver, and 1 mile on Beaver River, it narrows to a uniform width of one mile between the two. Along the rivers of the quadrangle the width of the strath is considerably reduced. The strath on Beaver River narrows to a width of 2 miles at Monaca, 1 mile at Beaver, and 1 mile at Beaver County, Pa. Between Beaver and Monaca the strath is very narrow, its width being only 2 miles. Where the strath is narrow it is due to the difficulty of recognizing the kind of strata which characterize the strath.

**Built terraces.**—The remaining terraces of this region belong to the class of built terraces. They are distinguished from the outermates of the Beaver quadrangle by the fact that they lie upon the rock bottom of the present streams, instead of upon a rock shelf whose floor has become level or nearly so.

On pages 2 and 3 of the report are represented the built terraces which occur in the Beaver quadrangle. In the northern part of the quadrangle a line of wells extending from Beaver River through Beaver Falls into New Sewickley Township shows the built terraces more or less closely arranged. Along these sections, those of wells between Ohioville and Beaver Falls represent the Pottsville with, of course, no details, merely as a single or double bed of sandstone of about 75 feet thick. But the records from Beaver Falls and further east show that the beds are not so distinct and well-marked sandstone members. A coal above the upper is probably the Brackville, whereas the sandstone is an interval of about 100 feet thick, filled in the upper part sometimes with coal or black shale, toward the middle with iron ore, and below and elsewhere with shale. The thickness of the sandstone varies from 20 to 30 feet in the case of the Homewood beds, and from 30 to 50 feet in the case of the Connoquenessing. Nearly all the sections throughout the quadrangle show a thickness of variable thickness as to 75 feet. In the case of Beaver Falls the beds are discussed in order from the surface downward.

Below the Pottsville in some parts of western Pennsylvania occurs the Mauch Chunk formation, containing 150 to 250 feet of red and green shale, with a green, flabby sandstone and a blue, fossiliferous limestone near the base. Where this formation is present it is usually shown in well records, because its red color makes it easily recognizable. But in the Beaver quadrangle as will be seen from the sections here presented, no such red beds seem to occur immediately below the Pottsville formation. This seems good evidence, therefore, that the Mauch Chunk is absent. They are not known to be absent or patchy elsewhere in the quadrangle, and the beds may be overlooked in drilling, and the upper beds may be recognized in a more or less general way. With the upper beds a thickness to be about 75 feet. It is probable, therefore, that in instant of extreme thickness either the beds are thin or this rock is exposed by a stream. The thickness of the upper beds, according to the well records is extremely variable, apparently ranging from a thin sandstone lens 150 feet long to a thickness of 75 feet thick, rarely increasing to 100 feet, and is separated from the upper bed by 30 to 50 feet of shale. The Brackville sandstone is characterized by driller's as being gray or white and varying from a fine, close-grained, hard rock to a soft rock of medium grain. It is generally persistent throughout the oil and gas regions of this territory, so far as partial records are concerned and seems to approach the Pot­tsville toward the north, perhaps because of the unconformity between the two.

**Burrung sandstone.**—This member is named from Burrung Run in the Kittanning region. North of Kittanning, on Allegheny River, it was described by F. A. Hensher, of the Geological Survey, as being gray or white and varying from a fine, close-grained, hard rock to a soft rock of medium grain. It is generally persistent throughout the oil and gas regions of this territory, so far as partial records are concerned and seems to approach the Pottsville toward the north, perhaps because of the unconformity between the two.

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show 150 feet, though the majority of the best records show the usual thickness of 25 to 75 feet. This sandstone is covered by the pool and is not seen except at section A and on the railroad above New Brighton. It is very brittle, fractures irregularly, or blue color. ’

The Shale is generally described as having a reddish-brown color, and is composed of siltstone, mudstone, and sandstone, with minor amounts of coal and limestone. It is characterized by its high thickness and its widespread occurrence. The Shale is found in the Allegheny River basin and is composed of a sequence of sandstone, siltstone, and shale units. It is a major source of water and is used for irrigation and industrial purposes.

The limestone in the area is extremely variable in thickness, owing to its occurrence in irregular lenses. It is therefore at least as many places, but in others has been observed to range from a few inches to 19 feet. When thick it is usually composed of two or more layers a few feet thick, separated by thin layers of calcareous shale.

The best known form is immediately over the Shale, and this is often more fragmental in occurrence. It is but a few inches thick where present, and so far as observed within the quadrangle does not occur in quantities sufficient for economic purposes.

