GENERAL RELATIONS.

Location and area.—The Gaine quadrangle is situated in northern Pennsylvania, immediately south of the northern end of the Allegheny Plateau and between the eastern and western limits of the State. It embraces the area between latitudes 41° 45' on the south and 42° on the north, and between longitude 77° 30' on the east and 77° 45' on the west, and includes one-sixtieth of a square degree of surface. Its north-south length is about 17.3 miles, its breadth about 13 miles, and its area 223.5 square miles. It includes portions of Potter and Tioga counties, and is named for the town of Gaines, situated on Pine Creek, in the southeastern part of the quadrangle, and the oil wells operations for the small oil field of the same name lying just outside of the quadrangle on the south.

The Gaine quadrangle is a part of the Appalachian province, which extends from New York on the north to central Alabama on the south, and from the Atlantic Coastal Plain on the east to the lowlands of the Mississippi River on the west, and has been subdivided into three divisions. The eastern division is marked by the more or less rounded and dissected ridges of altered sedimentary and igneous rocks, and the Appalachian Mountain proper; the central division, known as the Allegheny Mountain, lies to the north, straight, or gently curved gulfs produced by the erosion of strongly folded and faulted sedimentary rocks; and the western division, known as the Allegheny Plateau, by the deeply trenched plateau-like uplands extending over the region of gently folded rocks lying to the northwest of the central division. It is in this region of gentle folds and plateau-like topography that the Gaine quadrangle belongs, the southeastern corner as measured along the strike of the folds to the south being about 40 miles from the Allegheny Front, which constitutes the western margin of the Appalachian Valley. (See Fig. 5, Illustration sheet.)

TOPOGRAPHY.

Pine Creek.—The quadrangle is drained by two principal streams—Cowaneegee River and Pine Creek, which flow eastward, parallel to the trend of the rocks and—by a considerable number of smaller streams, flowing southwestward or southeastward to join the mentioned streams. A small stream also flows due west from the central part of the quadrangle, through the extreme southwest corner, was covered by Oligocene deposits and by the deposition of many thousand feet, and although only a small percentage, however, came to the surface of the sea containing the fossiliferous sandstones and shales. This layer of sandstones and shales, having as its base (not exposed in the Gaine quadrangle) the bluish sandstones of the Fort Payne group, and as its upper horizon the red or green sandstones of the Cattaraugus formation, was first recognized by the predominate colors of both the sandstones and the shales. The gray, greenish-gray, and buff sandstones, alternating with thick beds of black shales and thin seams of impure limestones, constitute the larger portion of the formation.

The sandstones sometimes appear to consist of a series of thin, flat-lying beds, each bed being a few inches to a few feet thick, and so arranged that the contacts between them are almost imperceptible. The sandstones are usually only a few inches but sometimes several feet thick and are usually quite free from fossils. The limestones are of two distinct types. The first, and most common, is a dark bluish-gray, sometimes almost black, argillaceous limestone, rich in brachiopod fossils, and occurring in beds usually only a few inches but sometimes several feet thick. The second type may be of gray, bluish-gray, or pinkish color, and is composed almost entirely of the fragments of small shells, in some instances exhibiting in their arrangement a typical cross-bedded structure. This limestone is firmly exposed to a thickness of several feet in the west bank of Elk Run, about 15 miles southwest of Gaines, but has been recognized only by fragments within the area of the quadrangle itself. It occurs in the upper portion of the Cowaneegee River, near the junction with the overlying Cattaraugus formation.

The general character of the Charge monuments is as follows: (1) The monument is a single, rugged, steep-sided, conical hill, with a distinct ridge extending from its summit to the main divide of the Allegheny Mountains. (2) The monument is a broad, low, gently undulating, almost featureless plain covered with gravel and sand, of moderate to large size, and extending over large areas of the quadrangle. (3) The monument is a series of rounded hills and is composed of a more or less impure limestone, coarse or fine, brown, or black, and ranging from a thickness of a few inches to several feet. (4) The monument is a series of irregularly shaped knobs, usually less than a mile in diameter, and composed of a coarse, lightly colored sandstone, commonly containing a large number of fossils, and ranging from a thickness of a few inches to several feet. (5) The monument is a series of irregularly shaped knobs, usually less than a mile in diameter, and composed of a coarse, lightly colored sandstone, commonly containing a large number of fossils, and ranging from a thickness of a few inches to several feet.
The rocks of the Oswayo formation constitute the upper portion of the hills along both sides of Pine Creek in the southern portion of the quadrangle, and along the northern boundary of the quadrangle, north of Oswayo Creek. They are also exposed in the crests along both sides of Cowanesque River.

