DESCRIPTION OF THE KITTANNING QUADRANGLE

By Charles Butts.

GENERAL RELATIONS.

Location.—The Kittanning quadrangle is located in the Allegheny Valley in the west-central part of Pennsylvania. It extends from latitude 41° 41' to 41° 48' and from longitude 79° 30' to 79° 45', and includes one-sixteenth of a square degree of the earth's surface, or about 290 square miles. The larger part of the quadrangle is in Armstrong County, but it includes a small portion of Clarion County on the northeast and a considerable strip of Butler County on the west. It takes its name from Kittanning, the most important town within its boundaries.

Relation to the Appalachian province.—In its physiographic and geological relations the quadrangle forms a part of the Appalachian province, which extends from the Atlantic Coastal Plain to the Mississippi lowlands, and from central Alabama to Canada.

Geography and Geology of Appalachian Province.

The Appalachian province may be divided into two nearly equal parts by a line which follows the Allegheny Front throughout Pennsylvania, Maryland, and West Virginia, and the eastern extremity of the Cambrian Plateau across Virginia, Tennessee, Georgia, and Alabama. East of this line the rocks are greatly disturbed by folding and faulting, and in many places are so metamorphosed that their original character cannot be determined only by waste. West of this line the rocks are less disturbed; they lie nearly flat, and the few folds and faults that are present are of the structure are so broad that they are scarcely noticeable. The general topographic features of the northern part of the province are well illustrated by fig. 10 (illustration sheet). Immediately east of the Allegheny Front are alternating ridges and valleys, which are described below. The Allegheny Front is situated entirely within the Allegheny Plateaus.

Allegheny Plateaus.

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

Drainage of the Allegheny Plateaus.—The drainage of the Allegheny Plateaus is almost entirely into the Mississippi Valley, but in the northeastern part it is diverted into the Great Lakes or into the Atlantic Ocean through Susquehanna, Delaware, or Hudson rivers.

In the northeastern part of the province the arrange- ment of the drainage is largely due to former erosion. Before the Glacial epoch all the streams north of central Kentucky probably flowed northward 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 course of the streams.

In the southern half of the province the westward-flowing streams not only drain the Allegheny Plateaus, but many of them have their sources upon the summits of the Blue Ridge and cross the Greater Appalachian Valley.

Role of the Allegheny Plateaus.—This division of the province is composed of a number of plains, the highest and most extensive of which lies in the northeastern margin.

These plateaus are believed to be the remnants of a very old land surface which has been reduced nearly to a plain by long-continued erosion, and could therefore properly be called a peneplain. This peneplain was first studied by Davis in the northern newen, and was so called by the Schooley peneplain because it is well developed in the region of Schooley Mountain. Proctor (Proc. Boston Soc. Nat. Hist., vol. 24, p. 257). The peneplain has been deformed by differential elevation, and on the eastern margin of the plateau it is surrounded by high, irregular ridges and valleys, but in the central part it is either into the Great Lakes or into the Mississippi Valley.

Drainage of the Allegheny Plateaus.

The drain­age of the Allegheny Plateaus is generally simple. The streams are nearly flat and their regularity is broken only by small faults and low, angular ridges. The most pronounced fold is a broad, low-arched fold known as the Cincinnati anticline. The major axis of this anticline enters the Allegheny province from the direction of Ohio, and a minor fold from the western end of Lake Erie meets the major axis near Cincinnati. Across the Cincinnati anticline, as described below, the Allegheny Plateaus are divided into two nearly equal parts by a line which follows the Allegheny Front.

Relief of the Allegheny Plateaus.

The Allegheny Plateaus are characterized by a nearly featureless plain, broken by small faults and low, angular ridges. In the central part of the State the plateau surfaces are so nearly featureless that it has been possible to determine the exact position of the Allegheny Front. In central West Virginia, and the eastern escarpment of the Allegheny Front are alternating ridges and valleys, but in the northeastern part of the province are well illustrated by fig. 10 (illustration sheet).

The Allegheny Plateaus are divided into two nearly equal parts by a line which follows the Allegheny Front. This line is situated entirely within the Allegheny Plateaus.

The drain­age of the Allegheny Plateaus is generally simple. The streams are nearly flat and their regularity is broken only by small faults and low, angular ridges. The most pronounced fold is a broad, low-arched fold known as the Cincinnati anticline. The major axis of this anticline enters the Allegheny province from the direction of Ohio, and a minor fold from the western end of Lake Erie meets the major axis near Cincinnati. Across the Cincinnati anticline, as described below, the Allegheny Plateaus are divided into two nearly equal parts by a line which follows the Allegheny Front.

Relief of the Allegheny Plateaus.

The Allegheny Plateaus are characterized by a nearly featureless plain, broken by small faults and low, angular ridges. In the central part of the State the plateau surfaces are so nearly featureless that it has been possible to determine the exact position of the Allegheny Front. In central West Virginia, and the eastern escarpment of the Allegheny Front are alternating ridges and valleys, but in the northeastern part of the province are well illustrated by fig. 10 (illustration sheet).