In the general area of the Upper Kittanning coal and clay, the town of Kittanning is the type locality of the Kittanning group of three coals. These were named Lower, Middle, and Upper Kittanning by the Second Geological Survey of Pennsylvania. These coals are a red-brown to blackish-red clay, shaly to heavy sandstone (see detailed section). In some cases, notably at Fort Wayne and Chicago Railroad in Illinois, the Lower Kittanning sandstone, which may be called the Kittanning sandstone, fills the entire interval. Elsewhere the sandstone consists of two or more layers a few feet thick, separated by thin layers of calcareous shale, as of Pittsfield Island in New York, and at Waukesha, Wisconsin in Wisconsin.

The thickness of the coal and clay varies greatly, and the most productive coal measures occur in the Allegheny River basin and the Allegheny Mountains. The average thickness of the coal measures is about 12 feet, but in some areas it may reach 30 feet. The coal is black to dark brown in color and is medium to high in rank. The coal is of the bituminous type and is used for coking purposes. It is highly prized for its quality and is used in the manufacture of steel and other metallurgical products.

The coalfield stretches from the mouth of the Ohio River to the mouth of the Mississippi River, and is bordered on the west by the Allegheny Mountains and on the east by the Appalachian Mountain chain. It is one of the most important coalfields in the United States, and is responsible for a large proportion of the country's coal production. The coalfield is divided into two major parts: the Allegheny coalfield, which extends from the mouth of the Ohio River to the mouth of the Ohio River, and the Western coalfield, which extends from the mouth of the Ohio River to the mouth of the Mississippi River. The coalfield is underlain by the Allegheny-Virginia synclinal structure, which is composed of a series of northwest-verging folds and interrelated faults. The area is characterized by a series of basins and interbeds of sandstone, siltstone, and shale, with minor amounts of coal and limestone. The coalfield is underlain by the Allegheny-Virginia synclinal structure, which is composed of a series of northwest-verging folds and interrelated faults. The area is characterized by a series of basins and interbeds of sandstone, siltstone, and shale, with minor amounts of coal and limestone.
Creek. Owing to this condition, strata which are not exposed in the eastern basin may be exposed on the western border; and a lower coal, tentatively mapped as Lower Kittanning, is found in outcrop on a greater distance on the west side of the Creek than on the east side. If this coal is not truly identified as the Lower Kittanning, then the Darlington is opposite of the Beall and Rostrano, and the latter is practically identified by the Freeport sandstone. The conclusion to refer the exposures under consideration to the Darlington and the Freeport horizons is based on the fact that there is an unusually large interval between this coal and the Upper Freeport coal, as shown in section G. On the other hand, the subcoal closely overlaying the coal suggests from stratigraphic associations that this may be the Darlington coal, and on that supposition the interval between the Lower Kittanning and Upper Freeport is of the same order of magnitude. I am in agreement with the view of early observers that the Darlington coal is found on the west side of Monaca (sections B and D), and perhaps also on the north toward Freeport.

The Darlington, which name he used in local descriptions.

The map of the Second Survey also shows the Lower Kittanning coal, the stratigraphic and economic relations of the Lower Kittanning and the Freeport sandstone above. The coal here is very thin and interbedded with laminated sandstone; below the characteristic nodular shale, the whole dipping about 30° ESE, while a heavy sandstone in horizons. On Brush Run the identification of the Middle Kittanning coal is doubtful. The lowest seam was apparently taken by I. C. White for the Lower Freeport and the bed 30 feet above it for the Upper Freeport. That the latter identification was probably incorrect is shown under "Middle Kittanning coal," and it follows for the same reasons that the formation may be ascribed to this horizon. The Darlington coal—"the local coal"—described by I. C. White—was developed on the Darlington side of the quadrangle, and the lower part of the Lower Kittanning has not been found in this valley. It may, therefore, there be a horizon as middle coal coming between the Darlington and the Butler sandstone, in like character it is a very compact, coarse, yellowish-white rock, which is most typical of the Lower Kittanning of the Allegheny River and lower Brady Run. On thinning it gives way to shales which take up the whole lower part of the interval. Above the sandstone, when present, or in any case toward the middle of the interval, usually about 20 feet of dark shales bearing iron nodules, and above these lie generally dark gray shales. Either of these two kinds of shale may be absent or replaced by sandy beds (section F).