The rocks of the Oswayo formation are most widely distributed in the northern half of the quadrangle, where they occur not only on the banks of the alluvial fans, but also in the lower portion of the Oswayo Creek. Farther south they are found on both sides of the Cowanesque River. The Oswayo formation in the southern portion of the quadrangle, near the crest of the anticline, consists mainly of thin-bedded gray sandstone and covered by a few clay lenses. The thickness of the Oswayo formation varies from a few feet to several hundred feet, and the lower part of the formation is often overlain by the Pennsylvanian coal measures.

The Oswayo formation is divided into two main divisions, the lower consisting of the well-known Oswayo conglomerate member, and the upper of a sequence of sandstones and shales, with one or more coal seams, which overlies the conglomerate and which is identifiable by its fossil content.

The Oswayo conglomerate member, which varies in thickness from 60 to 100 feet, is composed of almost entirely of quartz sands, and is frequently a coarse conglomerate rather than a conglomerate. The character of the sand grains and pebbles, which are commonly of pure white quartz, considerably gives the rock a bright, almost white appearance, quite different from other rocks with which it is associated. Sometimes this is due to the fact that the rocks are less resistant to weathering, and hence decompose more slowly.

The conglomerate consists of pebbles, cobbles, and boulders, consisting of quartz, feldspar, and other minerals, and is often covered by a thin layer of silt or clay. The conglomerate is often separated from the underlying sandstone by a thin clay layer, which gives rise to somewhat conspicuous cliff-like outcrops.

The following section, based largely on superficial exposures indicating an aggregate thickness of perhaps 40 feet or less of red clay lying immediately below the Sharon conglomerate member, which here forms the base of the Pottsville formation.

This clay, which occasionally contains small fragments of red sandstone, without doubt resulted from the decomposition of beds of shales of those colors. Although it is recognized that the occurrence may be of an especially pronounced example of the lenses of red shales which are occasionally found in the Oswayo formation, and which may be said that all of the larger and more important red beds of the Oswayo formation occur within a vertical interval of a few feet of each other.

The Pottsville formation is the uppermost of the formations exposed in the Gurnee quadrangle. In this region it may be separated into two main divisions, the lower consisting of the well-known Sharon conglomerate member, and the upper of a sequence of sandstones and shales, with one or more coal seams, which overlies the conglomerate and which is identifiable by its fossil content.

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indications, will give a good general idea of the character and succession of the beds. The section is from the top down.

**Section near Dawson**

- **Depth**
  - Drift (longitudinal and lateral)........ 50
  - Black shale........................ 5
  - Coal (1 ft. and over).................. 5
  - Inferred till........................ 5
  - Unstratified boulder sand................ 10
  - Rock of unknown character................ 10
  - Rock, unknown.......................... 5
  - Rock, unknown, 1 part to 20 or more............. 10
  - Rock, unknown, 1 part to 100 or more............. 10

The fossil plants associated with the coal indicate, according to identification by David White, that it is to be correlated with the Mercer horizon of the Potteville. The 25-foot bad of shale mixed with sandstone over the coal and shale has as yet yielded no fossils, but is almost certainly a part of the Potteville.

**Morainal terraces.**

The Pleistocene deposits in the Gaines region are of two classes, (1) those which were laid down either directly or indirectly through the agency of the great ice sheet which covered the region in the earliest portion of the period, and (2) those which have been deposited by streams or other agencies since the time of glacial withdrawal, but before the ice sheet. The former are known as Glacial deposits and the latter as post-Glacial or Recent deposits.

The Glacial deposits consist of materials which were picked up or dragged along in the bottom of the ice sheet during its southward movement, or which were transported by its associated streams.