The Allegheny Plateaus are divided into two nearly equal parts by a line which follows the Allegheny Front. This line is situated entirely within the Allegheny Plateaus.
represents the upper part of the great Carboniferous limestone of the Allegheny Mountains. The Mine Chank Chunk red shale occurs as a thin stratum in several wells drilled in the vicinity of Blairs-rangle. Chank Chunk Chalk is not present in the vicinity of Blairs-rangle. Along the Monongahela formation lie the highest rocks of the Carboniferous system, having a thickness in the southwestern part of Pennsylvania of about 800 feet. They are mainly shale and sandstone, but include beds of limestone. The coals are locally workable, but they are generally worthless. This group of rocks was formerly known as the Upper Bituminous formation of various names throughout western Pennsylvania. It is probable entirely part of the field carries several workable coal seams, it bears valuable beds of fire clay, lime stone, and bituminous coal fields of the State the thickness of the beds are known as the Mercer coal, clay, and limestone members separated in general by a bed of sandstone, respectively, because they are well developed and locally known. The Allegheny formation it contains a greater number of beds of workable coal seams than any of the lower formations of this system. It is especially distinguished by the fact that in the Northern Bituminous field it contains a greater number of workable coal seams than any of the lower formations of the system in this region, and on that account it was originally called the Lower Productive Measures. Nearly all the readable land of the State north of Pittsburg and east of Connellsville and Blairs-rangle is taken from it. In addition to its coal seams, it bears valuable beds of fine clay, limonite, and iron ore. These members are separated by beds of sandstone and shale. The clay and shale beds form the basis of important industries in several localities. The formation varies in thickness from 250 to 3000 feet on the Allegheny River in Blair and Cambria counties, Pa., to about 370 feet in parts of the Allegheny Valley. Connensuck formation.—The Connensuck formation lies conformably upon the Allegheny formation and includes all the rocks between the top of the Upper Freeport coal and the bottom of the Pittsburg coal. Its thickness varies from 600 to 700 feet, and it is not exposed on the Allegheny River in some localities where it is well developed and exposed. This formation is a large part of the Allegheny River because it is generally devoid of workable coal seams. In some parts of Pennsylvania, however, it contains workable coals of limited extent, sometimes accompanied by this limestone. The great mass of the formation is composed almost wholly of shale and sandstone. In the latter cases the formation is composed almost wholly of shale. Monongahela formation.—The Monongahela formation conformably overlie the Connensuck formation in the southwestern part of the State and extends from the bottom of the Pittsburgh coal to the top of the Waynesburg coal. Its thickness varies from 310 to 400 feet. It is so named because well exposed along Monongahela River. It contains several workable coal beds, of which the Pittsburg is by far the most valuable and the best known. It is much less easily and shaly than any other coal in the quadrangle. The upper part of this formation is particularly fine-grained and almost unstratified, the lower part of it is commonly fine-grained, and the upper part is preferably yellow in color, the lower part is preferably brown in color. The formation appears to be present in the vicinity of Allegheny River and the Monongahela River. The upper part of this formation is particularly fine-grained and almost unstratified, the lower part of it is preferably yellow in color, the lower part is preferably brown in color. The formation appears to be present in the vicinity of Allegheny River and the Monongahela River. The upper part of this formation is particularly fine-grained and almost unstratified, the lower part of it is preferably yellow in color, the lower part is preferably brown in color. The formation appears to be present in the vicinity of Allegheny River and the Monongahela River.
into southern New York, and by comparing its altitude at various places he has shown that in the course of its elevation the once nearly horizontal surface of the plain has undergone deformation, so that it now has the slope of an ellipse whose long axis is perpendicular to the stream from an altitude of 1300 feet at Pittsburg to 2200 feet at its culminating point in McKean and Potter counties in northeastern Pennsylvania. The surface of the ancient floor rises from 1340 feet at West Pittsburg to 1800 feet at West Winfield, and to 1500 feet at Kellersburg, about 7 miles north of the Worthington peneplain, from the town of that name north of Fenelton, and the region about the tops of which form well-marked terraces about 250 feet above the bed. Such rock shelves occur to the west of the old valley floor at rock outcrops on opposite sides of the river; the rock floors of the upper and lower terraces at the same elevation are almost level, and, beginning at the northern part, the river floor slopes upward, while the greater width at Ford City is due to the fact that the rocks are softer and more erodible in that locality.

The rock floor of the gravel-covered terraces extending from east of Ford City to Monoville stands at an altitude of about 940 feet above sea level and about 60 feet below the level of the more elevated remnants of the Parker strath. On the west side of the river opposite Ford City is another terrace with rock floor at about 950 feet. At Applewood and near at the mouth of the Conemaugh River, the rock floors on opposite sides of the valley are narrow and small gravel-covered rock outcrops only. On the other certain places the elevation at rock floor is somewhat lower one-half mile east of Ford City than in the brow of the bluff. This indicates a rise of the old valley floor toward the north and east by way of the old channel lay to the east at Ford City. The rock faces of the upper and lower terraces at the same elevation are almost level, and, beginning at the northern part, the river floor slopes upward, while the greater width at Ford City is due to the fact that the rocks are softer and more erodible in that locality.

EXPLANATION OF PLATE 2

Fig. 3.—Ideal section across Allegheny Valley illustrating the formation of terrace floors.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.

The narrowness here was due to the hardness of the strata and the fact that the rocks are softer and more erodible in that locality.
nortwest corner of the Kittanning quadrangle, its elevation at that point is about 1000 feet. The regular dip of the rocks to the northeast toward the Brady's Bend syncline is shown by the position of the limestone in many wells along the axis of the syncline. The Kittanning syncline is separated from the anticline in Brady's Bend Township by the north by the shallow depression between the Brady's Bend syncline and the shallow syncline at Chisum, as shown in many wells by elevations on the limestone of 1000 feet or a little less. Brady's Bend syncline.—Platt described the axis of this syncline as crossing the boundary between Beaver and Armstrong counties on Buffaloe Creek and extending in a straight line northeast through Brady's Bend. Evidence now in hand, however, shows that this axis lies farther to the west. Many oil wells on the Riley and Hickin farms northwest of Sugarcreek Township show the Vanport limestone at an elevation of about 900 feet above the sea. From these localities the limestone rises regularly to the axis of the Millenmont anticline, as shown by many wells. In the southeast corner of Duquesne Township, on the Goldfilder and Meary farms, about 1 mile west of the Hickin wells, three wells show that the elevation of the limestone is 1000 feet. The axis of the syncline then lies west of the latter locality, probably in the vicinity of the Hickin farm. Another line of evidence which leads to the conclusion that the axis lies considerably west of Platt's location. The Upper Freeport coal is near water level on the corner of Sugarcreek Township, in the neighborhood of the town of Sugarcreek. It rises constantly to the southeast, and one enters Armstrong County in the northwestern part of the Kittanning quadrangle. Buffalo Creek from the western margin of the above the stream. About a mile southeast of Fenelton the limestone rises regularly to the axis of the syncline at Chicora, as shown in many wells by elevations on the limestone of 900 feet above the sea. From these localities the limestone rises regularly to the axis near Phillipston. From this locality the limestone was observed north of the mouth of Redbank Creek at 1095 feet, and in the west corner of the quadrangle to the southeast. Numerous observations on the limestone and coal beds. One-half mile west of West Franklin pass through East Bradys, as is shown by the fact that the limestone of 1000 feet or a little less, north near West Franklin, dips southeastward to an altitude of 920 feet near Buffaloe. In the vicinity of the southwestern part of the Kittanning quadrangle, the limestone was being elevated by the strata to a point about 1 mile southeast of Fosters Mills, where two wells reveal the limestone at altitudes of 1100 and 1300 feet. Midway between Cowan­ville and Brown Crossroads the Freeport sand­stone, on the axis of the syncline, occurs at 1000 feet above sea, and since this stratum is about 200 feet above the limestone the latter has an altitude of about 1200 feet. From observations on the limestone and coal beds, one-half mile west of Fosters Mills and about 1 mile in a straight line northeast through Sugarcreek Township, in the neighborhood of Fosters Mills and Fos­sels, where the elevation of the limestone is 1000 feet above sea. In the vicinity of Adams well records show the elevation of the limestone to be about 1100 feet, and the stratigraphic evidence points to a regular rise of the rocks in that direction from the northwest corner of Sugarcreek Township. At the latter locality the axis bends sharply to the east and passes through East Brady, as is shown by the fact that the limestone at a point near the mouth of Holders and Sanders runs at an altitude of from 1020 to 1030 feet. From this locality it rises on the north to 1050 feet near the town of Fos­sels and 1100 feet near the town of Fine Run. 1100 feet one-half mile up Fos­sels, and 1110 feet one-half mile west of Fos­sels, where the elevation of the limestone is 1000 feet above sea. The pitch, however, is less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imperfect. In many cases records have been kept of deep wells bored for gas or oil and are more or less imper-
Burgess (Mountain) sandstone.—At the top of this group lies about 150 feet of loose, brownish, fine-grained sand, the Burgess sandstone, which is the lower part of the Mountain or Big-boy sand of the drillers, the upper 200 feet of which is exposed in the Allegheny Valley on the north slope of the Kellebergh anticline. For reasons given below, it is proposed to use the geologic name Burgess sandstone for this stratum.

