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# GEOLOGY OF OIL AND GAS FIELDS

IN

# STEUBENVILLE, BURGETTSTOWN, AND CLAYSVILLE QUADRANGLES

## OHIO, WEST VIRGINIA, AND PENNSYLVANIA

BY

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# GEOLOGY OF OIL AND GAS FIELDS IN STEUBENVILLE, BURGETTSTOWN, AND CLAYSVILLE QUADRANGLES, OHIO WEST VIRGINIA AND PENNSYLVANIA.

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## PART I.—GENERAL FEATURES OF THE REGION.

### INTRODUCTION.

This paper contains the results of a study of the geologic conditions which accompany or control the accumulation of oil and gas in the central part of the Appalachian oil fields. It treats of conditions in the Steubenville quadrangle, in Ohio, West Virginia, and Pennsylvania, and the Burgettstown and Claysville quadrangles, in Pennsylvania. Each quadrangle covers about 227 square miles. The principal oil-producing sand in the Steubenville quadrangle is the Berea sand; in the Burgettstown quadrangle, the Hundred-foot sand; and in the Claysville quadrangle, the Gordon, Fourth, and Fifth sands. The conditions in these three quadrangles may be regarded as typical of the various conditions under which oil and gas occur in the Appalachian field, and for this reason the first detailed study was undertaken in them.

The method of study was to map, by means of contour lines, the geologic structure of some prominent bed of rocks, such as sandstone, limestone, or coal, which shows at many places on the surface, and which is easily identifiable; then, by means of information gained from the wells already drilled, the depth of the oil sand below the reference stratum was determined wherever a well had been drilled, and from these data a contoured map of the oil sand was constructed. This map shows the oil sand as if everything had been removed and its upper surface were open to inspection. In this way the relation of the producing oil fields to the geologic structure can be studied.

Such a study should be of assistance in extending the limits of old and well-known fields and in locating new areas of productive territory.

This paper is not based solely on the work of the Geological Survey, but is the outcome of a combination of the results of that work with information procured from the oil operators and drillers in the territory. This information has been willingly furnished by the oil men. They have gladly allowed members of the Survey to inspect and copy their well records, and in many cases have put themselves to great inconvenience in searching through old files and procuring records that have long been out of use. To one and all of these men the thanks of the writers are given for their hearty cooperation.

The field work of the Steubenville and Burgettstown quadrangles was done by W. T. Griswold; that of the Claysville by M. J. Munn, under Mr. Griswold's general supervision. The theoretical discussion and the description of the Steubenville and Burgettstown quadrangles are by Mr. Griswold; the description of the Claysville quadrangle is by Mr. Munn.

In undertaking a study of the conditions governing the accumulation of oil and gas, it was hoped to interest two classes of readers—those who are conducting similar investigations of the general conditions governing the accumulation of oil, and those who have a financial interest in the territory under consideration. The detail required to make the results available to the engineer or operator who wishes to extend the work or to use it in locating wells makes slow and tedious reading. In order to avoid this, the area will first be described, the general conditions will be stated, and then each quadrangle will be taken up in detail and the most important geologic and engineering data available be given.

It should be distinctly borne in mind that the primary object of the field work was not to examine and report on territory for prospective operators, though this phase of the subject is incidentally treated in this report, but it is intended to present here the facts as they were found, especially in developed areas, so that the great oil and gas fields as a whole may be intelligently studied with the hope that the fundamental truths which each field reveals may be applied in an everyday business way in the unceasing hunt for new producing areas. For this reason it is not thought best to present in great detail the mass of information collected in regard to developed territory, such as the elevations, names, numbers, records, etc., of the hundreds of wells examined, nor to fill space in a reprint of the history of the development of these fields as given in other reports, but to show in as clear and concise a manner as possible the vital results extracted from these data so that they may be comprehended at a glance by the operator.

No attempt will be made to give a historical review of the theories advanced to account for the presence of petroleum within the earth's crust. In the great Appalachian oil fields, of which these three quadrangles are a part, there seems to be no good reason for questioning the conclusions of the early investigators that the great sedimentary deposits contained enough organic matter to constitute an adequate source of supply for the oil. There seems wanting, however, a theory that provides a logical sequence of events from the time the partially isolated bits of bituminous matter were entombed in the sedimentary deposits until they again appeared in the porous rocks as volatile hydrocarbon under enormous pressure. Since the operator is not concerned so much in this phase of the subject as he is in the forces and conditions which have influenced the segregation of the oil into pools of commercial value, the economic feature of the problem may be considered as beginning with the appearance of petroleum in the shales.

In dealing primarily with the economic side of the subject, the object is to collect facts from developed oil pools and by a careful comparison of such data to learn how these accumulations have taken place. With this question determined, but half of the problem is solved from a practical standpoint. To make use of this knowledge in locating new and undeveloped oil territory, it is necessary to know what and how many of the governing factors which control the accumulation can be determined from the surface and what amount of information will be required from the drill before prognostication with reference to oil territory can be successfully made. The problem therefore divides itself into two parts. First, what are the laws and conditions that govern the accumulations of oil? Second, are the geologic conditions such that from outcrops it is possible to determine where the accumulations are most likely to occur? Laws of accumulation, once determined, are applicable to all areas of similar physical conditions, but the relation of the deeply buried oil-bearing sands to outcropping rocks may be different in even closely associated areas. Hence the structural relation of surface and underground strata must be determined separately for each area examined, but a knowledge of the conditions existing in a number of different areas may show what can reasonably be expected in an uninvestigated territory.

# CHAPTER I.

## THEORETICAL DISCUSSION OF THE OCCURRENCE OF PETROLEUM AND NATURAL GAS.

### GENERAL CONDITIONS IN THE APPALACHIAN OIL FIELDS.

The rocks from which the oil and gas of the Appalachian fields are derived are of sedimentary origin. They are porous rocks, principally sandstones, embedded in and underlain by a great thickness of shale. Below the shale are probably heavy limestone beds. The sandstones are numerous; they lie approximately parallel to one another and occupy a section in the geologic column of more than 2,000 feet, extending from the Allegheny formation of the Pennsylvanian series nearly to the base of the Devonian system. Generally the rocks show evidence of fairly continuous sedimentation, but in the early stage of Pennsylvanian time the surface was raised above water level, and the greater part of the Mauch Chunk formation was eroded before the later sediments were deposited, leaving an unconformity at the base of the Pottsville formation.

The oil-bearing sandstones vary greatly in composition and texture. The upper or younger sands are usually white, some being of uniform texture and others containing lens-shaped bodies of conglomerate in which the separate pebbles are of considerable size. The older or lower beds are of brown or reddish sandstone and are usually more uniform in texture.

In general the Appalachian oil fields occupy the bottom and western side of a large spoon-shaped structural trough. The rim of this trough may be considered as passing through central Ohio, swinging eastward south of the Great Lakes, and thence southward along the western base of the Appalachian Mountains. The sandstones which show in outcrop in northern Ohio and New York are 2,000 to 3,000 feet underground in the southwest corner of Pennsylvania and in West Virginia. The dip of the formations is not regular, but is the result of two periods of folding. The main folds have a northeast-southwest trend, the secondary folds crossing these at right angles. On the northwestern side of the main trough the secondary folds give rise in places to northwest dips, but these are of minor significance in the general southeast slope of this side of the trough.

Each important sandstone bed underlies many square miles of territory, usually including a number of counties. They have been traced from point to point by means of the drill, until the limits of the different beds are fairly well known. These sandstones are most numerous and attain their greatest thickness in the center of the region, only the upper beds extending to the western margin of the fields. In some localities two or more sands produce oil. Usually, however, the lowest sand is the most prolific. It often happens that gas is produced from a number of sands in one locality.

The areas which have produced oil and gas have been of all sizes and shapes, and the depth of productive wells ranges from 100 to 4,000 feet. It has been noticed, however, that in many cases the area of oil production is in the form of a belt extending for a number of miles and having but slight width compared to its length. The direction of these belts of productive territory is parallel to the principal geologic folds of the region.

Drilling with the object of finding new productive territory is of a most speculative nature. Any one of five results may be the outcome of the well when the sand is pierced. (1) The sand rock may be found to be hard and close, incapable of holding oil or permitting the flow of any liquids through its mass; (2) the sand may be good but perfectly dry; or (3) it may be good sand and be completely saturated with salt water, which may fill the well to a depth of several hundred feet or even in some cases flow out upon the derrick floor. Favorable results may have any degree of success. (4) Gas may be found with hundreds of pounds of rock pressure to the square inch and in a volume of millions of feet a day, or there may be only sufficient gas to serve a house or one or two boilers. (5) Oil may be encountered in such quantities and with such pressure that it will gush from the well at the rate of thousands of barrels a day, or there may be only a gradual seeping of oil into the well that will amount to but a barrel or two a day.

## THEORY OF ACCUMULATION OF OIL AND GAS.

### ORIGIN.

The organic matter embedded in the shale which lies below and between the oil-bearing sandstones mentioned above may have been the original source of petroleum. This hypothesis is accepted in this paper, though such acceptance is not meant to imply that the hypothesis is established beyond question or that there are not facts and arguments which point to other sources of petroleum than the organic matter found in the accompanying sedimentary formations.

Whether the petroleum comes from within or from below the shales, it must pass through them, and to do this it must pass through the very small pores existing in those relatively impervious beds. The nature and cause of this movement are not understood. Capillary action and great rock pressure may be suggested as causes which aid in forcing the petroleum out from the shales, but there are not sufficient data on this subject to justify any scientific explanation. It matters little what is the ultimate source of the oil; the important facts are its occurrence now in the porous sandstones, its circulation through the rocks, and the conditions leading to its accumulation in commercial deposits.

### MOVEMENT IN POROUS ROCKS.

The porous rocks into which the oil and gas enter may be dry or they may be completely saturated with water. In most cases it is probable that a combination of these two conditions exist—that the porous rocks are completely saturated with water up to a certain level, but above that point they are dry. The movement of the hydrocarbons through the rocks will not be the same in the two cases, and therefore each condition must be considered separately.

If small quantities of oil and gas enter a dry porous rock at different points the oil will flow down as long as gravity is sufficient to overcome the friction and the capillary attraction. The gas will diffuse with the air or water vapor contained in the pores of the rock.

Oil and gas entering a porous rock that is completely saturated with water will be forced up to the top of the porous stratum by the difference in the specific gravity of the hydrocarbons and the water. Here the oil and gas will remain if the porous stratum be perfectly level, but if it has a dip sufficient to overcome the friction the particles of oil and gas will gradually move up this slope, the gas with its lower specific gravity occupying the higher places.

In case the porous rocks are partly saturated a combination of these two actions will take place. The oil entering above the line of complete saturation will flow down to that line and the oil entering below will be forced up to the top of the completely saturated portion.

The statements given above are based on the assumption that the oil-bearing rock is homogeneous throughout and that the oil will move with the same degree of freedom in every direction. This is rarely the case. Sandstones are noted for their irregularity in composition, as regards both the size of the individual grains of sand and also the material which cements the grains together. It is obvious that any fluid will move more rapidly through a coarse conglomerate imperfectly cemented than through a dense, fine-grained sandstone the particles of which are thoroughly coated and all the interstices filled with impervious cement. If the oil-bearing rock contains areas practically impervious, these areas, according to their size and position, will be more or less perfect barriers against the movement of the oil or the gas.

### PLACES OF ACCUMULATION.

(1) In dry rocks the principal points of accumulation of oil will be at or near the bottom of the synclines or at the lowest point of the porous medium, or at any point where the slope of the rock is not sufficient to overcome the friction, such as structural terraces or benches. (2) In porous rocks completely saturated the accumulation of both oil and gas will be in the anticlines or along level portions of the structure. Where the area of porous rocks is limited the accumulation will occur at the highest point of the porous medium, and where areas of impervious rocks exist in a generally porous stratum the accumulation will take place below such impervious stop, which is really the top limit of the porous rock. (3) In porous rocks that are only partly filled with water the oil accumulates at the upper limit of the saturated area. This limit of saturation traces a level line around the sides of each structural basin, but the height of this line may vary greatly in adjacent basins and in different sands of the same basin.

Partial saturation is the condition most generally found, in which case accumulations of oil may occur anywhere with reference to the geologic structure; it is most likely, however, to occur upon terraces or levels, as these places are favorable to accumulation in both dry and saturated rocks.

Under all conditions the most probable locations for the accumulation of gas are on the crests of anticlines. Small folds along the side of a syncline may hold a supply of gas, or the rocks may be so dense that gas can not travel to the anticline, but will remain in volume close to the oil.

## APPLICATION OF THEORY IN THE APPALACHIAN FIELDS.

The accompanying illustration, Pl. I, is a diagrammatic section through the oil-producing formations of Ohio and Pennsylvania based on data from actual surveys. It shows those sands which are found under the Steubenville quadrangle and extends to those that are known to exist in Pennsylvania. In it is represented the unconformity which has been shown by David White[a] to exist at the base of the Pottsville formation throughout the entire western edge and probably the central part of the Appalachian coal field, evidence in favor of which has been found in the well records examined in the course of this investigation. The Salt sand represents the base of the Pottsville formation. Below this is the Big Injun or Pocono sand-

[a] White, David, Deposition of the Appalachian Pottsville: Bull. Geol. Soc. America, vol. 15, 1904, pp. 267–282.

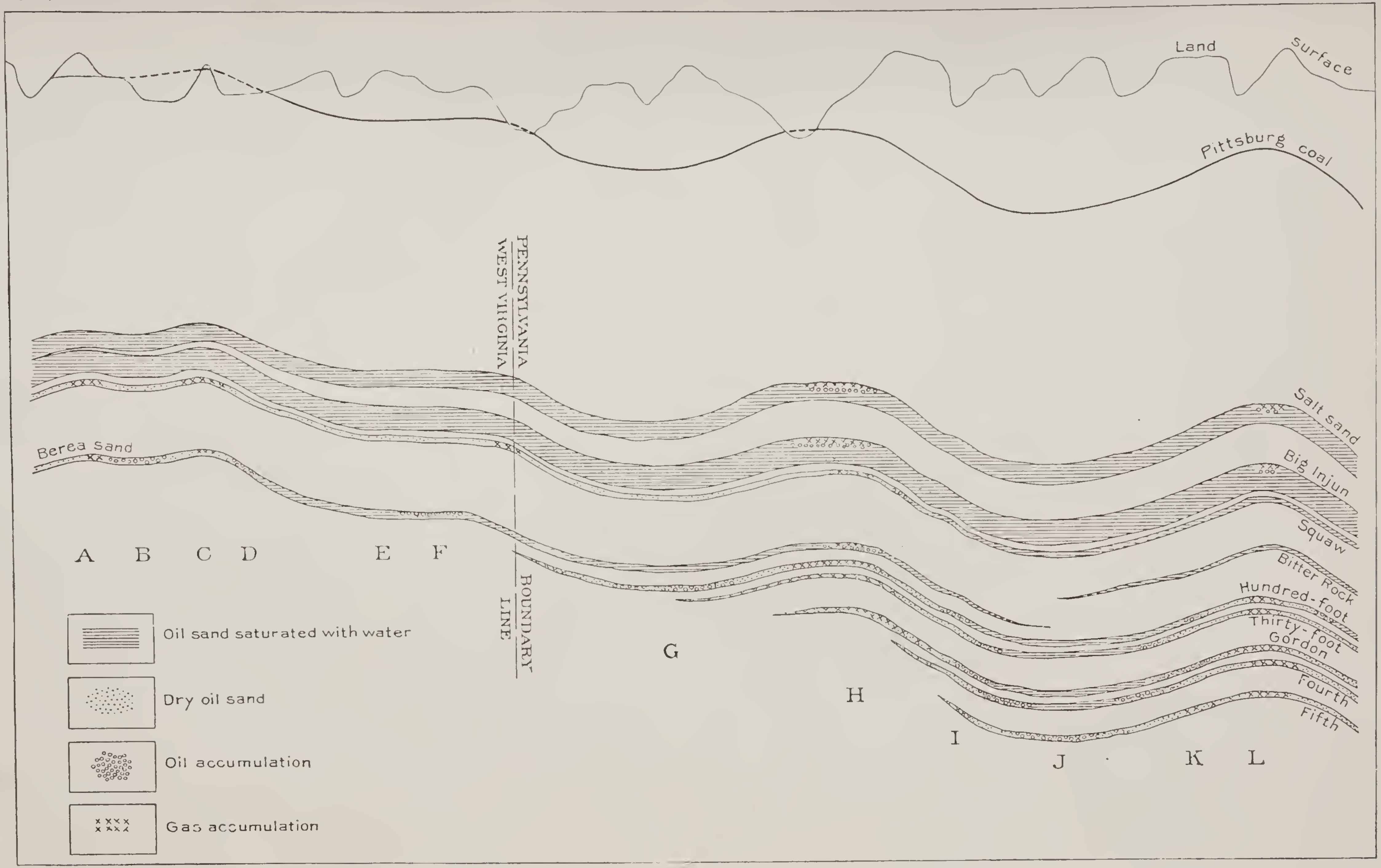
stone, and about 350 feet below the bottom of the Pocono is the Berea sand, which extends over a large portion of eastern Ohio and is represented by the Thirty-foot shells above the Hundred-foot sand in western Pennsylvania. Commencing not far from the line between Pennsylvania and West Virginia, the Hundred-foot sand appears below the Berea sand. Farther east in Pennsylvania the Thirty-foot the Gordon, the Fourth, and the Fifth sands appear. These sands are all represented on the sketch in approximately their correct vertical positions. It has been shown by the logs of wells that the Salt and Big Injun sands are pretty thoroughly saturated with water throughout most of the area investigated. The upper limit of saturation of the Berea sand, shown at the point D on the diagram, is about 250 feet below sea level.

In Pennsylvania the Hundred-foot sand is found to be dry through most of the Burgettstown quadrangle. After reaching the vicinity of the McDonald oil pool it is completely saturated with water. The Gordon sand in the Washington pool is saturated up to a definitely marked level around the sides of the syncline, with the productive area directly above. The Fourth and Fifth sands in this syncline have less water, and in them the oil is found much nearer the center of the basin.

By applying to the section (Pl. I) the conclusions regarding the movement and accumulation of oil and gas under various conditions, the probable points of accumulation can be shown. Any oil entering the Berea sand between G and I will accumulate at the point above H in close proximity to the gas. This part of the Berea sand is completely saturated with salt water, and the oil will be forced to the highest point.

Oil entering the Berea sand between the points F and G will be moved along from G to F. Here the sand is level, and the difference in specific gravity of the fluids only has a tendency to keep the oil in the upper portion of the sand and exerts no force to move it laterally. Between E and D the tendency of the oil is to move up to the top of the water at D. Beyond this point there is no tendency of the oil to rise. It would therefore accumulate at this point, the gas occupying the space higher up.

Oil entering between A and C would accumulate in the small syncline at B. If during some previous time, but while the rocks were in the same position as they are to-day, the water level of the Berea sand was higher than it is at the present time, all the oil which entered the stratum from B to E would have been forced up into the anticline at C. If since that time the water level has been gradually sinking, the oil would follow it down to the syncline at B and to the top of the water line at D.




DIAGRAMMATIC SECTION OF SANDS IN CENTRAL APPALACHIAN OIL REGION

The sand rocks were deposited in the sea, and at that time must have been completely saturated. The saline water now contained in these rocks may or may not be the water of original deposition. To state that the saline water within these sandstones is gradually diminishing would require proof and many explanations that are not at hand. There are, however, facts which point to this condition, the most important of which is that the smallest areas of complete saturation are found in the lowest and therefore oldest sandstones, and there are certain areas, notably in the Beaver quadrangle, where the Berea sand is relatively high and above the line of saturation. Within this area very small structural depressions seem to hold accumulations of oil out of proportion to the area drained.

The upper level of saturation in the Hundred-foot sand is lower than in the Berea sand. Oil entering that stratum between F and H would accumulate in the syncline at G, with the gas extending to the dome at H and to the limit of the sand toward F. In the synclinal trough between H and L the accumulation in the Hundred-foot sand would be at the water line above I and above K.

The area of saturation is less in each sand below the Hundred-foot. In the Fifth sand, which is the lowest found within the area so far investigated, the accumulation of oil is at the lowest point in the syncline, except in the lowest portions of tiny basins along the synclinal trough, where small areas of ponded water still remain.

## PRACTICAL APPLICATION OF PRINCIPLES GOVERNING THE ACCUMULATION OF OIL.

### FACTORS INVOLVED.

The previous discussion shows the importance of a knowledge of all the factors governing accumulation in any attempt to locate oil territory. These are the porosity of the reservoir rock, the geologic structure, and the degree of saturation by water. The first can be determined only by the drill; the second, under favorable conditions, can be determined by careful geologic work on the surface, and the third by the drilling of a few test wells. Knowledge of the first and third factors is absolutely necessary for a correct interpretation of what is shown by the map of the surface structure. For instance, in an area where two or more sands are productive the map may show producing wells on the anticlines along the steep slopes and also in the bottom of the synclines, the productive area not appearing in any way to conform to the structure; but if the top of the water in each of the sands be taken into consideration it will be seen that the sand producing oil on top of the anticline is wet, the one from which the oil is taken in the trough of the syncline is dry, and the one producing along the slope is saturated with water up to a certain level, with the oil immediately above.

### CONDITIONS NECESSARY TO DETERMINE SUBSURFACE STRUCTURE.

The geologic structure of the oil-bearing stratum is an important factor in the location of accumulations of oil and gas. The statement has been previously made that under certain conditions this factor can be determined prior to the descent of the drill. It now becomes necessary to consider what these conditions are, the reasons for the same, and what steps are necessary for determining the structure of a deep-lying oil sand.

The various rock formations which appear at the surface within the Appalachian oil fields, as well as the underlying strata that have been pierced by the drill, are of sedimentary origin—that is, they were laid down as sediments in a body of water.

The Appalachian oil fields occupy an area which was an inland sea or gulf during the Devonian and Carboniferous periods. Into this sea was washed the disintegrated and dissolved material from the surrounding land, and this material was deposited on the sea bottom in layers more or less parallel. The size of the inland sea did not remain constant. From the geologic evidence it is plain that at some periods the sea was increasing in area and depth and that at other periods it was diminishing. This expansion and contraction of the water-covered area probably was repeated many times, and the sediments laid down in this body of water varied according to the conditions of the sea. These deposits consist of shales, sandstones, limestones, and coals.

Fine soft shale results from the erosion of a much weathered and deeply disintegrated land surface, and it is deposited in that portion of the sea where the currents are slight and no longer have power to transport fine particles.

Sandstone represents a deposit made in moving currents or along shore where the motion of the water had power to wash out and carry along the finer particles of material, leaving the coarser grains to form sandstone.

Limestone may be formed in different ways. The lime and magnesia of the soil are washed out and carried to the sea in solution. Myriads of animals living in the sea have formed their shells and bones from the lime and magnesia in sea water and, on dying, left large deposits of these materials, which have been cemented together, forming limestones. Some plants of the sea cause a deposit of lime about themselves. Limestone may be formed by precipitation from the sea water. In these ways the great beds of limestone may have been formed. Those limestones which carry marine forms, such as shells, were probably laid down in still water and in smooth, even sheets over large areas. For this reason they are probably the best strata to be used as geologic markers for the formations.

The coal beds represent the remains of vast swamps in which moss, ferns, and trees grew. These plants, on dying, fell into the water and formed great beds of peat that later was compressed into coal.

Adjacent to the coal beds and at other horizons are found clays and fire clays. Clay is of the same composition as shale, without its bedding planes. Fire clays are clays from which has been extracted the more fluxible materials, presumably by the action of plant life. The degree to which the easily fusible material has been extracted determines the refractoriness of the clay.

In studying a region of sedimentary deposits it is possible to reason out with a fair degree of exactness what movements were taking place in the earth's crust at the time some particular deposit was laid down. As as example, it is interesting to consider what were the conditions during the time of the forming of the great sandstone known in Ohio as the "Berea grit" and in Pennsylvania as the "Thirty-foot shells."

This sandstone extends from the vicinity of Wheeling, W. Va., to the west fully a third of the way across Ohio, to the north nearly to the Great Lakes, and to the northeast almost to the line of New York State. The thickness of the sandstone remains nearly constant, being from 30 to 40 feet. It is composed of clean, fine-grained sand of nearly uniform texture. The upper portion of the rock to the depth of 18 to 20 feet is cemented probably by calcareous matter into an impervious rock. This cap is generally present and in some places has thickened to the full depth of the sandstone, making the complete stratum impervious to oil and gas. Directly above the cap to the Berea sand is a black shale, above which is shale of various colors, which extends for some hundreds of feet to the next great sandstone, the Pocono or Big Injun, as named by the drilling fraternity.

A sandstone of the extent and uniform thickness of the Berea could not have been laid down at one time. This sandstone must have grown, being extended on its outer edge by the sea gradually encroaching upon the land, the waves washing down and cleaning the material of the shores, depositing as a beach the heavier particles and carrying the finer portions out into deeper water. The rate of encroachment of the sea upon the land must have been slow and regular, as the sand is found thoroughly cleaned and of almost uniform thickness. The shore from which this sand was derived was probably low and consisted of previously worked-over deposits. From a bluff or rugged shore the broken pieces of rock would not be of the same uniform size as the grains of the Berea sandstone. When the sand beach became submerged it received upon its upper surface the calcareous deposits cementing it together, and later the full area of the sandstone was covered by the great shale deposits. From the conditions under which the Berea sandstone was deposited it is probable that this stratum was not level when laid down, but had a general dip seaward, the amount of which depended on the rate of subsidence of the land area.

### POSITION OF SEDIMENTARY DEPOSITS WHEN LAID DOWN.

From the mode of deposition of sedimentary formations it is evident that originally the strata consisted of smooth, though not necessarily level, sheets.

It is possible to conceive of a coal bed growing by the rising of the water of a sea, which extended the swamp farther inland while the outer edge became too far immersed to allow of vegetable growth, but coal beds were in all probability level when formed.

The Pittsburg coal, which covers an area of 6,000 square miles, carries within itself evidence of the level surface of the swamp in which it was formed. Not far from the middle of this bed are two small shale partings about 4 inches apart. The space between them is called the "bearing-in" bench. These partings are characteristic of the bed over a large area. They were formed by high water which carried fine sediment into and over the swamp at two periods not long apart geologically. As a large area received nearly the same amount of sediment, the bed must have been formed in one vast level swamp.

As each succeeding sedimentary deposit was laid down in a smooth, fairly even sheet upon the bottom of the sea the distance between beds remains nearly constant over small areas; in other words, there is a certain degree of parallelism between beds composing deposits of this character.

The amount of material laid down by the action of the waves and currents is not the same at all points, but may gradually thicken or thin in any direction. This difference in deposition from point to point prevents succeeding beds from lying perfectly parallel one with another, but probably this variation is fairly regular and at a somewhat uniform rate. This rate of variation of the interval between any two beds of rock may be determined if a number of measurements of the distance between the two beds at different points in the area under consideration can be obtained.

If, however, at any period all or a portion of the area was above sea level, it no longer received sediment but was worn down by erosion, which in some places may have removed only a little of the surface rocks, but in other places completely removed the underlying formations. In later periods when this surface was again submerged it received other sediments, generally in equal amounts, and the upper formations were laid down across it in approximately parallel layers, but not necessarily parallel to the earlier-deposited formations. The relation between the upper and the lower formations, under these conditions, depends on the uniformity of the erosion and the absence of any folding prior to the time of second submergence. This relation is called an unconformity. In areas where it exists it is necessary to have positive data with reference to the distance of the deep-lying beds from the surface strata at many points in order to be able to determine accurately the true structure of the lower formations.

### SUMMARY.

From the foregoing considerations it becomes evident that certain general geologic conditions should be known before undertaking the determination of the geologic structure of the oil-bearing sands from strata upon the surface, the first and most important being the possibility of an unconformity between the surface strata and the oil-bearing stratum.

From the nature of these deposits the coal and limestone beds seem to be the most reliable surface strata from which to determine the geologic structure.

## CHAPTER II.

### METHOD OF INVESTIGATION.

#### FIELD WORK.

Geologic field work is not practicable in some portions of the Appalachian region unless the area to be investigated is generally dissected by erosion to a depth of 100 feet or more, bringing the outcrops of different key strata to the surface.

Geologic work of this nature generally follows the making of careful topographic surveys, such as are now being carried on by the Geological Survey. In the topographic work, bench marks based on precise level lines brought from the sea are established. This is done by means of primary level lines run in circuits, with a closure restriction permitting an error of only 0.05 foot in the square root of the linear distance in miles. These primary lines are run in such a manner as to establish bench marks at intervals of not more than 6 miles from one another, leaving no point within the area distant more than 3 miles from a permanent bench.

In carrying on the geologic work proper, level lines based on the permanent benches were carried over each road and in many cases up stream channels and along the crests of ridges, with an accuracy of instrumental work that insures the closing of circuits with errors of less than a foot. In the course of this work the elevation was taken of outcrops of all beds that in any way could be recognized as marking geologic horizons. As the elevation of each outcrop was determined, its horizontal position was located on a topographic map carried by the levelman.

This combination of geologic and topographic work results in a mass of extremely accurate data for determining the intervals between important beds of rock and also the geologic structure or "lay" of the rocks.

For obtaining the vertical distance between well-recognized beds, certain outcrops were selected whose elevations could be compared directly one with another. Only such outcrops as are horizontally near together were selected for comparison, except in cases where the outcrop of one bed could be compared with two or more outcrops of another bed showing on different sides of the first exposure. The latter method was used to eliminate any error which might result from the failure to make allowance for the dip of the rocks.

Level lines were run to the mouths of a large number of oil and gas wells in the area, so that the elevations of the oil sands and other beds of rock whose positions are recorded in the logs of the wells could be determined, and from these elevations the distances and degrees of parallelism that existed between the outcropping and subsurface rocks could be established.

## CONSTRUCTION OF MAPS.

The work of making a map of a particular stratum lying at a considerable depth below the surface consists of three distinct steps—first, careful contour mapping of some prominent surface bed, called the "key horizon;" second, the more difficult task of ascertaining the distance between this key horizon and the producing oil sand below and the amount and direction of the variation in this distance; third, the application of a correction to the surface mapping equal to this convergence, so that lines drawn on this map connecting points of equal elevation above the sea (contour lines) will show the true shape of the surface of the oil sand.

### STRUCTURAL MAP OF THE KEY HORIZON.

On the completion of the field work, as previously described, the geologist had a topographic map of the area, on which the horizontal location and the elevation of the outcrops of different marking strata are shown at hundreds of points. By a comparison of these outcrops, the intervals between different marking beds were obtained. One bed was selected as the key horizon, usually that outcropping over the greatest area. By adding to or subtracting from the elevation of outcrops of other known beds the distance they have been found to be below or above the key horizon, the elevation of that stratum was obtained at a great many points. By drawing lines connecting the points of equal elevation, a contour map of the key horizon was produced.

### CONVERGENCE MAP.

A knowledge of the variation in distance between the key horizon and the oil sand was gained from the records of wells in different parts of the area, and without these records it would be impossible to make any illustration that would show the form and position of the sand, unless it were exactly parallel with the key horizon.