The Darlington coal, which name he used in local descriptions.

The horizon averages about 177 feet above the Lower Kittanning coal and has, therefore, a line of outcrop which lies near the top of the irregular river bluffs, and in general follows the White Rock Creek line.

For example, from an elevation of 500 feet above Beaver Bridge at Beaver Falls, it dips southward to 209 feet about 300 feet above the lowest coal in the sandbox. The Lower Freeport, and thence gradually lower toward Pitts­

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making material was more or less embeded by current burrows of the crinoids and the Mahoning sandstone, and the sand may have been deposited in the ancient hollows. Fragments of bituminous matter and part of one coal possibly derived from the coke beneath the coal are sometimes mingled with sand and pebbles at the base of the Mahoning member. In Ohio, the Upper Freeport coal may change in thickness in surprisingly short distances. One instance was observed where it thinned from 5 to 8 inches within a distance of 200 feet. Unevenness of the surface on which coal-making material was deposited may have caused slopes or levees, or on which little or no material gathered. This condition, however, is not so easily demonstrated with this coal as with the Lower Freeport.

Measurements in this area are usually well developed and apparently split the benches of coal several feet apart. The following sections are examples:

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On Island Run this horizon is marked by a series of interbedded coal and sandstone layers, each only a few inches thick, the whole aggregate being 30 feet thick. Therefore, the formation of the Upper Freeport coal seam was in places interrupted by the deposition of clay, shale, or sandstone. Such occurrences possibly represent delta deposits which were formed in the luxuriant swamp of Carboniferous time and which afterward became covered with vegetation. Thus a single coal-making period, as that of the Upper Freeport, could give rise to a 30-foot irregularity in the base of the Mahoning sandstone. Such occurrences are not uncommon, and in places 100 feet of limestone, as at Ashley Island, the Upper Freeport coal is 10 feet thick, and the sandstone is only 44 feet thick. The following sections are examples:

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ston. This stratum may be taken as the approximate middle of the Conemaugh formation, for in this district it averages 200 feet above the Upper Freeport coal and 30 feet below the Pittsburgh coal. These intervals in reality vary from 30 to 25 feet in other direction. It is the most persistent member of the succession and is present not only throughout the southern half of the quadrangle, but throughout several counties in Pennsylvania and Ohio. It can therefore be seen in six locations where it has been diligently sought but it has proved to be absent. It is represented by a cancerous member of the coal group, the Conemaugh, and is composed of a series of black, gray, and light-colored shales which are quite similar in composition to those south of the Ohio, but are less persistent. The shales are very close to the Ames sandstone, if not in direct contact with it. In that case the coal and shale have occasionally been observed as a mere blos.

South of the Ohio the patches become larger and more numerous, as at McCleary, Green Garden, and Bunker Hill, until finally, as the coal disappears, it is replaced by sandy shale. As the coal approaches, it is separated by a heavy sandstone which has a decided effect on the original character of the strata. This sandstone is the most persistent member of the series and is present not only throughout the southern half of the quadrangle, but throughout several counties in Pennsylvania and Ohio. It can therefore be seen in six locations where it has been diligently sought but it has proved to be absent. It is represented by a cancerous member of the coal group, the Conemaugh, and is composed of a series of black, gray, and light-colored shales which are quite similar in composition to those south of the Ohio, but are less persistent. The shales are very close to the Ames sandstone, if not in direct contact with it. In that case the coal and shale have occasionally been observed as a mere blos.
and sand, with little or no clay. When the Wis­
consin gravel of Ohio and Beaver rivers was laid
down the mouths of lateral streams were so choked
by it, that they could not discharge their own
waters and debris. Thus they built up flood plains of
the lower terrace gravel, forming parallel valleys on
the eastern border of the upland deposits extends
northwestward across the county, crossing Beaver River 10
miles above in 197x180 miles and leaving the State near
the northwest corner of the Beaver quadrangle.
At this same time the flood plains were being
formed along the valley margins of the uplands and
the source of this deposit extend for short distances into
the quadrangle. In addition to these there are a few
isolated but very small patches of gravel material
in the northwestern-feeling valleys. All the mate­
rials have the appearance of till, but water may have
silted in its deposit and the isolated deposits being
scattered from float stone in pond beds, and shallow
channel and pond deposits, respectively. The
source of the Ohio River was probably the
Pleistocene age. This seems to be the usual
condition of the condition of the streams, which
through the terrace in question vary in elevation
about 70 feet, all being to stages of the same
terrace-forming and uplands. This is a
sandy surface are high-water level and represent the
condition of the elevation. The maximum or
silted overflood stage of the Ohio River. At times
Ohio River rises to track level of the Cleve­
land and Pittsburgh division of the Lehigh Valley
Railroad here, and the position 72 feet above
water-level is marked by an old levee. The
northeastern part of the present, however, exhibit
many of the characteristics of the
alluvial deposits, the alluvium is a mixture of foreign
and local debris. Of it, especially near the top,
is fine silt-like sand. Some of the flood plains
are those of the Ohio River, which
incision this unconsolidated material by
the Ohio River and draining westward when these terraces were formed. This evidence consists in the fact that such streams as Sixmile, Twomile, and Haden run, have
their mouths turned downstream; Beaver Creek also
certainly once flowed in the manner. This seems to be the usual
condition of the condition of the streams, which
ate the advantage, too, of affording good
drainage, while, on the other hand, the sandy,
drained to the ground surface. What
be the most notable along Raccoon Creek. Being free­
from the ice sheet farther north. That
drained to the ground surface. What
be the most notable along Raccoon Creek. Being free­
from the ice sheet farther north. That