Patton shale.—In many wells a thin bed of red sand occurs just below the base of the Burgess sandstone. This is a widely distributed stratum and merits attention on account of its importance as a horizon marker. This bed was first described by Richiusius (Indiana folio) and was named by him the Patton shale on the assumption that it is the same as the red shale that occurs at Patton station on Red Bank Creek in Jefferson County. Lower sand (this sand).—In some of the well sections shown on the well-section sheet a sandstone is noted about 150 feet below the Mountain sandstone, and the Thirty-foot sand, just below the Hunnicutt grit of Venango County and the Berea grit of Allegheny Front east of Bennington, in Blair County. B is a deep well at Johnstown, 25 miles west of Mount Union, in Huntingdon County.

General correlation.—At the top of the cut immediately east of Allegheny Front the limit of the Loyalhanna lime-stones was exposed and measured to be about 40 feet. It is uncertain, however, whether this is the full thickness of the stratum or not, because its top is exposed at that point. Its thickness is probably not much over 40 feet. This stratum is here known in the region of its occurrence as the "Silicious lime-stones," though generally it is a rather calcareous sandstone. In faulted general usage it is here regarded as a shaly formation, and the name Loyalhanna is preferred for it. Occasionally throughout this group and from 500 to 700 feet below the top of the red shale, a number of species which were pronounced by James Hall to be typical Chemung forms, were collected on the National Pike, in Fayette County, about 50 feet below the base of the upper shale in the Allegheny Front, as shown in section A. This has been described as the Patton shale. On this basis it is seen at once that the Burgoon sandstone can be recognized in them all. In the Hellman and Montgomery wells this sandstone is known as the Patton or Big-boy sand. It is interesting to note that the red shale immediately underlying the Patton sandstone in the wells C and D also occurs in the same position on the Allegheny Front, as shown in section A. This has been described as the Patton shale. In all these sections there is a uniform sequence of rocks from the top of the Burgese sandstone to the main red beds, as follows: (1) Burgese sandstone, 300 to 400 feet; (2) shales and sandstones, 400 to 700 feet; (3) main thickness of red rocks. On the Allegheny Front the red rocks are about 2000 feet thick and belong to the Catskill formation. In the wells the red rocks are from 300 to 400 feet thick. Only the top of the red rocks is shown in the sections. In all these sections the Burgoon (Mountain) sandstone is universally assigned to the Pocopo formation. In section A this is shown in the well-section sheet and in the figures. (2) shales and sandstones, 400 to 700 feet; (3) main thickness of red rocks. On the Allegheny Front the red rocks are about 2000 feet thick and belong to the Catskill formation. In the wells the red rocks are from 300 to 400 feet thick. Only the top of the red rocks is shown in the sections. In all these sections the Burgoon (Mountain) sandstone is universally assigned to the Pocopo formation. In section A this is shown in the well-section sheet and in the figures.
system. There are, however, certain old gravels of coal-bearing rocks or Coal Measures of the Appalachian region; it includes workable coal beds of limited extent. The Pennsylvanian series includes the coal-bearing rocks or Coal Measure of the Appalachian coal fields, and is typically developed in Pennsylvania. Both series include a number of separate formations, which in turn include various members of local importance. In this quadrangle the Mississippian series is represented by the Pottsville, while the Pennsylvanian is represented by the Potomac, Allegheny, and Conemaugh formations.

POCONO FORMATION.

General discussion.—Considerable difference of opinion has been expressed regarding the existence of Pocano rocks at the surface along the Allegheny Valley south of Clarion River. In the final report of the First Geological Survey of Pennsylvania the latter was not included in the Pottsville formation, while in a preface to the report of the Second Geological Survey of Pennsylvania, W. G. Pratt recognized not only the Pocano sandstone but the Pocano shale also as rocks of respective thickness of 1100 feet at Broadtop, and about 140 feet in thickness, separates near the middle by a sandstone 40 feet thick, filling the interval between the Pocono and Pottsville formations in other parts of the state, as from the Allegheny Valley. In southern Indiana and northern West Virginia counties it has been found in many well sections, and range in thickness from a few to more than a hundred feet. It has a thickness of 150 feet in Beupack Creek valley near Beaver, of 250 feet in northern West Virginia, of 300 feet in the counties of the Greenbrier formation, of 180 feet along the Allegheny front, of 1100 feet at Beaver, and 150 feet in a great basin of Conemaugh and Allegheny rivers. In the Conemaugh river valley the Pottsville is here only a thin bed, being overlain by the Homewood sandstone, or the whole of the Connoquenessing sandstone. It is the same formation, which, according to him, consists of a great sandy series more than 1000 feet in thickness, making a maximum thickness of 260 feet of greenish sandstone, the Mountain or Big Injun sandstone.

Pottsville formation.—This formation consists of a great series of sandstone and shale, which is generally more than 1000 feet in thickness, and is overlain by the Homewood sandstone. The following section (fig. 6) shows the character of the rocks under consideration as they are exposed at the River view mine, 2 miles south of Redbank Junction.

POCONO FORMATION.

General character.—The Pocono formation overlies the Pottsville sandstones unformably and is exposed at the mouth of Sugar Creek, and varies from 340 to 360 feet in thickness. It consists of a series of sandstone and shale beds, which are generally more than 1000 feet in thickness, and is overlain by the Homewood sandstone. The Upper Freeport coal forms the top of the formation, and also the coal, as well as the top of the Pottsville sandstone in the middle of the quadrangle, can be traced with but a little difficulty, the limits of the formation have been very definitely determined. It is the purpose to discuss in this place only the general stratigraphy of the formation. A fuller description of the coal seams of the Pocono and lowest of the Mercer coals will be found in a subsequent section.

Distribution.—The Allegheny formation is exposed along the principal streams of the quadrangle and their tributaries, especially in places where the formation is not less than about 200 feet in thickness, and generally fills most of the interval between the Pocono and the lowest of the Mercer coals.
In the section above no trace of the limestone was detected, and the sandstone No. 8 were estimated to be 20 feet thick and occupies all or nearly all the interval between the coal and the limestone. The same is true on the south side of the river opposite Ewing. Along the west side of the river from Ewing to beyond the margin of the quadrangle it is scarcely thick, but forms in places a bold escarpment 30 to 50 feet high. Over the limestone or the horizon of the lower Kittanning coal.