The material has all been moved from its original position, and is therefore known as drift. This drift was frequently deposited directly by the ice, either being set down on top of the part of the country in which it has been frozen, or simply dropped and left behind as a sheet beneath the ice, as the friction between the drift in the bottom of the moving ice and the overridden surfaces becomes so great as to cause lagging and lodgment. The drift liberated by either of these methods usually consists of a heterogeneous mixture, including all grades of material, from clay to large boulders, and is known as till. Drift which was not deposited directly by the ice, but which was taken up and transported by glacial streams before it was finally deposited in more or less distinctly stratified masses, is known as stratified or modified drift. Each of these drifts has certain characteristics and features depending upon minor features of origin.

Of the till deposits two types, the terminal moraine and the ground moraine, have been recognized in the Gaines quadrangle, while the stratified drift consists of several types, depending upon minor features of origin.

Of the till deposits two types, the terminal moraine and the ground moraine, have been recognized in the Gaines quadrangle, while the stratified drift consists of several types, depending upon minor features of origin.

**Glacial streams and lake deposits.**—It has already been stated, in the discussion of the till sheet, that there are often considerable amounts of stratified drift in the valleys, especially in those of the larger streams, such as Cowanesque River and Pine Creek. The sedimentary deposits consist of sand and gravel, and are composed mainly of materials which were set free by the melting of the debris-laden portion of the ice and which were taken up, transported, and finally deposited by the streams originating in the melting ice sheet. The total thickness of these valley fillings, consisting in part of the gravels just mentioned and in part of the till, is shown on the Surficial Geology map. The information afforded by occasional water wells shows that it is considerable. Thus at the village of Northfork, 4 miles northeast of Pine Township, several flowing wells are said to draw water from an impervious gravel at a depth of 50 or 60 feet. In the same valley near the south line of Brookfield Township, E. M. Gardner’s well showed the presence of 75 feet of filling over the rock bottom. Again, in Mill Creek Valley, about three-quarters of a mile south of the main street of Westfield, a well did not reach rock at 90 feet. The drift in the main Cowanesque Valley is probably 75 to 100 feet or more in thickness.

A portion of the stratified drift was deposited in the beds of the glacial streams, but in the valley of Cowanesque River and in the lower portion of the tributary valleys entering it in Westfield and Harrison townships. Much of the material appears to have been deposited in a lake or marsh which lay across the course of the Cowanesque Valley at a point about a mile to the east of the limits of the valley. The outlets were across the divide between Mill Creek and Long Run south of Sabinesville and between James and Great Owls creeks in Chatham Township, about 4 miles east of Sabine Lake. The low lands west of the limits of the area under consideration.

The deposits laid down in this temporary lake, which is now occupied by the Cowanesque River, extend over a considerable area and can now be separated from contemporaneous or

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*Please note that the above text contains historical geological terms and data.*
subsequent stream deposits. The clays occurring from the older valley filling was deposited in the material brought from the ice front or eroded gravel knoll with kettle-like depressions a half margin into which flowed the waters resulting tary valleys and emerged upon the broad, flat sheet. In some respects they resemble morainal cavities beneath the ice, or in channels near the confusedly stratified sands, gravels, etc., which largely cut away by the present stream, but its point, whence it declines gently to the sharply south of the limits of the quadrangle, there is a quarters of a mile long above its mouth near the hills and the Chemung is confined mainly to the valley of the Chemung formation. These deposits are limited mainly to the valleys back the valleys tributary to Pine Creek, and been stated, at the mouths of the streams flowing between the mouths of Lick Run and Shin Hollow, Pine Creek swings to the east corner of the quadrangle. The exact center, as shown by the coal workings, becomes still shallower, nothing above the conglomerate is exposed, but also about 200 feet east of the road opposite the main syncline reaches its greatest depth near Gurnee, being 300 feet east of the road opposite the main syncline formation. Where the top of the Chemung has been eroded in the anticlinal areas the elevations are less pronounced, and finally subsides into the generally undulating, or almost flat structure of the area. The Chemung rocks are everywhere exposed except on the highest knobs, but as the exposure is insufficient, however, to give anything but a general idea of the structure.

Where the anticline enters the northern edge of the area the Channons are everywhere present except on the highest knobs, and the sediment subdues to the west, the rocks of the Cattaraugus formation form the upper portion of the westernmost part of the valley. The dips both to the north and south are very gentle, averaging only about 1° to 2 feet to a mile.