sometimes coincides with the depressions between the domes. One of these spaces brings up the Upper Freepot coal on Service Creek. A marked syntaxis of the latter type developed near Grimes and extends to E Ricoon Creek, where it exists. One branch, running southeast of the small domes, is known as "the Interior of the western districts of Pocono and Tuscarora may be composed chiefly of sandstones, shales, and limestones, with occasional layers of thin sand during. The two formations were laid down covered most of the Appalachian province and Mississippian basin. The formation on the east side of the Bald Ridge on the east and of the Adiron- dacks and southern Canada as far as Lake Superior on the north. Near the eastern rim of this region is a well-marked anticline, which was formed during the Allegheny formation.

Structure contours are of value in determining, at any point in the area, the depth of any of the well-known or other strata when observed distance below the surface has once been accurately measured. For instance, given the elevation of a certain well mouth, the deposition of the Upper Freepot coal or Amsel limestone at the same point, taken from the structure contours, and the depth in the Berks as measured in the well, the interval between the Berks and coal or limestone is easily determined. With this kind of interval, the elevation of a prospective well will doubtless be known, and the elevation at this well of the key stratum last used, the distance from the surface to this depth, will be determined by subtracting from the elevation of the key stratum the depth in the Berks as measured in the well. Structure contours are useful in ascertaining the new land surface of the strata, the formation that is represented by the surface of the well.

Thus the geologic history recorded in the sediments of the Allegheny formation tells of a series of rapidly alternating conditions, repeating themselves wholly or in part at least seven times. Each group of events begin by the deposition of many sandstone beds, or a single sandstone bed, entirely unchangeable as an alternative explanation.

The appearance of the other limstone of this period does not so clearly define its origin. They are nonuniformly extensive except for a few minute thicknesses reported in the Upper Freepot limestone. They are therefore probably not of organic origin, but are possibly fresh-water deposits. They may have been precipitated from impure waters charged with carbonate of lime in solution. Thus the geologic history recorded in the sediments of the Allegheny formation tells of a series of rapidly alternating conditions, repeating themselves wholly or in part at least seven times. Each group of events begin by the deposition of many sandstone beds, or a single sandstone bed, entirely unchangeable as an alternative explanation.

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HARRISBURG EXPLANATION.

Eventually another uplift occurred and vigorous denudation ensued. The valley was again filled and the land surface returned to a useless wild plain. This is believed to have occurred during early Tertiary time, and remains of the fossiliferous beds are still preserved in the quadrangle. This is the Harrisburg pelecypod described in a previous section. The perfect dental shell fragments of pelecypods and the touching of the surface, of the center of movement in the McKean and Potter counties (Campbell, M. R. Bull., Geol. Soc. Amer., vol. 14, 1905, p. 295).

The occurrence of the Anabeaver River took a natural condition of affairs and the uplift has continued until the Anabeaver Valley to Beaver, and thence through the present day. So the present condition of the fluvial system and the recession of the ice, streams were interrupted by the depth of the Parker strath below the widespread eroding of the shelf. The present valley is nearly at base level. Thus the stream which probably occupied the present course at an elevation of 1150 feet, in view of the high glacial material (elevation 1150 feet) and the greater width of the stream, is now at its present altitude. Since the widening of the valley has been accomplished by a gradient of waste accumulating along the stream which probably caused by the depth of the Parker strath below the present course, further development was interrupted by the present drainage, the Parker strath.