**Middle Kittanning coal.**—From 30 to 40 feet above the Vanport limestone is the greater portion of the quadrangle and may be as little as 15 to 20 feet in the northeast corner. This coal is from 4 to 5 feet thick wherever exposed to view, and probably underlies the entire quadrangle except in the limited areas where it has been eroded by the streams.

The Middle Kittanning coal shows a number of places on Buffalo Creek and on the west side of Cowanshannock Creek in Rayburn Township near the eastern margin of the quadrangle, and at North Buffalo near the south side of Glade Run.

**Upper Kittanning coal.**—Above the Middle Kittanning coal, in the vicinity of Sherrett and Peach Hill, at Somer­hannock Creek in Rayburn Township near the eastern margin of the quadrangle, and at North Buffalo near the south side of Glade Run.

Although the limestone is generally persistent, there are areas where it cannot be found, and it has not been observed elsewhere in the quadrangle. It is absent also on the north side of the river opposite Ewing. Along the west side of the river from Ewing to beyond the margin of the quadrangle, it is absent, but, from the number of old pits which occur at this point just beyond a heavy sandstone, it is evident that the ore is present and was mined extensively.

The evidence in favor of the assumption that the middle sandstone which underlies the coal and which at Kittanning affords a valuable clay for brick making. But at West Winfield, near the Davidsville, north and south of Allegheny River opposite Ewing this interval is occupied by a course, sandy, hardstone, known as the Kittanning sandstone. One-half mile west of West Winfield this sandstone is 40 or more feet thick and occupies all or nearly all the interval between the coal and the limestone. The same is true on the south side of the river opposite Ewing. Along the west side of the river from Ewing to beyond the margin of the quadrangle it is scarcely thick, but forms in places a bold escarpment 30 to 50 feet high. Over the limestone or the horizon of the lower Kittanning coal.

The continuity and bedded character of the ore throughout most of its extent, and the presence of ore often occurs and has been mined in places where the limestone is now absent.

The Middle Kittanning sandstone is an interval of from 40 to 50 feet above the Vanport limestone, and west of the stream to the eastern margin of the quadrangle. It is well exposed as a thin bed in the bluff just north of Applewood, and is present as a shaly bed in the ravine on the east side of Allegheny River just south of Kittanning. Its occurrence is observed north of Redbank Creek in the northeast corner of the quadrangle, about three-quarters of a mile northeast of Pittsburg on the road to East Brady, on the hills bordering Buffalo Creek west of Cowanshannock Creek in Rayburn Township near the eastern margin of the quadrangle, and at North Buffalo near the south side of Glade Run.

**Upper Kittanning coal.**—Above the Middle Kittanning coal is the greatest area of producer in the region between Allegheny River and Sherrett, Monongea Corner, and Adair. It is known in the ridge between Huling Run and Allegheny River. It is well exposed as a thin bed in the bluff just north of Applewood, and is present as a shaly bed in the ravine on the east side of Allegheny River just south of Kittanning. Its occurrence is observed north of Redbank Creek in the northeast corner of the quadrangle, about three-quarters of a mile northeast of Pittsburg on the road to East Brady, on the hills bordering Buffalo Creek west of Cowanshannock Creek in Rayburn Township near the eastern margin of the quadrangle, and at North Buffalo near the south side of Glade Run.

Although the limestone is generally persistent, there are areas where it cannot be found, and it has not been observed elsewhere in the quadrangle. It is absent also on the north side of the river opposite Ewing. Along the west side of the river from Ewing to beyond the margin of the quadrangle, it is absent, but, from the number of old pits which occur at this point just beyond a heavy sandstone, it is evident that the ore is present and was mined extensively.

The evidence in favor of the assumption that the middle sandstone which underlies the coal and which at Kittanning affords a valuable clay for brick making. But at West Winfield, near the Davidsville, north and south of Allegheny River opposite Ewing this interval is occupied by a course, sandy, hardstone, known as the Kittanning sandstone. One-half mile west of West Winfield this sandstone is 40 or more feet thick and occupies all or nearly all the interval between the coal and the limestone. The same is true on the south side of the river opposite Ewing. Along the west side of the river from Ewing to beyond the margin of the quadrangle it is scarcely thick, but forms in places a bold escarpment 30 to 50 feet high. Over the limestone or the horizon of the lower Kittanning coal.

The Middle Kittanning sandstone is an interval of from 40 to 50 feet above the Vanport limestone, and west of the stream to the eastern margin of the quadrangle. It is well exposed as a thin bed in the bluff just north of Applewood, and is present as a shaly bed in the ravine on the east side of Allegheny River just south of Kittanning. Its occurrence is observed north of Redbank Creek in the northeast corner of the quadrangle, about three-quarters of a mile northeast of Pittsburg on the road to East Brady, on the hills bordering Buffalo Creek west of Cowanshannock Creek in Rayburn Township near the eastern margin of the quadrangle, and at North Buffalo near the south side of Glade Run.

**Upper Kittanning coal.**—Above the Middle Kittan­ning coal is the greatest area of producer in the region between Allegheny River and Sherrett, Monongea Corner, and Adair. It is known in the ridge between Huling Run and Allegheny River. It is well exposed as a thin bed in the bluff just north of Applewood, and is present as a shaly bed in the ravine on the east side of Allegheny River just south of Kittanning. Its occurrence is observed north of Redbank Creek in the northeast corner of the quadrangle, about three-quarters of a mile northeast of Pittsburg on the road to East Brady, on the hills bordering Buffalo Creek west of Cowanshannock Creek in Rayburn Township near the eastern margin of the quadrangle, and at North Buffalo near the south side of Glade Run.
The tributary valley from Nichola to Rattigan, the tributary valley from Nichola to Rattigan, on the near the head of Long Run, in the southeast corner of Clearfield Township, near the southeast corner of West Franklin Township, and near the fork of Rough Run in Winfield. It is known by its bedrock and by its stream associations with sandstone in the bluffs on both sides of Allegheny River in the vicinity of Kinnittin. Along the Cowanshannock in eastern Rayburn Township it gives a good blossom.

The Upper Kittanning coal is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit of bituminous coal and enal shaly. These deposits are rare and of small extent. The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.

The deposit at Somerville is a good example. At this place the coal and shale reach a thickness of 13 feet, but no trace of these was observed in a bluff less than half a mile distant, where the bed should occur.