Chemung syncline.—The Chemung syncline takes its name from Cushman Hollow, north side of the valley, a feature, which occurs just west of the limits of the quadrangle, where the Cattaraugus and Pine Creek synclines unite into a single broad trough with only a gentle swell marking the continuation of the previously pronounced anticlines.

Chemung rocks are exposed in the eastern part of the area over a mile wide, and marked by long tongues of Chemung extending into the quadrangle. The thickness exposed is 700 feet or more. In the western portion of the area the anticline is so reduced in size that the Chemung is represented by a single, small, isolated patch of slight thickness.

The axis of the syncline extends for a considerable distance along the southern flanks of the synclinal mountain before it finally turns southwestward at Warren, about 8 miles north of Potter Brook. The whole of the Cattaraugus and Oswayo formations and a portion of the Sharon conglomerate are represented in the exposures of the mountain.

The formation of flood-plain alluvium and a few minor swamp deposits, as has been stated, at the mouths of the streams flowing southeast of the Chemung formation. Where the top of the Chemung has been eroded in the anticlinal areas the elevations are less pronounced, and finally subsides into the generally undulating, or almost flat structure of the area. The Chemung rocks are everywhere exposed except on the highest knobs, but as the exposure is insufficient, however, to give anything but a general idea of the structure.

The majority of the gravel fans occur, as has been stated, at the mouths of the streams flowing southeast of the Chemung formation. Where the top of the Chemung has been eroded in the anticlinal areas the elevations are less pronounced, and finally subsides into the generally undulating, or almost flat structure of the area. The Chemung rocks are everywhere exposed except on the highest knobs, but as the exposure is insufficient, however, to give anything but a general idea of the structure.
it was possible to observe on the surface.

The red Cattaraugus shales, which are the uppermost deposits of the Cattaraugus group, are characterized by a thick mudstone formation known as the Oswayo. The change from one to another, however, takes place without recognizable break. It is evident that the lands from which the materials were derived, the supply of material was also probably greater, because of an acceleration of erosion. Slight uplift of the land surface which appears to have accompanied the inauguration of Cattaraugus deposition.

The deposition of the Cattaraugus beds was preceded by an accumulated abundance of the sea, which is indicated by the great thickness and dips of the beds. The elevation of the land area, is not fully understood. It is known, however, that the time at which the deposition representing the advent of what is usually known as Catskill conditions took place was not the same throughout the area. It is possible to observe that the eastern portion of the embayment became progressively lower as the distance from the east increased. It is probable that the deposition of the peculiar deposits began soon after the close of the Hamilton, and as a result of the conditions then prevailing. In the western part of the region, however, the deposition of the red Cattaraugus beds has been considerably more extensive. In the absence of any abrupt change of conditions at the close of the Devonian, however, that conditions favorable to the deposition of red Cattaraugus beds came into existence in western New York. The presence of ripple marks and the presence of the fossiliferous sandstones, shales, and thin limestones are indicative of fluctuating conditions. The salt-water deposits of the Cattaraugus beds were followed by a period in which deposition began soon after the close of the Devonian, and while it is true that the Newark beds of later Triassic time that a slight elevation to 2500 or 2600 feet at the western end, the highest point of the Cattaraugus province, is generally supposed to belong to the lower part of the Pottsville period.

Devonian period.

GEOLOGIC HISTORY.

ACUMULATION OF THE LOCAL SEDIMENTS.

GANGES QUADRANGLE.-The earliest deposits that appear at the surface in the Ganges quadrangle are the fissioniferous sandstones, shales, and thin limestones of the Cretaceous series. The analysis of these sediments by the methods of limnologic characterization, etc., were laid down. These alternating conditions continued through Jurassic or early Cretaceous times. In this interval erosion progressed rapidly, though to what extent it is not established. It is known, however, that the Newark beds of later Triassic time, which occur at intervals along the Atlantic border, rest upon rocks reduced by erosion to a flat or gently rolling surface such as is known to geologists as a peneplain.