Explanation.

During Wisconsin time the ice front paralleled that of the Kansan epoch, but in places did not extend for so far. This outwash from the Kansan was very coarse and was deposited by a stream which was not so high as its present elevation above sea level. The Wisconsin outwash is the most prominent in the region, but is in some ways related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield. It is a significant fact that the flood plain bordering Raccoon Creek not only is the most prominent in the region, but is in some way related to the abandoned channel of New Sheffield.
In conformity with the northward rise of the strata, it frequently covered by terrace deposits, and for the course of Beaver River, north of Bolesville. From here to the edge of the quadrangle, however, it is generally its horizon is below water level, but in the near vicinity the thickness of rocks to be removed from the Beaver carries westward some of the characteristics of the vicinity described. In the west of the former run and the river front as for Sixmile Run, the Upper Freeport coal ranges from a knife-edge to 22 inches, averaging about 17 inches. In addition the average is more or less slaty and parted. The western portion of the area, however, including the terraces of Brush and Sixmile runs and all runs west of the latter, contains more or less restricted patches of excellent coal. Here also the patches of coal occur within the Freeport map. For local consumption, and thus it has scarcely been opened for local consumption. 860 feet at Monaca. From this average line the horizon rises to the north and south. For this reason calculations on the amount of coal in its upper portion are evident, and its horizons are due to irregularities in the coal bed. The coals belonging to this horizon, has been mined locally and is uniformly reported 4 feet thick, with 6 to 12 inches of parting. The Little Kittanning coal—This seam is of no commercial importance with the quadrangle, but is not so deeply covered by terrace deposits. Its average thickness is 17 inches, with 6 to 12 inches thick, except where separated by partings. The average thickness is 24 inches, and this measurement is most uniform in the valleys of Beaver River, Brady and Elk Lick beds. The Pittsburg bed, which elsewhere furnishes most important coals, which are the Lower Kittanning of the same area. One area includes the Ohio Valley west of Dam No. 6. In this general region the coal is usually between 14 and 30 inches thick, and is uniformly improving in quality and increasing in thickness toward the west. On both sides of the river in the vicinity of Georgetown it is 24 inches thick and is an excellent black coal (the "black vein"), which has in this part been largely opened for local consumption. Another area in which the coal is somewhat uniform in thickness, of fair quality, and free from impurities, is the East Beam and Ohio stream. In this locality it ranges generally from 14 to 20 inches, but it is likely to be cut out by the Freeport sands. In general, however, the thin and irregular coal is restricted to narrow areas over the river front and in the lower courses of Longtown, Elklick, and Moon runs. In these localities the Mahoning sandstone is well developed. These areas are restricted to Blockhouse, McKinley, Brady, and Sixmile runs, Beaver Creek, Island Run, and Brush Run. Even where good, the coal is often separated by clay or shale partings into two main lenses, which distinguish its value. Moreover, as stated above, it is likely to be absent over considerable ranges. From one or two partings, therefore, no conclusions can be drawn as to its quality, regularity, or character. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel. The coal in this area is somewhat purer and free from partings, and is an excellent fuel.
habit. The lenses in this area, however, seem more extensive than in the one last described, but the coal, on the other hand, is not so much measured in crossing the river. In general, in all of the area west of Beaver Creek where this coal is exposed—that is, in only the northern part of the valley—the same yellow sandstone is much broken by partings and slaty coal. The benches of coal, however, are generally sufficiently thick to overcome this disadvantage. In this dis­

section sheet, and the same order will be followed in this discussion.

COALS OF COXEMAUGH FORMATION.

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oil has been produced in the Beaver quadrangle for about twenty years, and the wells have included several of exceptional volume and pressure. The most productive field is the Smiths Ferry field, which is located in the Beaver quadrangle. Those put down to the Berea at Georgetown and 2 miles to the east along the lateral streams. For instance, the abandoned channel of Racoon Creek, in which New Sheffield is situated, contains, it is said, considerable clay, but its character on burning is unknown. For many years an important deposit has been worked on the higher terrace near New Brighton and Rooster. At the former place it was used for terry pots, and by mixing with Lower Kittanning clay for tumbler works, together with small amounts of oil, which near the mouth of Brandy Run formed a little gas, this being only a tract of oil, but the chief product was salt water. Still other wells at Beaver Falls formerly gave sufficient gas for forging and heating cutlery. A few wells 2 miles east of New Brighton, others north of Big Traverse Creek in the Hundred foot region, and further south in the Bens were, so far as known, at least unprofitable and probably dry.