Fire clay sandstone.—Between the Upper Kittanning and Lower Freeport coals there is generally present the Freeport sandstone. This is a sandstone, or fine-grained, fine-grained, of Wescott, or coarse, massive, and conglomeratic, as in its maximum development. It is at least 50 feet thick in this locality, and probably replaces the Lower Freeport and Upper Kittanning coals. It is best developed along a railroad cut below the mouth of Cowanshannock Run, where it is known as the "pot vein," from its habit of thickening suddenly into a post-lime deposit in the sandstone.
feet of shale, above which there is a greater or less thickness, though not usually of great extent, of sandstone, usually thin banded and bugggy, but sometimes coarser, which probably represents the Mahoning sandstone; and at the northeastern corner of the quadrangle there is a sandstone both above and below the coal has practically disappeared from the section.

The upper sandstone, in a few places, is 20 feet thick. The latter thickness is well shown at the crossroads by the church about 1 mile southeast of Worthington. The coal varies from a few inches to 20 feet in thickness. It can be seen along the road between West Bay and Walkillsch, in the road on the hilltop west of Sipes Run, and along the road from Beatty's mill to Worthington, and in a ravine near the road one-quarter of a mile northeast of Beaver's Run. This coal occurs at the same horizon and is undoubtedly the same as the Sipsey Run coal described by I. C. White in southern Butler County.

Berkshire coal.—About 75 feet above the Brushton and east coal and 150 feet above the Upper Freport coal another small and probably worthless coal occurs. Its occurrence has been observed at a few points in western Beaver County, especially Buffalo Township, Kittanning Township, and about 11 miles southwest of Coldspring in Clarion Township. This coal may be simply a small extension of the same as the Berkshire coal described by White in southern Butler County.

OLDEST GLACIAL GRAVEL (KANSAN OR PRE-KANSAN).— Probable age.—The high-level gravel deposits which are so conspicuous along the lower Allegheny River and which are known to exceed 100 feet in thickness are not recent. Where the current was weak the deposit is clayey in nature and can be traced with difficulty through sedimentary rocks. Such is the case in the terrace opposite Kittanning, where the gullies and wells show little else than a considerable deposit of like nature in other parts of the State, and just above the Mahoning sandstone. This deposit has been substituted for the descriptive name Carmichaels. On these grounds the C. L. White, in southern Butler County.

Because they contain erratics of various kinds and because they cover a large area of the Allegheny Valley are known to be of Glacial age there is no great reason for regarding them as of pre-Kansan age. Probably the most conspicuous and widely prevalent pebbles are those of granite, greenstone, and quartzite, which are characteristic of the Allegheny Valley, and probably the most conspicuous of the larger local rocks appearing in it, and stones of the same kind as those in the Allegheny Valley that are above the 960-foot contour. With the exception of those in the Mahoning sandstone, the local rocks in the Allegheny Valley are not to be found in the upper limits of the terrace, the thin sandstone.

The state of decay of the pebbles is on the whole satisfactory, but a considerable deposit of like nature in the Allegheny Valley is not known to be of pre-Kansan age. Probably the most conspicuous and widely prevalent pebbles are those of granite, greenstone, and quartzite, which are characteristic of the Allegheny Valley, and probably the most conspicuous of the larger local rocks appearing in it, and stones of the same kind as those in the Allegheny Valley that are above the 960-foot contour. With the exception of those in the Mahoning sandstone, the local rocks in the Allegheny Valley are not to be found in the upper limits of the terrace, the thin sandstone.

Because they contain erratics of various kinds and because they cover a large area of the Allegheny Valley are known to be of Glacial age there is no great reason for regarding them as of pre-Kansan age. Probably the most conspicuous and widely prevalent pebbles are those of granite, greenstone, and quartzite, which are characteristic of the Allegheny Valley, and probably the most conspicuous of the larger local rocks appearing in it, and stones of the same kind as those in the Allegheny Valley that are above the 960-foot contour. With the exception of those in the Mahoning sandstone, the local rocks in the Allegheny Valley are not to be found in the upper limits of the terrace, the thin sandstone.

The state of decay of the pebbles is on the whole satisfactory, but a considerable deposit of like nature in the Allegheny Valley is not known to be of pre-Kansan age. Probably the most conspicuous and widely prevalent pebbles are those of granite, greenstone, and quartzite, which are characteristic of the Allegheny Valley, and probably the most conspicuous of the larger local rocks appearing in it, and stones of the same kind as those in the Allegheny Valley that are above the 960-foot contour. With the exception of those in the Mahoning sandstone, the local rocks in the Allegheny Valley are not to be found in the upper limits of the terrace, the thin sandstone.

Because they contain erratics of various kinds and because they cover a large area of the Allegheny Valley are known to be of Glacial age there is no great reason for regarding them as of pre-Kansan age. Probably the most conspicuous and widely prevalent pebbles are those of granite, greenstone, and quartzite, which are characteristic of the Allegheny Valley, and probably the most conspicuous of the larger local rocks appearing in it, and stones of the same kind as those in the Allegheny Valley that are above the 960-foot contour. With the exception of those in the Mahoning sandstone, the local rocks in the Allegheny Valley are not to be found in the upper limits of the terrace, the thin sandstone.
whitening usually extends only one-fourth to one-half inch from the surface, but there is more or less alteration to the center. The local sandstones are usually a very advanced stage of decalcification. If these thin lenses were brought in by the glacial waters with the Molisin sandstone and other Paleozoic rocks, they have been dissolved so completely that none were found after prolonged search at several points.

LATER GLACIAL DEPOSITION.

The Illinoian and Iowa drift sheets are not exposed in the region drained by the Allegheny and may not reach the northern limits of its watershed. Nothing has been noted in the Allegheny Valley, either within or above the Kittanning quadrangle, that indicates an outwash into it from an ice sheet between the early one that furnished sandstones exposed in the region drained by the Allegheny River where the river bed is gravelly. In the Kittanning quadrangle. Farther down, the terminal moraine passes west of the border of the Alleghenian water shed, and the present boundary of the Allegheny is 110 feet from a point on the Allegheny. It has been laid down by the streams at times of overflow and on the adjacent sea floor; at other times the lands were swifter and the sediments coarser, and thus the materials of great strain of sandstones were brought in and spread out along the shore and over the adjacent sea floor; at other times the lands appeared to be an area of delta and the bottom of the Mississippiian deposits. In the beginning the accumulation of these sediments was begun at a time when the interior sea was formed and the Great Lakes and the adjacent sea floor; at other times the lands were swifter and the sediments coarser, and thus the materials of great strain of sandstones were brought in and spread out along the shore and over the adjacent sea floor; at other times the lands appeared to be an area of delta and the bottom of the Mississippiian deposits.

KITTANNING DEPOSITION.

Before the beginning of Champlain deposition, indeed soon after the close of Hamilton time, the Catskill phase of sediments was being laid down. From this time onward the deposition of these rocks continued, being contemporaneous at first with the marine Portage, late in the Catskill sandstone spread farther and farther westward and southeastward, and toward the end the line of deposition receded gradually westward into the Allegheny Valley. Just as the marine Portage was succeeded by the Catskill sandstone spread farther and farther westward and southeastward, and toward the end the line of deposition receded gradually westward into the Allegheny Valley. It may afterwards have been moved over by wave action or by tidal currents and may have been continued. One of the most interesting and significant phases of Pennsylvanian history was the accumulation of coal seams of considerable extent and thickness in Virginia and West Virginia. These coal seams herald the approach of the biologic and physiographic conditions under which the great deposits of coal in the later formations were accumulated.