The uplift accompanied by the tilting and faulting of the Newark beds in late Triassic or early Jurassic times has probably centralised the effect of previous erosion. Erosion in the new cycle proceeded vigorously, with the result that the continental border was reduced in late Jurassic or early Cretaceous times that a slight elevation of the land surface to the present limits of the Coastal Plain. Erosion, however, continued its attack on the remaining highlands with diminished energy until late Cretaceous times when they had been reduced to a peneplain—the Cretaceous peneplain—on which the beds of the Appalachian region were represented. It at all, even by brook, low, flat hills, the component strata, both hard and soft, and of all ages, being alike cut down to the peneplain level. The highest point of this peneplain, in the north at least, as is apparently indicated by the surviving drainage, is supposed to have been in northern New York, from which the Newark beds of the Appalachian region is probably sloped away in all directions. In the Ganges region its position is indicated by the flat-topped moraines, which simply are remnants of the old surface not yet reduced by erosion. The general crest lines of the mountain belts are not level, but rise gently to the high point of about 2500 feet at the western end. The central portion of the quadrangle the crests of the Oswayo mountain belt increase in elevation to 2500 or 2600 feet at the western limits, while the Pine Creek mountain belt, starting in the east at an elevation of 2500 feet,
increases to 2400 at the southwest corner of the area, and from 2400 to 2500 feet as it becomes associated with the Cowanesque belt to the northwest.

Over the Chemung and Catskill anticlinal areas between the Cowanesque and Pine Creek mountain belts and to the north of the former there are no apparent sub-surface features, the higher knobs reaching only to about 2500 feet.

Early Tertiary peneplains.—In the Elkland and Tioga quadrangles, lying east of the Guineas quadrangle, there are evidences of plateau-like surfaces of the eastern parts of the known Cowanesque peneplain along the western flanks of the Allegheny mountain system toward the south.

In the Guineas quadrangle the area which can be referred to the later reduction see the small antecedent areas of relatively soft rocks, and in the Cowanesque quadrangle it is probable whether the land of those areas was reduced to the level of the Tertiary peneplain, although it probably stood well below the Cowanesque peneplain.

The vertical interval between the upper and lower peneplains varies from an average of 400 feet in the area just east of the Guineas quadrangle to 1100 feet in the vicinity of Harrisburg, and probably to the southeastern part of the State.

What the altitude may have been relative to sea level can not be told, but it is probable that it was not much in excess of the figures indicated.

The uplift following the development of the Tertiary peneplain, as indicated by the existing altitude of its remnants, reached its maximum in the north instead of in the south, as was the case of the early uplift, and realized in a partial or, as in certain regions in central Pennsylvania, they were much reduced in elevation.

The results indicate that the development and depression of the early Tertiary peneplain occupied a large part of the northeastern United States. In western Pennsylvania, near Corning, New York, the natural outlet for the waters of the southward-draining streams of Cowanesque River and Pine Creek were the same, the actual length of the valley of the latter stream being much greater. This is evident because of the greater drainage area of Cowanesque River, the larger supply of water more than counterbalancing the more circuitous course of the creek and the greater hardness of the rocks over which it flowed.

Late Tertiary events.—It has been generally conceded among geologists that the advent of the Pleistocene ice sheet was preceded by a general uplift of the northern portion of the continent affecting the surface throughout the northern part of the United States. In western Pennsylvania there is evidence that the uplift recorded by the geography of the Morongahela and Allegheny rivers did not occur until after the first ice invasion. The uplift recorded along the Susquehanna valley is believed to be due to a somewhat pronounced coalescence of local ice sheets, such as might have been formed in the Adirondack region of New York or in the highlands of northeastern Canada. After their incorporation into a single ice sheet the borders of the latter continued to spread outward, the ice advancing, as has been seen, into the latitudes of northern Pennsylvania.

Outline of glacial stages.

Rounded drift of Wisconsin type.

KANSAS OR PRE-WISCONSIN INVASION.

Advance of the ice.—The cause of the accumulation of the glacial ice and its spread over a large bulk of the northern portion of the continent is not well understood, but it is generally believed to be due to a somewhat pronounced uplift of the land and an increase of snowfall, added perhaps by a relative lack of carbonic acid gas in the atmosphere and by certain favorable climatological conditions.

The eastern portion of the great ice sheet had its origin, perhaps, in the occurrence of local ice sheets such as might have been formed in the Adirondack region of New York or in the highlands of northeastern Canada. After their incorporation into a single ice sheet the borders of the latter continued to spread outward, the ice advancing, as has been seen, into the latitudes of northern Pennsylvania. (See Fig. 2.)