To make use of the well records and construct an actual map of the oil-bearing sand the following method was employed: On the map of the structure of the key horizon were plotted all the wells drilled within the area. As the elevation of the mouth of each of these wells had been determined, the position of the key stratum with reference to the mouth of the well was obtained directly from the map, and with this information the distance from the key stratum to the oil-bearing sand at this point was obtained from the record of the well.

By making this computation for each well of which a reliable record could be obtained, the distance from the key horizon to the oil-bearing stratum was obtained in different parts of the area. Generally this distance is not the same at different wells, but decreases in one direction or the other.

The correction for the convergence between the key horizon and the oil sand is applied by means of a mechanical drawing called a "convergence sheet." This drawing was made on tracing cloth by connecting the location of the oil wells from which reliable records had been obtained by straight lines. The lines were then divided proportionately to the amount of convergence found between the two wells, so that each division on the lines would represent an increased distance of 10 feet between the key stratum and the oil-bearing sand.

After all the lines connecting the different wells had been thus divided the points that show an equal distance from the key stratum to the oil sand were connected, and a drawing was built up that, when placed over the map on which the elevation of the key stratum was noted at many different places, showed directly what distance should be subtracted from each elevation of the key stratum to make it equivalent to the elevation of the oil sand at that point.

The regularity and uniformity of this mechanical drawing shows whether it is possible or not to make a map of the oil sand that will be of any practical value. If the distance between the 10-foot lines, which are called isochor (equal space) lines, is regular and the decrease is uniformly in one direction, a map of the lower sands can be made practically correct. If, however, the distance from the key horizon to the sand decreases first in one direction and then in another, the lines on the convergence sheet will run in circles and show that there is little use in trying to interpret the structure of the sand from a map of the surface structure. It can hardly be hoped that the wells used have been located at the exact point of the greatest distance between the two strata. In all probability the resulting convergence sheet is incorrect over limited areas.

The amount of convergence per mile is another condition to be considered. If it amounts to 50 or 60 feet to the mile, there is little probability that the resulting map of the sand will be correct within a limit of 20 or 30 feet. If, however, the convergence is only 10 or 20 feet to the mile, the resulting map should be of the same degree of accuracy as the map of the surface structure.

In making maps of subsurface strata in areas that have not been productive, most of the records used for making a convergence sheet must be taken from "wild-cat wells." In certain cases it is difficult to procure the records of such wells, and often the best that can be obtained is the depth, from memory, at which the sand was found. Here is a source of serious error, for a mistake in this distance may make the resulting map incorrect for a considerable distance about the well.

In making a subsurface map, full knowledge should be had of the well records used for constructing the convergence sheet, and if any reliable records have been thrown out whose distances would change the convergence sheet the reason for discarding them should be given. In selecting the records for the construction of a convergence sheet it is desirable to consider wells from which a good record is obtainable and those that are located near the outcrop of an easily recognized surface stratum.

## MAP OF OIL SAND.

With the convergence sheet completed, the operation of making a contour map of the oil sand was very simple. The tracing was placed over the map on which are noted the elevations of the key horizon. From each of these elevations the amount shown by the convergence sheet was subtracted. This gave the elevation of a point on the oil sand. By connecting the points of equal elevation by lines a contour map of the oil-bearing sand was made.

# CHAPTER III.

## GENERAL GEOLOGY OF THE STEUBENVILLE QUADRANGLE.

### DESCRIPTION OF SURFACE.

#### LOCATION.

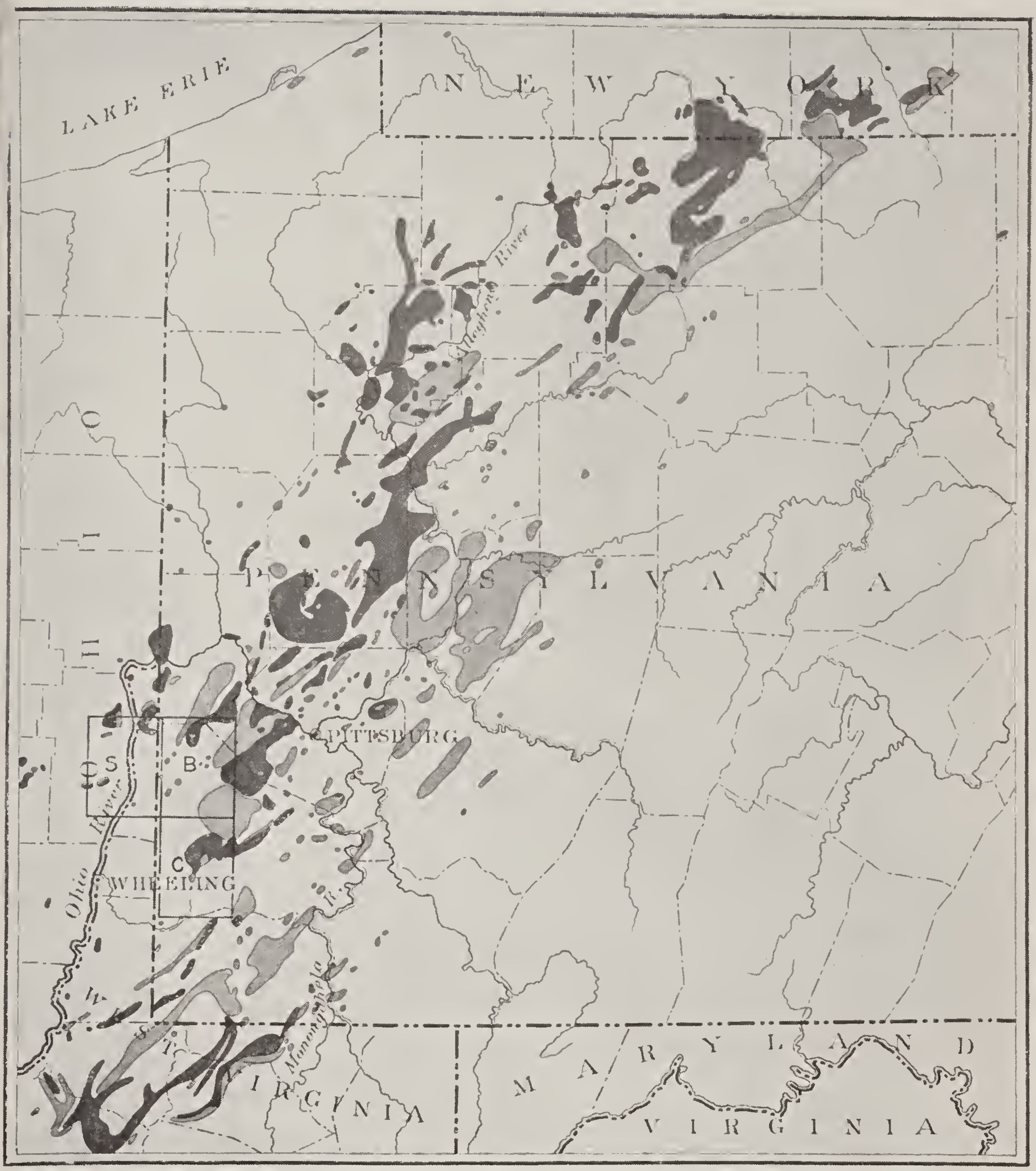
The entire area investigated is shown by the inclosed quadrangl in the map, Pl. II. This map represents the Appalachian oil fiel and shows the areas that have produced oil and gas.

The Steubenville quadrangle is located mainly in the eastern pa of Ohio, but extends to the east across Ohio River, including a pa of the West Virginia "panhandle" and a small strip about 1 mil in width belonging to the State of Pennsylvania. The city of Steu benville is located near the middle of the quadrangle, and from thi place it takes its name.

#### TOPOGRAPHIC FEATURES.

The governing feature in the drainage of the Steubenville quadrangle is Ohio River. This stream crosses the quadrangle from north to south almost in the middle. At fairly regular distances main tributaries flow into the river almost at right angles to its course. The smaller runs, which furnish the water for the main creeks, flow from the north and south, generally parallel with the course of the river.

The upland surface between the streams is in general from 400 to 500 feet above the main drainage lines. In most places the tops of the hills have been worn off to a smooth oval surface, but near the main drainage lines the ridges are narrower, the hill slopes are steeper, and the streams flow in deep canyons. Each small run has eroded a deep channel in the soft sedimentary rocks, and in all parts of the quadrangle the upland is greatly dissected.




MAP SHOWING DISTRIBUTION OF GAS AND OIL FIELDS IN WESTERN PENNSYLVANIA AND ADJACENT REGIONS.

## GEOLOGIC FEATURES SHOWING AT THE SURFACE.[a]

### SECTION OF ROCKS EXPOSED.

Upon the surface of the Steubenville quadrangle are exposed strata that represent a vertical section of over 1,000 feet in the Pennsylvanian series. This section consists of a part of the Washington, all of the Monongahela, Conemaugh, and most of the Allegheny formations. The Lower Kittanning coal of the Allegheny measures comes to view along Ohio River in the northern portion of the quadrangle, while the Washington coal of the Washington formation lies near the top of the highest hills in the southeast corner of the quadrangle. Between these two limits are a number of beds that are easily recognizable and of use in determining positions within the geologic section. Most prominent among these are the Ames limestone, Pittsburg coal, Meigs Creek coal, Benwood limestone, Uniontown coal, and Waynesburg coal.

### KEY HORIZONS.

The base of the Pittsburg coal has been taken as the horizon upon which to represent the geologic structure at or near the surface. This important bed outcrops in all portions of the quadrangle except in an area east of New Cumberland, where an anticlinal dome has raised its horizon a couple of hundred feet above the highest hills and the coal bed has been eroded.

The Ames limestone of the Conemaugh formation exceeds the Pittsburg coal in its area of outcrop. This limestone and the Pittsburg coal have furnished most of the information for the plotting of the surface structure. The Lower Kittanning coal was used along Ohio River in the northern half of the quadrangle, and the Sewickley (Meigs Creek) coal in some portions of the southern half.

In order to make use of these beds in determining the geologic structure of the Pittsburg coal, careful measurements were made of the intervals between them in as many places as was possible.

### MEASUREMENT OF INTERVALS BETWEEN KEY HORIZONS.

The interval between the Pittsburg and the Lower Kittanning coals was not obtained by direct measurement. The distance of the

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[a] In this paper the names of oil sands and other beds that are known only through the exploration of the drill are those commonly used by the well drillers. Many of these names are fanciful, but they have come into common use throughout the oil fields, and for that reason are used in this report. In most cases the equivalent geologic names are also given, so that the reader is enabled to correlate with the same beds where they show in outcrop.

Lower Kittanning coal below the Ames limestone was determined by direct measurement only in a few places. By comparison, however, of the elevations of other coals of the Allegheny formation at some places with the elevation of the Ames limestone and at others with the elevation of the Lower Kittanning coal, the interval was found to be 473 feet. The probable error of this determination is less than 10 feet.

A number of direct comparisons of the elevations of the Ames limestone and the Pittsburg coal were made. At other places the interval between these beds was ascertained by comparing the elevation of a given point on one stratum with the elevations of two or more points on the other stratum. This interval was measured at 32 different places, with an average result of 219 feet. The largest interval obtained was 231 feet and the smallest 201 feet.

The Meigs Creek coal outcrops in three-fourths of the quadrangle. The elevation of this coal was compared with that of the Pittsburg coal at 24 different places, with the average result for the interval of 103 feet. The largest interval obtained was 113 feet and the smallest 94 feet.

The results of these measurements of intervals between the different strata indicate that it is practicable to map the surface rocks of the Steubenville quadrangle so that the vertical position of any point shall not be in error more than one contour interval, or 10 feet, and also that this is about the limit of exactness that can be acquired when more than one surface stratum is used in determining the structure.

## CONTOUR MAP OF PITTSBURG COAL AND STRUCTURE.

After reducing all determined elevations on the various key rocks to equivalent positions on the base of the Pittsburg coal and connecting by lines the points of equal elevation, the contour map (Pl. III) was produced. The contours printed in green on the topographic base of the Steubenville quadrangle represent the surface structure. The small crosses of the same color, with numbers adjacent, show at what point spirit-level elevations were obtained on some known stratum, and the crosses which are underlined show the points where the elevation of the Pittsburg coal itself was obtained.

The rocks of the Steubenville quadrangle have little regularity of structure. They form parts of two structural basins and a portion of the anticline which divides them. The most prominent feature is this anticline, which culminates a little east of New Cumberland. Here the rocks rise in a dome nearly 300 feet above their general position in the surrounding region. The slopes are steep to the east, south, and west. This feature is, named the New Cumberland anticline.

From the south end of this anticline a structural nose puts off toward Paris, Pa., whence it extends southward along the Pennsylvania-West Virginia line, ending south of Colliers Station in a terrace which has been called the Collier terrace.

From the southwest end of the New Cumberland anticline another nose passes through a very low saddle and connects with the main anticline of the Cadiz quadrangle. Two miles west of the village of Wintersville the beds are nearly level and form what is called the Wintersville terrace.

The main syncline of the area, known as the Mingo syncline, enters the quadrangle near the southeast corner and extends northwestward to the town of Mingo Junction, where it swings to the north toward Hollidays Cove. The trough rises rapidly after passing the mouth of McMahan Run and soon attains the general level of the adjacent structure.

In the northwest corner of the quadrangle is the end of a synclinal basin which extends into the quadrangle from the north. This is called the Somerset syncline, after the village of New Somerset, in the Wellsville quadrangle. Besides these main features there are a number of local basins and some anticline noses or terraces which are not of enough importance to deserve distinctive names.

## GEOLOGIC FEATURES BELOW THE SURFACE.

### SOURCE OF INFORMATION.

A knowledge of conditions below the surface is obtained from the logs of shafts and wells. Some logs are recorded in great detail, but in most of them only the strata that are of importance to those who are drilling are noted. The sandstones are the formations that interest the oil and gas drillers, but if they have not previously produced either oil or gas their positions are noted only by "string measurement." In this method a string is tied around the main cable which holds the drilling tools at the top of the bull wheel. The distance over the crown pulley to the mouth of the well on the derrick floor is measured, or assumed to be 160 feet. When the string has gone over the crown pulley and entered the hole, a second string is attached at the bull wheel. When the driller desires to know the depth of a particular bed of rock in which the drill is working, he multiplies 160 feet (or the measured distance) by the number of times strings have entered the hole and to this product adds the distance which the last string has moved up the derrick.

When a sandstone is reached in which oil or gas is expected to occur, its position below the mouth of the well is carefully measured by a steel tape. If the string and tape measurement were both recorded, the error of the string measurement would be known and could be adjusted back through the other formations.

### CONVERGENCE BETWEEN BEDS.

In the Steubenville quadrangle the sandstones of the Allegheny formation are present, but since they have produced no oil or gas little attention is paid to them. The Salt sand and Big Injun are the formations usually noted in the records.

A feature of great importance to those interested in making a map of the Berea sand is the varying distance between it and the Pittsburg coal. To illustrate this and show where it takes place, the records of six wells have been plotted and are shown on Pl. IV. These wells are located in nearly a straight line across the quadrangle from north to south. The first well (No. 11 [a]) is one-half mile west of Knoxville. The second well (No. 53) is a little more than 1 mile south of the first. The third (No. 114) is 3 miles south and a little east of the second. The fourth well (No. 407) is nearly 7 miles in a direction south by a little east from the third. The fifth well (No. 466) is out of line, being 5 miles in a southwest direction from the fourth. The section of this well is included for the reason that it shows the limestone at the top of the Big Injun sand. The sixth well (No. 479) is at Wellsburg, 4½ miles south and a little east of well No. 407. The records are so placed that the position of the Ames limestone is on a horizontal line.

The position of the Ames limestone is not noted in the records of these wells. Its elevation, however, was determined by outcrops close to the wells. In well No. 11 the top of the Berea sand is 1,113 feet below the Ames limestone. This distance increases in each well to the southeast across the quadrangle, being 1,405 feet in well No. 479. This shows an increase in the interval between the Ames limestone and the top of the Berea sand of nearly 300 feet. This change is mostly accounted for by the increasing interval between the top of the Salt sand and the bottom of the Big Injun sand. As previously stated, an unconformity exists at the base of the Salt sand. In the northwestern part of the quadrangle all of the Greenbrier limestone and part of the Pocono or Big Injun sand had been removed by erosion prior to the time of the second deposition; in the southeastern part some of the limestone and all of the Pocono sandstone remain.

An allowance for this difference of interval between the key stratum and the producing oil sand must be made in determining the structure of the oil sand. This has been done by means of the convergence sheet shown in Pl. V.

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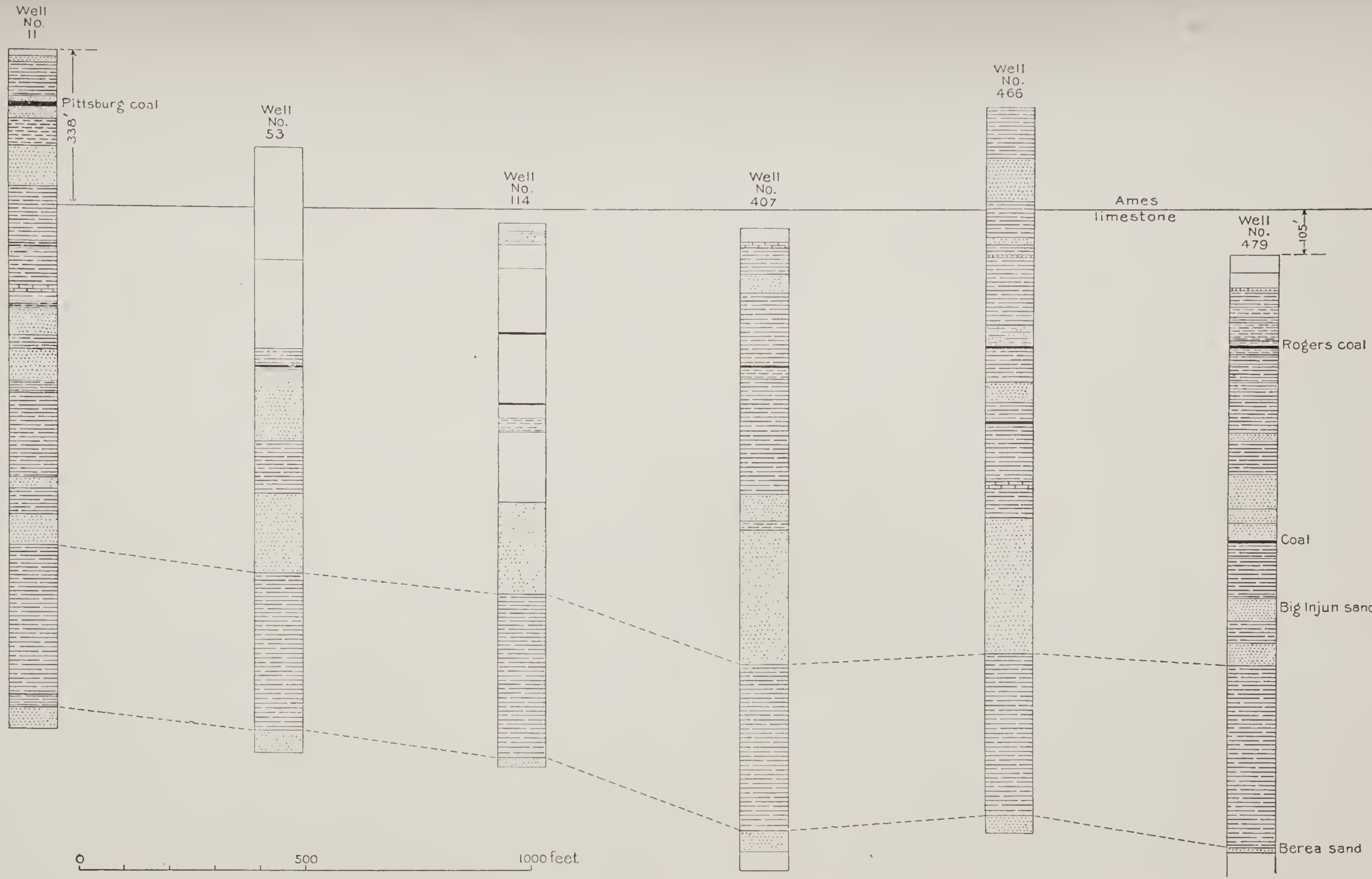
[a] The numbers given in connection with references to wells indicate the corresponding numbers on the maps.




SUBSURFACE STRATIGRAPHY, SHOWING CONVERGENCE OF BEREA SAND WITH RESPECT TO AMES LIMESTONE.

### CONVERGENCE SHEET.

The method of construction and use of the convergence sheet has been described on pages 23–25. The records obtained from each well from which the convergence sheet is made are given in Part II of this volume (pp. 99–113). It is here necessary only to consider two records, which were obtained but not used for the following reasons:

Well No. 147 is on the farm of Joseph Sapp, on Croxton Run. It is 1 mile west of well No. 149 and 2 miles east of No. 71. The elevation of the mouth is 1,053 feet. The Ames limestone outcrops a short distance from the well at an elevation of 1,009 feet, or 44 feet below the mouth of the well. The Berea sand is recorded in the log at 1,000 feet. This gives a distance of 956 feet from the Ames limestone to the Berea sand and 1,178 feet from the Pittsburg coal to the Berea. This distance seems too small by nearly 200 feet. The well was drilled below the Berea sand and to a depth of 1,455 feet. Red rock is noted in the log at 280 feet below the Berea. This is 120 feet greater than the interval between the Berea and red rock in well No. 149. This abnormal interval indicates that there is some mistake in the position of the Berea as given by the log. For this reason the well was not used in making the convergence sheet.

*Log of Joseph Sapp well (No. 147).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Limestone and red rock | 0 | 100 |
| Sandstone | 100 | 150 |
| Slate | 150 | 300 |
| Salt and red rock | 300 | 700 |
| Sandstone (showed black oil) | 700 | 780 |
| Slate | 780 | 1,000 |
| Sand, Berea | 1,000 | 1,040 |
| Slate and hard shells | 1,040 | 1,320 |
| Red rock | 1,320 | 1,330 |
| Slate gray | 1,330 | 1,340 |
| Shale black | 1,340 | 1,455 |

Well No. 488 is on the farm of Sophie Wright, south of Colliers Station. The Berea sand is reported in this well at a depth of 1,490 feet. The elevation of the well mouth is 1,067 feet. The Pittsburg coal outcrops near the well at an elevation of 1,137 feet, or 70 feet above the mouth of the well. According to the record of this well the Berea sand is 1,560 feet below the Pittsburg coal. The well is within the triangle made by wells Nos. 485, 491, and 295. Well No. 485 found the Berea at 1,600 feet below the Pittsburg coal; well No. 295 of the Burgettstown quadrangle found it at 1,637 feet, and well No. 491 at 1,634 feet. These distances are all greater than that found in well No. 488. As the well was carried to the lower sands, it is thought there may have been a slight error in the measurement to the Berea. The log, therefore, was not considered in making the convergence sheet.

*Log of Sophie Wright well (No. 488).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Casing | 850 | |
| Sand, Big Injun, bottom | 1,160 | |
| Sand, Berea | 1,490 | 1,510 |
| Red rock | 1,790 | |
| No Hundred-foot sand. | | |
| No Thirty-foot sand. | | |
| No Gordon sand. | | |
| Sand, Fourth | 2,150 | |
| Sand, Fifth | 2,205 | 2,215 |
| Total depth | | 2,225 |

No other data have been discarded in forming the Steubenville convergence sheet. Wells have been selected so as to control the territory as well as possible. Those whose mouths were near some known stratum were selected so as to avoid any error in the interval which might arise from incorrect contouring of the surface structure.

The convergence sheet is the key to the map of the underground stratum, and should be studied carefully by anyone intending to use the map of the oil sand. The result in the Steubenville quadrangle is considered fairly satisfactory. The wells are evenly distributed over the sheet and produce isochor lines that are fairly regular. The distance between these lines increases regularly to the southeast. In one portion of the map, however, the isochor lines are too close together for good results on the lower sands. This area lies in the northeast corner of the quadrangle, over the Turkeyfoot oil pool, and extends to Ohio River across the south slope of the new Cumberland anticline. Here the increasing divergence is nearly 50 feet to the mile. An increase at this rate would require a large-scale map and many check wells to obtain accurate results on the lower sands.

In the construction of the map of the Berea sand of the Cadiz quadrangle[a] a convergence sheet, governed along the east edge by the records of wells Nos. 221 and 228 of the present report, was used. The difference in interval at these two wells was divided proportionately over the distance between them. Since that map was made two other wells (Nos. 145 and 402) have been drilled in the Steubenville quadrangle near the line of the Cadiz quadrangle. These wells show that the interval increases more rapidly at the south than at the north. Owing to this new information, the con-

[a] Griswold, W. T., The Berea grit oil sand in the Cadiz quadrangle, Ohio: Bull. U. S. Geol. Survey No. 198, 1902, Pl. I.

tours on the Berea sand between these two wells will not coincide with those published on the map of the Cadiz quadrangle.

## DISCUSSION OF CONDITIONS AS SHOWN BY MAP OF BEREA SAND.

### POSSIBILITY OF THE EXISTENCE OF OTHER PRODUCTIVE SANDS.

In the Steubenville quadrangle oil and gas are derived principally from the Berea sand. (See Pl. VI.) The Salt sand has produced some gas (see p. 35) and the Big Injun a little oil, but practically the area may be considered as "a one-sand district." The lower sands of the Venango oil group probably are not present in any portion of this quadrangle, except along the southeastern quarter. Well No. 149, on Croxton Run, was drilled 250 feet below the Berea and reports no sand. The record of well No. 147, previously given, extends 415 feet below the Berea and reports no sand. Well No. 405 was put down near Fernwood with the avowed purpose of drilling for the lower sands. It reached the Berea at 1,288 feet and was continued down to a depth of 3,000 feet and reports that only "markers" of the lower sands were found. On the east side of the quadrangle well No. 488, south of Colliers Station, was drilled 735 feet below the Berea. Its record shows no Hundred-foot, Thirty-foot, nor Gordon, but does include the Fourth and Fifth sands.

Well No. 478, on Cross Creek, produces gas from what is probably the Hundred-foot sand. The record obtained did not give the position of the Berea sand, but from the interval of the producing sand below the Pittsburg coal it is evidently below the Berea. This producing sand may extend some distance farther west, as no tests for the lower sands have been made between this point and Fernwood.

### UPPER LIMIT OF SATURATION.

The major portion of the Steubenville quadrangle is within the same structural basin as the southeastern part of the Cadiz quadrangle. Owing to this fact, the line of complete saturation in the two quadrangles should be about the same. In the Cadiz quadrangle this line is at an elevation of about —280 feet, or, as the contours are numbered on the map of the Steubenville quadrangle (Pl, VI)—from a datum plane 1,000 feet below sea level—at an elevation of 720 feet. The wells of the Island Creek pool produced salt water and are the highest wells that may be spoken of as salt-water wells. In them the elevation of the sand is from 730 to 770 feet, indicating that in the Steubenville basin the line of complete saturation is somewhere near the 750-foot contour.

## DESCRIPTION OF OIL POOLS.

In the description of the structure and oil accumulation the writer will take the opportunity of pointing out what appear to be favorable conditions for the extension of existing pools or the location of new ones, but in doing so he simply expresses an opinion as to conditions and in no way prophesies oil or gas production.

### TURKEYFOOT POOL.

The New Cumberland anticline, being the most prominent structural feature of the quadrangle, is deserving of first consideration. The top of this anticline is above the line of complete saturation. If at some former period the water line was at a higher level, it would have caused the oil to accumulate at the top of the anticline, and with the gradual lowering of the water level the oil would have followed it down unless caught by small terraces or impervious rock. This seems to be the condition on the east side of the New Cumberland anticline. Here oil pools occupy the steep eastern slope as far down as its base or the present water line. The governing factor in the location and production of these pools seems to be the condition of the sand.

The Turkeyfoot pool was the first to be developed in the quadrangle. It is probable that many more wells have been drilled than are shown on the map. A large number have been abandoned and all traces of them effaced. Since the first discovery of oil at Turkeyfoot there have been periods when the price of oil was very low. During such times many wells that did not pay a profit, but were not yet exhausted, were abandoned.

No records were procured of wells Nos. 275 to 279. It was learned, however, that these wells produced some oil and large quantities of salt water. The drilling was probably extended from well No. 275 in a northwest line in the hope of getting out of the water area. This result would have been better accomplished had the development been extended to the west or southwest instead of to the north.

### KNOXVILLE POOL.

On the west side of the New Cumberland anticline oil is found in the flat at the base of the steep slope. Theoretically this is a correct location for oil territory. All of the area lying between Knoxville, Osage, and Island Creek post-office should be productive territory. In many places, however, it has been found barren, owing to the hard and impervious condition of the sand. The most probable area in this locality not yet prospected seems to be south of well No. 10, where the structural conditions indicate good territory as far as the village of Osage.

### ISLAND CREEK POOL.

Wells Nos. 114 to 170, with few exceptions, represent the Island Creek pool. The western limit of this pool seems to be pretty well determined by dry holes Nos. 142, 143, and 144, which are all on the theoretical extension of the pool in that direction. Well No. 145 is a fair "gasser" in the Berea sand. Since the 750-foot contour of the sand passes one-half mile southeast of the well, the conditions seem to be favorable for a water-line accumulation of oil at this point. The east end of the Island Creek pool has extended up the structural slope higher than would be expected. From the vicinity of wells Nos. 114 and 115 the producing territory should extend due east, south of the village of Pekin, and on to the headwaters of Little Island Creek, across Browns Island, and north of Braithwaite station. The writer does not intend to predict that oil will be found to this extent, but to imply that the area is favorable, since the location is about the top of the completely saturated area of the Berea sand. From this line northward the sand rises rapidly. It is to be expected that the oil would accumulate at the base of the anticlinal dome on the south, as it has on both the east and west. A small amount of oil has been procured in wells Nos. 387, 388, and 389. If development from these wells had been extended a little north of west instead of in a north-south line, the probabilities are that the results would have been favorable.

### BLUCK POOL.

The Bluck pool in Island Creek township is the latest discovery in the Steubenville quadrangle. To the north and east it is limited by gas wells and dry holes. The structural conditions are such as to indicate the extension of the pool due west.

### WINTERSVILLE TERRACE.

Two miles northwest of the village of Wintersville is a structural terrace, which presents a favorable location for oil. The top of this flat is below the line of complete saturation. The oil should, therefore, be on the top level of the terrace. Well No. 517 produced large quantities of salt water. No positive information was obtained with reference to well No. 518, though it was reported dry, but theoretically its location seems to be good. The best location seems to be between Nos. 518 and 402.

### GAS WELLS NOT FROM THE BEREA SAND.

Wells Nos. 400 and 401 are represented on the map of the Berea sand. They were not, however, drilled to that sand. In the Salt sand a heavy flow of gas was encountered through which it was impossible to drill. The wells were therefore shut in and the tools moved to the location of well No. 402, which was carried through to the Berea sand with unfavorable results.

### GOULD AND M'INTYRE.

The Gould and McIntyre pools, in the southern part of Cross Creek Township, lie at the same elevation along the strike of the formations. They are probably accumulations caused by small terraces. This is shown by the contours on the Gould pool. The 470-foot contour passes through the center of the McIntyre pool and therefore destroys the semblance to a terrace as represented by the contours, though the records show that the elevation of the sand is nearly the same in most of the wells in this pool. To the northeast of the Gould pool are two wells (Nos. 411 and 412) which produced some oil and large quantities of salt water. Well No. 410, to the northwest of these, was dry, owing to the poor sand. Between these wells is a very small area that appears to be favorably located and may prove to be productive territory.