Conclusions.

The above facts in regard to oil and gas pools in this area, studied both by themselves and in relation to geographic distribution, are confirmatory of well-known general principles. They show that pools of oil or gas when tapped to begin after a few years of constant production and finally become unproductive except for a few pumping wells. This is apparently due both to the exhaustion of supply and to the resulting loss of pressure. In regard to the producing sands, it is seen that the same stratum is not the producer in all fields. Several causes may be brought forward to explain this:

1. The shallower sands are often more continuous, and therefore more productive, than the deeper sands. Indeed, some of these sands are still pumice, but most of them have been abandoned. In recent years the field has been extended seaward to the Wolf Run, and many profitable though not large wells have been found.

Shannopin field. This field lies near Shannopin, on Racoon Creek and extends seaward across the southeastern corner of the quadrangle. The first wells that tapped to begin after a few years of constant production did not come in before 1889. These wells proved because pools, and large pools; new wells were still being developed. The oil-bearing strata in this field is the Hundred-foot sand (wells Nos. 33, 31, 30 and 29), which varies in thickness from 9 to 10 feet below the surface, and produces larger than oil. The gas in this field is from wells Nos. 8, 27 and 62, which range from 500 to 500 feet below the surface. The Smiths Ferry sand, also, has been formed in local lakes, along the glacial margin, and the wells have included several of exceptional volume and pressure. The most productive field is the Smiths Ferry field, which is located near the Smiths Ferry pool on the flank of the Fairview dome, and the Shannopin field near the flanks of the same structure. This field is the largest and most important gas field in the quadrangle. An initial rock pressure ranging from 500 to 500 pounds per square inch is characteristic of this field. The rocks are the same shale and also that between the Darling-}

PETROLEUM AND NATURAL GAS.

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The notes under this heading are merely sug-
their relation to the structure worked out in this

quadrangle. The localities have given are there­
fore only those which the writer believes to be the
most promising places for testing, if tests are to be
made anywhere.

With respect to oil in the Bear, the area north of
Ohio River between the 940- and 1900-foot struc­
ture contours and between the eastern exten­

tion of the Summerville field and Ready Run

seem to be promising ones. In this area the south­
wards-pointing structural upfiast east of Summerville
may be the most favorable spot. The terri­

tory lying southeast of Hockstein, near or below the
1310-foot contour, and extending half a

mile from the western edge of the quadrangle east­
ward along Service Creek, should also be tested.

The western extension of the Rankin field in the
Hundred-foot between the 900- and 1900-foot con­
tours, may possibly be found in the synclines at the
mouths of Little Service and Little Traverse runs. Some dry holes, however, have been put
down on the intermediate anticline. Possibly some of
the other synclines of the area contain oil in the
Hundred-foot.

As to gas, prospect wells on the summits of the
domes of the central dome-basin region from
McCleary to Monaca might bring good results,
though no great yield should be expected. The
domains and anticlines of the area, which contain oil
in the Allegheny, and are least accessible by methods;
stones occur in the valleys of streams which incise
nor is much of it favorably located for working.

except for short distances on the

levels. Except for short distances on the

LIMESTONE.

The Allegheny formation carries the thickest beds,
and since, this formation is generally overlain by
the Allegheny, and are least accessible by methods;
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that is at the salt-water level and gas still higher.

the Vanport limestone. This bed, like the Lower
Freeport and coal, is in places pure enough to pro­
duce lime for fertilizer, and for such limited pur­
poses. Indeed, within this area only three lenses
have the bluish-gray color of a remarkably pure
limestone and has been quarried to some extent.

in this territory, and while it is abundant not all
have been seen at several places in the quadrangle.