Obstructions and deflection of drainage.—When the ice margin advancing from the northeast reached the lower portion of the Tioga River near Corning, New York, the natural outlet for the waters of that river and its tributaries, draining the Susquehanna area and the whole of the northern and eastern portions of Tioga County, was obstructed and a series of long, narrow lakes similar to the Finger Lakes of New York, but more crooked and meandering in the valley of the Tioga and its larger tributaries. The water in the branching lake must have continued to rise until it finally overflowed at the lowest divide and passed southward to the Susquehanna.

The lowest divide appears to have been about 8 miles east of Gaines, at a point about 3 miles south of Amosia. Its elevation can now be determined, but it had probably undergone great reduction by the backward cutting of the headwaters of such streams as have been the sequence of the uplift and tilting of the early Tertiary peneplain.

Of the drift sheets of the various stages only two have been recognized in Pennsylvania and of those only one can be assigned with certainty to a definite stage. This is the main drift sheet covering the northern part of the State and including the Guineas quadrangle. It is assigned to the Wisconsin stage. The other recognized drift sheet consists of scattered fragments or a thin sheet deposited by ice and its associated drainage beyond the moraines marking the southern limits of the Wisconsin drift. From its associations further west it is believed to belong to the Kansas or pre-Wisconsin stage.
When, on the continued advance of the ice, the margin reached the lower portion of Conesus Lake, the area of the early lakes occupying its valley became a separate lake, which continued to rise until it divided a flume at the head of James Creek about the limits of the Gaines quadrangle. The elevation appears to have been originally 1600 or 1700 feet, but it was gradually reduced to a level of 700 feet as the water continued to pour over its crest. On the closing of this outlet by the advancing ice a new one was opened at an elevation of probably 1800 feet or more, over the divide between Mill Creek and Long Run, southwest of Sabattusville. This in turn was gradually reduced in height by the overflowing waters until the advancing ice covered the region and brought the first chapter of the history of the lake to an end.

Drift deposits.—So scanty are the remains of the early glacial ice sheet over the Pine Creek region that within the area covered by the later advance of the ice it has almost entirely escaped observation. Nowhere in the Gaines area has it been distinguished from the later drift, and even beyond the limits of the later drift sheet, in the case of the extraordinary drift shown in fig. 5, the deposits are so attenuated that it is very difficult if not impossible to determine the limits of the earlier ice invasion. The area south of Pine Creek, outside of the central part of the quadrangle, has been mapped as driftless because no drift was found on the mountain at that point, yet such detailed studies of others in the region farther south it appears possible that the early ice advance may have extended southward beyond the limits of the Gaines quadrangle. (See fig. 5.)

INTERTVAL OF INTEGRATION.

With the cessation of the conditions favorable to its existence, the ice sheet drew back to the north and possibly entirely disappeared from the continent. During this retreat it is probable that there occurred a series of events similar in character but in reversed sequence to those occurring during the advance. It seems likely that the lakes were of shorter duration than the earlier, and that the divides over which the waters escaped suffered relatively little reduction. The reduction of the divide south of Amsuson appears to have been slight, so that it afforded, even at the disappearance of the first ice sheet, the outlet for the waters of the upper Pine Creek. Following the disappearance of the ice, the streams and the atmosphere began their work upon the glacial deposits, with the result that considerable portions of the drift were doubtless washed away, and in some portions of Pennsylvania, at least, the underlying rocks were strongly trimmed by the streams. Such drift as remains is deeply weathered and oxidized, the crystalline rock fragments, more or less weathered, often lying in the form of disintegration. The calcareous elements of the drift are almost entirely leached out. These evidences of long exposure to the weather as compared with the fresh, almost unchanged Wisconsin drift, taken in connection with the extensive erosion which in many places in the country is known to have occurred since the earlier drift was deposited, has led to the belief that the time interval between it and the Wisconsin drift is many times as long as the period which has elapsed since the latter was laid down. This long intervening period was marked in other regions by the development of new drainage basins, as the ice receded over the sediments, vegetation, and other drift deposits, and by stages of deglaciation, when the low lands were left free of ice and were subjected to the work of erosion. The depths of the drifts have been uniformly low, but it continued to exist for a longer period, completely disappearing only after the ice had melted back beyond the site of Corning, N. Y.