### COLLIER TERRACE.

South of Colliers Station two wells have been drilled which showed indications of gas in the Salt sand. South of these wells the structural conditions are favorable for either oil or gas.

# CHAPTER IV.

## GENERAL GEOLOGY OF THE BURGETTSTOWN QUADRANGLE.

### DESCRIPTION OF SURFACE.

#### LOCATION.

The Burgettstown quadrangle joins the Steubenville on the east, lying between 80° 15′ and 80° 30′ west longitude and 40° 15′ and 40° 30′ north latitude. Most of the area covered by the quadrangle is in Washington County, Pa. A small part of Beaver County is included along the north edge and a portion of Allegheny County in the northeast corner. Burgettstown, from which the quadrangle receives its name, is situated on the Pittsburg, Cincinnati, Chicago and St. Louis Railway, near the center of the quadrangle.

#### TOPOGRAPHIC FEATURES.

The streams of the quadrangle are all tributaries of Ohio River, but they flow in various directions to reach this stream. Raccoon Creek, whose two main branches rise in the southern half of the quadrangle, flows directly north through the middle of the northern half. On both sides of this stream are main dividing ridges, from which the waters flow in both directions—on the east to Chartiers Creek, and on the west direct to Ohio River.

All the streams have cut deep valleys, between which are rounded hills whose summits reach from 200 to 300 feet above the main valley levels. The complete dissection of the surface by the smaller streams presents favorable conditions for geologic work.

### GEOLOGIC FEATURES SHOWING AT THE SURFACE.

#### SECTION OF ROCKS EXPOSED.

The surface of the quadrangle is composed of the Conemaugh, Monongahela, and Washington formations. The total section exposed is about 750 feet. In the northern half the surface outcrop is about equally divided between the Conemaugh and the Monongahela formations. In the southern half little of the Conemaugh formation is exposed, by far the larger part of the surface being occupied by the Monongahela, which, however, toward the south passes below water level and is succeeded by the Washington formation.

## KEY HORIZONS AND INTERVALS.

Within the formations exposed are a number of easily identifiable beds that make excellent guides by which to follow the geology. Of these the Pittsburg coal is by far the most prominent. Its base has therefore been selected as the key horizon upon which to show the surface structure. This coal shows in outcrop in all of the northern half of the quadrangle, except a small area in the northwest corner. Throughout most of this section the outcrop appears at enough places to furnish sufficient data for complete structural work. South of the Pittsburg, Cincinnati, Chicago and St. Louis Railway the dip of the formations carries the coal under cover a short distance from the railroad. It appears again on Chartiers Run and Westland Run in the southeast corner and on Cross Creek in the southwest corner.

Below the Pittsburg coal the principal marking stratum is the Ames limestone, which occurs near the middle of the Conemaugh formation. This limestone outcrops in the valley of Raccoon Creek from the north edge of the quadrangle to the mouth of Brush Run, also in Harmon Creek and Aunt Clara Fork of Kings Creek, but was not noted on Kings Creek. The conditions are not favorable for measuring the interval between the Ames limestone and the Pittsburg coal within the Burgettstown quadrangle. This distance as determined in the Steubenville quadrangle to the west varies from 219 to 224 feet, and in the Beaver quadrangle to the north it is about 230 feet. These intervals were accepted along the borders of the quadrangles.

The Monongahela formation has a number of members that may be used as key rocks. The Sewickley and Uniontown coals at the bottom and top of the Benwood limestone are available for this purpose. They were little used, however, owing to the fact that both of these coal beds are small and their outcrops inconspicuous. Although small, the coals are usually present and they were identified in a number of places. The Sewickley coal is about 102 feet above the base of the Pittsburg, and the Uniontown coal is from 206 to 222 feet above the same horizon.

The two beds in the lower section of the Benwood limestone called the Dinsmore and Bulger limestones, which are described in the chapter on stratigraphy in Part II of this paper (pp. 69–70), are the best marking strata in the middle of the Monongahela formation. These two beds have been employed more extensively in determining the structure of the rocks than any other member except the Pittsburg coal. On the east side of the quadrangle, south of the Pittsburg, Cincinnati, Chicago and St. Louis Railway, the Bulger limestone is an excellent guide as far south as Cherry Run, also through the southern part of Mount Pleasant Township. In the western part of the quadrangle south of the railroad the Dinsmore is more prominent than the Bulger limestone, but the latter is present, and was used in many places.

Many comparisons of elevations were made for determining the distance of these two beds above the Pittsburg coal, with the following results: In Jefferson Township the Dinsmore bed is 138 feet and the Bulger bed 167 feet above the base of the Pittsburg coal; in Smith Township the Dinsmore bed is 132 feet and the Bulger bed 155 feet above; in Mount Pleasant Township the Dinsmore bed is 140 feet and the Bulger bed 165 feet above.

The Waynesburg coal, at the top of the Monongahela formation, maintains a fair thickness in all parts of the quadrangle except in the central part of Mount Pleasant Township. This coal is in Smith Township, 264 feet; in Mount Pleasant Township, 270 feet; and in Jefferson Township, 278 feet above the base of the Pittsburg coal. In the Claysville quadrangle, south of Burgettstown quadrangle, this interval was determined from well records to be about 290 feet near the north edge. In view of this fact an interval of 285 feet was used along the south edge of the Burgettstown quadrangle.

In the Washington formation the Waynesburg "A" and "B" coals are guides to the stratigraphy. They were, however, little used for determining the surface structure except in a limited area east of Hickory.

The Washington coal is the best marker between the Waynesburg coal and the Upper Washington limestone. This coal was used largely in determining the geologic structure in the middle of the southern half of the quadrangle. The distance of the Washington coal above the Pittsburg coal in Smith Township was determined by well records to be 364 feet. In Mount Pleasant Township the Washington coal averages 108 feet, and in Cross Creek Township 107 feet above the Waynesburg coal.

### PROBABLE ERRORS IN MEASUREMENT OF INTERVALS.

An examination of the results of these measurements shows a gradual increase in the intervals from north to south. This increase, however, is not large enough to demand the averaging of measurements taken in different parts of any one township.

In the measurements of the distance between the different strata, a range of 20 feet was found in the intervals. This range was remarkably constant, being the same for short distances as for long distances. Thus the variation of interval between the Pittsburg coal and the limestone closely underlying it is nearly 20 feet, and the range of intervals between the Pittsburg coal and the Bulger limestone and between the Pittsburg coal and the Waynesburg coal, distances of 165 and 270 feet, respectively, is about the same. With a range of results of 20 feet, the average is probably correct within 10 or 15 feet. The limit of error, therefore, in the map showing the structure of the Pittsburg coal should be within 10 or 15 feet at points where outcrops were located. Between such locations the difference of elevation is spaced in by the contour lines, the correctness of which depends on the number of located points. About 600 geologic locations were made in the quadrangle, the positions of which are shown on the map (Pl. VII). Three small areas are noticeably deficient in information. The apparent absence of the Ames limestone on Kings Creek and the uncertainty regarding the identity of the coal bed there exposed leave a number of square miles without reliable data. In a small area near and to the north of Bavington the Ames limestone is not exposed, and the hills are not high enough to catch the Pittsburg coal. This small area could be easily spanned by contours were it not for the fact that the coal on the west side of the creek is in a syncline and that to the east nearly on the crest of an anticline, there being a difference of 60 or 70 feet in the elevations. Owing to this absence of outcrops of marking strata the east side of the syncline is not well defined. In the main synclinal trough southeast of Cross Creek the located outcrops are good, but few in number. The map of this area could be improved by level work off the roads, but the present work did not seem to warrant this expense. With these exceptions the representation of the surface structure shown on Pl. VII is believed to be fully up to the contour limit of accuracy.

## STRUCTURE.

The geologic structure represented by the contour lines on Pl. VII brings out prominently the results of the two systems of folds that are present in the Burgettstown quadrangle. These systems are at right angles to each other, with strikes a little east of north for the major system and north of west for the minor system. The compression in an east-west direction has formed anticlinal ridges and synclinal troughs, whereas the compression in a north-south direction has formed hardly more than monoclines and terraces, with the strong dips of the monoclines to the south. The combination of these two systems has formed a number of domes, terraces, and basins.

The most important structural feature of the quadrangle is the Burgettstown syncline. This trough enters the quadrangle at the south edge, east of West Middletown, and extends in a direction about due north nearly to the north edge of the quadrangle. Here the trend changes to northeast. This syncline has been broken by the east-west folding into three important structural basins in this quadrangle. The northernmost is at Five Points, where the crossing of a shallow syncline in an east-west direction forms a basin of considerable extent. The next basin to the south is at the bottom of the most pronounced east-west break and in the line of the Burgettstown syncline. This basin is named from Cross Creek village, although the center of the basin is over a mile to the east of the village. Near the south edge of the quadrangle is the third basin, which extends into the Claysville quadrangle. The center of the basin is a little to the east of West Middletown, on the south fork of Cross Creek. It is called the West Middletown basin.

Two important domes rise on the east side of the Burgettstown syncline. One of them, called the Candor dome, is located north of the village of Candor. The rocks rise steeply through a distance of over 100 feet from the east, south, and west toward the center of the dome, but to the northwest the descent is gentle, the total amount being about 30 feet. The Westland dome, at Westland, in the southeast corner of the quadrangle, is a small but pronounced feature from which the rocks descend in all directions.

On the west side of the quadrangle from Eldersville southward the rocks remain comparatively high as far as Cross Creek. This produces an anticlinal nose, on the end of which is a very low dome, called the Gillespie dome.

## GEOLOGIC FEATURES BELOW THE SURFACE.

### CONVERGENCE SHEET.

As has been previously stated, the convergence sheet is the drawing on which the final map of the sand depends, for with its completion the map making becomes a mechanical operation, in which judgment forms only a small part. The convergence sheet should be carefully studied and thoroughly understood before any actual drilling operations which are suggested by the representations of the map are undertaken.

The convergence sheet of the Burgettstown quadrangle is made from the records of 60 oil wells whose positions are fairly well distributed over the quadrangle. Most of the records accepted are direct steel-tape measurements to the Hundred-foot sand, but where the Hundred-foot is absent or where the gas and oil comes from lower sands the steel-tape measurement to some other sand has been taken and the average distance that the Hundred-foot sand is known to be above or below this sand subtracted or added to obtain the interval for use on the convergence sheet. This method has been employed in the northwest corner of the quadrangle, where the Berea is the lowest sand reached by the drill and where the Hundred-foot sand is probably not present. To the recorded distance of the Berea below the surface in this area 190 feet has been added. This interval is obtained from a number of records of wells in the Steubenville quadrangle, which show the distance of the Berea above the "red rock," also from records of wells in Jefferson township, in the Burgettstown quadrangle, which show the Hundred-foot shells or Berea sand above the "red rock" and the Hundred-foot sand below the "red rock."

In the McDonald pool, on the east edge of the quadrangle, and in the Westland gas territory, most of the oil and gas comes from the Gordon sand and the Fifth sand. By a comparison of a large number of records from this territory, it is found that the Gordon lies from 195 to 220 feet below the Hundred-foot, with an average distance of 210 feet, and that the Fifth sand averages 119 feet below the Gordon, or 329 feet below the Hundred-foot. These figures have been used in reducing measurements to the Gordon or Fifth sand to measurements to the Hundred-foot sand.

For the northeast corner of the quadrangle better results could be obtained if more well records were employed in the construction of this part of the convergence sheet. Many wells have been drilled in this locality and the elevations of the mouths of most of them were obtained, but all efforts to procure the records of these wells have been without success.

The convergence sheet is shown upon Plate VIII. This illustration is printed upon transparent paper, so that any new information obtained may be added, and the drawing then used to correct the map of the Hundred-foot oil sand. The data from which the convergence sheet was made are given in detail in Part II (pp. 132–148).

The irregularity of convergence between the Pittsburg coal and the Hundred-foot oil sand in the Burgettstown quadrangle, as shown on Pl. VIII, is not favorable for detailed mapping of the sand. There is a difference of 200 feet in the interval between these two members. This could be easily taken care of were it a gradual increase from one corner of the quadrangle to the other, but the well records show an area of small interval, which extends in a northwest-southeast direction across the southern third of the quadrangle, and from this area the coal and sand diverge in all directions. The determination of the exact location of the area of lesser interval is difficult. It can hardly be assumed that the wells have been drilled at the exact points of least interval; nor is it probable that the convergence is regular between these wells and adjacent wells.

As has been stated, the area of small interval is in the southern third of the quadrangle. As determined, it extends from the vicinity of Cross Creek village in a southeasterly direction toward Hickory, and thence on to Westland. The data for this location are furnished by four complete records of the following wells: Well No. 832 shows a distance of 1,748 feet between the Pittsburg coal and the Hundred-foot sand; well No. 630, an interval of 1,747 feet; well No. 649, an interval of 1,750 feet, and the Parkinson well, No. 661, 1,760 feet. These records are given in detail on pages 137–141.

It will be noted that in the Miller well (No. 630) the Thirty-foot sand occurs at a distance of 100 feet below the Hundred-foot, and the Fifth sand at a depth of 419 feet below the Hundred-foot. No Gordon sand was noted in this record. In the Lyle well (No. 649), drilled by the same company, the Thirty-foot sand was found at 101 feet, the Gordon at 320 feet, and the Fifth at 430 feet below the Hundred-foot sand. These records show an excess in the interval between the Hundred-foot sand and the Gordon sand of about 100 feet. This would indicate that the Hundred-foot sand has risen in the general section, reducing the interval between it and the Pittsburg coal and increasing the interval between it and the Gordon sand. This fact, if proved, would be interesting, but for the reason that few wells have been drilled below the Hundred-foot sand there are not sufficient data to establish it.

The increasing interval to the northeast from the Pry, Miller, and Lyle wells is not a sudden break, but a gradual increase; not probably as regular as is represented by the convergence sheet, but with some degree of regularity. This is shown by a line of wells through the Burgettstown oil field from Cherry Valley to the valley of Burgetts Fork. In these wells the distance from the Pittsburg coal to the Hundred-foot sand increases to the northeast.

## OIL AND GAS SANDS.

Below the surface of the Burgettstown quadrangle are found most of the sands from which oil and gas have been produced in western Pennsylvania. The Murphy sand, although probably present, is not mentioned in the well records examined and has produced no oil or gas within the area. The first two sands below the Pittsburg coal that are noted in the well records are the Little and Big Dunkard sands. They are not productive in any portion of the Burgettstown quadrangle and are noted in but few of the well records. These sands are the equivalent of the two parts of the Mahoning sandstone of the Conemaugh formation. The top of the Big Dunkard, or lower sand rock, is about 425 feet below the Pittsburg coal.

Next below the Big Dunkard is a sand 35 to 100 feet thick that has produced gas in different parts of the quadrangle, and is named by the drillers and operators the "Gas" sand. Its geologic position is in the Allegheny formation, and it probably corresponds with the Homewood sandstone. The average distance of the top of this sand below the Pittsburg coal is about 600 feet.

The next lower sand is the Salt sand of the Pottsville formation. This bed lies at a distance of about 840 feet below the Pittsburg coal. It is a white sand and a gas producer in most of the geologically high localities; at other places it is saturated with salt water. This sand is always cased off in wells which are drilled to the lower sands. At the base of the Salt sand is the unconformity already noted (p. 15).

Below this unconformity and above the Big Injun sand are usually found two limestones and an intervening sand. These are known to the drillers as the Little and Big lime and the Keener sand. They belong to the Mauch Chunk formation and represent the Greenbrier limestone.

At the base of the Big lime is the Big Injun sand. This is a heavy sandstone stratum ranging from 150 to more than 200 feet in thickness, in which the sands are of different colors and of different degrees of coarseness. The top of this sand is about 1,050 feet below the base of the Pittsburg coal. At about 1,340 feet below the Pittsburg coal and a short distance below the base of the Big Injun sand is a sand 20 to 35 feet thick, called by the drilling fraternity the "Squaw" sand. This sand has shown indications of oil in different places within the Burgettstown quadrangle, but so far has furnished no productive wells.

At a distance of 1,480 to 1,520 feet below the Pittsburg coal a small sand is often found, heavily charged with salt water and called the Bitter Rock. Between 1,600 and 1,700 feet below the Pittsburg coal lies the Berea sand of Ohio, but in this area it consists almost entirely of closely cemented hard shells called the Thirty-foot shells. From 90 to 100 feet below the Thirty-foot shells is the "red rock." This is not a sandstone, but a shale, and is generally noted by the drillers on account of its red color. Almost exactly 100 feet below the top of the "red rock" is the top of the Hundred-foot oil sand. This is the most prolific sand of the Burgettstown quadrangle, and its upper surface is represented by the red contours on the map (Pl. IX). Its distance below the Pittsburg coal in different parts of the quadrangle is shown by the isochor lines on the convergence sheet. The Hundred-foot sand and those above it, up to and including the Big Injun sand, belong to the Pocono formation. About 100 feet below the Hundred-foot is the Thirty-foot sand. This has produced oil in a portion of the Burgettstown oil field and has yielded gas at other places in the quadrangle. About 210 feet below the Hundred-foot sand is the Gordon, which is the principal producing sand in the southeastern portion of the quadrangle. Along the southern border of the quadrangle an extra sand appears a few feet above the top of the Gordon, and is called the Gordon Stray sand. At a distance of about 60 feet below the Gordon sand is the Fourth sand, and about 120 feet below the Gordon is the Fifth sand. Both of these lower sands are producers in the eastern portion of the quadrangle, but have been reached in only a few places in the central portion and in these have been found unproductive.

## DISCUSSION OF CONDITIONS AS SHOWN BY MAP OF HUNDRED-FOOT SAND.

### DESCRIPTION OF MAP.

A contour map of the top of the Hundred-foot oil sand constitutes Pl. IX. The contours that represent the upper surface of the sand are printed in red on the topographic base map. These contours do not extend fully over the map, owing to the lack of reliable information in the northeast corner of the quadrangle for constructing a convergence sheet. The vertical interval between the contours is 10 feet. The numbers upon them represent the elevation from a datum plane 2,000 feet below sea level. This datum plane was adopted to avoid the use of the minus sign. The wells drilled in the quadrangle are represented by the accepted symbols for dry holes, producing oil wells, and gas wells. These symbols are printed in two colors—red and blue. Those in red represent wells that have been drilled no deeper than the Hundred-foot sand, and where they are known to have stopped in one of the sands above the Hundred-foot, a red cross is placed to the right of the symbol. The symbols printed in blue represent wells drilled to the Gordon, Fourth, or Fifth sands.

### CONDITION OF SATURATION.

The wells of this region show that the Hundred-foot sand contains little, if any, salt water within the Burgettstown quadrangle. Since the producing sand is generally dry, the oil should be found in the synclines rather than in the anticlines. This condition is found to exist. Of the three pronounced synclinal basins in a north-south line through the middle of the quadrangle, two contain oil pools of considerable size; the third has by no means been thoroughly tested.

## DESCRIPTION OF OIL POOLS.

### FIVE POINTS POOL.

In the northern half of the quadrangle the synclinal basin rises west of Five Points. The oil has accumulated on the slope of this basin from the north, west, and southwest. The presence or absence of salt water in the center of the basin was not positively determined. If the water is absent, there seems to be no good reason why the oil should not extend to Raccoon Creek and southward to Bavington. It will be noted, however, that the surface structure shows the Five Points syncline as an independent basin. This structure has been largely eliminated on the convergence sheet. If lack of sufficient data on the convergence sheet has thrown the map of the Hundred-foot sand into error and the Five Points syncline is an independent basin on that sand, the same as on the Pittsburg coal, there is good reason why the production should not extend to Bavington.

It is not known whether any wells have been drilled below the Hundred-foot sand in search of lower sands in the center of the Five Points basin, but if this has not already been done it seems advisable to do so, for if the lower sands are present in this locality they are probably productive.

### FLORENCE POOL.

The oil pools southeast of Florence are accumulations upon structural terraces. The conditions of accumulation in these pools are impossible to determine from the surface, owing to the lack of parallelism between the outcropping strata and the oil-bearing sand.

### BURGETTSTOWN POOL.

The oil pool which now extends from Cherry Valley to the village of Cross Creek was in course of development during the progress of the field work on which this report is based. The development of this pool commenced in Cherry Valley and extended in a southwesterly direction to the valley of Burgetts Fork. Here it seemed for a time to be limited by a dry hole (No. 572) on the farm of R. J. Lyle. As this limitation did not appear to agree with the geologic conditions as known at that time, the writer then suspected that an accumulation of oil existed on the western side of the synclinal basin, as had been found on the eastern side. This territory has since proved to be productive.

From structural conditions there seems no reason why all of the area lying south and east of the 1,090-foot contour, which goes through Cross Creek village and passes to the north and west of Quakers Knob and thence northeast and east to a point north of the first area of development in Cherry Valley, should not be productive. There has been an attempt to extend the development in this direction, but the wells drilled have been of small production, and this has tended to discourage the further testing of the field. The small yield of the wells is probably due to the hard and compact condition of the sand. This may change at any point and wells of large production be developed.

From the Cross Creek syncline a long, narrow trough extends to the Krackemer wells at the head of Cherry Valley. These wells produce oil from the Gordon sand. The structural conditions seem favorable for the existence of an oil pool in the Hundred-foot or one of the lower sands along the bottom of the north slope of the trough from the Krackemer wells to the Cross Creek development.

### WEST MIDDLETOWN SYNCLINE.

The only large syncline in the quadrangle which has as yet furnished no oil is the West Middletown syncline, which extends southward into the Claysville quadrangle. One test well (No. 818) on the Gilbert Stewart heirs' farm was drilled by Barnsdall & Co. in connection with the Wheeling Gas Company in what would appear to be a very favorable location. No detailed record or positive information could be obtained about the well, but there seems to be little doubt that it was dry in all sands. Probably the most favorable location for a test well in this territory would be along the Wabash Railroad 1 mile west of the Twin Bridges. Since the completion of the field work information has been received that a well was drilled near the intersection of the public roads three-fourths of a mile northeast of West Middletown. This location is almost exactly in the bottom of the syncline, at a favorable position for an oil pool. It is understood that the sands here were also found to be dry.

### M'DONALD POOL.

On the east edge of the quadrangle a portion of the McDonald pool is represented. The oil here comes from the Gordon and Fifth sands, and the wells are therefore represented on the map in blue. As only a portion of the pool is shown the map does not fully represent the conditions causing the accumulation at this point. The oil is found, however, as in the previously described pools, in the bottom and on the northwest slope of the syncline. The conditions from Primrose to the Krackemer wells at the head of Cherry Valley all seem to be favorable for oil accumulation, though at the present time there is considerable acreage within this area that is not producing. The country was not sufficiently examined for old dry holes or unsuccessful tests to say that this area has not been thoroughly prospected.

# CHAPTER V.

## GENERAL GEOLOGY OF THE CLAYSVILLE QUADRANGLE.

### DESCRIPTION OF SURFACE.

#### LOCATION.

The Claysville quadrangle lies directly south of the Burgettstown quadrangle, between meridians 80° 30′ and 80° 15′ west and parallels 40° and 40° 15′ north. The territory lies within the boundaries of Washington and Greene counties, Pa., only a narrow strip along the southern border being in the latter county.

#### TOPOGRAPHIC FEATURES.

This quadrangle lies wholly within the basin of Ohio River. Roughly, the eastern third is drained at the north by Chartiers Creek into the Ohio at Pittsburg, and at the south by Tenmile Creek eastward to Monongahela River. Streams in the northwestern quarter of the quadrangle drain through Buffalo Creek into the Ohio at Wellsburg, W. Va. In the southwestern quarter, Robinson, Templeton, and Rocky runs carry the drainage through Wheeling Creek to Ohio River at Wheeling.

The topography made by these streams is of the same general type as that already described for the Steubenville and Burgettstown quadrangles. The height of the hills above the main streams is from 200 to 400 feet.

### GEOLOGIC FEATURES SHOWING AT THE SURFACE.

#### SECTION OF ROCKS EXPOSED.

The outcropping rocks of the Claysville quadrangle belong to the Permian and Pennsylvanian series. Of the former, there are about 500 feet of the Greene formation and the entire thickness (275 feet) of the Washington. The Pennsylvanian series is represented by about 300 feet of the Monongahela, including the rocks down to a bed a few feet above the Pittsburg coal. The rocks are all of sedimentary origin, being principally sandstones and shales, which carry at irregular intervals beds of limestone and coal. Of these beds the Claysville and Prosperity limestones of the Greene formation, the Upper Washington limestone and Washington coal of the Washington formation, and the Waynesburg coal of the Monongahela are easily recognized and widespread in outcrop. These beds have furnished most of the data from which the surface structure was determined, and for this reason are the only ones mentioned below. A detailed description of all the rocks showing at the surface is given in Part II of this paper (pp. 149–175).

### KEY ROCK AND INTERVALS TO IMPORTANT BEDS.

The Upper Washington limestone marks the top of the Washington formation. It is a thick and very persistent limestone bed, having two or three characteristic milk-white layers near the top that render its identification easy over a large portion of the Claysville quadrangle. For this reason, and also because it shows in outcrop over a greater area than any other bed in the southern portion of the quadrangle, it has been selected as the key horizon from which the structure of the surface rocks is mapped. This limestone is well exposed along the sides of the valleys of the larger streams in the townships of Morris, North and South Franklin, East and West Finley, and the southern portions of Donegal, Buffalo, and Canton. To the north of the Baltimore and Ohio Railroad it is well up toward the tops of the hills, and in Independence and Hopewell townships it is present only in the highest hills. In Chartiers township the bed is entirely absent.

The Claysville and Prosperity limestones outcrop in more or less isolated patches along the tops of the high ridges of East and West Finley, North and South Franklin, and both Morris townships. Owing to the pronounced dip of the rocks over the small area in which these beds are exposed and the great horizontal distance between their outcrops and that of the Upper Washington limestone, it is not possible to determine accurately the vertical distance or intervals between them. At only seven places in the quadrangle were the intervals between the Upper Washington limestone and these beds obtained with a degree of accuracy worth recording. These measurements show the Claysville limestone to be from 185 to 221 feet (mean, 203) and the Prosperity from 101 to 115 feet (mean, 108) above the key rock. In several places these beds have been of great value in determining the direction and amount of dip of the rocks.

The Washington is the most conspicuous bed of coal in the Claysville quadrangle. It is entirely under cover in the townships of East and West Finley, Morris, and South Franklin, but is well exposed in North Franklin, Canton, Hopewell, Blaine, Buffalo, Donegal, Independence, and portions of Cross Creek and Mount Pleasant townships. The value of this coal bed as a geologic marker lies in the fact that it is best exposed in the northern portion of the Claysville quadrangle, where the outcrops of the Upper Washington limestone are scanty or entirely wanting. The exposures of these two beds overlap sufficiently to allow accurate measurement of the interval between them. More than 40 measurements were made, ranging from 156 to 168 feet, showing an average of 162 feet.

The Waynesburg coal marks the top of the Monongahela formation and is next to the Washington coal in importance in the Claysville quadrangle. Its southern line of outcrop is in the valley of Dutch Fork near Budaville, Donegal Township; in the valley of Buffalo Creek just south of Taylorstown; and in Chartiers Creek in the vicinity of Washington. From these points northward its area of outcrop widens to the border of the quadrangle. No direct measurements were made of the distance between this bed and the Upper Washington limestone, because of the difficulty of finding outcrops of both near enough to eliminate the dip. Good measurements were obtained, however, by adding the distance between the Waynesburg and Washington coal beds to that found at other places in the immediate vicinity between the Washington coal and the Upper Washington limestone. The mean interval, as determined from over 30 measurements, is 275 feet.

## GEOLOGIC FEATURES BELOW THE SURFACE.

### IMPORTANT HORIZON.

Below the Waynesburg coal the next important geologic marker is the Pittsburg coal. This bed does not outcrop in the Claysville quadrangle, but a general knowledge of it has been obtained from mine shafts and from deep wells. It is only a few feet under cover at the point where Chartiers Creek leaves the quadrangle, but throughout most of the area it lies so far below the surface that it has not yet been mined, though it is everywhere accessible. Its distance below the Upper Washington limestone increases from north to south at a fairly uniform rate. Over Hopewell, Independence, Chartiers, and the northern portion of Canton townships the interval is about 550 feet. Through the middle tier of townships it gradually increases from 600 to 625 feet at their south edges, from which to the south border of the quadrangle the distance appears to increase more rapidly, reaching a maximum of about 700 feet, though the information is meager, as few wells have been drilled in this vicinity.

Of the rocks below the Pittsburg coal direct information comes from the logs of deep wells. Within the Claysville quadrangle over 1,200 wells have been drilled to depths varying from a few hundred to more than 4,000 feet. Drillers have noted and named certain prominent or easily identified beds found in the wells, and have in most instances recorded the depths at which each of these beds was encountered. Owing to the uniform and widespread occurrence of the Pittsburg coal and the ease with which it is recognized by the driller, it has come to be universally used in this region as the base from which the intervals to underlying beds are measured. This interval and the known sequence of the beds form the principal means by which they are identified, though some strata have individual characteristics by which they may be recognized over large areas. In this connection it should be stated, however, that there are certain other factors to be taken into consideration and it is necessary to accept information from well records with caution. Some drillers are careful and exact both as to measurements and the correlation of sands; others are careless and neglectful, giving little heed to any rocks except those producing oil or gas. In a few instances where the information is conflicting in a given area it has been difficult, for this reason, to choose between the good and the bad. Another source of error is in the measurements themselves. Especially is this true where measurements have been taken by cable to unproductive beds and by steel line to the productive sands in the same well. Where a steel line is used the distance is measured very accurately, but with the cable as a measuring line the results are as a rule unreliable. (For a detailed description of these methods, see p. 29.)

### SECTIONS OF SUBSURFACE ROCKS.

In order to illustrate the relative position and thickness of the prominent subsurface beds within this quadrangle the records of six wells, situated on a zigzag line across the quadrangle from south to north, have been selected to show typical sections of the rocks of the vicinity from which each is taken. It is believed that a careful examination of these sections (Pl. XI) will give a clearer and more comprehensive knowledge of the relative thickness and stratigraphic relations of these beds than could be conveyed by pages of description. Below the Pittsburg coal are several prominent sandstone beds of the Conemaugh, Allegheny, and Pottsville formations down to the unconformity between the Pottsville and the Mauch Chunk, the whole being generally designated the shallow sands. The second group or upper sands extends from the top of the Mauch Chunk through the Pocono formation, the bottom of which is probably a short distance above the Gordon Stray sand. All sandstone beds below this horizon in the upper portion of the Devonian are generally designated the lower sands by the oil fraternity.