MAUCH CHUNK DEPOSITION.

The deposits of the pre-Cambrian age at the edge of the Appalachian region was probably greater, for in the region of the Allegheny Front the bottom bed of the Mauch Chunk sandstone reached a thickness of over 2000 feet, a fact which indicates continued subsidence of the region. The Mauch Chunk formation, however, is red shale, which in eastern Pennsylvania reaches a thickness of over 2000 feet, a fact which indicates continued subsidence of the region. The Mauch Chunk formation, however, is red shale, which in eastern Pennsylvania reaches a thickness of over 2000 feet, a fact which indicates continued subsidence of the region. The Mauch Chunk formation, however, is red shale, which in eastern Pennsylvania reaches a thickness of over 2000 feet, a fact which indicates continued subsidence of the region. The Mauch Chunk formation, however, is red shale, which in eastern Pennsylvania reaches a thickness of over 2000 feet, a fact which indicates continued subsidence of the region.
water a large land area extending from southern New York to at least the Pennsylvania/New Jersey line and possibly the upper part of the Pocono were eroded before the deposition of the overlying Pottsville. Just when this uplift occurred cannot be definitely determined, but it presumably took place during the latter part or at the close of Mississippian time.

POTTVILLE DEPOSITION.

The Pottsville is one of the most important and interesting epochs in the history of the province, just when this uplift occurred can not be definitely determined. Assuming that the movements of the earth's crust indicated in the preceding paragraph took place, there would exist at the beginning of Pottsville deposition a deep trough in eastern Pennsylvania and northeastern Maryland by which both sides around the northern end and on the southeast. From these border lands, which were probably high on the southeast, the rapid streams brought in immense quantities of coarse material, including a large portion of quartz pebbles which form the thin and extensive beds of coarse conglomerates of the Pottsville formation. It is believed that these conglomerates were largely derived from the southeastern side of the trough, because there is no source of quartz pebbles on the other side. This deposition of coarse material went on until 1000 feet of strata were accumulated in the southern Appalachian field. At times conditions were favorable to a luxuriant growth of plants, and thin, extensive, and valuable beds of coal were accumulated there which now preserved in the Southern Appalachian field.

Still further south, along Kanawha River and in other parts of West Virginia, a still greater thickness of Pottsville rocks was deposited. These include the coal beds of the Pocahontas, New River, and Konseling quadrangles, which rank among the most valuable deposits of coal in the United States.

While most of 900 feet of sediments accumulated in the Southern Appalachian field, the land surface on the west had probably been worn down to sea level and then submerged by a subsidence, so much so that at times conditions were favorable to a luxuriant growth of plants and thin, extensive, and valuable beds of coal were accumulated there which now preserved in the Southern Appalachian field.

The submergence of the old land surface west of the Kittanning region came to an end. The interval of sea water for a short period. Over a large area of this region coal were accumulated, parts of which are now preserved in the Southern Appalachian field.

DUNKARD DEPOSITION.

With the emergence of dry land, a new sea finally formed in the area of the Allegheny Front in Pennsylvania. On its south margin a new sea was formed in the area of the Allegheny Front in Kentucky. On its south margin a new sea was formed in the area of the Allegheny Front in Kentucky. On its south margin a new sea was formed in the area of the Allegheny Front in Kentucky.
of this strath probably marked the close of Tertiary time, for the further development of this feature was arrested by the events of the Glacial epoch, which are described in the succeeding paragraphs.

KANASSA REGIONS.

The further development of the Parker strath was arrested probably at the beginning of the Glacial epoch by the invasion of the ice sheet of the earliest stage of glaciation known to have affected this region. This ice sheet, moving from the north, transported great quantities of rock debris from the area over which it passed and deposited much of the same as gravel, sand, and silt over the glacial region. This condition the Kansans or pre-Kanassans described below.

The drift sheet covered an area in northwestern Pennsylvania extending to a line roughly drawn from the point where Beaver River enters the northern boundary of Beaver County through Kennesh, Oil City, Tioga County, and Warren, following the north side of the Allegheny from Oil City northeastward. (See fig. 1.) This drift sheet, great quantities of material were washed down the Allegheny and deposited by the overloaded waters upon the Parker strath. The deposition of this material continued until 100 to 130 feet had accumulated in the valley, as is indicated by the fact that stream-borne pebbles are now in some cases found on the hillside 130 feet above the strath.

Near the head. With the advent of warmer climatic conditions the ice sheet receded, leaving the surface covered with drift and all the old valleys filled to great depths. This valley-filling was so great in many cases that the streams were deflected from their pre-Glacial courses and new drainage basins were established.

INTER-GLACIAL VALLEY EROSION.

After the drainage changes at the close of this last stage of glaciation, the Allegheny, now the lower Allegheny, enlarged to four times its former width, was flowing upon its bed of glacial debris, and for the first time in its history was free from all obstruction. This new erosional work was done quickly, and mostly removed, leaving only those portions which have been described as covering the remnants of the Parker strath. The valley filling was so great in many cases that the streams were deflected from their pre-Glacial courses and new drainage systems were established.

VIRGENA DEPOSITION.

Between the earliest stage of glaciation already described and the latest or Wisconsin stage were two or three stages during which the Allegheny valley was not free from the influence of ice covering. During this Wisconsin stage the ice again invaded northwestern Pennsylvania, and deposited its load of drift, now approximately the area covered by the drift strath. In margins lay nearly parallel to the margins of the older strath, but not quite as far to the southwest. The outwash from this drift con- sisted of coarse pebbles and boulders near the margin, and of boulders and coarse material at the Kittingen quadrangle, was composed mainly of fine silt, which covered the bottom of the Alle- gheny to a depth of about 50 feet. Since that time the river has been eroding its present bed, and the most valuable deposits have been probably working them to a greater or less extent.

COMPARATIVE LENGTH OF GLACIAL AND POST-GLACIAL TIME.

This can be estimated by comparing the amount of material deposited by the streams in two epochs. During Glacial time over 100 feet of glacial deposits were deposited in the Allegheny river, the material was then removed and a trench cut 300 feet into the solid rock, after which the 60 feet of material were deposited. During this Glacial time the river has merely thrashed the material of mass to a depth of 40 to 50 feet. These facts indicate that the Glacial epoch was many times longer than post-Glacial time.

Recent Erosion.

During post-Glacial time the alluvium forming the modern flood plains was deposited by the streams as they overflowed their banks from time to time, just as they may be observed to do at the present day.

MINERAL RESOURCES.