POST-GlacIAL REPORT.

As the valleys were successively opened up by the retreat of the ice front the streams of the steeper ones entered actively upon the work of removing the glacial deposits from their bottoms and of returning to their former condition. The deposits thus removed from the smaller and steeper valleys have been carried to the broad, open valleys of gentle slope, where they have been incorporated in the general filling on which the present flood plains are built, or, left in the form of broad, low gravel fans at the mouths of the streams. The valley fillings are probably composed mainly of glacial deposits, but the filling of the inequalities and the building of the flood plains and drift-obstructed valleys or in depressions, and the lining of flood plains along the streams.

The Cowanesque lake did not come into existence until either the Pine Creek lake had been drained, but it continued to exist for a longer period, completely disappearing only after the ice had melted back beyond the site of Corning, N. Y.

GEEOLOGICAL RESOURCES.

Oil has not yet been found in paying quantities at any point within the Gaines quadrangle, but the northern edge of the oil field is within one-tenth of a mile of the southern edge of the quadrangle, and the whole field falls within a strip a mile wide, adjoining the quadrangle on the south. The center of operation for the field is at Gaines, from which town the quadrangle, as well as this oil field, takes its name. Because of the intensity of the relation of the oil field to the Gaines quadrangle it has appeared desirable to consider the occurrence of the oil at some length.

Discovery and development of the Gaines oil field.—Wells were sunk in search of oil in the vicinity of Gaines as early as 1884, but although some small shows were obtained, nothing of value was found, and after the drilling of a few more scattered wells along Pine Creek from Gale­town to Amsuson in 1885 and 1886, the search for oil was abandoned until 1897-8. At this time a well was put down at Galetown which gave a sufficient show to encourage further drilling in the field and led to the sinking of a well at Gaines by Woodward & Co., of Waterville, N. Y. This well gave salt water and a good show of oil, and led to the sinking of a well by E. M. Atwell on his own estate. This well, known as Atwell No. 1, produced in 1906 out 20 barrels of salt water from a fractured sandstone lying at a depth of about 190 feet. The appearance of the sand under the microscope is shown in fig. 10 of the Illustration sheet.

Following the Atwell No. 1, other wells were sunk in rapid succession, most of which had an initial production of 10 to 20 barrels, though a few showed much higher production. As the drilling proceeded, however, it soon became evident that the pool was of very limited area, and as finally outlined by the wells was found to cover only a narrow belt, less than one-quarter of a mile wide, extending from near Gaines about a mile west of Watseka.
producing wells, nearly all of which were yielding oil (in 1901), after from 1 to 3 years of pumping, well, was being developed, a new oil horizon was about Watrous, but along more or less open bed location of the wells is indicated in fig. 3. The a few barrels up to 2100 barrels a day, this being all told, the production at the start varying from producing. There were about 30 producing wells, zone in which the oil occurred consisted of an under the microscope is shown in fig. 9.

Production of wells of the Gaines oilfield, as reported by the records. In direction it is a little west of north, bed which has been taken as marking the bottom of the Cattaraugus formation. It is thus seen to the drain, and even if oil were to be found it seems almost certain that no further development is to be expected in the field itself unless at depths greater than those yet penetrated by the drill.
An analysis made and published by the Second (Geological Survey of Pennsylvania (Rep. C, p. 385) is as follows:

\[\text{Red analysis of coal from the Gaines fields.} \]