### CONTOUR MAP OF UPPER WASHINGTON LIMESTONE.

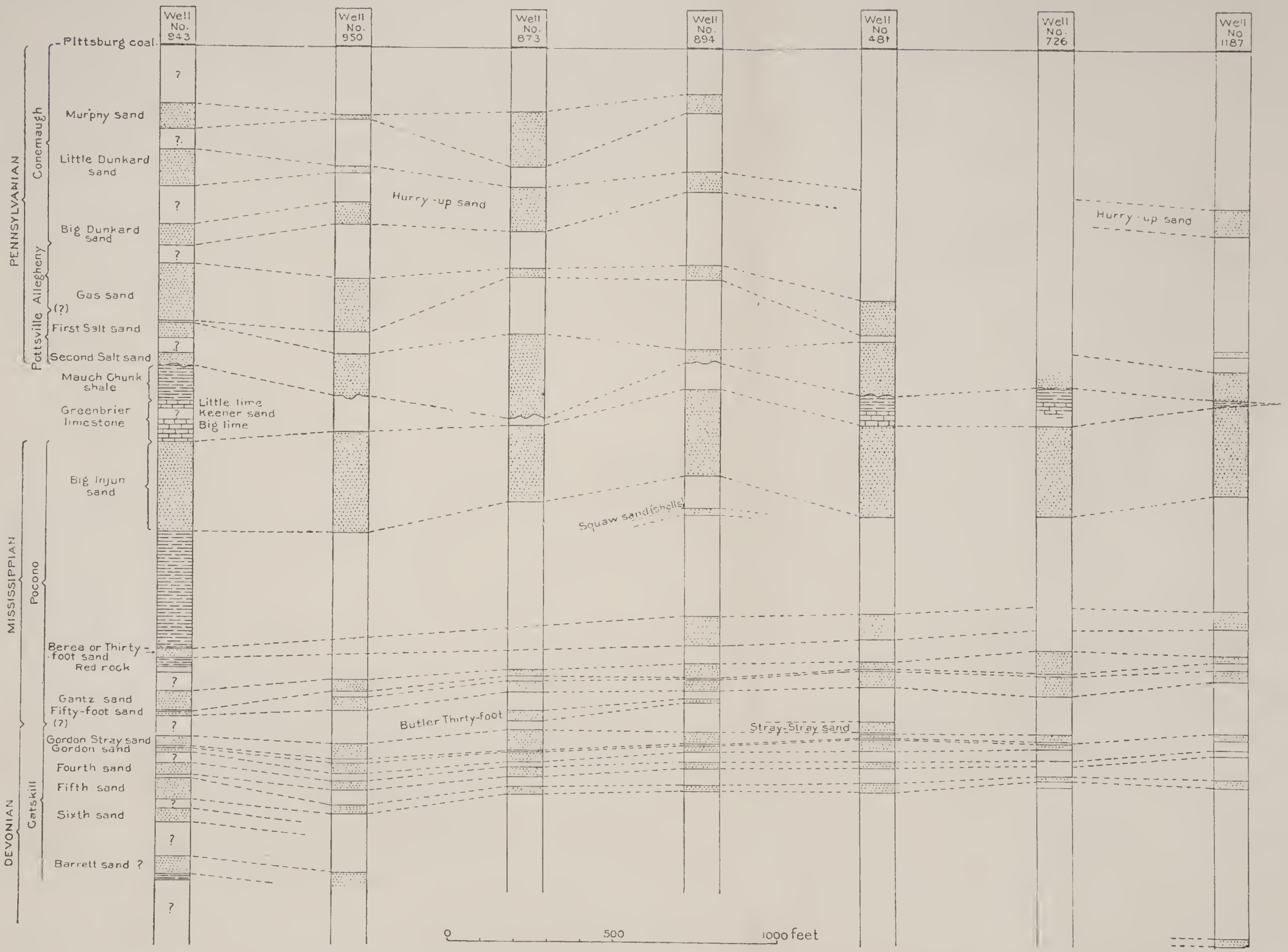
To reduce the elevations taken on other horizons than the Upper Washington limestone to the equivalent elevation of that stratum, the mean intervals mentioned above for each marking stratum have been used with few exceptions. Over a considerable portion of the northeast corner of the quadrangle, where the horizons of the Upper Washington limestone and the Washington coal are above the highest hills, and the Waynesburg coal is too thin to be easily recognized, the surface structure has been mapped from the Pittsburg coal as a secondary key horizon. To the elevations of this coal, as given in numerous oil wells and by the map of the Arden mine, was added an interval of 575 feet to determine the position of the key rock. This amount is the mean of all measurements obtained from wells along the east line of outcrop of the Washington coal and Upper Washington limestone. The map of the surface structure in the northeast corner of the quadrangle, as made from these elevations, may be in error in certain places in amount equal to the difference between this mean interval and the true one between the Pittsburg coal and Upper Washington limestone at those places.

With these elevations established on the Upper Washington limestone over the whole quadrangle, a map of the surface structure, as shown by the key rock, was easily made by drawing contour lines (level lines) connecting points of equal elevation. On Pl. X contour lines showing the structural position of the surface rocks are printed in green on the topographic base map. These lines have a contour interval of 10 feet and are numbered with reference to their distance in feet above sea level.

By a study of these contours it will be seen that the Upper Washington limestone, together with the other surface rocks of the Claysville quadrangle (which were first laid down under water in fairly horizontal layers), in being raised to its present position has been subjected to more or less wrinkling. This folding or wrinkling results in structural features of two general types—(*a*) the "highs," or irregularly ridge-like anticlines, the tops of some of which culminate in small domes, and (*b*) low troughs or synclines, the bottoms of which here and there form shallow basins.

### WASHINGTON ANTICLINE.

The most prominent anticline crossing the Claysville quadrangle enters it from the east a short distance from Arden station on the Pennsylvania Railroad, 3 miles north of Washington. The crest of this ridge, which is called the Washington anticline, pitches very steeply toward West Washington, reaching the bottom of a low saddle between two domes about 1 mile to the southwest of this town,




SECTIONS OF DEEP WELLS IN THE CLAYSVILLE QUADRANGLE.

near the pumping station of the Citizens' Water Company. From this point the crest rises slowly to the southwest to a point about a mile west of Lagonda, where it culminates in a small dome. Thence the crest line changes its direction slightly toward the south and pitches again to a low divide, the bottom of which is at the point where this anticline crosses Tenmile Creek, $1\frac{1}{2}$ miles northeast of Pleasant Grove. The top of the next dome is about three-fourths of a mile south of this village, near the corner of East Finley, Morris, and South Franklin townships. Continuing southward the crest pitches steeply to a point a little west of the Joint schoolhouse, from which it describes a sweeping curve to the south and southwest, leaving the quadrangle at a point almost directly south of East Finley. From the village of Gale southward the location of the crest is not clearly determined owing to the scarcity of recognizable outcrops.

### NINEVEH SYNCLINE.

The Nineveh syncline, which lies to the southeast of the Washington anticline, extends across the southeastern part of the quadrangle. It enters from the south, 2 miles from the southeast corner, and leaves the east border 2 miles directly east of Van Buren, near Cross Roads schoolhouse. Southeast from this trough the rocks rise again to the crest of the Amity anticline, which lies less than a mile beyond the southeast corner of the quadrangle.

### FINNEY SYNCLINE.

Northwest of the Washington anticline is the Finney syncline, the bottom of which crosses the south border of the quadrangle $2\frac{1}{2}$ miles from the southwest corner, near the junction of Rocky and Templeton runs. Its bottom is broad and irregular at the south line of the quadrangle, but rises and narrows abruptly to the northeast, the greatest contraction occurring 1 mile south of Fargo, where a low cross fold, with an indistinct northwest-southeast trend, raises the bottom of the syncline sufficiently to form a small basin to the north. At the point where Buffalo Creek crosses the East Finley and Buffalo township line there is another shallow trough, and from this the bottom on the syncline rises 60 feet to the next basin, which extends from a point a short distance south of Coffeys Crossing to Woodell and a mile farther west. From the northeast end of this basin the bottom of the syncline swings northward in an almost direct line toward the northeast corner of the quadrangle, rising about 100 feet per mile until it dies out against the high, broad dome near this corner. Stevenson[a] calls this trough the Mansfield syncline, con-

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[a] Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 31.

sidering it the southward continuation of the one crossing the Pennsylvania Railroad at Mansfield, Allegheny County, but since it appears to be entirely cut off from that syncline in this quadrangle it seems advisable to give that portion which lies within the quadrangle and to the south a new name.

### CLAYSVILLE ANTICLINE.

The next anticline west of the Finney syncline enters the quadrangle on its west border within 2½ miles of the southwest corner. From this point it has a general northeasterly trend, the crest line rising and falling in a series of domes and saddles, but continuously gaining in elevation northward until it culminates in a high, broad dome, the top of which lies in the Burgettstown quadrangle to the north of Gretna. This "high" covers the northern part of Chartiers and Canton and the eastern part of Hopewell townships to a point a mile south of Buffalo village, and from it the rocks dip in all directions except to the northeast. Between this point and the high dome 1½ miles north of Claysville the crest line of this anticline is very indistinct. These domes are separated by a broad, low saddle in which rises a tiny steep-sided dome of only a few hundred acres in extent lying half a mile north of Taylorstown. South of the dome near Claysville the crest pitches, with but a single small interruption, to the west edge of the quadrangle.

### WEST MIDDLETOWN SYNCLINE.

The West Middletown syncline enters the quadrange from the north, its starting point being northeast of West Middletown, and passes out on the west border near Buffalo Creek. About 1 mile north of the last-named location is the bottom of a deep basin from which the rocks rise steeply along the trough to the north boundary of the quadrangle. From this syncline northwestward the rocks rise about 300 feet before the corner of the quadrangle is reached.

### CONVERGENCE SHEET.

A number of measurements taken between the Upper Washington limestone and the Gordon sand at different points in the Claysville quadrangle show that these beds do not lie parallel over any considerable area, but that they converge more or less rapidly from southeast to northwest. Pl. XII is intended to show the rate of this convergence so far as it has been possible to determine it. The foci from which radiate straight lines represent wells at which measurements of the intervals between these beds were taken. The differences in the intervals shown by adjacent wells are laid off proportionately for each 5 feet of vertical change on a straight line connecting the wells. The isochor lines (curved lines on the drawing) are supposed to be drawn through points of equal distance between the beds. It can be readily seen, however, that in this way no account is taken of changes in the rate of convergence that may exist over local areas between wells, and that it is possible to refine the drawing indefinitely as new measurements between the beds are introduced. At several places in this quadrangle the evidence of a change in the rate of convergence between wells has been considered sufficiently strong to warrant the drawing of the isochor lines so as to cross the straight lines connecting wells at points other than those obtained by proportioning the distance. The most notable deviation of this kind from the regular method of making up the drawing is over a large portion of the lower right-hand corner. By placing the transparent convergence sheet over the map of the oil sand (Pl. XIII) it will be seen that a broad belt of very rapid convergence is shown to pass through the southern part of South Franklin, the northwest corner of Morris, and the southeastern part of East Finley townships. Evidence showing the existence of this rapid change in distance between the beds in the southern portion of the belt is presented by wells Nos. 956 and 948. In No. 956 the J. H. Irwin well No. 1, on Rocky Run, 1 mile west of the village of Gale, the distance between the Upper Washington limestone and the Gordon sand is 2,710 feet. In the Ben Farabee well (No. 948), 1 mile north of Old Concord, the distance, though not accurately determined, is about 2,805 feet, showing a change of 95 feet in the interval between these beds. On the convergence sheet this change is represented as occurring uniformly between the wells, but it is possible that the rate varies considerably, though there is no way of determining at what place these variations occur. From the Farabee well above mentioned to well No. 947, on the Lee Andrews farm one-half mile north of Lindleys Mill, the distance between the Upper Washington limestone and the Gordon sand increases only 20 feet. This increase, it should be noticed, is not distributed proportionately between the wells, and it is possible that the change in the rate of convergence just east of the Farabee well is even less abrupt than that shown by the isochor lines. Unfortunately, the J. L. Hogue well (No. 946), three-fourths of a mile east of Old Concord, did not reach the Gordon sand, and of the wells of Greene County a short distance south of this quadrangle none afford a good measurement between the Upper Washington limestone and the Gordon sand, so the isochor lines in that vicinity are drawn more or less hypothetically. At well No. 951, the B. C. McCarroll well No. 1 on Crafts Run, the distance between these beds is 2,780 feet, which shows a change of 70 feet between this well and the

Irwin well west of Gale. The David Craft well No. 2 (No. 953) shows the same distance as No. 951, and the J. S. Hunter well (No. 954), 1 mile farther north, shows the distance to be 2,776 feet, or a convergence of only 4 feet. In the Bell gas well (No. 828), 1½ miles northeast of well No. 954 and about 1 mile west of Van Buren, the distance from the Upper Washington limestone, which outcrops on both sides of this well, to the Gordon sand is but 2,701 feet, showing a convergence of 75 feet between this point and well No. 954. At the mouth of the S. J. Plymire well (No. 830) the exact elevation of the Upper Washington limestone is not known, but it is calculated with sufficient accuracy to give the distance between it and the Gordon sand within a few feet, the interval as determined being 2,732 feet. This shows an increase of only 31 feet, and is fairly conclusive evidence that the belt of rapid change in distance between these beds passes to the south of this well. This evidence is strengthened by the fact that the interval changes 93 feet between wells Nos. 830 and 947, mentioned above, as against 20 feet for the considerably longer distance between wells Nos. 947 and 948. Hence the proportional distance for isochor lines between wells Nos. 830 and 947 has been ignored, and relatively the same rapid change in distance between the beds is shown to the south of well No. 830 as was found to exist between wells Nos. 828 and 954 and also from well No. 956 to well No. 948. Good measurements to the Gordon sand in the Blackley Lindley well (No. 952) and the Booth heirs' well (No. 1100) would have definitely settled this point and admitted of the determination of the convergence throughout this area with much greater exactness. Though repeated efforts were made to procure the records of these wells, unfortunately neither of them could be obtained.

To the north and west from this belt of rapid convergence the interval between the beds decreases at a very regular rate, so far as can be determined. Over a broad strip along the west edge of the quadrangle no attempt has been made to show the convergence, because no data are at hand on which to base it. A sufficient number of wells have been drilled in this territory, but a most careful and persistent inquiry resulted in procuring only two of their records, and it is extremely doubtful if the others were preserved. At the J. R. McCleary well (No. 1121), of which a record was obtained, the elevation of the Upper Washington limestone could not be had. In the William Patterson well (No. 1120) the interval shown from the record to be 2,650 feet seems a little small, if judged from that given at wells Nos. 1125 and 1113. For want of more information in regard to the conditions farther west this measurement was not used. It will be seen from the isochor lines that northwest and north of the John N. Rush well (No. 1161) the distance between the beds increases. The straight lines radiating in those directions from this well are drawn to wells in the Burgettstown and Steubenville quadrangles, which go down to the Hundred-foot sand, the distance from this sand to the Gordon being estimated. Along these lines and in several other places throughout the quadrangle the isochor lines have not been drawn proportionally between wells, for the reasons given above.

## DISCUSSION OF CONDITIONS AS SHOWN BY MAP OF GORDON SAND.

### DESCRIPTION OF MAP.

Within this quadrangle every principal sandstone bed from the Gas sand to the Fifth has produced more or less oil or gas. Nearly all of this yield comes, however, from the Gantz, Gordon Stray, Gordon, Fourth, and Fifth, the Gordon easily leading both in area of producing sand and in amount of oil and gas furnished. On Pl. XIII wells getting their oil or gas from the shallow and upper sands, down to and including the Gantz, are represented in orange, those from this horizon through the Gordon in red, and those from the Fourth and Fifth in blue. In areas where each well produces from two or more of these groups alternate wells have been given the colors of the groups represented. Many records do not show from what group the oil comes; these and all dry holes, together with the structural contours on the Gordon sand, are also in red. The above outlined division is only a general one. A large number of wells in this territory have been exhausted and abandoned. Many of these old wells were not located in the course of the field work, and no information could be had in regard to some of those that were located. The incompleteness of the records also makes a correct grouping of all the wells impossible.

The Gordon sand lies between 1,000 and 2,000 feet below sea level. In order to avoid the confusion likely to arise from the use of minus elevations a datum plane 2,000 feet below sea level was selected from which to draw the structural contours on this sand. The contours are numbered in feet above this datum plane, and to ascertain the depth below sea level of the sand at any point it is necessary only to subtract the elevation of the contour at that point from 2,000 feet.

### STRUCTURE OF GORDON SAND.

The structure of the Gordon sand as shown by these contours conforms in a general way to that already given for the surface rocks, though in detail it is at many points quite different. The more important of these variations are referred to on page 55. This structure throughout the productive area is shown in greater detail than that of the surface rocks. Level lines were run to hundreds of wells in which the distance to the sand was given by the record, so that in most of this territory the mapping has been done from measurements made directly to the sands, thereby avoiding the use of the less accurate convergence sheet. For this portion of the quadrangle the map is probably almost as correct as the scale and contour interval will allow. For the southeastern and southern parts of the quadrangle the result is far less accurate, owing to the scarcity of wells and also because of the rapid and very unequal change in distance between the Gordon sand and the surface rocks, which renders the convergence sheet of little aid in working out the structure of the underground beds. In this portion of the sheet the general features are correctly represented, but an implicit dependence on the details as shown is not to be encouraged. In an area of this kind there are always more or less conflicting data, and the small structural features shown on the map simply represent the preponderance of evidence. However, it is believed that the map is sufficiently accurate to be of great value in drilling that portion of the quadrangle which still remains untested.

## DESCRIPTION OF OIL ANG GAS POOLS.

### WASHINGTON-TAYLORSTOWN OIL POOL.

The Washington-Taylorstown oil pool, together with its extensions to the south and southwest, embraces the entire productive area of the quadrangle, with the exception of a group of three small producing wells about 1 mile south of Point Lookout, with which this pool seems to have no direct connection. As may be seen from the map (Pl. XIII), one or more of the three groups of producing sands previously mentioned contain oil in the bottom and along the sides of the northern portion of the Finney syncline in a continuous belt from Washington to a point within half a mile of Claysville, and southward along the eastern slope of this trough to and around the nose of the Washington anticline, near the low saddle on Tenmile Creek. In this basin are finely revealed the conditions set forth on Pl. I (p. 16). More or less salt water is found in all the sands, but in no two is it at the same level. In each sand the lower edge of the productive belt lies directly above the top of the salt water in that bed, and, so far as the records reveal it, this line is practically horizontal. The upper limit of the productive belt in each bed is parallel to the lower edge only in a general way, the width of the belt being governed apparently by minor structural features and the dip, thickness, and porosity of the sands.

It will be seen from Pl. XIII (pocket) that the productive area of the Gordon sand lies in a broad belt around the steeply pitching crest of the Washington anticline at Washington and along the northern slope of the Finney syncline between the 580-foot and 680-foot contours. Throughout this area the Gordon sand has an average thickness of not more than 15 feet, being rarely 30 feet, and having a pay streak usually less than 10 feet thick. Nevertheless, it has been one of the most prolific sands in the region, a large number of the wells having had an initial flow of 100 to 500 barrels per day. Many of these were drilled ten to twenty years ago, but are yet being pumped. To the north and west from Taylorstown station the oil is derived entirely from this sand. It should be noted that the productive belt is widest where the rocks have the least dip. In the vicinity of Taylorstown the top of the Claysville anticline is flat, the crest line being very indistinct, and, as shown on Pl. XIII, it lies at least a mile farther to the west than the corresponding feature shown on the map of the surface structure (Pl. X, pocket). In the productive region along the eastern side of this anticline measurements were made directly to the sand in a large percentage of the wells, and the structure is mapped with great accuracy. The occurrence of several dry holes (Nos. 82, 83, and 720) and a gas well (No. 719) northeast of Taylorstown is inexplicable, so far as structure goes, all of them being clearly within the productive area as indicated by the structural map (Pl. XIII). The nonproductiveness of this spot may be due to the imperviousness of the sandstone over a small area, though the fact that well No. 719 is a small gas well would be somewhat against this view. No mention is made of the condition of the sands in the records of these wells. The records of wells Nos. 719 and 720 were used in making the structural map. Eastward from this point the width of the belt gradually narrows as the dip increases, and at the same time the productive area of the Fourth and Fifth sands overlaps more and more that of the Gordon sand group until in the vicinity of West Washington and a mile or so farther west most of the wells have obtained at least a showing of oil in all the sands below and including the Gantz, many of them having been pumped from three sands.

At the east end of the basin at Finney the Fourth and Fifth sands produce oil in about the same territory as the Gordon sand group, with the exception that the pool in the Gordon sand seems to extend farther to the south along the top and eastern slope of the Washington anticline. Most of the gas in the northern portion of this dome comes from the Fifth sand, the records showing but one well (No. 347) that obtained gas in the Gordon sand. On the northern side of the small basin west of Woodell the southernmost line of wells is in the Fifth sand. These all show salt water in the lower portion of the sand, with oil directly above. On the southern side of this basin after diligent inquiry, only the wells shown on the map could be found, and hence it is taken for granted that the evidence furnished by the dry holes (Nos. 380, 442, 417, 1200, and 1201, the records of none of which could be obtained) and by the presence of salt water in the Fifth sand in the row of wells to the north has been considered sufficient by the operators to condemn this country. The record shows that the Fifth sand in well No. 443 is "shelly," and it is possible that this territory is condemned because of poor sand in the Fourth and Fifth. Otherwise, if the sands are good, this area is not sufficiently tested, and a well put down a little less than half a mile due southeast of well No. 380 would have a good show of getting oil in any sand below the Gantz, and especially in the Fourth and Fifth sands. Should a test here show oil a detailed map on a large scale would probably be worth many times its cost.

In the bottom of the Finney trough to the east and south of Coffeys Crossing, the Fourth sand carries the greater amount of oil, though the Fifth is usually a good producer. In all the productive territory of the Fourth, it appears to carry very much less salt water than either the Gordon or the Fifth sand. Along the crooked bottom of the trough southwestward from Coffeys Crossing, the Fifth sand soon becomes the prominent oil-bearing bed. At well No. 544 this sand is 22 feet thick, carrying two streaks of coarse pebbly pay sand, 2 and 5 feet thick, with gas above. This well yielded 353 barrels of oil in the first twenty-four hours, and is still a good producer. In this area the Fourth sand carries gas, the Gordon salt water, and the Gordon Stray in many wells both gas and oil. The records of wells Nos. 489 and 499 were not obtained, and for this reason the structure of the small area surrounding them in which no wells are shown on the map (Pl. XIII, pocket) is to be taken with some allowance, though it is not far from correct. In this area the Gordon is doubtless filled with salt water, but there is no structural reason why both the Fourth and Fifth sands should not be productive. If these sands are good within the area, there are probably portions of them which contain oil.

Between well No. 554 and the west edge of the shallow basin east of Coffeys Crossing, the Fifth sand does not seem to carry much salt water, probably because the bottom of the trough pitches so steeply that the water has drained down into the next basin to the southwest. At dry hole No. 885 the Fifth sand is completely saturated, and it is likely to be found in that condition at all points within the basin below the 480-foot contour. Above this line around the sides of the basin there is a possibility of the sand carrying more or less oil. Southward from well No. 544 the productive belt seems to lie principally between the 540-foot and 590-foot contours, the oil coming from the Gordon Stray and Fifth sands, but mostly from the Fifth. It will be noted that a line of dry holes (records of which could not be obtained), beginning with No. 1092 at the north and ending with No. 1194 at the south, appears to mark effectively the western limit of this productive area. Well No. 1091, at the center of the saddle on the Washington anticline where it crosses Tenmile Creek, is a small producer in what is reported to be the Gordon sand, but according to the record of this well the interval between the producing sand and the Pittsburg coal is the same as that given in adjacent wells for the Gordon Stray sand, and it is possible that the producing sand has been incorrectly identified. The productive belt seems to pinch out at this point, but the chances of its extension to the southwest are discussed on page 63. On the north side of this basin, to the west of well No. 544, the Fourth and Fifth sands have been found productive as far west as Buffalo Creek, but so far as known none of the test wells put down west of this creek struck the sand at the right level to obtain oil.

Most of the oil coming from the Gantz and Fifty-foot sands is found in and to the west of Washington and around the head of the basin northwest of Woodell. These sands also carry more or less oil at a few other places, as shown on the map (Pl. XIII).

As stated elsewhere these sands together are equivalent to the Hundred-foot sand of the Burgettstown quadrangle. The original Gantz well (No. 1040) is in the borough of West Washington. This well was finished January 1, 1885, and was the first paying oil well drilled in Washington County. It flowed 50 barrels per day from the Gantz sand and was later drilled deeper and became a producer from the Gordon sand.[a] The Gantz sand is reported in all the detailed well records throughout the quadrangle, with a thickness ranging from 10 to 60 feet. Its greatest production comes from the eastern portion of the Washington-Taylorstown field. The Fifty-foot is also widespread and yields oil and gas in about the same localities as the Gantz. In only a few records is any mention made of salt water in these sands.

### POINT LOOKOUT OIL POOL.

The Point Lookout pool contains only three producing wells, all of which obtain oil in the Fifth sand. No information in regard to the condition of the different sands penetrated in these wells could be obtained, and the records fail to show the facts of most vital importance in regard to the extension of the pool, namely, the amount of salt water occurring in the different sands. Two dry holes (Nos. 876 and 798) have been drilled near enough to this territory to be of value in determining the direction in which to prospect, but unfor-

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[a] For the early history of the Washington field see Carll, J. F., Ann. Rept. Geol. Survey Pennsylvania for 1886, 1887, pp. 622–623.

tunately the records of dry holes seem to be considered by most operators as not of sufficient value to justify preservation. For this reason it can not be stated definitely whether this pool is at or near the top of the salt water, or is far above or below the line of saturation. It is possible for small accumulations to occur at almost any point because of local conditions in the sand or of structural features too minute to be shown on a small-scale map. If, however, the Fifth sand is of good quality at this place, and the wells are located at or near the top of the salt water, there is a possibility that the pool may be extended to the southwest along the strike of the rocks.

### BUFFALO GAS FIELD.

The Buffalo gas field includes all the gas territory on the high dome north of the Washington-Taylorstown oil pool. From it has been produced an enormous quantity of gas, which comes in varying amounts from all the principal sands below and including the Salt sand. Most of it, however, is obtained from the Salt, Gantz, Gordon, Fourth, and Fifth sands. Southwest of Buffalo and in one or two wells to the north, the Salt sand is a heavy producer. Northeast of Buffalo most of the gas comes from the Gordon, though some is from the Fourth and Fifth sands. Farther east the Gordon appears to be the most productive, so far as is shown by the records. Many of the wells in this sand are still producing. By an examination of the map (Pl. XIII) it will be seen that between the northern boundary of the Washington-Taylorstown oil pool and this gas field there is a narrow belt in which neither oil nor gas has been found. No explanation of this phenomenon is apparent. The information furnished by records of wells over this territory is very meager, and but little is known of the conditions of saturation in the shallow and upper sands, but in a number of places salt water is reported in the Salt and Big Injun sands, and less commonly in the Gas sand.

On the small dome north of Claysville are located a number of wells which obtain gas from the Gordon sand. On the high anticlinal nose jutting out southward from this dome well No. 1117 has a fine flow of gas from either the Thirty-foot or the Gordon Stray sand. South of this well some gas was found in the Fifty-foot sand in wells Nos. 1118 and 1115. According to report well No. 1110, in the southwest corner of the quadrangle, obtained a small flow of gas in the Dunkard sand. All other gas wells in this vicinity are small producers from the Big Injun and Fifty-foot sands.

In the small field near the head of Crafts Run, 3 miles west of Prosperity, gas is obtained from the lower portion of the Hurry-up or Big Dunkard sand, the Big Injun sand, and also some from the

Fifty-foot sand. The wells are all light producers, and the structural conditions are unfavorable for a great extension of this territory.

On the eastern slope of the Washington anticline, near the south end of the dome south of Washington, are a number of gas wells, the records of which were not obtained, though the facts learned in the field apparently indicate that most of these are producing from the upper sands.

### FAVORABLE LOCATIONS FOR NEW PRODUCTIVE TERRITORY.

As previously stated, the primary object of the work here reported was not to locate new oil pools. The suggestions herein made are merely intended to point out those places which, in the judgment of the writer, are worthy of more careful study.

From a study of the developed territory in the quadrangle it appears that the Finney syncline offers the best opportunity for further extension of the Washington-Taylorstown pool. The position of any productive territory in this basin to the south of the present line of development will doubtless be governed by the amount of salt water contained in the rocks. Unfortunately, the records of most wells outside of the developed area do not afford sufficient information regarding the condition of the sands and the amount of salt water contained in them to enable the writer to determine whether or not the sands are saturated, and, if saturated, to locate the upper limit of the water. In both directions from well No. 885 the top of the salt water in the Fourth and Fifth sands appears to be at about the 480-foot contour. It is possible, however, that this level does not persist over more than a small area of salt water held in the basin to the southwest of well No. 885, in a similar way to that found in the bottom of the basin east of Finney. In well No. 1116 water was found in the Gordon and a small amount of oil in the Fourth, but no mention is made in the record of salt water in either the Fourth or the Fifth sand, both of which are here reported to be of poor quality. In the records of wells Nos. 1114, 1115, and 1118 no mention is made of water in the sands. Well No. 955 is one of the pioneers of this region, and was drilled so long ago that even the owners of the farm do not remember the name of the company which drilled it. They claim, however, that a good showing of oil was found here, but it is not known from which sand it came. This being one of the early wells, it is probable that it was not drilled below the Gordon sand. The log of well No. 887 reports a small amount of oil in the Gordon sand, with water immediately below. The thickness of the sands in this well is reported as follows: Gordon, 43 feet; Fourth, 23 feet; and Fifth, 28 feet. No mention is made of water in the Fourth and Fifth sands. Aside from the general idea of the structure as shown by the contours, the facts above given comprise all that is known regarding the character of the Fourth and Fifth sands and the amount of salt water contained in them along the trough to the southwest of well No. 887. From this evidence it appears that the Fourth and Fifth sands are here above the main line of saturation, and that the chain of small pools in the shallow basins along the bottom of this trough are all that now remains of the salt water, which apparently once stood at a much higher level and which was later partially drained away, probably by a change in the rate and direction of the folding. From the above discussion the great value of an accurate detailed record of well No. 955 is apparent. If this well found the Fourth and Fifth sands to be of good quality and not saturated with water, the best chance for oil is about halfway between it and well No. 1116 and southward along the strike of the rocks to a point beyond Templeton Run. If the Fourth and Fifth sands were found to be saturated with salt water in well No. 955 and the sands are of good quality, all the region southeast of this well to the top of the dome and as far east as well No. 1091 is favorable territory. The dome southeast of Pleasant Grove may possibly be above the water line in the Gordon sand; in any case, it is worth testing for oil and gas through all the sands.

On the north side of the Finney syncline, west of Buffalo Creek, there is probably productive territory in the Fourth and Fifth sands somewhere on the slope between wells Nos. 907 and 1117, if the water level in these sands is at or near the 480-foot contour line. In this syncline, south of well No. 1116, the well records do not show salt water in the Fourth and Fifth sands. Well No. 1109 found some oil in the Fifth sand. These sands seem to be of poor quality, and if salt water does not appear to be plentiful in them prospectors will do well to keep toward the bottom of the trough until more is known regarding the height of the water line. The Gordon sand appears to carry water in this vicinity, in some places completely filling up the well.