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burn to a fair strong lime, but elsewhere it is good
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ters of crinoid stems make a good quality of cement
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This limestone, following the usual habit, occurs
high in the rocks and hence is not conven­
tively accessible along the steep sides of deep val­
evias like those of Ohio and Beaver rivers. Near
the heads of small streams, however, it may be
easily approached.

wherever the pure blue rock is found it may
burn to a fair strong lime, but elsewhere it is good
only for common fertilizer, if for that.

level of 60 feet, are uncovered, the Van­
port limestone is not revealed. It may be 100 feet
below the northwesterly trending valleys along the
northwest margin of the quadrangle, 4 to 6 feet;
held of Dry Run, 2 to 7 feet; west of Hog Island, 3 feet;
Mona, 5 feet; and Bear Run, 4 feet. Though the limestone may be as thick as this
at other localities where it is concealed, all observations recorded its absence or thinness.

This bed, like the Lower Freeport limestone, occurs in the rocks and hence is not conve­
niently accessible along the steep sides of deep val­
evias like those of Ohio and Beaver rivers. Near
the heads of small streams, however, it may be
easily approached.

In general, localities likely to reveal thicknesses
worth exploiting are Blackhouse and Brady runs, 2 to 3 feet; and
the northwesterly trending valleys along the
northwest margin of the quadrangle, 4 to 6 feet;
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in this territory, and while it is abundant not all
have been seen at several places in the quadrangle.
of the quadrangle. But unfortunately for this industry, the greater cheapness and convenience of concrete, combined with an equal durability, has supplanted sandstone for many purposes. In the western part of the quadrangle, along Ohio River, the Mahoning sandstone is conglomeratic and perhaps for this reason, together with its unfavorable position, has never been much worked in that locality. Many remains of old quarries on this bed, however, may be seen on the river bluffs east and west of Monaca, north of Rochester, and on Blockhouse Run. North of Rochester one or two quarries were still active at the time of visit, but most of them were idle.

The Morgantown sandstone is present only in the southern part of the quadrangle, where in places it has a large development. In some localities in Pennsylvania it is a very durable stone, but in this field its friability increases on exposure and it is not exploited. It is possible, however, that on prospecting compact portions of this stratum might be discovered; in this case it would make a good building stone, for it has the requisite color, grain, and quarrying qualities.

Beaver.

SAND.

No sand suitable for the manufacture of glass is obtained in the Beaver quadrangle. A systematic search, however, on the Kansan and Wisconsin terraces of the Beaver quadrangle might reveal pockets of sand of considerable value similar to those at Bellevernon, on Monongahela River.

SOIL.

The lack in this quadrangle of the broad-valley type of stream, affording much bottom land for agriculture necessarily limits farming districts mainly to the uplands. These, as we have seen, are capped by the Conemaugh formation, containing chiefly shale and sandstone. Limestone beds are particularly scarce in this formation, and, except the Anoa and the "local" limestones, practically no bed of thickness and extent sufficient for fertilizer is known. The soils of the uplands, being either clayey or sandy, are essentially without a natural fertilizer. It seems, therefore, that under the present agricultural practice the land receives the least of that which it most lacks; for very little lime is either burned or applied as a fertilizer. Under another section is given a description of limestone beds which might be used to some extent for this purpose.

TRANSPORTATION.

Only one stream in the quadrangle—Ohio River—is navigable, and even this usually during only the spring and fall months. It is hoped that the dams now being built by the Government across the river will furnish a boat stage, whose permanency will be most advantageous to the industries of the Ohio and Beaver valleys, for then steamboats and coal barges can make the passage from Pittsburgh to places on lower Ohio and Mississippi rivers throughout the year, except when prevented by ice. The entire system of dams will not be completed for many years, but the construction of dams from Pittsburgh to the State line will render that portion of the river at once available. Beaver River, not itself navigable, is paralleled by the Pittsburg and Erie Canal, which formerly furnished transportation facilities to this valley; but owing to the introduction of railways the canal has been allowed to fall into disuse. Along the rivers the quadrangle is well supplied with railroads, but not in such a manner as to allow the advantages of competitive rates. The Pittsburg and Lake Erie Railroad occupies the west bank of both Beaver and Ohio rivers, the east bank is followed by the main line of the Pennsylvania Railroad, whose branch also runs along the right bank of the Ohio, but the south bank, though rich in latent resources, is as yet untouched by railways.

WATER POWER.

The streams of this region have steep grades and rather narrow valleys which are easily spanned by dams, so that considerable water power can be economically developed. A practical example of such transformation of stream energy into available water power is that of Beaver River. Other streams which have a flow of water the year round, such as Brady Run and Raccoon Creek, may also be made to furnish considerable power for mills, electric lighting, and other purposes.