\begin{tabular}{|l|c|c|c|c|c|c|c|}
\hline
\textbf{Coal} & \textbf{Water} & \textbf{Ash} & \textbf{Fixed carbon} & \textbf{Hematite} & \textbf{Sulphur} & \textbf{Silica} & \\
\hline
\textbf{South Penn Oil Company} & 32.75 & 8.67 & 61.48 & 2.36 & 0.13 & 0.83 & \\
\textbf{Atwood mine} & 31.92 & 8.97 & 61.03 & 2.21 & 0.15 & 0.81 & \\
\textbf{Diamond mine} & 32.12 & 8.99 & 61.25 & 2.24 & 0.16 & 0.82 & \\
\textbf{Legal Ohio Coal Company} & 32.95 & 8.96 & 61.42 & 2.26 & 0.15 & 0.81 & \\
\textbf{North Oil Company} & 32.75 & 8.67 & 61.48 & 2.36 & 0.13 & 0.83 & \\
\textbf{Marshall Oil Company} & 31.92 & 8.97 & 61.03 & 2.21 & 0.15 & 0.81 & \\
\textbf{Kerrville Oil and Gas Company} & 31.92 & 8.97 & 61.03 & 2.21 & 0.15 & 0.81 & \\
\textbf{Company} & 31.92 & 8.97 & 61.03 & 2.21 & 0.15 & 0.81 & \\
\textbf{Buckwheat Oil and Gas Company} & 31.92 & 8.97 & 61.03 & 2.21 & 0.15 & 0.81 & \\
\textbf{Oil and Gas Company} & 31.92 & 8.97 & 61.03 & 2.21 & 0.15 & 0.81 & \\
\textbf{Grounds} & 31.92 & 8.97 & 61.03 & 2.21 & 0.15 & 0.81 & \\
\hline
\end{tabular}

**Gravels.**

Gravels occur in abundance at many points, especially along the larger streams and in the larger gravel bars, especially at the mouths of the larger streams. They have long been used on the Selective Geological map. The material is used elsewhere in the midstream gravel, and in the construction of roads along the river.

**Mineral water.**

A well put down in search for oil near Harrison Valley in 1900 obtained a flow of 2500 barrels of water a day from a depth of only 100 feet. The water possessed a recognizable taste, and the amount of calcium carbonate, sodium carbonate, potassium carbonate, iron carbonate, and some alumina, alum, and natural gas. It was used for domestic and other non-technical purposes.

**Clay.**

The glacial clays have been opened at the brickyard of J. A. Smith just west of the Westmoreland Fairgounds. The principal bed consists of a red limonite clay from 4 to 18 feet thick, resting on a gravel seam 4 to 6 inches thick, below which, again, is a bluish clay. Similar clays probably occur at other points along the valley of Cattaraugus River, but have not yet been seen anywhere.

**Ore.**

The soils of the Gaines area are of two types, glacial and alluvial. True sedentary soils, or those formed in the exact spot where they are found and composed of insoluble sands and clayey products of decay of the immediately underlying rock, occur only over a small area southwest of Pine Creek, in the extreme southwestern corner of the quadrangle.

The glacial soils of the region, however, are fundamentally of sedentary derivation, the glacial having merely taken up the soil it found covering the surface on its advance, transported it a short distance and then, as the ice melted, deposited it. The soils thus formed consist of heterogeneous aggregates of materials ranging in size from clay to large fragments, the finer portions of which are thoroughly destroyed. Most of the soils of this type, like the true sedentary soils, agree in composition with the underlying rock, whereas the geological map showing the distribution of the rocks will also show, in a general way, the distribution of the soils. The best farming land appears to be in those locations where the soil most nearly approaches the character of a true sedentary soil.

Of the formations represented on the maps the Chemung gives the most regular and gentle slopes and soils most nearly resembling those of sedentary origin. It underlies the broad belt of low hills lying between the Cattaraugus and Pine Creek Mountain belt and also the low belt north of the former. It includes all the valuable farming land except that along the alluvial flood plains of the larger streams, and yields excellent crops of wheat, oats, corn, etc.

Next to the Chemung the Cattaraugus formation affords the most valuable soil, but because of the presence of heavy beds of flinty sandstones and its association with the relatively massive Oswayo formation, the areas are usually steep and rough and are not well adapted to cultivation. Buckwheat is the principal crop.

The Oswayo formation gives extremely steep slopes and soils composed almost entirely of a mass of sandstone fragments. Its areas are mostly forested and have in the past yielded quantities of timber and of lumber tax bark. Occasional small clearings have been made and small amounts of buckwheat and other grains are raised.

The outcrops of the Mauch Chunk shales and of the Sharon conglomerates are of very limited extent and the resulting soils are so slight as to be negligible.

The alluvial soils are partly the result of deposition by glacial streams and partly the result of the deposition of fine sediments on the flood plains of the larger streams in recent times. The glacial alluvium is irregular in its distribution, occurs in small areas, and is impersistent as a soil. The flood plain alluvium, however, furnishes the principal source of the region and gives fine crops of superior tobacco.