On Rocky Run the record of well No. 956 gives water in the Gordon and some oil in the Gordon Stray sand. The gas wells on Crafts Run show water in the Gordon at about the 450-foot level, but no information is to be had regarding dry hole No. 1096. This well seems to be located too high on the structure to be productive in the Fourth or Fifth sands and too low to catch any oil or gas that may have collected above the salt water in the Gordon sand on the dome to the north.

In regard to the area southeast of the Washington anticline, but little can be added to what is shown by the structure. None of the records of wells in this area are complete enough to be of value in making deductions. Along the southern border from well No. 948 to No. 942 the area seems fairly well tested, though the well having the best structural position (No. 946) was abandoned a short distance below the Pittsburg coal. If productive this well should have found oil in the Fourth or Fifth sands, with water in the Gordon sand. The record of well No. 830 mentions no salt water, though doubtless the Gordon at least is saturated, but reports gas in the Fifth sand. It is possible that this well touches the Fifth sand above the salt-water line; if so, it would seem that a well near the edge of the quadrangle east of this point might find oil in the lower sands. In view of the analogy between this basin and the Finney trough, it seems remarkable that no productive territory has been found along its bottom or sides within the quadrangle. This may be accounted for by the facts that the Gordon sand is completely saturated in this region and that the Fourth and Fifth sands have no water in them, except possibly in the shallow basin at the south, or that the salt-water line in the last-named beds encircles the steep sides of the basin, with only a narrow belt of oil on the slope directly above. It may be that the wells of the Point Lookout pool get their oil from this belt and that accumulations at about this level may be found southwest of this field. These pools, if present, will be difficult to locate, however, owing to their narrowness, the steep dip of the rocks, and small inaccuracies in the map of the structure.

Practically nothing is known regarding the geologic structure and the conditions of the oil sands in that portion of the quadrangle for which no contours are drawn. On the convergence sheet are shown all the wells that have been drilled to date in the quadrangle or near enough to the west edge to make a knowledge of the conditions found in them of value in a study of the sands in the quadrangle. Except those of wells Nos. 1120 and 1121, not a single record seems to have been preserved. In other words, of the $40,000 or $50,000 expended in examining this region nothing remains except a dozen dry holes and a little hearsay knowledge handed down from mouth to mouth. Enough facts might have been secured by careful observation of the local conditions of the rocks passed through, the amount of salt water encountered, and by good measurements of distances between beds, to enable the geologist to outline clearly those remaining localities that are worth testing. It is quite possible that within this unmapped area there is valuable oil territory, but its discovery and exploitation will probably cost several more wells than would be necessary if the work were guided by a good structural map of the sands and a knowledge of their condition and degree of saturation at the points where they have been touched.

No record of well No. 1125 was found. The distance to the Pittsburg coal and Gordon sand, as remembered by persons residing in the vicinity at the time, was used in the mapping. Well No. 1175 has no record, but from all accounts no Gordon sand was found in it, nor in any of the wells in the unmapped area to the north. No. 1176 is a shallow well, but the others went below the horizon of the Gordon sand. In well No. 1132 the Gordon is made up of 10 feet of "shells." No information could be secured in regard to the other sands in this area, but the general impression seems to be that none of the lower sands are present.

# PART II.—DETAILED DESCRIPTIONS.

## CHAPTER I.

### GENERAL STRATIGRAPHY.

#### INTRODUCTION.

The second part of this bulletin is intended to include such detailed information as will assist in the further investigation of the area or of adjacent areas. For this purpose a description of the different members which make up the formations will be given, together with an account of their peculiarities and their positions relative to other members, all of which assist in the identification of the different marking strata. After this each quadrangle will be considered separately by townships, the topographic position of the outcrops of the principal beds that have been located being described.

The rocks to be considered include a section of about 3,000 feet, extending from a horizon near the base of the Devonian system nearly to the top of the Carboniferous.

The sequence of the formations is shown by the following section:

*General geologic section in Steubenville, Burgettstown, and Claysville quadrangles.*

| System. | Series. | Formation. | Approximate thickness. |
|---|---|---|---|
| | | | *Feet.* |
| Carboniferous | Permian | Greene | [a] 500 |
| | | Washington | 275 |
| | Pennsylvanian | Monongahela, including Pittsburg coal | 325 |
| | | Conemaugh | 500 to 600 |
| | | Allegheny | 250 to 350 |
| | | Pottsville | 150 to 350(?) |
| | Mississippian | Mauch Chunk | 0 to 100 |
| | | Greenbrier | 0 to 125 |
| | | Pocono | 750 to 850 |
| Devonian | | Catskill | |

[a] Greatest thickness.

In the detailed description of the rocks they will be considered by formations, those from the base of the Monongahela formation in ascending order to the highest strata found in the area being first discussed, and then each stratum from the base of the Monongahela down to the lowest oil sand concerning which reliable information has been obtained. The reason for thus commencing in the middle and going in both directions is that the Pittsburg coal, at the base of the Monongahela formation, is well known by all oil operators and engineers of the region and has long been used by them as a datum plane.

## FORMATIONS ABOVE THE PITTSBURG COAL.

### MONONGAHELA FORMATION.

The rocks from the base of the Pittsburg coal to the top of the Waynesburg coal are included in the Monongahela formation. This is one of the most important formations in the quadrangle, not only as to area covered, which includes the greater part of the surface of the two northern quadrangles, but also as to economic value. Economically the more important members of this formation are the Pittsburg coal, Benwood limestone, and Waynesburg coal.

#### PITTSBURG COAL AND ASSOCIATED ROCKS.

The important coal bed, known as the Pittsburg coal, lies at the base of the Monongahela formation. It is the most persistent coal bed known in the Appalachian field, covering much of southwestern Pennsylvania, eastern Ohio, and northern West Virginia.

In the three quadrangles considered the bed maintains a thickness of nearly 5 feet of workable coal. It is divided into four, and locally into five, benches by thin partings of clay or shale.

The conditions above the Pittsburg coal differ materially in different portions of the area investigated. In the eastern half of the Burgettstown quadrangle the upper division of the Pittsburg coal is present, consisting of alternate bands 6 or 8 inches in thickness of shale and coal which extend for a distance of 7 or 8 feet above the main bed.

In the northern part of the Burgettstown quadrangle and over most of the Steubenville quadrangle the main Pittsburg coal is overlain by shale and a bed of dark-blue limestone 1 to 2 feet thick, the top of which is from 8 to 20 feet above the base of the main coal bed. Above the limestone is a coal bed from 6 inches to 2 feet in thickness. This is known as the Pittsburg Rider or Rooster seam.

In the western part of the Burgettstown quadrangle and the eastern part of the Steubenville quadrangle the upper division of the Pittsburg coal and the rocks described above are replaced by the Pittsburg sandstone. This is a medium-grained brown sandstone from 12 to 30 feet in thickness. It has the appearance of being a fair building stone.

### REDSTONE COAL.

In a portion of the Burgettstown quadrangle the Redstone coal, a few inches in thickness, occurs 60 to 70 feet above the base of the Pittsburg coal. It is underlain by an easily disintegrating limestone. The coal is not present, however, over most of the area investigated.

### SEWICKLEY COAL.

The Sewickley coal, which is equivalent to the Meigs Creek coal of Ohio, is only 4 to 8 inches thick in the Burgettstown quadrangle and the eastern part of the Steubenville quadrangle. In the western and southern parts of the Steubenville quadrangle it increases in thickness to more than 2 feet and appears to be of good quality. The interval separating the Sewickley coal from the Pittsburg Rider coal is occupied by an unbroken deposit of shale 70 feet thick, locally rather sandy, especially in the lower portion.

### ROCKS BETWEEN SEWICKLEY AND UNIONTOWN COAL BEDS.

*General description.*—The rocks lying above the Sewickley and below the Uniontown coal are generally calcareous. In the early surveys of Pennsylvania this bed was called the "Great" limestone on account of its thickness (150 feet), which is unusual for a limestone bed in the coal-bearing rocks. Later it has been called the Benwood limestone, from the town of Benwood, W. Va., a short distance below Wheeling. In the area investigated this portion of the Monongahela has a thickness of about 100 feet and contains many beds of limestone, but they are not numerous enough to justify their grouping together into a distinct limestone member.

*Lowest beds.*—The lowest few feet of these rocks consist of thinly bedded limestone, which on weathering breaks up into slabs of a cream-white color. The space between the beds is filled with calcareous shale. Above this limestone is calcareous shale, but in a few localities it is overlain by a massive layer of light-blue limestone about 7 or 8 feet thick, with a conchoidal fracture and a smooth surface. This bed is rather impure, containing much clay. It is not persistent and in many places its position is occupied by yellow shale.

*Dinsmore limestone.*—About 35 feet above the Sewickley coal is a series of limestone beds which are so characteristic that they have been traced and identified through the entire area of the two northern quadrangles. For this reason they are considered as an independent member of the Monongahela formation and are named from the town of Dinsmore, Washington County, Pa. The total thickness of this member is about 4 feet. It is composed of a number of cream-white limestone beds from 4 to 8 inches in thickness. The spaces between the beds are filled with calcareous shale, which generally weathers out and leaves the limestone ledges in bold relief. This limestone is the most persistent feature of this part of the Monongahela formation.

The Dinsmore limestone is overlain by about 20 feet of shale, which is olive-green in color on top and red or yellow below.

*Bulger limestone.*—Above the shale just mentioned is another characteristic layer of limestone, which is treated as a separate member of the Monongahela formation and is named from the town of Bulger, Washington County, Pa. In the type locality it is prominent, forming terraces on the sides of the hills, and consists of a solid brown limestone from 1 to 2 feet in thickness, breaking with an uneven fracture and showing a number of small crystals of calcite. West of the type locality, in the Steubenville quadrangle, the Bulger limestone has a thickness of a foot or more, is of a muddy brown color, and breaks with a smooth fracture. Its stratigraphic position, however, remains constant, and it is underlain by the same green shale. It makes a reliable key rock in most of this region.

*Top beds.*—Usually four separate beds of limestone can be identified above the Bulger limestone, though they are not well developed in the Steubenville quadrangle. Immediately overlying the Bulger limestone is 15 to 20 feet of coarse calcareous shale, above which is solid limestone about 1 foot thick. This rock shows a yellow surface when weathered and is blue when freshly broken. The weathered surface always shows small protuberances, due to the presence of particles that are more resistant than the surrounding matrix. This gives it the appearance of being covered with small pimples, and by this peculiar and characteristic feature it may be easily recognized. Ten feet above this limestone is another about 1 foot thick, composed of two slightly different materials which on weathering give a spotted surface. This appearance is characteristic and serves to identify the rock wherever it is found. From 16 to 18 feet above the last-mentioned bed is a blue limestone, which on weathering has a white residue of clay upon its surface, but despite this fact the rock is easily distinguished from the other white limestone, for the blue generally shows through the surface color. A foot or so above this bed is the top stratum of the Benwood limestone. On a weathered outcrop this is a soft yellow limestone, but on fresh fracture it shows a brownish-red color. It disintegrates readily and is seldom found in a solid ledge. Usually its outcrop is marked by the presence of brown limestone nodules.

## UNIONTOWN COAL.

A few feet above the Benwood limestone is the Uniontown coal, which has little or no economic importance in these quadrangles. It is less than 1 foot thick, and its outcrop is in many places concealed by the heavy sandy shale above, which has a tendency to wash down and cover the coal. Above the Uniontown coal is an interval of 40 feet or more to the Waynesburg coal. This interval is occupied by yellow shale, with black sandstone layers.

### WAYNESBURG COAL.

The Waynesburg coal outcrops over the southern half of the Steubenville and Burgettstown quadrangles and the northern half of the Claysville quadrangle. It varies greatly in quality, and the thickness ranges from less than 1 foot in parts of Mount Pleasant Township, in the Burgettstown quadrangle, to over 5 feet near the junction of Buffalo Creek and Brush Run, in the Claysville quadrangle, where it has the following general section:

*Section of Waynesburg coal near Buffalo Creek and Brush Run.*

| | Feet. |
|---|---|
| Coal | $\frac{1}{2}$ to $\frac{2}{3}$ |
| Blue clay | $\frac{1}{6}$ to 2 |
| Coal with a variable number of thin shale partings | $2\frac{7}{12}$ to $4\frac{1}{2}$ |
| Fire clay | $\frac{1}{4}$ to 2 |

In Jefferson Township, in the Burgettstown quadrangle, and in the southern part of the Steubenville quadrangle the coal has a thickness of 3 feet or more, but is of poor quality, owing to the presence of many small partings of clay.

### WASHINGTON FORMATION.

The rocks from the top of the Waynesburg coal to the top of the Upper Washington limestone are included in the Washington formation. The Waynesburg coal at the bottom, the Washington coal near the middle, and the Upper Washington limestone at the top are excellent key beds. Between these prominent beds are a number of marking strata of minor importance. No general description can be given, however, that will apply to all localities. For careful geologic structural work the use of the smaller coal beds is not deemed advisable, for they are probably not continuous throughout the area.

### WAYNESBURG SANDSTONE.

Above the Waynesburg coal is a foot or so of shale, overlain by 6 to 8 inches of gray limestone. The limestone disintegrates easily and is in many places entirely wanting. Above the limestone is a sandstone which is locally massive, but much of which is so laminated as to closely resemble shale. The total thickness of the sandstone and shale is from 10 to 35 feet.

### WAYNESBURG "A" COAL.

The small coal known as the Waynesburg "A" is only a few inches thick. It is generally present in the Claysville quadrangle, being often found in two small layers 1 to 6 inches thick, divided by 1 to 3 feet of bluish clay. Above the coal is a hard blue limestone a foot or more in thickness. The distance of this coal above the Waynesburg is from 40 to 55 feet.

### WAYNESBURG "B" COAL AND ASSOCIATED ROCKS.

From 20 to 30 feet above the limestone overlying the Waynesburg "A" coal is a coal bed (the Waynesburg "B"), usually 1 foot or more in thickness, but locally wanting and here and there apparently split into two small beds 10 or 12 feet apart. Above the coal is a sandy shale which in places becomes massive. This in turn is overlain by a limestone, the bottom layer of which is about 18 inches thick, weathers to a light yellow, and shows a mottled gray color when freshly fractured. This layer resists weathering so well that it is usually found in rather bold outcrop. The top layer of this limestone is from 12 to 15 inches thick and of a bluish-gray color, in some places with a slight reddish tinge.

### LITTLE WASHINGTON COAL.

From 8 to 20 feet above the limestone just noted is the Little Washington coal, which consists of 6 inches to 1 foot of hard blocky coal, free from shale partings and apparently of good quality. This little coal bed is very persistent, being invariably present where its horizon is exposed, though it is easily overlooked because the hard coal makes little smut. The distance between this bed and the Washington coal above varies from 6 to 15 feet over small areas, but shows a much greater variation between widely separated parts of the quadrangles, the maximum distance found being about 28 feet.

### WASHINGTON SANDSTONE.

Between the Little Washington coal and the Washington coal is the Washington sandstone. This bed is from 5 to 25 feet in thickness. It is usually found in thin layers, which when closely examined are seen to be oxidized on the surface to a deep red, the interior being of a light-gray color and very micaceous, with numerous black specks of carbonaceous matter. In the vicinity of Washington, Pa., this sandstone is massive, with layers as much as 5 feet thick. Here the major part of the carbonaceous matter seems to be confined to indistinct bands running through the rock, roughly parallel to the bedding planes. The amount of carbonaceous matter is not so large as to affect the usefulness of the stone for building purposes. Remarkable variations in the thickness of the Washington sandstone may be noted in the cuts along the Baltimore and Ohio Railroad from Washington westward to Woodell station. Here the top of the bed, capped by the Washington coal, dips gently and evenly to the west, whereas the bottom of the bed, overlying the Little Washington coal, rises and falls in a series of undulations measuring from a few feet to 100 yards or more from crest to crest, the difference of thickness of the sandstone by this unevenness of its bottom being in places as much as 6 or 8 feet, though the usual range is from 1 to 3 feet.

### WASHINGTON COAL.

The Washington coal lies not far from the middle of the Washington formation. Next to the Pittsburg coal it is the most prominently outcropping and most easily recognized coal bed of the area investigated. It shows in outcrop in the southeast corner of the Steubenville quadrangle, in all townships south of the Panhandle Railroad in the Burgettstown quadrangle, and throughout the middle and northern portion of the Claysville quadrangle.

The general thickness of the Washington coal bed is from 7 to 8 feet. This total is made up by a succession of layers, about 6 inches thick, of coal and shale in the upper part of the bed and a bench of solid coal, from 2½ to 3 feet thick, in the lower part. The seams of shale in the upper part of the bed seriously affect the economic value of the coal, but in no way detract from its value as a guide to geology. If the coal is exposed in section, it can be readily recognized by its lower bench, the shale and clay partings along the center of the bed, and the 4-inch seam at the top overlapping 1 to 2 feet of fire clay.

### LOWER WASHINGTON LIMESTONE AND ASSOCIATED ROCKS.

Above the Washington coal is from 5 to 15 feet of coarse black and brown shale, which extends upward to the Lower Washington limestone. The bottom layer of this limestone is from 10 inches to 2 feet thick and bluish gray, with reddish streaks. The thickness and texture of this layer differ greatly in many adjacent localities. It is, in general, rather argillaceous and in many places weathers to a bright yellow. Overlying it are several thin layers of limestone, having a total thickness of 2 or 3 feet. These rocks are usually gray in color and have a somewhat slaty cleavage. They are succeeded by 10 to 18 inches of a yellowish-gray limestone, which shows on fresh fracture a steel-gray color. Overlying this limestone is from 5 to 6 feet of black or blue shale containing, in one or two places noted, a few inches of shaly coal. The next two limestone layers above this shale are of about equal thickness, amounting to a total of 4 to 6 feet. Both are somewhat cherty, have a steel-gray color on fresh fracture, changing to light gray when exposed to weathering, and disintegrate very readily into small, roughly cubical blocks.

Directly overlying the Lower Washington limestone is a bed of dark to black fossiliferous shale from 1 to 6 feet thick. Near the bottom of this shale there is exposed in numerous localities a thin bed of shaly coal, which, at a few places near Taylorstown in the Claysville quadrangle, attains a thickness of about 18 inches. This black shale is capped by 6 or 8 feet of yellowish shale, which merges into a reddish thin-bedded sandstone, usually from 5 to 20 feet thick. This sandstone varies greatly in thickness, in places being massive and filling the entire interval between the Lower and Middle Washington limestones, with the exception of a few inches of black and yellow shales at the top and bottom. In an old quarry once operated by the Baltimore and Ohio Railroad, on Buffalo Creek, one-fourth mile south of the "S" bridge, the bed is between 40 and 50 feet thick, with a single 20-foot layer near the bottom. Above this sandstone is usually 4 to 6 feet of brown shale to the bottom of the Middle Washington limestone.

### MIDDLE WASHINGTON LIMESTONE.

The Middle Washington limestone lies from 50 to 65 feet above the Washington coal. It consists of several limestone layers separated from each other by a few inches to 2 or 3 feet of shale, and having a total thickness of 10 to 30 feet. There are but four layers in the bed that are at all easily recognized—a 2 to 6 inch deep-pink ledge at the bottom, two yellow ledges about the middle, and near the top a 6 to 8 inch cream-white layer which has a dark mottled color on fresh fracture, the white appearing on the outside as if the stone had been painted. The yellow layers are from 1 to 2 feet thick. The lower one is about double the thickness of the upper, is very prominently exposed, and may be easily recognized by its tendency to exfoliate when exposed to weathering. The other layers of the bed are usually from 6 inches to 2½ feet thick, in color bluish to gray and steel gray on fresh fracture.

For about 35 feet above the Middle Washington limestone the rocks are, in the main, shaly sandstones, which at places occur in massive layers from 3 to 5 feet thick. Above these sandstones is usually from 5 to 15 inches of soft shaly coal (the Jollytown coal of Stevenson[a]) of no geologic or economic value. This coal is overlain by 50 to 65 feet of yellowish to reddish shales and sandstones that extend to the bottom of the Upper Washington limestone.

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[a] Stevenson, J. J., Second Geol. Survey Pennslyvania, Rept. K, 1876, p. 48.

### UPPER WASHINGTON LIMESTONE.

The Upper Washington limestone, the top member of the Washington formation, is the most important guide rock above the Washington coal, from which it maintains a fairly constant distance of 165 feet. It is a heavy and persistent limestone bed, having two or three characteristic layers that render its identification easy. It appears in outcrop at few places in the Burgettstown quadrangle, but is generally exposed over the entire area of the Claysville quadrangle. This bed is thickest in the vicinity of Washington, where it consists of ten to twelve layers of limestone varying from a few inches to 3 feet in thickness and separated by partings of shale. The lowest layer of this bed is a rusty-brown limestone from 1 to 2 feet thick, which, on fresh fracture, is of a dark steel-gray color and shows numerous tiny crystals of calcite. The next three or four layers are nearly identical in general appearance. They have a total thickness of 6 to 7 feet, are of dark to reddish-brown color, very hard and tough, and of irregular fracture, and some of the layers have numerous calcite crystals. They generally weather to a rusty cream color, though a small layer toward the bottom of this group weathers locally to a light reddish yellow. Above this group is a hard, thin-bedded, dark-brown limestone from 8 inches to 2 feet in thickness. It is argillaceous in places, breaks rather easily with an uneven fracture, and weathers to a rusty cream color. This is the only layer in the lower portion of the Upper Washington limestone that may be easily recognized, and is one of the important markers of the member. The weathered surface of this rock has a rough, finely striated, filelike appearance, by which, when it has once been identified in the field, it may be recognized at a glance. From 3 to 5 inches of coarse brown shale separates this layer from the one above, which is a dark reddish-brown limestone in two beds having a total thickness of about 2½ feet. It is very hard and tough and weathers a rusty cream color. The face of a fractured portion of this limestone presents a crimped appearance around the edges. Above these layers is from 6 to 8 inches of coarse black shale. The next limestone above is dark gray, very hard, and somewhat cherty, and breaks easily under the hammer into small cubical blocks. Around Washington this layer is one of the thickest in the bed, being from 2½ to 3 feet in thickness. It is, however, variable both in quality and quantity, and in many localities is wanting. Overlying this limestone is from 3 to 6 inches of coarse black shale, which in the type locality around Washington directly underlies a few inches of thin-bedded sandstone. In various portions of the Claysville quadrangle this shale and sandstone appear to thicken greatly at the expense of the underlying limestone. At a few places the shale was found to be rather carbonaceous, carrying tiny partings of coal, with a total thickness of 3 or 4 inches. The limestone layer directly overlying this shale is cream white, but has a dark mottled appearance on fresh fracture. It appears locally as two ledges 1 to 2 feet thick, with a parting of calcareous shale. It is overlain by a layer of soft black shale from a few inches to a foot or more thick, which on weathering has a mealy, frosty-white appearance. Above this shale is a light-buff, thin-bedded, argillaceous limestone, from 1 to 3 feet in thickness, which weathers to a bluish white. This layer is thickest in the vicinity of Washington, where it assumes a massive appearance, but is easily recognized by its tendency to break into thin sheets. In the vicinity of Good Intent this layer is very much darker and has the mottled appearance of the top layer, described below, resembling it closely both on fresh fracture and when exposed to the weather. Overlying this layer is from 1 inch to 3 feet of black shale, and this is in turn overlain by the top layer of the bed, which is from 6 inches to 2 feet thick, very hard and brittle, dark to black on fresh fracture, and cream to snowy white on weathering. Weathered portions of a ledge of this layer when broken present a peculiar brown-black mottled appearance, which, as already stated, is also characteristic of the third layer from the top. In fact, the three top layers of this bed form a group whose outcrop is always easily recognized.

### GREENE FORMATION.

Only the lower portion of the Greene formation is present in the area studied, and that to a very small extent except in the Claysville quadrangle. Its greatest thickness of 475 feet occurs in Morris Township, on the dividing ridge between Washington and Greene counties.

### UPPER WASHINGTON COAL.

Above the Upper Washington limestone, the top of which is the base of the Greene formation, the rocks are different in many adjoining localities. Dark shale with a thickness of 3 to 15 feet is most common, though the same interval is in many places filled by argillaceous sandstone. Above this is the Upper Washington coal, consisting of 1 to 5 feet of black bituminous shale, in which are frequently found embedded thin layers of coal. The shale is uniformly present, but the coal is variable, its maximum thickness being not more than 14 inches, including shale and clay partings. White [a] calls this the Jollytown coal, though Stevenson [b] designates a coal farther down in the series by that name and calls this the

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[a] White, I. C., Geol. Survey West Virginia, vol. 2, 1903, p. 111.
[b] Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 48.

Upper Washington coal. Above the black bituminous shale is from 5 to 20 feet of gray laminated sandstone, reaching within a few inches of the Donley limestone.

### DONLEY LIMESTONE.

For the most widespread and uniform limestone in the Greene formation throughout the Claysville quadrangle the name Donley is here proposed. It is from 18 to 45 feet above the bottom of the formation, and in this quadrangle is invariably present where its horizon comes to the surface. In the vicinity of Donley, Donegal Township, a typical section shows this limestone in three or four layers, having a total thickness of 5 or 6 feet. The characteristic feature is its dark, rusty, lichen-covered surface when exposed to weathering. The limestone is very hard and tough, and fractures unevenly with a dark steel-gray to almost black color, having a very coarse grain and showing numerous calcite crystals. The bed is also distinguished by its peculiar jointing, which has a striking resemblance to that of dry mud, the blocks being irregular in shape and from 1 to 3 feet in diameter. The joints are usually very distinct, many of them being from 1 to 3 inches wide, filled with dark red clay.

### SPARTA COAL AND ASSOCIATED ROCKS.

Above the Donley limestone is a sandstone with a thickness of 15 to 20 feet, usually of a light-gray color and laminated, but in places consisting of several massive ledges. Above this is a few feet of reddish shale which reaches to the Sparta coal, the most important coal bed of the Greene formation. The coal is from 6 inches to 3 feet thick. It attains its greatest thickness in the vicinity of East Finley, where it was once mined, though all banks have long since been abandoned. Those who have used it say that the best of it is somewhat rusty in color, makes a hot fire, and burns to a small white ash.

### PROSPERITY LIMESTONE.

The next distinctive member above the Sparta coal is a rusty-yellow limestone, having a maximum thickness of 10 or 12 feet, which is here named the Prosperity limestone, from the village of that name in Morris Township. The top layers are in places light bluish, fracturing irregularly with a dark-gray to rusty-black color, and very coarse grained. The other layers are dark gray to buff on fracturing. This limestone is fairly persistent over the southern half of the Claysville quadrangle, being present on all the hillsides in the vicinity of Pleasant Grove. Its heaviest outcrop is northeast of Pleasant Grove, along the top of the ridge between East Finley and South Franklin townships.

### DUNKARD COAL AND ASSOCIATED ROCKS.

About 125 feet above the bottom of the Greene formation there is a fairly persistent but thin layer of bituminous shale which locally occurs as a coal bed a few inches thick. This is probably the Dunkard coal, as named by Stevenson,[a] though the fewness of the exposures noted makes this correlation somewhat doubtful.

For 100 to 125 feet above the Dunkard coal bed are reddish laminated sandstones and shales, in which two or three thin beds of limestones occur. At one or two places in the vicinity of East Finley a small coal smut was noted in these rocks at about 155 feet above the top of the Upper Washington limestone, but the bed appears to be only of local extent.

### CLAYSVILLE LIMESTONE AND ASSOCIATED ROCKS.

From 205 to 225 feet above the base of the formation lies a limestone, separated into two layers by 6 to 8 feet of yellow shale. The top layer is from 6 to 8 inches thick, bluish white, and dark brown on fresh fractures. The bottom layer is here and there as much as 18 inches thick, weathers with a rough surface to a reddish or yellow color, and is a dark gray on fresh fracture. This limestone is present over a considerable area in the southern and western parts of the Claysville quadrangle. In the northern part of East and West Finley and Morris townships it is a rather compact bed, from 6 to 8 feet thick, the top layers being heaviest and all having a dark-gray color. Since it can not be correlated with any bed previously named and is among the most prominent limestones of the Greene formation in this section, it has been thought advisable to call this bed the Claysville limestone, from the town of that name in Donegal Township, Washington County.

Above the Claysville limestone are 50 or 60 feet of reddish and dark-colored shales, in which at irregular intervals are embedded thin sandstone layers. These shales are overlain at many places by 2 to 6 feet of light-gray to brown limestone. The top layer is heaviest, and on fracturing is light buff; the lower layers are very thin and easily disintegrate to small gray nodules. Above this limestone is a few inches of carbonaceous shale and 25 or 30 feet of reddish shales, capped by 10 or 15 feet of thin grayish laminated sandstone.

### NINEVEH COAL AND LIMESTONE.

About 325 feet above the base of the Greene formation and 100 feet above the Claysville limestone is a rather persistent coal bed, from 6 inches to 1 foot in thickness. This is probably the Nineveh

[a] Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 35.

coal, though it is not present over a sufficient area to permit a definite correlation. It is usually underlain by about 10 feet of reddish shale, below which is 2 or 3 feet of bluish clay or shale, overlying 4 or 5 feet of bluish-white to cream limestone in two or three rather massive layers, very hard and tough, and a light buff on fracturing. This limestone caps the tops of many of the highest hills in Morris and East and West Finley townships.

A few feet above the Nineveh coal is a small gray limestone a few inches in thickness. This small limestone is overlain by about 50 feet of laminated sandstone, which extends to a rather prominent layer of bluish-gray limestone from 1½ to 2½ feet thick, very hard, and with a dark-brown mottled appearance on fresh fracture. This is one of the most prominent beds in the Greene formation.

## FORMATIONS BELOW THE PITTSBURG COAL.

### CONEMAUGH FORMATION.

The Conemaugh formation lies below the Monongahela, extending from the base of the Pittsburg coal to the top of the Upper Freeport coal. It is a mass of shale and sandstone nearly 500 feet thick and contains little of economic importance. Few of its beds have distinctive characteristics by which they may be used as key rocks for the determination of the position of other beds. The strata are described from the top downward.

#### INTERVAL BETWEEN PITTSBURG COAL AND AMES LIMESTONE.

Below the Pittsburg coal is a limestone that occurs here and there in two beds. The upper and more persistent bed maintains a thickness of 1 to 2 feet. It is hard, shows a blue color on fresh fracture, and weathers to a bluish white. The lower bed is brownish red, and in places it is as thick as the upper bed, but at many points it is wanting.

The interval from these limestones to the Ames limestone is occupied by shales and flaggy sandstone having a thickness of about 200 feet. Near the Ames limestone these rocks give way locally to a massive brown sandstone from 10 to 20 feet thick. In some places the sandstone lies directly above the Ames limestone, and in others it is separated from the limestone by red shale 10 to 15 feet thick.

#### AMES LIMESTONE AND COAL BEDS.

At about the middle of the Conemaugh formation is a group of beds that are very persistent and easily recognized. They consist of the Ames limestone and adjacent coal beds. The limestone ranges from a few inches to 8 feet in thickness. It is of a light gray color in outcrop, but when freshly broken shows a crystalline fracture with a greenish tinge. Its upper portion is crowded with fossil crinoid stems and brachiopods. From the abundance of crinoid stems this bed is often spoken of as the "crinoidal" limestone. In its greatest development it consists of two benches which are fossiliferous, but the upper bench carries the larger number of fossils.