In the preparation of this chapter the reports of the Second Geologic Survey of Pennsylvania, particularly Report H5, by W. C. Platt, have been freely drawn upon.

Coal is today the most important mineral resource of the Kittingen quadrangle. There are but few areas within the quadrangle where there does not exist one or more workable seams of coal, of which the greater number are small and held in small exception to the Allegheny formation. A large number of the various coal seams are given on the coal-section sheet, and a number of analyses of the coals are given in the table at the end of this chapter. In some cases the coals have been studied at the University of Pennsylvania. What appears to be this coal was observed partially exposed in the bed of Limestone Run near its mouth and may be there 2 feet thick.

Corticeau coal.—On a former page this name is adopted for a coal apparently of small extent in the vicinity of Beaver Falls. It was described as covering the region over which it passed and depositing much of its load of fine silt, which covered the bottom of the Allegheny to a depth of about 50 feet, after which the 50 feet of material were deposited. Since that time the river has been eroding its present bed, and the most valuable deposits have been probably working them to a greater or less extent.

COMPARATIVE LENGTH OF GLACIAL AND POST-GLACIAL TIME.

This can be estimated by comparing the amount of material deposited by the streams in two epochs. During Glacial time over 100 feet of glacial deposits were deposited in the Allegheny river, the material was then removed and a trench cut 300 feet into the solid rock, after which the 60 feet of material were deposited. During this Glacial time the river has merely thrashed the material of mass to a depth of 40 to 50 feet. These facts indicate that the Glacial epoch was many times longer than post-Glacial time.

Recent Erosion.

During post-Glacial time the alluvium forming the modern flood plains was deposited by the streams as they overflowed their banks from time to time, just as they may be observed to do at the present day.

MINERAL RESOURCES.

In the preparation of this chapter the reports of the Second Geologic Survey of Pennsylvania, particularly Report H5, by W. C. Platt, have been freely drawn upon.

Coal is today the most important mineral resource of the Kittingen quadrangle. There are but few areas within the quadrangle where there...
of East Franklin Township. In addition to these working banks there is a number along Glade Run, to the west of Kittanning, and the Murreyville sand seems to be almost immediately on the top of the Hundred-foot sand at the top of the Venango group. The oil produced in the quadrangle comes from a group of coarse sandstones, frequently interbedded with red shale and sandstones, which are believed to intimate the character of the oil. The oil is mostly obtained from the Third sand and from the Fifth sand below the oil sands. The latter's lower bench, the Thirty-foot sand, is a most valuable source of gas; in others it is of much less importance than some of the underlying sands. The oil sands occur at various levels, the higher generally lying to the north and the lower to the south, and it is possible that these gas-bearing sands encountered in drilling a well has been called the Murreyville sand.

**Vermont Oil Sand.** The oil produced in the quadrangle comes from a group of coarse sandstones, frequently interbedded with red shale and sandstones, which are believed to represent the character of the oil. The oil is mostly obtained from the Third sand and from the Fifth sand below the oil sands. The latter's lower bench, the Thirty-foot sand, is a most valuable source of gas; in others it is of much less importance than some of the underlying sands. The oil sands occur at various levels, the higher generally lying to the north and the lower to the south, and it is possible that these gas-bearing sands encountered in drilling a well has been called the Murreyville sand.

**Vermont Oil Sand.**

The oil produced in the quadrangle comes from a group of coarse sandstones, frequently interbedded with red shale and sandstones, which are believed to represent the character of the oil. The oil is mostly obtained from the Third sand and from the Fifth sand below the oil sands. The latter's lower bench, the Thirty-foot sand, is a most valuable source of gas; in others it is of much less importance than some of the underlying sands. The oil sands occur at various levels, the higher generally lying to the north and the lower to the south, and it is possible that these gas-bearing sands encountered in drilling a well has been called the Murreyville sand.

**Vermont Oil Sand.**

The oil produced in the quadrangle comes from a group of coarse sandstones, frequently interbedded with red shale and sandstones, which are believed to represent the character of the oil. The oil is mostly obtained from the Third sand and from the Fifth sand below the oil sands. The latter's lower bench, the Thirty-foot sand, is a most valuable source of gas; in others it is of much less importance than some of the underlying sands. The oil sands occur at various levels, the higher generally lying to the north and the lower to the south, and it is possible that these gas-bearing sands encountered in drilling a well has been called the Murreyville sand.

**Vermont Oil Sand.**

The oil produced in the quadrangle comes from a group of coarse sandstones, frequently interbedded with red shale and sandstones, which are believed to represent the character of the oil. The oil is mostly obtained from the Third sand and from the Fifth sand below the oil sands. The latter's lower bench, the Thirty-foot sand, is a most valuable source of gas; in others it is of much less importance than some of the underlying sands. The oil sands occur at various levels, the higher generally lying to the north and the lower to the south, and it is possible that these gas-bearing sands encountered in drilling a well has been called the Murreyville sand.

**Vermont Oil Sand.**

The oil produced in the quadrangle comes from a group of coarse sandstones, frequently interbedded with red shale and sandstones, which are believed to represent the character of the oil. The oil is mostly obtained from the Third sand and from the Fifth sand below the oil sands. The latter's lower bench, the Thirty-foot sand, is a most valuable source of gas; in others it is of much less importance than some of the underlying sands. The oil sands occur at various levels, the higher generally lying to the north and the lower to the south, and it is possible that these gas-bearing sands encountered in drilling a well has been called the Murreyville sand.

**Vermont Oil Sand.**

The oil produced in the quadrangle comes from a group of coarse sandstones, frequently interbedded with red shale and sandstones, which are believed to represent the character of the oil. The oil is mostly obtained from the Third sand and from the Fifth sand below the oil sands. The latter's lower bench, the Thirty-foot sand, is a most valuable source of gas; in others it is of much less importance than some of the underlying sands. The oil sands occur at various levels, the higher generally lying to the north and the lower to the south, and it is possible that these gas-bearing sands encountered in drilling a well has been called the Murreyville sand.
of shale. The occurrence of bands of red shale and sand is very common in the Murrysville group. These are nearly always thin and may be broken by thin beds of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

Blue Monday and Boulder sands.—Near the center of the group, in many wells, known as the Blue Monday and Boulder sands, the former above the latter. They are the equivalent of the Vereen sandstone, the oil-bearing beds are found near the bottom of the group. When drilling began in that part of Butler County in and adjacent to this quadrangle, the first oil-bearing sand was called the Third sand and was supposed to be the equivalent of the Vereen sand. Later a hundred-foot sand was discovered, which was called the Fourth sand. Mr. Curly, of the Vereen sand, and a little above it. A year or more after the correlation of the Butler County and Venango Third sands is a mistake, that the Butler Third is the equivalent of the Vereen sand, and that the Butler Fourth sand really represents the Venango Third sand. However, that may be, the names originally adopted for the sands in this region will be used here. These names have been applied to the various oil-prone beds of the region according as the drillers believed that they could distinguish them as one or the other, so the oil-producing bed being separate and not continuous, is, as the name implies, thin bands of sandstone may be separated by thin bands of shale. Where the shale bands disappear and thick beds of sandstone occur, it is probable that the shale bands are thin and may not be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