Two small coal beds are closely associated with the limestone. The upper bed, which is from 1 to 20 feet above the limestone, is not more than 1 foot thick. The lower bed is more constant and usually maintains a distance of 20 feet below the limestone, although here and there it occurs directly beneath that bed. This coal is in many places 1½ to 2 feet thick and breaks from the bed in long rectangular blocks.

### CAMBRIDGE LIMESTONE.

About 95 feet below the Ames limestone is another limestone of similar composition and appearance. It probably contains a greater number of brachiopod shells, but the fragments of crinoid stems are much less abundant. This bed is commonly known as the Cambridge limestone, from its occurrence at Cambridge, the county seat of Guernsey County, Ohio. It was positively identified at only two points in the Steubenville quadrangle.

### MAHONING SANDSTONE.

The lowest member of the Conemaugh formation is the Mahoning sandstone, which is rather coarse and of a light yellowish-gray color. It varies from 30 to 60 feet in thickness and has some value as a building stone. It is also a good water-bearing stratum when under cover. In places it is rather prominent, but not persistent, and in many localities it appears to be displaced by shale.

### ALLEGHENY FORMATION.

The Allegheny formation includes all the rocks from the top of the Upper Freeport coal to a horizon about 100 feet below the Lower Kittanning coal. This group of strata is important economically because of the coal and fire clay contained in it. In the area investigated it carries five coal beds, each of which is mined at some place in the area, although as a rule not more than two are mined in any one locality. This formation also contains a few beds of limestone, but generally they are thin and inconspicuous.

### FINLEY COAL.

The Finley coal of the Steubenville quadrangle is believed to be equivalent to the Upper Freeport coal of Pennsylvania, though this is not considered proved. It varies greatly in thickness, changing from a bed 5 feet thick in one locality to a mere streak of coal a few miles away. Usually this coal is underlain by limestone and overlain at a distance of a few feet by a heavy sandstone.

### ROGER (UPPER KITTANNING) COAL.

The Roger coal bed occurs about 100 feet below the Finley coal. Considerable uncertainty exists regarding the correlation of this coal bed with the type section of Pennsylvania. Orton [a] considered that it was equivalent to the Lower Freeport of Pennsylvania. From data collected during the present survey, especially in the valley of Kings Creek, West Virginia, it seems probable that this coal bed does not maintain regular distances to the coal and limestone beds above and below, but that it varies within rather wide limits, while the interval between these coal and limestone beds remains constant. The coal is from 3 to 4 feet thick and has a parting 14 to 16 inches from the bottom. It is of good quality and has been extensively mined. Generally the bed is overlain by light-yellowish shale, which changes to sandy shale above.

### MIDDLE KITTANNING COAL AND ASSOCIATED ROCKS.

From 80 to 100 feet below the Roger coal is the Middle Kittanning bed. This attains in but few places a thickness of 3 feet. It appears to be of fair quality, but is not extensively mined. Overlying the coal is a heavy bed of light-colored sandstone that has a thickness of 50 to 80 feet. Below the Middle Kittanning coal is a sandstone 15 to 20 feet thick, which reaches within a few feet of the Lower Kittanning coal. These two sandstones, one above and the other below the Middle Kittanning coal bed, probably represent the first and second Cow Run sands noted in many well records.

### LOWER KITTANNING COAL AND FIRE CLAY.

The Lower Kittanning coal is from 2 to 3 feet thick and is underlain by a bed of fire clay from 8 to 12 feet thick. The coal is high in sulphur and is sometimes spoken of as the "sulphur" bed. The clay varies considerably in appearance. The upper portion is of a light cream color in outcrop; the lower has disseminated through it crystals of pyrites that give it a yellow appearance on weathering. On fresh fracture the upper portion is of a light dove color, breaking with uneven fracture and having a soapy feel. The lower portion is much darker, though giving a very light streak.

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[a] Orton, Edward, Geol. Survey Ohio, vol. 5, 1884, pp. 49–62.

The Lower Kittanning coal is not generally mined for commercial purposes, owing probably to the high percentage of sulphur which it contains. The clay below the coal is extensively developed and used for the basis of a large pottery business along Ohio River.

POTTSVILLE FORMATION.

The Pottsville formation includes the rocks from the Homewood sandstone to the unconformity described on page 15. In this region the Pottsville was deposited upon a subsiding land area, which consequently had a migrating shore line. For this reason it generally consists of coarse sandstones and conglomerates that were thoroughly washed by the waves and currents. The finer sediments were sorted from the coarse material and carried far out into deep water, while the coarser sediments were deposited along shore.

HOMEWOOD SANDSTONE.

The Homewood sandstone, the uppermost member of the formation, is probably represented in the well records by the Gas sand. This may be true, however, only in part of the records, and in others the sand called the Gas sand may be the equivalent of the Connoquenessing sandstone below the Mercer coal.

MERCER COAL.

In the records of some of the deep wells in the northern part of the Steubenville quadrangle are notes of one or two coal beds above the Salt sand. It is difficult to class these coals, owing to the lack of detailed information, but it seems probable that they occur below the base of the Allegheny formation, and, therefore, possibly represent the Mercer coal beds of the Beaver Valley in western Pennsylvania. In the type locality the Mercer coals occur between the Homewood and Connoquenessing sandstones, but in the Steubenville well records no sandstone is noted immediately above the coals, and hence it seems probable that the Homewood sandstone is not extensively developed in this region. The data are not sufficient to make definite correlations, but the preponderance of evidence seems to indicate that these are Mercer coals.

SALT SAND.

The Salt sand is a coarse white sandstone 20 to 30 feet thick. Usually it is saturated with salt water, and from this condition it receives its name. Below the Salt sand is an irregular bed of shale ranging in thickness up to 20 feet. With the evidence at hand it is impossible to say whether this bed is a part of the Pocono sandstone or whether it belongs to the Pottsville formation. It seems probable that the latter is true and that it is the first member laid down on the eroded surface.

## ROCKS BELOW THE POTTSVILLE FORMATION.

### UNCONFORMITY BETWEEN THE MISSISSIPPIAN AND THE PENNSYLVANIAN SERIES.

In the Appalachian region south of the Steubenville quadrangle the Pocono sandstone is overlain by the great Greenbrier ("lower Carboniferous") limestone, which first appears in the section in the southern half of the Steubenville quadrangle as a thin wedge. This increases in thickness rapidly to the south until in the Tennessee region it attains a maximum of more than 1,000 feet.

In the northern half of the Appalachian region this great limestone mass is overlain by an immense body of red shale which reaches its maximum development of 5,000 to 8,000 feet in thickness in eastern Pennsylvania, where it is known as the Mauch Chunk shale. This shale does not appear to be present in the three quadrangles investigated. The nearest point of outcrop of the Greenbrier limestone and Mauch Chunk shale is in the Chestnut Ridge of Pennsylvania and northern West Virginia, where both formations are present, but with a maximum thickness of not more than 300 feet. From the numerous drill records in southwestern Pennsylvania it is possible to trace the red shale to the northwest as far as Washington, Pa., and the Greenbrier limestone a short distance beyond. Beyond these points there are no traces of the formations, either in outcrop or in drill records.

From recent studies[a] in the northern Appalachian coal field it has been demonstrated that the absence of these formations and also of a large part of the lower portion of the Pottsville is due to a great unconformity which exists on the western side of the Appalachian coal field between the Mississippian and Pennsylvanian series of rocks. After the deposition of the Mauch Chunk shale, which was probably laid down throughout the Appalachian province, the rocks on the northwestern side of the province were elevated above sea level, forming a land mass in what is now northwestern Pennsylvania, Ohio, Kentucky, and Tennessee. Erosion was active on this land area and most, if not all, of the Mauch Chunk shale and the Greenbrier limestone was removed. This area continued above water level until at least two-thirds of the Pottsville formation was deposited in

[a] White, David, Fossil floras of the Pottsville formation in the Southern Anthracite field, Pennsylvania: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 751–930; Deposition of the Appalachian Pottsville, Bull. Geol. Soc. America, vol. 15, 1904, pp. 267–282.

the anthracite region to the east. It was then depressed below water level and sedimentation was resumed, but the conditions were those of fresh or brackish water and the coarse conglomerates and sandstones of the upper Pottsville were deposited. The eroded surface upon which they were laid down was somewhat irregular, and consequently the parallelism of the beds above and below this line of unconformity is not exact.

### KEENER SAND.

The Greenbrier limestone is usually divided into two sections by a small sand rock, which is known as the Keener sand.

### BIG INJUN SAND.

The Pocono sandstone, which is known to the drillers as the Big Injun, has a thickness of 100 to more than 200 feet. Generally it is a fine-grained homogeneous sandstone, and is white, yellow, or almost any color, except red. In some localities there is a "break" or layer of shale in the lower part of this formation, which is spoken of by some drillers as the "break in the Big Injun." By other drillers the sandstone below the "break" is regarded as a separate bed, and is called the Squaw sand.

### CUYAHOGA SHALE.

The Pocono sandstone is underlain in Ohio by a soft blue and gray shale, more than 300 feet thick, which is known as the Cuyahoga, from its outcrop in Cuyahoga County, Ohio.

### BITTER ROCK SAND.

In Pennsylvania a sandstone is present in the Cuyahoga shale at a point about 100 feet from the bottom. This sand is known as the Bitter Rock, from the large amount of salt water contained in it.

### SUNBURY ("BEREA") SHALE.

Below the Cuyahoga shale is a very dark or black shale, about 25 feet thick, which lies directly above the Berea sandstone. This is known as the Sunbury shale, from its outcrop at that place, in central Ohio.

### BEREA SAND.

The Berea sandstone, named by Newberry from the village of Berea, Cuyahoga County, Ohio, is the great oil-producing bed of eastern Ohio. It is a fine-grained white sandstone. Generally the upper portion of the bed, for a distance of 12 to 20 feet, is cemented into a hard impervious rock, which is often called the "limestone cap." This term is somewhat misleading, for in no case can it be considered a limestone, although the cementing material may be in part calcareous. This portion of the rock is hard to drill, and is brought to the surface by the bailer in flakes, some of which are nearly half an inch in diameter. Below the "limestone cap" the rock is soft and easy to drill, appearing as a pure white sand, which is known to the drillers as "pay" sand. This sand may continue to the bottom of the bed, but in some places it grades downward into a hard white sand. The position of the "pay" sand varies somewhat from place to place. In some wells it occurs 6 to 12 feet from the top of the bed and in others 24 to 30 feet from the top. In still other wells no pay streak has been encountered, and the rock is a hard cemented sand from top to bottom. The thickness of the pay streak varies greatly. In some wells it is only a few inches to a foot in thickness and is divided by layers of hard rock.

Over considerable areas the Berea sand is divided into two parts by a thin bed of shale. In such places the lower part is often spoken of as the "second-pay" sand, and in some wells it has been the source of valuable oil production.

In eastern Ohio few wells have been drilled below the Berea sand, and consequently little is known regarding the presence or absence of lower sands, but in Pennsylvania the Berea is represented by the "thirty-foot shells," below which most of the oil-producing sands have been found.

### HUNDRED-FOOT SAND.

The Hundred-foot sand is about 190 feet below the Berea sand and 100 feet below the red shale. It is a gray sand of medium fineness, containing white quartz pebbles as large as small peas. It receives its name from its thickness in Butler County, Pa.

### GANTZ SAND.

In parts of Washington and Greene counties the top part of the Hundred-foot sand is named the Gantz, and the sand below the first "break" is the Fifty-foot. It is probable that these two sands are together equivalent to the Hundred-foot.

### NINEVEH THIRTY-FOOT SAND.

The position of the Nineveh Thirty-foot sand is 100 feet below the top of the Hundred-foot. It is gray in color and very fine grained.

### GORDON SAND.

The Gordon sand is about 210 feet below the Hundred-foot. It varies from a knife-edge to 60 feet in thickness in the Claysville quadrangle, with an average of 15 or 20 feet. It is a fine gray sandstone, usually containing near the middle of the bed a band 2 to 12 feet thick, which is more or less conglomeratic. This portion is made up of fine white to gray sand and well-rounded quartz pebbles up to the size of a bean. There is a break in the sand near the top, which thickens to the south across the Claysville quadrangle, until in places the two portions of the sand are separated by 25 feet of shale. In this condition the upper portion is called by drillers the Gordon Stray sand. North of the Claysville quadrangle the Gordon Stray, as a distinct sand, is mentioned in the records of few wells.

### STRAY-STRAY SAND.

In parts of the Claysville quadrangle another thin sandstone bed a few feet above the Gordon Stray is noted in a number of detailed records. This is usually called by drillers the Stray-Stray sand. It is apparently of local extent only, and from the information at hand it is impossible to say if the sand is a part of the Gordon Stray or a separate lenticular sandstone in the shale above.

### FOURTH SAND.

The Fourth sand is from 60 to 70 feet below the Gordon. It is a white to grayish sandstone, much of it conglomeratic. In thickness it ranges up to 35 feet, averaging between 10 and 20 feet. It underlies about the same area as the Gordon sand, but is not so constant either in thickness or quality.

### FIFTH SAND.

The Fifth sand is from 95 to 120 feet below the Gordon sand. It is usually a fine white sand, carrying irregular lenticular patches of conglomerate. In the Claysville quadrangle it is rarely over 15 feet thick, but is fairly constant both in thickness and quality over the eastern half of that quadrangle. Over the western half this sandstone, as well as the Gordon and Fourth sands, is wanting in many places. This is especially true of a large area in the northwestern quarter of the quadrangle, where the sandstones are missing or are represented only by a few thin "shells." The Fifth sand is the lowest usually reached by the drill in the area investigated, though a few wells report a sand called the Sixth or Bayard, and below this one called the Elizabeth sand.

# CHAPTER II.

## DETAILED GEOLOGY OF THE STEUBENVILLE QUADRANGLE.

In this chapter a concise statement will be given of the more important formations outcropping in the different townships, and a description of the condition of the prominent marking bed in different parts of each township. The intervals obtained by comparing the elevations of different beds will be given in tabulated form.

### KNOX TOWNSHIP, JEFFERSON COUNTY, OHIO.

Knox Township, which reaches beyond the northern limit of the quadrangle, presents a geologic section from the middle of the Monongahela to the base of the Allegheny formation. Town Fork of Yellow Creek has cut a deep valley in the west side, and Ohio River bounds it on the east side. The formations rise from a point west of Knoxville both to the east and west, and slightly to the south.

*Benwood limestone.*—Along the ridge pike from Knoxville to Osage the lower ledges of the Benwood limestone occur in the hills.

*Meigs Creek coal.*—On both the north and the south sides of this ridge the Meigs Creek coal outcrops some distance from the summit. It is associated with shale, and has a thickness of less than 2 feet.

*Pittsburg coal.*—Northwest of Knoxville the Pittsburg coal outcrops at the base of the hills. From this point it rises rapidly to the east, reaching the top of the higher summits in a north-south line about 1 mile east of Knoxville. To the west also the coal rises, but not so rapidly. Along the ridge road from Osage to Richmond it is caught by the higher knobs. In the central part of the township the coal is well under cover, and has been opened for mining in a number of places. The bed is generally accompanied by two limestones, one from 11 to 13 feet above and the other from 1 to 5 feet below. It is also accompanied by the small Rider coal bed, which maintains a distance of 25 to 30 feet above the main bed. Two determinations were made of the interval between the Meigs Creek coal and the Pittsburg coal, as follows:

*Distance between top of Meigs Creek coal and base of Pittsburg coal, Knox Township, Ohio.*

| | Feet. |
|---|---|
| On road directly north from Knoxville | 103 |
| On private road to coal bank 1 mile southwest of Knoxville | 102 |

The interval of 70 feet between the Rider coal and the Meigs Creek coal is mostly occupied by shale and sandy shale.

*Ames limestone.*—The Ames limestone is well developed throughout the greater portion of the township wherever its horizon comes to view. Halfway down the slope into Town Fork of Yellow Creek it shows as a solid bed 2 feet or more in thickness. East and southeast of Knoxville it is found in the streams and can easily be followed for 2 miles or more to the east. In this direction it rises rapidly, but before reaching the summit of the hills it appears to have been cut out or replaced by a heavy brown sandstone. Near the summit of Myers Knob, back of Toronto, is a disintegrated limestone which is believed to be the Ames, but it could not be positively identified. On Hale Run south of Knoxville the point of outcrop of the Ames limestone is near the township line. Here it is a solid bed about 1 foot thick. The elevation of the Ames limestone and the Pittsburg coal were compared in the following places for determining the interval between them:

*Distance between base of Pittsburg coal and top of Ames limestone, Knox Township, Ohio.*

| | Feet. |
|---|---|
| On road from Richmond pike to Town Fork | 209 |
| On road from Osage to Town Fork | 231 |
| North of Island Creek Church | 211 |
| Head of Croxton Run | 218 |
| Average | 217 |

The interval between the Pittsburg coal and the Ames limestone is occupied principally by shale and sandstone, except for a small limestone adjacent to the coal. The normal position of the sandstone is about 20 feet above the Ames limestone, but in many places it displaces the limestone. The shale when adjacent to the limestone is of a red color. The coals usually accompanying the Ames limestone were not found in Knox Township.

*Finley coal.*—The Finley coal, which is probably equivalent to the Upper Freeport of Pennsylvania, shows in outcrop in the north fork of Croxton Run and in the river hills back of Toronto and Freemans. The thickness of the coal is less than 3 feet, and although opened in a few places it has not been successfully mined.

*Roger coal.*—The Roger coal is opened for mining on Croxton Run a mile and a half from Ohio River. From this point it may be followed down the run and along the river hills. Its thickness is something more than 3 feet.

*Middle Kittanning coal.*—The small bed between the Roger and Lower Kittanning coals was not examined in Knox Township. It should outcrop along the river hills west of Calumet.

*Lower Kittanning coal.*—This coal bed and the accompanying fire clay outcrop in the valley of Croxton Run just west of the railroad. From this point they rise to the north and are found above railroad grade back of Freemans.

*Intervals between the Ames limestone and Allegheny coal beds.*—It was not possible to obtain elevations on the different coal beds of the Allegheny formation in such horizontal proximity to outcrops of the Ames limestone as to permit accurate determination of the distances between them. By comparison of all the elevations of the coals with each other, however, and with the elevations of the Ames limestone in Knox and Island Creek townships of Ohio, and Clay and Butler townships of West Virginia, results were obtained which are given with their probable limits of error in the following statement:

*Distance between top of Allegheny coal beds and top of Ames limestone, Knox Township, Ohio.*

| | Feet. |
|---|---|
| Ames limestone to Finley coal | 246±15 |
| Ames limestone to Roger coal | 357±15 |
| Ames limestone to Middle Kittanning coal | 443±10 |
| Ames limestone to Lower Kittanning coal | 473± 8 |

## ISLAND CREEK TOWNSHIP, JEFFERSON COUNTY, OHIO.

Island Creek Township includes most of the drainage area of Island Creek and Wills Creek. The geologic section exposed in this area includes the lower half of the Monongahela formation, all of the Conemaugh, and most of the Allegheny.

*Benwood limestone.*—On Norton Hill, in the western part of the township, the lower beds of the Benwood limestone show.

*Meigs Creek coal.*—The Meigs Creek coal is found on Norton Hill and along the western portion of the ridge road south of Island Creek. Its thickness is less than 2 feet.

*Pittsburg coal.*—The Pittsburg coal outcrops over the greater portion of the township. In the ridges around the headwaters of Wills Creek it is well under cover, and has been opened in many places for mining. It rises to the east along the Richmond and Pekin pike, and adjacent to Pekin is found only in the high hills. The coal bed dips to the south from Pekin to Steubenville, where it is under considerable cover. The bed is of normal thickness, and is accompanied by limestone beds and the Rider coal seam. Only one comparison of elevation was made for determining the interval between the base of the Pittsburg coal and the top of the Meigs Creek coal. This was on the ridge south of Island Creek and resulted in a measurement of 103 feet.

*Ames limestone and associated rocks.*—The Ames limestone is well developed throughout almost the whole of Island Creek Township. It is exposed in a heavy ledge on the nose of the ridge to the north of Costonia, and from this place can be easily followed on both sides of Island Creek and its tributaries. It goes under cover near the point where the Island Creek road leaves the creek and climbs to the Richmond pike. To the west of the forks of Wills Creek the limestone is well developed, but on this stream east of the forks and in the neighborhood of Stanton Park it was not found in solid beds, though the adjacent coal beds were noted in Rush Run and some small pieces of limestone float were found. A number of comparisons of elevation were made to determine the interval between the Ames limestone and the Pittsburg coal, as follows:

*Distance between base of Pittsburg coal and top of Ames limestone, Island Creek Township, Ohio.*

| | Feet. |
|---|---|
| Between Shelley Run and the ridge road to the south | 227 |
| On Island Creek oil field | 218 |
| On hill west of Pekin | 230 |
| On ridge between two branches of Island Creek | 228 |
| On Hartley Run and hills on both sides | 222 |
| On Wills Creek, Little Island Creek, and ridge between | 206 |
| On Wills Creek | 214 |
| Comparisons of four elevations of Ames limestone on North Fork of Wills Creek with three elevations of Pittsburg coal on different sides | 223 |
| Comparison of elevation of Ames limestone on Cedar Lick Run with that of Pittsburg coal south of Two Ridge Church | 215 |
| Average | 220 |

On Little Island Creek and Rush Run is another limestone about 30 feet above the Ames limestone. It has a smooth surface, is yellow in color, devoid of fossils, and is underlain by 4 to 6 feet of fire clay.

*Finley coal bed.*—The Finley coal is 5 feet thick on the lower portion of Island Creek, and is mined in a small way on both sides of the creek. Both up and down the stream it thins rapidly, soon becoming only a few inches in thickness.

*Roger coal bed.*—The Roger coal outcrops at the iron bridge over Island Creek, 1 mile from its mouth, and may be followed down the stream and along the river hills north to Jeddo; also on the hills back of Toronto.

## CROSS CREEK TOWNSHIP, JEFFERSON COUNTY, OHIO.

Cross Creek Township includes the larger portion of the drainage of Cross Creek. The geologic section exposed extends from a horizon near the top of the Monongahela formation to the Ames limestone in the Conemaugh.

*Uniontown coal.*—The Uniontown coal occurs in the ridge south of McIntyre Creek. It is not of workable thickness, but is fairly constant and is a good geologic guide. Its distance above the Meigs Creek coal was determined in the following places:

*Distance between top of Uniontown coal and top of Meigs Creek coal, Cross Creek Township, Ohio.*

| | Feet. |
|---|---|
| On road from McIntyre Creek to New Alexandria | 103 |
| On road from Fells to New Alexandria | 109 |
| On road from McIntyre Creek to Smithfield | 107 |
| Average | 106 |

*Benwood limestone.*—The different beds of the Benwood limestone are present in all of the hills northeast of New Alexandria and in the high hills south of Fernwood. The separate members, the Dinsmore and Bulger limestones, do not remain prominent and distinctive throughout this area, and no good elevations could be taken for obtaining intervals.

*Meigs Creek coal.*—The Meigs Creek coal is in general not more than 1 foot thick. It is constant, however, and maintains a fairly uniform distance above the Pittsburg coal.

The elevations of the Pittsburg coal and the Meigs Creek coal were compared in the following places for the purpose of determining the thickness of the interval between them:

*Distance between base of Pittsburg coal and top of Meigs Creek coal, Cross Creek Township, Ohio.*

| | Feet. |
|---|---|
| On road from Georges Run to Cross Creek | 102 |
| On road from McIntyre Creek to New Alexandria | 100 |
| On road from Fells to New Alexandria | 97 |
| On road from Fells to Smithfield | 103 |
| On road from Slabcamp Creek to Smithfield | 92 |
| At head of Polecat Hollow | 97 |
| On ridge north of Fells | 104 |
| Average | 100 |

*Pittsburg coal.*—The Pittsburg coal outcrops throughout Cross Creek Township. South of McIntyre Creek and between that creek and Cross Creek it is well under cover. North of Cross Creek it occurs in the ridge west of Dry Fork and between Dry Fork and

Permars Run. It is also present in the ridge from Wintersville to Two Ridge Church, and from this point south to Fernwood.

The average thickness of the coal bed is about 4½ feet. It is usually accompanied by limestone above and below. The Rider bed, having a thickness of about a foot, is invariably present. A number of comparisons of elevation were made to determine the distance of this Rider bed above the base of the Pittsburg coal as follows:

*Distance between top of Rider coal and base of Pittsburg coal, Cross Creek Township, Ohio.*

| | Feet. |
|---|---|
| On road from Cross Creek to New Alexandria | 39 |
| On road from McIntyre Creek to New Alexandria | 32 |
| On road from Fells to New Alexandria | 26 |
| On road from McIntyre Creek northward | 30 |
| On road from Fells northward | 29 |
| On road northwestward from McIntyre oil field | 29 |
| On road southwestward from McIntyre oil field | 28 |
| On west edge of quadrangle | 29 |
| On pike south of Fernwood | 27 |
| On spur between Longs Run and Cross Creek | 32 |
| Average | 30. 6 |

*Ames limestone.*—The Ames limestone is present in normal thickness in the hills south of Gould station, but farther up McIntyre Creek it is probably wanting. Farther up Cross Creek it develops into a prominent bed, being from 1 to 2 feet thick in the vicinity of Fernwood and up the side ravines. The following comparisons of elevations were made to determine the interval between the Ames limestone and the Pittsburg coal:

*Distance between top of Ames limestone and base of Pittsburg coal, Cross Creek Township, Ohio.*

| | Feet. |
|---|---|
| On pike south of Fernwood | 212 |
| On north side of ridge between Longs Run and Cross Creek | 214 |
| On road from New Alexandria to Cross Creek | 226 |
| On road from Two Ridge Church to Reeds Mills | 224 |
| On Fernwood Creek, Ames limestone with Pittsburg coal on opposite sides [a] | 201 |
| On Dry Fork [a] | 197 |
| Average | 219 |

STEUBENVILLE TOWNSHIP, JEFFERSON COUNTY, OHIO.

Steubenville Township extends along the west side of Ohio River. In it are exposed rocks from the middle of the Monongahela to the middle of the Conemaugh formations.

[a] Not included in average.

*Benwood limestone.*—The lower beds of the Benwood limestone are present in the summits of the hills between Wells Run and Cross Creek.

*Meigs Creek coal.*—The Meigs Creek coal is present in the hill north of Cross Creek and also between Cross Creek and Georges Run.

*Pittsburg coal.*—The Pittsburg coal does not occur in this township north of Steubenville. West of Steubenville and north of Permars Run it is present near the summits of the hills. From this locality southward it is present in all the hills and outcrops in the top of the river bluffs between Steubenville and Mingo Junction. The coal is about 5 feet thick and it is accompanied by both the upper and lower limestones. The lower limestone is unusually heavy.

*Ames limestone.*—The Ames limestone is by far the best geologic marker in Steubenville Township. It is prominent and well developed from Alikanna to Georges Run. It outcrops in the hillsides south of Alikanna and can be followed along the bluff above the river. It is about halfway up the slope below La Belle View and shows in strong outcrops in Permars and Wells runs. It is present in the bluff just above the pike from Steubenville to Mingo Junction. On both sides of Cross Creek it is well developed. On the sides of Georges Run it is not so prominent, but can be located by a little search. The following comparisons of elevation were made for determining the interval between the Ames limestone and the Pittsburg coal:

*Distance between base of Pittsburg coal and top of Ames limestone, Steubenville Township, Ohio.*

| | Feet. |
|---|---|
| On ridge between Steubenville and Mingo Junction | 218 |
| Southwest of Steubenville | 214 |
| On Wells Run | 214 |
| On Georges Run and hills on both sides | 222 |
| On hill north of Cross Creek | 218 |
| Average | 217 |

## WELLS TOWNSHIP, JEFFERSON COUNTY, OHIO.

Wells Township extends to the south edge of the quadrangle. The section exposed extends from the Waynesburg coal of the Monongahela formation to the Ames limestone of the Conemaugh formation.

*Waynesburg coal.*—The highest hills southwest of New Alexandria contain the Waynesburg coal near their summits. The coal ranges in thickness from 2 to 3 feet and is underlain by yellow limestone. Its position with reference to the Pittsburg coal was not well determined, though the interval from the top of the Waynesburg coal to the base of the Pittsburg is not far from 245 feet.

*Uniontown coal.*—The Uniontown coal is found in the New Alexandria ridge and in the western part of the township. All of the comparisons of elevations for the determination of intervals have been credited to Cross Creek Township (p. 91).

*Meigs Creek coal.*—The Meigs Creek coal is a good geologic marker over most of the township, although its thickness is in most places less than 2 feet. The following comparisons of elevation were made for determining the thickness of the interval between the Meigs Creek coal and the Pittsburg coal:

*Distance between top of Meigs Creek coal and base of Pittsburg coal, Wells Township, Ohio.*

| | Feet. |
|---|---|
| On road southward from New Alexandria | 96 |
| On road from New Alexandria to Salt Run | 99 |
| On road at head of west branch of Salt Run | 108 |
| On private road south of Georges Run | 94 |
| Average | 99 |

*Pittsburg coal.*—The Pittsburg coal is present throughout the township and its outcrop is well up the sides of the hills. It is usually accompanied by limestones above and below. The Rider coal is uniformly present, with a thickness of about 1 foot.

*Ames limestone.*—The Ames limestone is well developed in the eastern part of the township. Heavy outcrops were examined on Tarrs Run and back of the mine in Brilliant. In all the runs south of this point it was found, but it is generally thin and in some places hard to locate. The following comparisons of elevation were made for determining the interval between the Ames limestone and Pittsburg coal:

*Distance between top of Ames limestone and base of Pittsburg coal, Wells Township, Ohio.*

| | Feet. |
|---|---|
| On Tarrs Run west of Brilliant | 220 |
| On pike west of Brilliant | 226 |
| On Blockhouse Run | 231 |
| Average | 226 |

## CLAY TOWNSHIP, HANCOCK COUNTY, W. VA.

In describing the areal geology and the intervals in the townships of West Virginia, a small portion of Pennsylvania along the eastern limit of the quadrangle will be included.

The formations in Clay Township are much higher in elevation than in any other portion of the quadrangle. The section exposed extends from the middle of the Conemaugh formation through most of the Allegheny formation.

*Ames limestone.*—The Ames limestone caps the highest hills just east of New Cumberland. A well-developed outcrop was found on the small butte east of Chelsea. The elevation of the limestone remains about the same to a point near the middle of the township, whence it dips steeply to the southeast. On North Fork of Kings Creek it is only a short distance above the stream bed. The outcrops are usually prominent throughout the township, except on Holbert Run. On this stream, although float was encountered, the bed was not found in place.

*Finley coal.*—The outcrop of the Finley coal occurs in the river hills and also on the north fork of Holbert Run.

*Roger coal.*—The Roger coal has been opened for mining east of New Cumberland and Blackhorse, also near the intersection of the different forks of Holbert Run. The coal has a thickness of about 3 feet and is embedded in a soft brown shale.

*Lower Kittanning coal.*—The Lower Kittanning coal and its underlying fire clay is opened for mining back of New Cumberland and at Blackhorse. Its outcrop can be easily followed along the river. The distances between the coal beds of the Allegheny formation and the Ames limestone are given under Knox Township, Jefferson County, Ohio (p. 89).

## BUTLER TOWNSHIP, HANCOCK COUNTY, W. VA.

Butler Township includes most of the West Virginia tributaries of Kings Creek. In the northern portion of the township the formations are high, but they dip steeply to the south and southeast, so that the Pittsburg coal is caught in the higher hills along the south edge of the township and at Paris, Pa.

*Pittsburg coal.*—The ridge between Kings Creek and New Cumberland Junction contains the Pittsburg coal near the summit. The high ridge between North Fork of Kings Creek and Aunt Clara Fork catches the Pittsburg coal in two places. It is also exposed near the schoolhouse at the intersections of roads east of Aunt Clara Fork. The average thickness of the coal is a little less than 5 feet. It is overlain by a heavy sandstone and has been opened for mining in a number of places.

*Limestone beds below the Pittsburg coal.*—The interval between the Ames limestone and the Pittsburg coal contains two or three blue limestone beds, each about 1 foot in thickness. Their positions were not well established, though they may be said to be approximately 20, 80, and 120 feet below the Pittsburg coal.

*Ames limestone.*—The Ames limestone is especially well developed throughout the Turkeyfoot oil field and along North Fork of Kings Creek; also south of Kings Creek in the eastern portion of the township. The bed was found on the summit of a small knob south of the ridge road 1 mile southeast of Kings Creek station. It could not be located, however, in the high knob directly east of Kings Creek station nor in the knob south of Kings Creek station and between Kings Creek and the river. Only one comparison of any value was made of elevations to determine the interval between the Ames limestone and the Pittsburg coal. This gave a result of 220 feet.

*Cambridge limestone.*—In this township two outcrops of the Cambridge limestone were found, one in a small run northwest of Paris, Pa., and the other on the road from Paris to Turkeyfoot oil field. This bed is about 95 feet below the Ames limestone.

*Finley coal.*—The Finley coal is of considerable importance, being mined about 1 mile southeast of Zalia station. It is accompanied by a heavy limestone below.

*Roger coal.*—This coal outcrops along the river front back of Zalia and Kings Creek station; also at the iron bridge over Kings Creek, and from that place almost continuously up the creek beyond the Turkeyfoot oil field. The bed is about 3½ feet in thickness and is mined in a number of places, furnishing an excellent quality of coal. The interval between this coal and the Ames limestone does not remain constant, differing fully 75 feet between the Turkeyfoot oil field and the mouth of Kings Creek. The bed of coal is undoubtedly not parallel to the other strata of the formation. This peculiarity of the Roger coal has been noticed at other locations, and for that reason it is not a reliable stratum to use for careful structural work.

*Middle Kittanning coal.*—The Middle Kittanning coal is at the same elevation as the wagon road from Holbert Run to the mouth of Kings Creek, where it is just above the grade of the railroad.

*Lower Kittanning coal.*—The Lower Kittanning coal and its underlying fire clay have been opened for mining at Zalia and to the south. This coal dips under the river at the mouth of Kings Creek. The intervals from this coal and the three preceding to the Ames limestone are given under Knox Township, Jefferson County, Ohio (p. 89).

### CROSS CREEK AND BUFFALO TOWNSHIPS, BROOKE COUNTY, W. VA.

Cross Creek Township includes most of the drainage of Harmon and Cross creeks, in West Virginia. The small portion of Buffalo Township which reaches to the southern limit of the quadrangle will be considered in connection with Cross Creek Township. These townships present a geologic section from the Washington coal of the Washington formation to the Cambridge limestone of the Conemaugh formation.

*Washington, Waynesburg, and Uniontown coals.*—The Uniontown and Waynesburg coals occur in a considerable area south of Cross Creek, and the Washington coal is present on the higher hills near the town of Independence, Pa. None of these coals is of commercial value in the quadrangle. The Uniontown is a small bed not over 1 foot thick. The Waynesburg is about 2 feet thick and overlain by sandstone. About 30 feet above the Waynesburg is the Waynesburg "A" bed, about 1 foot thick and underlain by fire clay. The Washington coal has a thickness of about 4 feet and is overlain by limestone. Not enough good measurements of the distances between these upper coals could be obtained to tabulate the results. By comparing the elevations of these coal beds and the elevation of the Pittsburg and Meigs Creek coals at different places the following measurements for the interval between them were obtained:

*Distance between top of various coal beds and bottom of Pittsburg coal, Cross Creek and Buffalo townships, West Virginia.*

| | Feet. |
|---|---|
| Uniontown coal | 206 |
| Waynesburg coal | 250 |
| Waynesburg "A" coal | 278 |
| Washington coal | 355 |

*Benwood limestone.*—The Benwood limestone is present in the high land between Cross Creek and Buffalo. It is also found in the higher knobs of the ridge which extends eastward from Ohio River south of Harmon Creek. The separate beds of the Benwood limestone are not characteristic enough to be used as marking strata for determining the geologic structure.

*Meigs Creek coal.*—The outcrop of the Meigs Creek coal is present in most places on all roads leading north and south from the main ridge south of Harmon Creek. The coal is not of sufficient thickness to be of economic value, but is a good geologic marker. The outcrops of the Meigs Creek coal, whose elevations were determined in the northern portion of the township, were not in position for direct comparison with the Pittsburg coal. In the southern part of Cross Creek Township and in Buffalo Township the Meigs Creek coal is of very poor quality, its position usually being represented only by a stratum of black shale. The distance of the Meigs Creek coal above the Pittsburg is somewhat greater in this area than elsewhere in the quadrangle, as shown by the following measurements:

*Distance between top of Meigs Creek coal and base of Pittsburg coal, Cross Creek and Buffalo townships, West Virginia.*

| | Feet. |
|---|---|
| On road down Potrock Run | 102 |
| On road from Cross Creek to Pierce Run | 111 |
| On hill between Cross Creek and Scott Run | 110 |
| On ridge road from Cross Creek to Fowlersville | 109 |
| On ridge east of Ebenezer Run | 113 |
| Average | 109 |

*Pittsburg coal.*—The Pittsburg coal outcrops throughout Cross Creek Township. In the northwestern part, in the vicinity of Wheeling Junction, it is near the tops of the hills, but dips to the southeast and is about halfway down the slopes at Cross Creek and reaches water level in Pierce Run at the south edge of the quadrangle. The average thickness of the coal is fully 5 feet. It is overlain by the Pittsburg sandstone, which is from 20 to 30 feet thick. The overlying limestone and the Rider coal are absent in nearly all of this area.

*Ames limestone.*—The Ames limestone is well developed on both sides of Harmon Creek, along Cross Creek, and east of Ohio River back of Wellsburg. It is usually accompanied by its two coals, one 20 feet below and the other from 10 to 20 feet above. The only portion of Cross Creek Township in which the limestone is not well developed is in the vicinity of Wheeling Junction and New Cumberland Junction. The following comparisons of elevations were made for determining the thickness of the interval between the Pittsburg coal and the Ames limestone:

*Distance between base of Pittsburg coal and top of Ames limestone, Cross Creek and Buffalo townships, West Virginia.*

| | Feet. |
|---|---|
| On road south of Colliers Station | 219 |
| On road south of Harmon Creek | 210 |
| On road to ridge east of Colliers Station | 223 |
| On pike south of Colliers | 224 |
| On ridge west of Colliers, coal compared with the average elevation of four outcrops of limestone | 210 |
| On road northeast of Mahan | 224 |
| On road up ridge between Painters and Titt runs | 226 |
| On hill east of Wellsburg | 218 |
| On hill east of Lazearville | 215 |
| Average | 219 |

*Cambridge limestone.*—Only one outcrop of the Cambridge limestone was found in this area. It occurs in the small run entering McMahan Run at Lower Ferry. Its position is 97 feet below the Ames limestone.

# CHAPTER III.

## WELL LOGS USED IN MAKING THE STEUBENVILLE CONVERGENCE SHEET.

### WELLS IN THE STEUBENVILLE QUADRANGLE.

The convergence sheet of the Steubenville quadrangle was constructed from the records of 36 wells within the quadrangle and 7 wells near its edge in adjoining quadrangles. The wells selected in the quadrangle are shown by the numbers on the convergence sheet (Pl. V, pocket).

*Well No. 10.*—This well is No. 1 on the farm of W. H. McCullough. The Berea sand was found at a depth of 1,348 feet. The elevation of the well mouth is 1,126 feet. The Pittsburg coal near the well is at an elevation of 1,155 feet, or 29 feet above the mouth of the well. The Berea sand is therefore 1,377 feet below the Pittsburg coal.

*Log of W. H. McCullough well No. 1 (No. 10).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal | 400 | 407 |
| Sand, Cow Run | 520 | 555 |
| Sand, Big Injun | 960 | 1,158 |
| Sand, Berea | 1,348 | 1,395 |

*Well No. 16.*—This well is No. 2 on the farm of J. F. McLean. The Berea sand was found at a depth of 1,473 feet. The elevation of the well mouth is 1,250 feet. The well passed through the Pittsburg coal at 150 feet. The Berea sand is therefore 1,323 feet below the Pittsburg coal.

*Log of J. F. McLean well No. 2 (No. 16).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 145 | 150 |
| Fire clay | 650 | .......... |
| Sand, Big Injun | 960 | 1,155 |
| Sand, Berea | 1,473 | .......... |
| Sand, first pay | 1,480 | .......... |
| Sand, second pay | 1,508 | .......... |
| Total depth | .......... | 1,516 |

*Well No. 22.*—This well is No. 2 on the farm of S. Z. Alexander. The Berea sand was found at a depth of 1,354 feet. The elevation of the well mouth is 1,135 feet. The limestone above the Pittsburg coal outcrops near the well at an elevation of 1,111 feet. The base of the Pittsburg coal is therefore 39 feet below the mouth of the well, and the Berea sand is 1,215 feet below the Pittsburg coal.

*Log of S. Z. Alexander well No. 2 (No. 22).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Fire clay | 525 | |
| Sand, Big Injun (water at 950 feet) | 840 | 1,040 |
| Sand, Berea | 1,354 | |
| Sand, first pay | 1,364 | |
| Total depth | | 1,406 |

*Well No. 71.*—This well is No. 1 on the farm of C. Cooper, owned by Frudenburg & St. Clair. The Berea sand was found at a depth of 1,436 feet. The elevation of the well mouth is 1,205 feet. The Pittsburg coal outcrops on both sides of the well at an elevation of 1,158 feet, or 47 feet below the mouth. The Berea is therefore 1,389 feet below the Pittsburg coal.

*Well No. 149.*—This well is on the farm of J. W. Johnson, on Croxton Run. The Berea sand was found at a depth of 750 feet. The elevation of the mouth of the well is 744 feet. The Roger coal outcrops close to the well at an elevation of 750 feet, or 6 feet above the mouth. The Berea sand is therefore 756 feet below the Roger coal, or 1,335 feet below the Pittsburg coal.

*Log of J. W. Johnson well No. 1 (No. 149).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Water | 150 | |
| Gas | 160 | |
| Coal | 235 | |
| Coal | 275 | |
| Sand, Salt | 350 | |
| Sand, Berea | 750 | 815 |
| Red rock | 950 | |
| Total depth | | 1,000 |

*Well No. 110.*—This well is on the farm of Mary Wallace. The only information obtained about it is from the files of the inspector of mines, who reports the total depth of the well as 1,175 feet. From this it is assumed that the depth to sand is 1,145 feet. The elevation of the mouth of the well is 905 feet. The Ames limestone outcrops near the well at an elevation of 953 feet, or 48 feet above the mouth. The Berea sand is therefore about 1,193 feet below the Ames limestone and about 1,415 feet below the Pittsburg coal.

*Well No. 111.*—This well is on the farm of the McClelland heirs, on Island Creek. The Berea sand was found at a depth of 1,090 feet. The elevation of the mouth of the well is 837 feet. The Ames limestone outcrops on all sides of the well, at an elevation of 944 feet, or 107 feet above the mouth. The Berea sand is therefore 1,197 feet below the Ames limestone and 1,419 feet below the Pittsburg coal.

*Well No. 173.*—This well is on the farm of J. Slentz. The Berea sand was found at a depth of 1,237 feet. The elevation of the mouth of the well is 1,054 feet. The Ames limestone outcrops south of the well at an elevation of 1,032 feet, being about 1,030 feet at the well, or 24 feet below the level of the mouth. The Berea sand is therefore 1,213 feet below the Ames limestone and 1,435 feet below the Pittsburg coal.

*Well No. 180.*—This well is on the farm of Mrs. T. J. Wells, on the bank of Ohio River, between Costonia and Toronto. The Berea sand was found at a depth of 1,005 feet. The elevation of the mouth of the well is now 828 feet. The Roger coal outcrops a short distance north of the well at 687 feet, being about 683 feet at the well, or 145 feet below the level of the mouth. The Berea sand is therefore 860 feet below the Roger coal, 1,217 feet below the Ames limestone, and 1,439 feet below the Pittsburg coal.

*Log of Mrs. T. J. Wells well (No. 180).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand | 168 | 235 |
| Coal | 236 | .......... |
| Clay | 241 | .......... |
| Sand, Big Injun (break at 580 feet) | 500 | 720 |
| Sand, Berea | 1,005 | 1,065 |

*Well No. 188.*—This well is on the farm of D. W. Swearinger. The Berea sand was found at a depth of 1,130 feet. The elevation of the well mouth is 984 feet. The Ames limestone outcrops west of the well at an elevation of 1,103 feet. The elevation is about 1,090 feet at the well, or 106 feet above the level of the mouth. The Berea sand is therefore 1,236 feet below the Ames limestone, or 1,456 feet below the Pittsburg coal.

*Well No. 360.*—This well is No. 11 on the farm of John Lunduff. The Berea sand was found at a depth of 1,235 feet. The elevation of the well mouth is 1,200 feet. The Ames limestone outcrops east of the well at an elevation of 1,152 feet, and west of the well at an elevation of 1,184 feet, being 1,165 feet at the well, or 36 feet below the level of the mouth. The Berea sand is therefore 1,200 feet below the Ames limestone and 1,420 feet below the Pittsburg coal.

*Well No. 303.*—This well is No. 2 of B lease of the Longfitt farm. The Berea sand was found at a depth of 1,338 feet. The elevation of the well mouth is 1,163 feet. The Ames limestone outcrops east of the well at 1,040 feet, being about 1,045 feet at the well, or 118 feet below the level of the mouth. The Berea sand is therefore 1,220 feet below the Ames limestone, or 1,440 feet below the Pittsburg coal.

*Well No. 284.*—This well is on the farm of Emma Morrow. The Berea sand was found at a depth of 1,205 feet. The elevation of the well mouth is 1,024 feet. The Ames limestone lies at an elevation of 1,085 feet at the well, or 61 feet above the level of the mouth. The Berea sand is therefore 1,265 feet below the Ames limestone, or 1,486 feet below the Pittsburg coal.

*Log of Emma Morrow well (No. 284).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand | 10 | 40 |
| Coal | 150 | .......... |
| Sand, Hurry-up | 350 | 410 |
| Coal, big bed | 410 | .......... |
| Sand, Salt | 580 | 633 |
| Sand, Big Injun | 775 | 960 |
| Sand, Berea | 1,205 | .......... |

*Well No. 207.*—This well is No. 15 on the Cable farm. The Berea sand was found at a depth of 1,272 feet. The elevation of the well mouth is 1,052 feet. The Ames limestone is at an elevation of 1,072 feet at the well, or 19 feet above the level of the mouth. The Berea sand is therefore 1,291 feet below the Ames limestone, or 1,511 feet below the Pittsburg coal.

*Well No. 254.*—This well is No. 3 on the farm of Sarah E. Warwick. The Berea sand was found at a depth of 1,528 feet. The elevation of the well mouth is 1,244 feet. From the contoured map the Pittsburg coal has an elevation at the well of 1,249 feet, or 5 feet above the mouth. The Berea sand is therefore 1,533 feet below the Pittsburg coal.

*Well No. 389.*—This well is on the farm of John Owens. The Berea sand was found at a depth of 1,435 feet. The elevation of the well mouth is 1,107 feet. The Pittsburg coal has an elevation of 1,193 feet at the well, or 86 feet above the level of the mouth. The Berea sand is therefore 1,521 feet below the Pittsburg coal.

*Well No. 154.*—This well is No. 6 on the Morrow heirs farm. The Berea sand was found at a depth of 1,210 feet. The elevation of the well mouth is 965 feet. The Ames limestone outcrops on the road near the well at 980 feet, or 15 feet above the level of the mouth. The Berea sand is therefore 1,225 feet below the Ames limestone and 1,445 feet below the Pittsburg coal.

*Well No. 114.*—This well is No. 3 on the farm of the Morrow heirs. The Berea sand was found at a depth of 1,189 feet. The elevation of the mouth of the well is 935 feet. The Ames limestone outcrops to the south at an elevation of 968 feet, which is equivalent to 974 feet at the well, or 39 feet above the level of the mouth. The Berea sand is therefore 1,228 feet below the Ames limestone and 1,448 feet below the Pittsburg coal.

*Log of Morrow well No. 3 (No. 114).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Drift | 29 | .......... |
| Sand | 48 | .......... |
| Red rock | 100 | .......... |
| Coal | 243 | .......... |
| Coal | 400 | .......... |
| Fire clay | 430 | .......... |
| Sand, Big Injun | 620 | 825 |
| Sand, Berea | 1,189 | 1,211 |

*Well No. 135.*—This well is No. 2 on the farm of the Morrow heirs. The Berea sand was found at a depth of 1,456 feet. The elevation of the well mouth is 1,179 feet. The Pittsburg coal outcrops near the well at an elevation of 1,182 feet, or 3 feet above the level of the mouth. The Berea sand is therefore 1,459 feet below the Pittsburg coal.

*Well No. 143.*—This well is on the farm of J. S. Watt, on Island Creek. The Berea sand was found at a depth of 1,237 feet. The elevation of the well mouth is 956 feet. The Ames limestone outcrops near the well at an elevation of 965 feet, or 9 feet above the level of the mouth. The Berea sand is therefore 1,246 feet below the Ames limestone and 1,464 feet below the Pittsburg coal.

*Well No. 145.*—This is well No. 1 on the Price farm. The Berea sand was found at a depth of 1,297 feet. The elevation of the well mouth is 1,066 feet. The Pittsburg coal outcrops at an elevation of 1,215 feet to the southeast and at 1,251 feet to the northwest, this being equivalent to 1,231 feet at the well, or 165 feet above the level of the mouth. The Berea sand is therefore 1,462 feet below the Pittsburg coal.

*Well No. 402.*—This well is on the farm of M. Rheinhart. The Berea sand was found at a depth of 1,362 feet. The elevation of the well mouth is 1,054 feet. The Ames limestone outcrops south of the well at an elevation of 984 feet, or 70 feet below the level of the mouth. The Berea sand is therefore 1,292 feet below the Ames limestone and 1,510 feet below the Pittsburg coal.

*Log of M. Rheinhart well (No. 402).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal | 325 | 330 |
| Sand, Salt | 660 | 800 |
| Sand, Big Injun | 820 | 980 |
| Sand, Berea | 1,362 | 1,369 |

*Well No. 501.*—This well is No. 5 on the C. & W. Bluck farm. The Berea sand was found at a depth of 1,496 feet. The elevation of the well mouth is 1,182 feet. The Pittsburg coal outcrops near the well at an elevation of 1,176 feet, or 6 feet below the level of the mouth. The Berea sand is therefore 1,490 feet below the Pittsburg coal.

*Well No. 515.*—This well is on the farm of F. Roberts. The Berea sand was found at a depth of 1,517 feet. The elevation of the well mouth is 1,143 feet. The Pittsburg coal outcrops near the well at an elevation of 1,165 feet, or 22 feet above the level of the mouth. The Berea sand is therefore 1,539 feet below the Pittsburg coal.

*Well No. 405.*—This well was drilled by the Eastern Ohio Oil Company in the first ravine west of Fernwood. The Berea sand was found at a depth of 1,288 feet. The elevation of the well mouth is 861 feet. The Ames limestone outcrops on the side of the creek at an elevation of 918 feet, or 57 feet above the level of the well mouth. The Berea sand is therefore 1,345 feet below the Ames limestone and 1,562 feet below the Pittsburg coal. This well was drilled to a depth of 3,000 feet. Only traces of the lower sands were found.

*Well No. 466.*—This well is on the farm of S. Parr. The Berea sand was found at a depth of 1,563 feet. The elevation of the mouth of the well is 1,019 feet. The Pittsburg coal outcrops near the well at an elevation of 1,028 feet, or 9 feet above the level of the mouth. The Berea sand is therefore 1,572 feet below the Pittsburg coal.

*Log of S. Parr well (No. 466).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand (water at 165 feet) | 110 | 205 |
| Sand | 285 | 300 |
| Sand | 320 | 325 |
| Sand | 475 | 500 |
| Coal | 525 | .......... |
| Sand | 600 | 645 |
| Coal | 690 | .......... |
| Limestone | 820 | 835 |
| Sand, Big Injun | 900 | 1,200 |
| Sand, Berea | 1,563 | .......... |
| Sand, pay | 1,570 | .......... |
| Total depth | .......... | 1,602 |

*Well No. 442.*—This is well No. 2 on the farm of R. M. McIntire. The Berea sand was found at a depth of 1,427 feet. The elevation of the well mouth is 896 feet. The Pittsburg coal outcrops south of the well at an elevation of 1,042 feet and north of the well at an elevation of 1,053 feet, which is equivalent to 1,048 feet at the well, or 152 feet above the level of the mouth. The Berea sand is therefore 1,579 feet below the Pittsburg coal.

*Well No. 435.*—This well is No. 10 on the Lewis farm. The Berea sand was found at a depth of 1,645 feet. The elevation of the well mouth is 1,125 feet. The Pittsburg coal outcrops near the well at an elevation of 1,062 feet, or 63 feet below the level of the mouth. The Berea sand is therefore 1,582 feet below the Pittsburg coal.

*Well No. 407.*—This well is No. 1 on the Nicholson farm, at the south end of Steubenville. The Berea sand was found at a depth of 1,843 feet. The elevation of the mouth of the well is 800 feet. The Ames limestone outcrops near the well at an elevation of 835 feet, or 35 feet above the level of the mouth. The Berea sand is therefore 1,378 feet below the Ames limestone, or 1,591 feet below the Pittsburg coal.

*Log of Nicholson well No. 1 (No. 407).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Shale and limy shells | 24 | 30 |
| Limestone | 30 | 40 |
| Shale, white | 40 | 100 |
| Sand, white | 100 | 140 |
| Shale | 140 | 330 |
| Casing through Roger coal | ........ | 310 |
| Shale and shells | 330 | 593 |
| Sand | 593 | 653 |
| Shale | 653 | 673 |
| Sand, Big Injun | 673 | 973 |
| Shale | 973 | 1,343 |
| Sand, Berea | 1,343 | 1,386 |
| Shale, hard | 1,386 | 1,421 |

*Well No. 485.*—This well is on the farm of John McKim. The Berea sand was found at a depth of 1,660 feet. The elevation of the mouth of the wall is 1,124 feet. The well passes through the Pittsburg coal at a depth of 60 feet. The Berea sand is therefore 1,600 feet below the Pittsburg coal.

*Log of John McKim well (No. 485).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 55 | .......... |
| Coal | 460 | .......... |
| Coal | 570 | .......... |
| Sand, Big Injun | 1,030 | .......... |
| Cased (not Big Injun) | 1,070 | .......... |
| Sand, Berea | 1,660 | 1,690 |

*Well No. 514.*—This well is on the farm of George Strong. The Berea sand was found at a depth of 1,387 feet. The elevation of the mouth of the well is 737 feet. The Ames limestone outcrops east of the well at an elevation of 760 feet, or 23 feet above the level of the mouth. The Berea sand is therefore 1,410 feet above the Ames limestone and 1,632 feet below the Pittsburg coal.

*Well No. 392.*—This well is on the Peterson farm. The Berea sand was found at a depth of 1,240 feet. The elevation of the well mouth is 820 feet, and that of the Ames limestone at the well is 934 feet, or 114 feet above the level of the mouth. The Berea sand is therefore 1,354 feet below the Ames limestone and 1,572 feet below the Pittsburg coal.

*Well No. 393.*—This well is on the Cable farm. The Berea sand was found at a depth of 1,463 feet. The elevation of the well mouth is 1,074 feet. The Pittsburg coal outcrops near the well at an elevation of 1,177 feet, or 103 feet above the level of the mouth. The Berea sand is therefore 1,566 feet below the Pittsburg coal.

*Well No. 479.*—This well is on the Barclay farm, south of the city of Wellsburg. The Berea sand was found at a depth of 1,300 feet. The elevation of the well mouth is 657 feet. The Ames limestone outcrops near the well at an elevation of 760 feet, or 103 feet above the level of the mouth. The Berea sand is therefore 1,403 feet below the Ames limestone and 1,625 feet below the Pittsburg coal.

*Log of Barclay gas well (No. 479).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Clay, yellow | 0 | 20 |
| Clay, blue | 20 | 40 |
| Sand, blue | 40 | 72 |
| Coal | 72 | 78 |
| Fire clay | 78 | 113 |
| Sand, white | 113 | 135 |
| Fire clay | 135 | 147 |
| Shale | 147 | 187 |
| Coal | 187 | 199 |
| Fire clay | 199 | 204 |
| Shale | 204 | 234 |
| Sand, white | 234 | 274 |
| Shale | 274 | 314 |
| Sand | 314 | 388 |
| Shale | 388 | 403 |
| Sand | 403 | 478 |
| Sand, white | 478 | 553 |
| Sand, gray | 553 | 583 |
| Sand, blue | 583 | 623 |
| Coal | 623 | 629 |
| Shale | 629 | 660 |
| Sand, white | 750 | 800 |
| Shale | 800 | 850 |
| Sand, white | 850 | 900 |
| Shale | 900 | 1,300 |
| Sand, Berea | 1,300 | 1,310 |

*Well No. 490.*—This well is on the Lee farm, on Pierce Run. The Berea sand was found at a depth of 1,695 feet. The elevation of the well mouth is 956 feet. The Pittsburg coal outcrops south of the well at an elevation of 907 feet and is about 915 feet at the well, or 41 feet below the level of the mouth. The Berea sand is therefore 1,654 feet below the Pittsburg coal.

*Well No. 491.*—This well is on the Cassiday farm. The Berea sand was found at a depth of 1,520 feet. The elevation of the well is 928 feet. No outcrop of Pittsburg coal was found close to the well. From the contour map of the Pittsburg coal the elevation is 1,037 feet at the well, or 109 feet above the mouth. The Berea sand is therefore about 1,629 feet below the Pittsburg coal.

*Log of Cassiday well (No. 491).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil and loose rock | 0 | 13 |
| Sand, soft | 13 | 50 |
| Shale | 50 | 140 |
| Limestone, hard | 140 | 155 |
| Shale and shells | 155 | 300 |
| Sand, white, hard | 300 | 350 |
| Shale, black, soft | 350 | 500 |
| Sand, gray, hard | 500 | 620 |
| Coal | 620 | 625 |
| Shale, gray, soft | 625 | 690 |
| Sand, white, hard | 690 | 720 |
| Slate, black, soft | 720 | 775 |
| Sand, gray, soft | 775 | 800 |
| Shale, dark, hard | 800 | 875 |
| Limestone, brownish, hard | 875 | 925 |
| Sand, top yellow, bottom gray, Big Injun | 925 | 1,160 |
| Shale | 1,160 | 1,480 |
| Shale, black, soft | 1,480 | 1,520 |
| Sand, dark, hard, Berea | 1,520 | 1,545 |
| Shale, gray, soft | 1,445 | 1,449 |

## WELLS IN THE WELLSVILLE QUADRANGLE.

Along the north edge of the quadrangle the convergence sheet is governed by two wells on the south edge of the Wellsville quadrangle, as follows:

*New Cumberland gas well.*—This well is situated on the farm of J. B. Campbell, at the north end of New Cumberland. The mouth of the well is at an elevation of 655 feet. The Lower Kittanning coal outcrops at an elevation of 737 feet east of the well and at 703 feet across the river to the west. The elevation of this coal bed directly above the well would be about 725 feet, or 70 feet above the mouth. The interval between the Lower Kittanning coal and the Pittsburg coal is 695 feet. Therefore the Berea sand is about 1,354 feet below the Pittsburg coal.

*Log of J. T. Campbell gas well, New Cumberland.*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal | 72 | .......... |
| Coal | 120 | .......... |
| Sand, Big Injun | 220 | 280 |
| Sand, Berea | 599 | .......... |

*Edmonston well.*—The J. & J. Edmonston well is situated near the south edge of the Wellsville quadrangle, west of Knoxville. The Berea sand was found at a depth of 1,355 feet. The well mouth is at an elevation of 1,103 feet. The well passed through the Pittsburg coal at a depth of 10 feet. The Berea sand is therefore 1,345 feet below the Pittsburg coal. This well was drilled 618 feet below the Berea sand, and two lower sands were discovered, as shown by the record. A show of oil is reported in the Berea sand.

*Log of J. & J. Edmonston well, near Knoxville.*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Surface material | 0 | 40 |
| Coal, Pittsburg | 4 | 10 |
| Shale | 10 | 59 |
| Sand | 59 | 90 |
| Shale | 90 | 520 |
| Sand | 520 | 648 |
| Shale | 648 | 970 |
| Sand | 970 | 1,000 |
| Shale | 1,000 | 1,325 |
| Shale, black | 1,325 | 1,355 |
| Sand with oil, Berea | 1,355 | 1,402 |
| Shale | 1,402 | 1,800 |
| Sand | 1,800 | 1,830 |
| Shale | 1,830 | 1,900 |
| Sand | 1,900 | 1,920 |
| Shale | 1,920 | 2,120 |

## WELLS IN THE CADIZ QUADRANGLE.

Along the west edge of the quadrangle the convergence sheet is controlled by three wells in the Cadiz quadrangle, as follows:

*Well No. 221.*—This well is on the farm of W. Andrews, on Town Fork of Yellow Creek. The Berea sand was found at a depth of 1,085 feet. The elevation of the well mouth is 880 feet. The elevation of the Pittsburg coal near the well is 1,245 feet. The distance from the Pittsburg coal to the Berea sand is therefore 1,450 feet.

*Well No. 218.*—This well is on the farm of J. L. Palmer. The Berea sand was found at a depth of 1,472 feet. The elevation of the well mouth is 1,070 feet. The Pittsburg coal near the well is at an elevation of 1,150 feet, or 80 feet above the level of the mouth. The Berea sand is therefore 1,552 feet below the Pittsburg coal.

*Well No. 196.*—This well is on the farm of J. W. Southerland. The Berea sand was found at a depth of 1,432 feet. The elevation of the well mouth is 918 feet. The Pittsburg coal at the well is at an elevation of 1,062 feet, or 144 feet above the level of the mouth. The Berea sand is therefore 1,576 feet below the Pittsburg coal.

## WELLS IN THE BURGETTSTOWN QUADRANGLE.

Along the east edge of the quadrangle the convergence sheet is governed for the northern half by two wells in the Burgettstown quadrangle that were drilled to the Berea sand, as follows:

*Well No. 182.*—This well is on the farm of the William Arnold heirs. The Berea sand was found at a depth of 1,331 feet. The elevation of the well mouth is 1,036 feet. The Pittsburg coal is at an elevation of about 1,253 feet at the well, or 217 feet above the level of the mouth. The Berea sand is therefore 1,548 feet below the Pittsburg coal.