First sand of Venango County, the change being supposed to be the equivalent of the Venango Second sand, and the Third sand could not be referred to either of these two sands the same Stray sand was adopted, making here and there a Stray sand pool. The Stray sand is regarded as occurring at a higher or a lower horizon, or it may be an unbroken bed 100 feet thick or it may be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

The occurrence of bands of red shale and sand is very common in the Murrysville group. These are nearly always thin and may be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

Blue Monday and Boulder sands.—Near the center of the group, in many wells, known as the Blue Monday and Boulder sands, the former above the latter. They are the equivalent of the Vereen sandstone, the oil-bearing beds are found near the bottom of the group. When drilling began in that part of Butler County in and adjacent to this quadrangle, the first oil-bearing sand was called the Third sand and was supposed to be the equivalent of the Vereen sand. Later a hundred-foot sand was discovered, which was called the Fourth sand. Mr. Curly, of the Vereen sand, and a little above it. A year or more after the correlation of the Butler County and Venango Third sands is a mistake, that the Butler Third is the equivalent of the Vereen sand, and that the Butler Fourth sand really represents the Venango Third sand. However, that may be, the names originally adopted for the sands in this region will be used here. These names have been applied to the various oil-prone beds of the region according as the drillers believed that they could distinguish them as one or the other, so the oil-producing bed being separate and not continuous, is, as the name implies, thin bands of sandstone may be separated by thin bands of shale. Where the shale bands disappear and thick beds of sandstone occur, it is probable that the shale bands are thin and may not be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

First sand of Venango County, the change being supposed to be the equivalent of the Venango Second sand, and the Third sand could not be referred to either of these two sands the same Stray sand was adopted, making here and there a Stray sand pool. The Stray sand is regarded as occurring at a higher or a lower horizon, or it may be an unbroken bed 100 feet thick or it may be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

The occurrence of bands of red shale and sand is very common in the Murrysville group. These are nearly always thin and may be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

Blue Monday and Boulder sands.—Near the center of the group, in many wells, known as the Blue Monday and Boulder sands, the former above the latter. They are the equivalent of the Vereen sandstone, the oil-bearing beds are found near the bottom of the group. When drilling began in that part of Butler County in and adjacent to this quadrangle, the first oil-bearing sand was called the Third sand and was supposed to be the equivalent of the Vereen sand. Later a hundred-foot sand was discovered, which was called the Fourth sand. Mr. Curly, of the Vereen sand, and a little above it. A year or more after the correlation of the Butler County and Venango Third sands is a mistake, that the Butler Third is the equivalent of the Vereen sand, and that the Butler Fourth sand really represents the Venango Third sand. However, that may be, the names originally adopted for the sands in this region will be used here. These names have been applied to the various oil-prone beds of the region according as the drillers believed that they could distinguish them as one or the other, so the oil-producing bed being separate and not continuous, is, as the name implies, thin bands of sandstone may be separated by thin bands of shale. Where the shale bands disappear and thick beds of sandstone occur, it is probable that the shale bands are thin and may not be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

First sand of Venango County, the change being supposed to be the equivalent of the Venango Second sand, and the Third sand could not be referred to either of these two sands the same Stray sand was adopted, making here and there a Stray sand pool. The Stray sand is regarded as occurring at a higher or a lower horizon, or it may be an unbroken bed 100 feet thick or it may be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.

The occurrence of bands of red shale and sand is very common in the Murrysville group. These are nearly always thin and may be broken by thin bands of shale into three members, which in descending order are called the Second or Hundred-foot sand, Fifty-foot sand, and Thirty-foot sand. So far as is known this bed never produces oil in this quadrangle, but it is one of the most important gas-producing rocks of Armstrong County.
Allegheny River. The workings in West Frank­bon coal deposits are exhausted.

The Freeport ore is described as a solid, compact, very argillaceous layer 2 to 4 feet thick, 26 inches below the Upper Freeport coal. It is a car­bonate ore yielding a little over 30 per cent of metallic iron. The iron is disposed to be red short and would be improved by a mixture of one-quarter magnetic or red hematite ores (Second Geol. Surv. Pennsylvania, Rept. H5, p. 220).

While the Freeport ore probably can not be regarded as an important source of future supply of iron, it is evident that in the Bahntons ore there exists an almost unlimited store of medium-grade ore which may be an important source of supply when the more productive and profitable deposits are exhausted.

Analyses of coals of Kittanning quadrangle.

<table>
<thead>
<tr>
<th>Name of seam</th>
<th>Locality</th>
<th>Collector</th>
<th>Volatile hydrocarbons</th>
<th>Coke</th>
<th>Ash</th>
<th>Fuel ratio</th>
<th>Character of coke</th>
<th>Sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kittanning</td>
<td>Ass.</td>
<td>E. C. Sullivan, U. S. G. S.</td>
<td>0.000</td>
<td>100.00</td>
<td>0.00</td>
<td>1:1.44</td>
<td>Good</td>
<td>0.00</td>
</tr>
<tr>
<td>Kittanning</td>
<td>Ewing</td>
<td>W. F. Schaller, U. S. G. S.</td>
<td>0.000</td>
<td>100.00</td>
<td>0.00</td>
<td>1:1.44</td>
<td>Good</td>
<td>0.00</td>
</tr>
<tr>
<td>Kittanning</td>
<td>Inclined</td>
<td>W. F. Schaller, U. S. G. S.</td>
<td>0.000</td>
<td>100.00</td>
<td>0.00</td>
<td>1:1.44</td>
<td>Good</td>
<td>0.00</td>
</tr>
<tr>
<td>Kittanning</td>
<td>West Winfield</td>
<td>W. F. Schaller, U. S. G. S.</td>
<td>0.000</td>
<td>100.00</td>
<td>0.00</td>
<td>1:1.44</td>
<td>Good</td>
<td>0.00</td>
</tr>
<tr>
<td>Kittanning</td>
<td>Erdman</td>
<td>W. F. Schaller, U. S. G. S.</td>
<td>0.000</td>
<td>100.00</td>
<td>0.00</td>
<td>1:1.44</td>
<td>Good</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Kittanning.

At West Winfield the Saltsburg and Clarion sandstones are being ground into sand. In the vicinity of Kittanning large quantities of sand are dredged from the river and used for grinding plate glass at the Kittanning Plate Glass Works. It is also used to a less extent for mortar. The Mahon­ving sandstone is extensively quarried on the west side of the river opposite Ford City by the Pitts­burg Plate Glass Company. It is reduced to sand, which is used for grinding glass at Ford City.

November, 1903.