*Well No. 205.*—This well is No. 1 on the Martin farm. The Berea sand was found at a depth of 1,534 feet. The elevation of the well mouth is 1,115 feet. The Pittsburg coal at the well is at an elevation of 1,218 feet, or 103 feet above the level of the mouth. The Berea sand is therefore 1,637 feet below the Pittsburg coal.

*Log of Martin well No. 1 (No. 205).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Shale, dark gray, soft | 12 | 52 |
| Sand, gray, soft | 52 | 82 |
| Shale, gray, soft | 82 | 202 |
| Shale, red | 202 | 347 |
| Sand, white, soft | 347 | 362 |
| Coal | 362 | 367 |
| Fire clay | 367 | 377 |
| Shale, dark, soft | 377 | 452 |
| Sand, white | 452 | 467 |
| Coal | 467 | 477 |
| Shale, gray | 477 | 497 |
| Sand, gray, very hard | 497 | 517 |
| Shale, gray and brown, soft | 517 | 617 |
| Sand, gray, soft | 617 | 632 |
| Shale, black, soft | 632 | 707 |
| Sand, gray, hard | 707 | 722 |
| Sand, white, soft | 722 | 890 |
| Shale, black, soft | 890 | 925 |
| Sand, brown | 925 | 940 |
| Limestone, white, hard | 940 | 950 |
| Sand, yellow, hard | 950 | 1,176 |
| Shale, | 1,176 | 1,524 |
| Shale, black, Sunbury | 1,524 | 1,534 |
| Sand, Berea, dark, hard | 1,534 | 1,564 |

For the southern half no wells within the Burgettstown quadrangle have been used to extend the convergence sheet to the east. This is owing to the fact that the wells of Pennsylvania do not furnish reliable information as to the position of the Berea sand. East of the Pennsylvania line the Berea sand is no longer an oil or gas producer.

## CORRELATION OF THE BEREA OIL SAND WITH SANDS IN PENNSYLVANIA.

East of the Steubenville quadrangle the sand known as the Hundred-foot is the great oil and gas producer. It lies below the horizon of the Berea sand. Any wells drilled to it must pass through the Berea sand if this rock is present. The logs of eight wells drilled for gas along the west edge of the Burgettstown quadrangle will be given for the purpose of discussion and correlation of the Berea with the sands of Pennsylvania.

*Well No. 206.*—This is well No. 1 on the Kidd farm, situated at the south end of Eldersville. The elevation of the well mouth is 1,316 feet.

*Log of Kidd well No. 1 (No. 206).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 270 | 275 |
| Coal, Freeport | 900 | |
| Sand | 1,100 | |
| Sand, Big Injun | 1,290 | |
| Shells, Hundred-foot (no sand) | 2,051 | |
| Sand, Thirty-foot | 2,155 | |
| Total depth | | 2,205 |

This log gives the Pittsburg coal at 1,015 feet above the Big Injun sand and 1,776 feet above the top of the Hundred-foot sand.

*Well No. 811.*—This well is No. 1 on the farm of Alex. Smith, situated half a mile south of well No. 206. The elevation of the mouth of the well is 1,119 feet, and that of the Pittsburg coal is 1,044 feet, or 75 feet below the level of the mouth.

*Log of Alex. Smith well No. 1 (No. 811).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 70 | |
| Coal, Freeport | 670 | |
| Sand, Salt (gas and salt water) | 910 | |
| Sand, Big Injun | 1,055 | |
| Small show of oil | 1,255 | |
| Sand, Hundred-foot | 1,860 | 1,868 |
| Total depth | | 1,892 |

This log gives the Pittsburg coal at 980 feet above the Big Injun sand and 1,786 feet above the Hundred-foot sand.

*Well No. 816.*—This is well No. 1 on the Metcalf farm, situated half a mile due south of well No. 819. The elevation of the mouth is 1,246 feet, and that of the Pittsburg coal is 1,000 feet, or 246 feet below the level of the mouth.

*Log of Metcalf well No. 1 (No. 816).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal | 225 | |
| Sand, Dunkard | 680 | |
| Water | 696 | |
| Sand, Salt (much salt water) | 1,075 | 1,155 |
| Limestone | 1,260 | |
| Casing, 6¼-inch (no break in Big Injun) | 1,275 | |
| Sand, Squaw, and Gas | 1,590 | |
| Sand, Hundred-foot | 2,044 | 2,053 |
| Total depth | | 2,081 |

This log shows the limestone at 1,014 feet, the Squaw sand at 1,344 feet, and the top of the Hundred-foot sand at 1,798 feet below the Pittsburg coal.

*Well No. 817.*—This well is on the farm of David Cole, situated half a mile south and a little east of well No. 816. The elevation of the mouth is 1,263 feet. The Pittsburg coal at this point is at an elevation of 1,002 feet, or 261 feet below the level of the mouth.

*Log of David Cole well (No. 817).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Salt | 1,095 | 1,140 |
| Sand, Bitter Rock | 1,600 | 1,645 |
| Water | 1,647 | .......... |
| Sand, Hundred-foot | 2,077 | 2,087 |
| Total depth | .......... | 2,113 |

This log shows that the Pittsburg coal is 1,339 feet above the Bitter Rock and 1,816 feet above the Hundred-foot sand.

*Well No. 819.*—This well is No. 1 on the farm of Henry C. Cooper, situated 1 mile due south of well No. 811. The elevation of the mouth is 1,213 feet. The Pittsburg coal at this point is at an elevation of 1,000 feet, or 213 feet below the level of the mouth.

*Log of Henry C. Cooper well No. 1 (No. 819).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 240 | .......... |
| Sand, Dunkard | 600 | .......... |
| Water | 640 | .......... |
| Sand, Big Injun (break at 1,300 feet) | 1,200 | 1,440 |
| Sand, Squaw | 1,542 | 1,573 |
| Sand, Hundred-foot | 1,996 | 2,006 |
| Total depth | .......... | 2,044 |

This log shows that the Pittsburg coal is 987 feet above the Big Injun sand, 1,329 feet above the Squaw sand, and 1,783 feet above the top of the Hundred-foot sand.

*Well No. 820.*—This well is on the farm of Mary and Elmas Cunningham, situated half a mile west of well No. 817. The elevation of the well mouth is 1,051 feet. The Pittsburg coal outcrops near the well at an elevation of 999 feet, or 52 feet below the level of the mouth.

*Log of Mary and Elmas Cunningham well (No. 820).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal | 50 | .......... |
| Sand, Dunkard | 460 | .......... |
| Sand, Salt (no gas; break of 20 feet at 1,170 feet) | 880 | 1,440 |
| Sand, Salt, and water | 1,380 | .......... |
| Shells, Hundred-foot | 1,650 | .......... |
| Sand, hard | 1,750 | .......... |
| Sand, Hundred-foot | 1,855 | 1,865 |
| Total depth | .......... | 1,892 |

This log shows that the Pittsburg coal is 1,597 feet above the Hundred-foot shells, 1,697 feet above the hard sand, and 1,803 feet above the Hundred-foot sand.

*Well No. 822.*—This well is on the farm of G. Cunningham, situated 1 mile south a little east of well No. 820. The elevation of the well mouth is 1,125 feet, and that of the Pittsburg coal is 1,005 feet, or 120 below the level of the mouth.

*Log of G. Cunningham well (No. 822).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Mountain | 90 | .......... |
| Coal, Pittsburg | 119 | 125 |
| Red rock | 300 | 330 |
| Sand, Little Dunkard | 415 | 425 |
| Coal, Freeport | 477 | 483 |
| Sand, Big Dunkard | 537 | 636 |
| Sand, Salt | 920 | 1,019 |
| Sand, Keener | 1,070 | 1,085 |
| Sand, Big Injun | 1,115 | 1,240 |
| Sand, Bitter Rock (some gas) | 1,600 | 1,614 |
| Shells, Hundred-foot | 1,750 | 1,830 |
| Red rock | 1,830 | 1,900 |
| Sand, Hundred-foot | 1,954 | 1,973 |
| Sand, Thirty-foot | 2,053 | .......... |
| Sand, Gordon Stray | 2,125 | 2,135 |
| Sand, Gordon | 2,147 | 2,159 |
| Sand, Fourth | 2,209 | 2,217 |
| Total depth | .......... | 2,302 |

This log shows that the Pittsburg coal is 995 feet above the Big Injun sand, 1,480 feet above the Bitter Rock sand, 1,630 feet above the Hundred-foot shells, and 1,834 feet above the Hundred-foot sand.

*Well No. 823.*—This well is on the farm of James Martin, situated 1 mile southwest of well No. 822. The elevation of the well mouth is 946 feet, or 42 feet below the base of the Pittsburg coal.

*Log of James Martin well (No. 823).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Shale and limestone | 16 | 310 |
| Coal | 316 | .......... |
| Shale, black | 370 | .......... |
| Sand, Dunkard | 370 | 435 |
| Sand, Lower Dunkard | 495 | 545 |
| Shale and lime | 545 | 630 |
| Sand, Gas | 630 | 685 |
| Sand, Salt, much water | 780 | 825 |
| Sand, Salt, second | 860 | 885 |
| Sand, Big Injun | 1,005 | 1,375 |
| Sand, Bitter Rock | 1,450 | 1,455 |
| Sand, Stray | 1,610 | .......... |
| Red rock | 1,700 | .......... |
| Sand, Hundred-foot | 1,804 | 1,809 |
| Total depth | .......... | 1,832 |

The log of this well shows that the Pittsburg coal is 1,047 feet above the Big Injun, 1,492 feet above the Bitter Rock, 1,652 feet above the Stray sand, and 1,846 feet above the Hundred-foot sand.

*Conclusions.*—These eight wells are in a line from Eldersville to Cross Creek, about 1½ miles east of the boundary line of the Steubenville quadrangle. They are separated by distances of one-half to 1 mile. Their logs show that the distance from the Pittsburg coal to the Hundred-foot sand increases regularly toward the south. In well No. 206 this distance is 1,776 feet; in well No. 811, one-half mile to the south, 1,786 feet; in well No. 819, 1 mile farther south, 1,783 feet; in well No. 816, one-half mile still farther south, 1,798 feet; in wells Nos. 820 and 817, which are one-half mile farther south and one-half mile east and west from each other, 1,802 feet and 1,816 feet, respectively; in well No. 822, 1 mile farther south, 1,834 feet, and in well No. 823, 1 mile still farther south, 1,846 feet. These steel-tape results are satisfactory. The increasing distance to the south is to be expected.

The data regarding the sands above the Hundred-foot are of little value. The top of the Big Injun is 1,015 feet below the Pittsburg coal in well No. 206; 976 feet in well No. 811; 987 feet in well No. 819; 995 feet in well No. 822, and 1,047 feet in well No. 823. The Bitter Rock sand is 1,339 feet below the Pittsburg coal in well No. 817; 1,480 feet in well No. 822, and 1,497 feet in well No. 823. Well No. 820 shows a hard sand 1,597 feet below the Pittsburg coal; well No. 822 gives the Hundred-foot shells 1,630 feet below the coal; well No. 823 gives the Stray sand 1,657 feet below the coal. These results prove that for close work no reliance can be placed on anything in a well record but steel-tape measurements. To make any deductions from other portions of the record is dangerous.

The Bitter Rock sand in Pennsylvania is said to have the peculiarities of the Berea and is believed by many to be its equivalent. The distance of the Berea sand below the Pittsburg coal has been followed step by step across the Steubenville quadrangle. This distance increases to the southeast, reaching about 1,640 feet at the southeast corner of the quadrangle. The Pennsylvania well logs show the Bitter Rock sand to be about 1,485 feet below the Pittsburg coal and the Hundred-foot shells or Stray sand to be 1,630 to 1,640 feet below the coal. From the interval, therefore, the Hundred-foot shells are more probably the equivalent of the Berea sand than the Bitter Rock.

# CHAPTER IV.

## DETAILED GEOLOGY OF THE BURGETTSTOWN QUADRANGLE.

### HANOVER TOWNSHIP, BEAVER COUNTY.

A small part of Beaver County is represented in the Burgettstown quadrangle by a strip of land 1½ miles wide along the western half of the north edge. The surface of the quadrangle is almost entirely composed of the Conemaugh formation.

*Rocks above the Ames limestone.*—The Pittsburg coal occurs in the ridge along the south edge of Hanover Township, at Frankfort, and in the hills a mile north and west of that village. The limestone below the Pittsburg coal extends to the ridges beyond the last outcrop of the coal. The upper portion of the Conemaugh is a sandy shale that merges downward into a massive sandstone 30 to 40 feet thick, the base of which is just above the Ames limestone, and in some places has entirely replaced this valuable marking stratum.

*Ames limestone.*—At Murdocksville and along Raccoon Creek to the north the Ames limestone is well developed and can be easily followed to the north edge of the quadrangle. In this vicinity the Lower Ames coal is 1½ feet thick and lies directly under the limestone. A heavy bed of the Ames limestone shows in the main run below Frankfort Springs and again in the run in the northwest corner of the quadrangle.

*Subsurface stratigraphy.*—Very little reliable information was obtained with reference to the conditions below the surface in this township. Along the east end oil is obtained from the Hundred-foot sand and northwest of this pool is a gas field in the same sand. It is very doubtful if the Hundred-foot sand continues much farther west than this field.

### HANOVER TOWNSHIP, WASHINGTON COUNTY.

Hanover is the northwesternmost township of Washington County. It includes the area west of Raccoon Creek to the north of Smith and Jefferson townships and extends beyond the limits of the quadrangle to the west boundary of Pennsylvania. Most of the surface of the township is composed of the Conemaugh formation, though the high hills in all parts include the lower beds of the Monongahela.

*Pittsburg coal.*—In that portion of the township south of the ridge road from Florence westward to Paris the Pittsburg coal is a hundred feet or more below the tops of the higher knobs. In the valleys the coal outcrops not far from the ridge road, but, owing to the steep dip of the formations to the southeast, it remains under cover the whole length of the ridges to the south and east. Northwest of this ridge road the Pittsburg coal occurs only in the higher hills, except in the vicinity of Five Points and farther east. In this area a structural basin carries the coal a hundred feet or more below the summits of the hills. East of the Florence-Frankfort road the Pittsburg coal is overlain by shale and a bed of limestone. Twenty feet above the main coal bed is the Rider coal, which is fully 2 feet in thickness. West of this road the conditions above the Pittsburg coal are entirely different, the coal being overlain by the Pittsburg sandstone, which is from 20 to 30 feet thick. Only a few hills within the township are high enough above the Pittsburg coal to show any distinctive marking strata. These hills are along the Florence ridge. The knob west of Florence reaches well into the Benwood limestone, and the knobs 1 mile and 2 miles east of Florence are capped by the slabby white Dinsmore beds of the lower part of the Benwood.

*Rocks between the Pittsburg coal and Ames limestone.*—The Pittsburg limestone is everywhere present below the coal, at a distance of 7 to 20 feet. Below the limestone is a sandy shale, extending about 180 feet below the coal. At this point a massive sandstone appears, which reaches close to the position of the Ames limestone and locally replaces it. In the shale 100 feet below the Pittsburg coal is the Bavington coal, which is present in a limited area southwest of Frankfort. It is thick enough to be of commercial value and is opened for mining.

*Ames limestone.*—The Ames limestone outcrops along Raccoon Creek, from Murdocksville to the mouth of Brush Run, also on Aunt Clara Fork of Kings Creek. The easternmost outcrop on the latter stream is about 1½ miles from the west edge of the quadrangle, near a small shop. At this point the limestone is directly under a massive sandstone, by which it appears to have been partially replaced. Lower down the creek, near the edge of the quadrangle, the limestone has its normal thickness of about 2 feet. Kings Creek cuts deep enough into the Conemaugh formation to reach the Ames limestone, but it was not located on that stream. A small coal outcrops not far from the road level along the creek for a distance of more than 2 miles from the edge of the quadrangle. This coal is probably the Lower Ames coal, as it is about 240 feet below the Pittsburg coal.

No comparison of elevation was made to determine the intervals between beds in this township. The structure of the rocks was determined entirely from elevations on the Pittsburg coal.

## FINDLEY AND NORTH FAYETTE TOWNSHIPS, ALLEGHENY COUNTY.

Parts of the townships of Findley and North Fayette, of Allegheny County, are included in the northeast corner of the Burgettstown quadrangle. The surface of these townships is about equally divided between the lower half of the Monongahela formation and the upper half of the Conemaugh.

*Monongahela formation.*—The Pittsburg coal outcrops in all parts of North Fayette Township and throughout Findley Township, except for a distance of 2 miles on the west edge. The coal maintains a thickness of about 5 feet. The upper division and the Rider coal are absent throughout most of the area of these townships. In North Fayette and the southeast corner of Findley the Monongahela formation is thick enough to bring the different beds of the Benwood limestone to view on the higher ridges. Both the Dinsmore and Bulger limestones are prominent in the ridge to the south of Santiago and in the top of the knobs 2 miles northwest of that town.

*Conemaugh formation.*—The Pittsburg limestone is present at 7 to 20 feet under the coal. In a few localities a limestone bed was noted at an interval of about 120 feet below the Pittsburg. The streams do not cut deep enough into the Conemaugh formation to reach the horizon of the Ames limestone, except in Potato Garden Run, a mile and a half from the west edge of Finley Township. Here the Ames limestone appears in outcrop, and may be followed down the creek to the township line.

*Subsurface rocks.*—Little information was procured with reference to subsurface conditions. A number of wells have been drilled in these townships, but the records of only a few could be obtained.

## ROBINSON TOWNSHIP, WASHINGTON COUNTY.

Robinson Township is the northeasternmost township of Washington County. The surface is about equally divided between the Monongahela and the Conemaugh formations.

*Pittsburg coal.*—The Pittsburg coal outcrops throughout the township, except in the northwest corner. An exposure of this coal can be found on nearly all the roads and ridges. It was the only stratum used for determining the structure within its area of outcrop. The Redstone coal shows as a small blossom in the central portion of the township. In the southeast corner of the township the formations dip so that the Sewickley coal and some of the beds of the Benwood limestone show in the higher hills. Measurement of the distances of these strata above the Pittsburg coal was made at one point only. This was 1 mile east of Candor, and the measurement showed the Sewickley coal to be 97 feet and the Bulger limestone 169 feet above the base of the Pittsburg coal.

*Conemaugh formation.*—The Pittsburg limestone is present throughout the township, about 18 feet below the coal. In some localities a second limestone bed occurs at 45 to 50 feet below the coal. The streams do not cut deep enough into the Conemaugh formation to bring any other distinctive member to view, except in the northwest corner of the township. Here Raccoon Creek cuts through the Ames limestone, which is 2 feet thick and well filled with fossils. It can be easily followed up the creek for a distance of a little more than a mile, to the point where it goes under cover. The Ames coal lies directly below the limestone and is from 1 to 1½ feet thick.

*Subsurface stratigraphy.*—Most wells in the township show a coal from 615 to 660 feet below the Pittsburg coal. The records are indefinite regarding the positions of the Salt, Big Injun, and Bitter Rock sands. This is owing probably to careless measurement in taking the records. The Salt sand is reported at 812 to 936 feet, the Big Injun at 1,007 to 1,237 feet, and the Bitter Rock at about 1,500 feet below the Pittsburg coal. The distance of the Hundred-foot sand below the coal is 1,850 feet in the northwest end of the township, increasing to 1,935 feet in the southeast. The top of the "red rock" averages 103 feet above the Hundred-foot sand. The Thirty-foot sand averages 117 feet below the Hundred-foot sand, the Gordon 207 feet below, and the Fourth 273 feet below. A large number of wells show an average distance of 122 feet between the Gordon and the Fifth sands, making the latter 329 feet below the Hundred-foot sand.

## SMITH TOWNSHIP, WASHINGTON COUNTY.

Smith Township is located in the central portion of the quadrangle and contains the town of Burgettstown, from which the quadrangle derives its name. The surface of the township is composed mostly of the Monongahela formation. Below this a section of nearly 200 feet of the Conemaugh formation is exposed in the valley of Raccoon Creek, north of the Pittsburg, Cincinnati, Chicago and St. Louis Railway. South of the railroad very little of the Conemaugh appears. The rocks dip steeply to the south, so that the hills on both sides of Burgetts Fork reach above the upper limit of the Monongahela formation, and some hills show nearly a full section of the Washington formation. In the northwest corner the Pittsburg coal is at an elevation of 1,167 feet above tide and in Cross Creek basin at an elevation of 768 feet, making a total descent of 400 feet.

*Washington formation.*—The hills between Cherry Valley and Burgetts Fork and those west of Burgetts Fork reach well into the Washington formation. The Waynesburg "A" and "B" coals outcrop on the roads leading from Burgetts Fork. Above these small coals is the heavy blossom of the Washington coal, with the Lower Washington limestone above. On the central ridge the Washington coal reaches as far north as the Burgettstown oil field and on the ridge west of Burgetts Fork it extends half a mile north of Quakers Knob. Owing to the relatively steep dip of the formations in the southern part of the township the conditions are unfavorable for making reliable measurements of intervals by comparisons of elevation of outcrops. A comparison of the elevation of the three outcrops of Washington coal in the Burgettstown oil field with the elevation of the Pittsburg coal, as determined by the records of wells near each outcrop, gave the following results:

*Distance between top of Washington coal and base of Pittsburg coal in Burgettstown oil field.*

| | Feet. |
|---|---|
| Outcrop near William Russell well No. 9 | 362 |
| Outcrop near William Russell well No. 5 | 366 |
| Outcrop near William Russell well No. 2 | 365 |
| Average | 364 |

*Waynesburg coal.*—At the crossroads on the Jefferson Township line, south of Dinsmore, is the best outcrop of the Waynesburg coal in the township. It has a thickness of over 2 feet. East of this point the coal is thinner and somewhat difficult to identify. East of Burgettstown it is near the summit of the hill. At the center of the Cross Creek basin it is at about the level of the valley road. From this point it rises to the southeast, keeping in about the same relation to the water level of the creek.

*Uniontown coal.*—The Uniontown coal has a thickness of about 8 inches in this township. It was identified on the roads from Cherry Valley to Burgetts Fork and west of this fork.

*Benwood limestone.*—The Benwood limestone is well developed throughout Smith Township. The hills in the northwestern portion of the township are mostly capped with the Dinsmore ledges of limestone. In the northeastern portion all of the hills carry the Dinsmore and Bulger beds, and some of the higher hills reach to those of the upper part of the Benwood. South of the railroad the upper beds of the Benwood limestone remain above water level in Cherry Valley to the eastern boundary of the township. Up Burgetts Fork the beds of limestone dip steeply, going under cover within 2 miles of Burgettstown.

*Sewickley coal.*—The Sewickley coal, which lies at the bottom of the Benwood limestone, is only about 8 inches thick in this township. By searching, it can be located on nearly all roads. It is valuable only as a guide to geologic location.

*Redstone coal.*—The Redstone coal is represented here by a thin layer of black shale above a bed of easily disintegrated limestone. The distance of this coal above the bottom of the Pittsburg bed was determined by the comparison of elevations at the following places:

*Distance between top of Redstone coal and base of Pittsburg coal, Smith Township, Pennsylvania.*

| | Page. |
|---|---|
| West of Burgettstown | 70 |
| Crossroads north of Bulger | 60 |
| South of Raccoon station | 72 |
| Average | 67 |

*Rider coal.*—In the northwestern portion of the township the Rider coal is a distinct bed from 1 to 2 feet thick, lying fully 20 feet above the top of the main Pittsburg coal bed. Near the railroad the Rider apparently forms the upper bench of the Pittsburg coal, being a succession of thin bands of coal interspersed with clay and shale.

*Pittsburg coal.*—On the north side of the railroad the Pittsburg coal outcrops on the hillsides. It is opened for mining in many places and can be followed with ease. South of the railroad it rapidly sinks under cover. The last outcrop in Cherry Valley is about 1 mile from Raccoon station, and the last on Burgetts Fork at the south end of Burgettstown.

*Intervals.*—The measurements obtained for determining the intervals between the base of the Pittsburg coal and the different marking strata of the Monongahela formation are shown in the subjoined table. Most of the comparisons of elevation were made to determine the distance of the Bulger limestone above the Pittsburg coal. This distance is from 145 to 160 feet, with an average of 155 feet, the smaller intervals being in the vicinity of Bulger.

*Distance between base of Pittsburg coal and top of marking strata of Monongahela formation, Smith Township, Pennsylvania.*

| Locality. | Sewickley coal. | Dinsmore limestone. | Bulger limestone. | Uniontown coal. | Waynesburg coal. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| Crossroads north of Bulger tunnel | | | 149 | | |
| North side of Bulger Hill | | 120 | 145 | | |
| West side of Bulger Hill | | | 159 | | |
| South side of Bulger Hill | | 127 | 150 | | |
| North side of Raccoon station, outcrop compared with Taylor well No. 2 | | 135 | 160 | | |
| 1 mile south of Raccoon station, outcrops on private road | 99 | 133 | 156 | | |
| Road from Burgettstown to Cherry Valley | | 125 | | 204 | |
| Cherry Valley oil field, outcrop compared with record of R. G. Scott well No. 2 | | 131 | 151 | | |
| Cherry Valley oil field, outcrops compared with record of Scott heirs well No. 1 | | | | 203 | |
| Cherry Valley oil field, outcrops compared with record of Scott heirs well No. 6 | | | | 221 | 261 |
| Outcrop by Pittsburg and Eastern shaft No. 2 | | 139 | 159 | | |
| On road south from Dinsmore | 92 | 140 | 160 | | |
| Outcrop compared with record of L. M. Cook well | | | | | 266 |
| 2 miles south of Burgettstown, outcrop compared with record of John Easton well No. 2 | | 136 | | | |
| Average | 95 | 132 | 155 | 209 | 264 |

*Conemaugh formation.*—Below Pittsburg limestone is shale with no distinctive marking strata for a distance of about 100 feet. At this horizon in the vicinity of Bavington is a coal bed of variable thickness to which the name Bavington coal has been given. This lies in shale and varies abruptly in thickness from a knife-edge to 5 or 6 feet. At an outcrop near the iron bridge over Raccoon Creek, on the valley road from Burgettstown to Bavington, it has a thickness of 26 inches. On the east side of Martha McBride's farm at Bavington this coal has a thickness of more than 5 feet and is opened for mining. The same coal shows in outcrop in the run west of Bavington and also at the head of Brush Run. The interval between it and the Pittsburg coal is not regular. The following comparisons of elevations were made:

*Distance between top of Bavington coal and base of Pittsburg coal, Smith Township, Pennsylvania.*

| | Feet. |
|---|---|
| On Raccoon Creek south of Bavington | 115 |
| East of Bavington | 136 |
| West of Bavington | 96 |
| Average | 116 |

*Subsurface stratigraphy.*—The well records of the township show the top of the Salt sand to be somewhere between 850 and 940 feet below the Pittsburg coal. The Big Injun sand comes in at about 1,050 feet below the coal and has a thickness of 230 to 290 feet. Below the bottom of the Big Injun is a fairly regular interval of 540 feet to the Hundred-foot sand. In this interval is the Squaw sand, the Thirty-foot shells, and the "red rock." The top of the "red rock" is a little less than 100 feet above the Hundred-foot sand. The top of the Thirty-foot shells is 260 to 300 feet above the Hundred-foot sand.

There is some doubt as to whether the Thirty-foot shells represent the Berea sand. The distance from this bed down to the "red rock" as found in this township is nearly a hundred feet too great.

## JEFFERSON TOWNSHIP, WASHINGTON COUNTY.

Jefferson Township is situated south of Harmon Creek, on the western side of the quadrangle. It extends beyond the quadrangle boundary to the West Virginia line. The surface of the township is mostly in the Monongahela formation, though a section of 200 feet of the Conemaugh formation is shown in the deeper valleys of the principal creeks. Because of the dip of the rocks to the southeast, the tops of the highest hills along the east edge of the township are still capped by the Washington formation. Throughout the western and southern parts of the township the Waynesburg coal underlies most of the higher hills.

*Waynesburg "A" coal.*—Along the Eldersville ridge road both east and west of Lee schoolhouse the Waynesburg "A" coal outcrops 55 feet above the top of the Waynesburg coal.

*Waynesburg coal.*—Throughout most of the township the Waynesburg coal is near the summit of the ridges. The ridge roads cross and recross its outcrop many times in all parts of the township. The coal has a thickness of over 2 feet and makes a very prominent blossom on the roads. It has been opened for mining at one place on the north side of the ridge road 3 miles east of Eldersville, but the bank is abandoned, partly owing to the poor quality of the coal. In the following table will be found results obtained by comparing the elevation of the top of the Waynesburg coal with the base of the Pittsburg coal, and also with the top of the Bulger limestone.

*Distance from base of Pittsburg coal and top of Bulger limestone to Waynesburg coal, Jefferson Township, Pennsylvania.*

| Locality. | Bulger to Waynesburg. | Pittsburg to Waynesburg. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Crossroads south of Dinsmore | 104 | 273 |
| At Lee schoolhouse | ........ | 270 |
| Outcrop near Sanky Well No. 1 | ........ | 275 |
| Road to west from south end of Eldersville | ........ | 281 |
| At head of Scott Run | 105 | ........ |
| North of Bethel Church | 120 | 280 |
| Outcrop near Gillespie Well No. 1 | 125 | 291 |
| Average | 113 | 278 |

*Uniontown coal, Benwood limestone, and Sewickley coal.*—The ledges of the Benwood limestone, with the Sewickley coal below and the Uniontown coal above, show in all parts of the township. Neither the Sewickley nor the Uniontown coal is of any importance beyond that of a geologic marker. These coals are not over 1 foot thick, and they are usually represented by but a few inches of bituminous shale.

The Dinsmore white limestone is especially well developed. There are more thick beds of limestone than usual in this part of the quadrangle, which makes it somewhat doubtful if the same heavy bed is selected each time for determining the distance to the Pittsburg coal.

The Bulger limestone has not the prominence and clear crystalline appearance here that it has in the vicinity of Bulger and throughout the eastern portion of the quadrangle. In Jefferson Township it is an earthy limestone, having the appearance of hard dark-green shale. It maintains it position, however, directly above 20 feet or more of soft green shale. The heavy blue bed near the top of the Benwood limestone is prominent in the vicinity of Eldersville.

In the following table will be found the intervals obtained by comparing the different elevations of the two coals and the limestone bed with the elevation of the base of the Pittsburg coal in different parts of the township:

*Distance between base of Pittsburg coal and top of marking strata of Monongahela formation, Jefferson Township, Pennsylvania.*

| Locality. | Sewickley coal. | Dinsmore limestone. | Bulger limestone. | Blue limestone. | Uniontown coal. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| On road from Hanlin to Eldersville | ........... | 142 | 181 | 206 | ........... |
| On road from Hanlin to Lee schoolhouse | 105 | 132 | ........... | 199 | ........... |
| On road from Dinsmore to Cross Creek | 89 | 132 | 170 | ........... | ........... |
| On road from Hanlin to Pattersons Mill Creek | 111 | ........... | 158 | ........... | ........... |
| On road east of McCreed Run | ........... | 138 | 178 | 208 | 215 |
| On ridge east of Bethel Church | 102 | 142 | 171 | ........... | ........... |
| On ridge west of Bethel Church | ........... | 144 | 163 | ........... | ........... |
| At head of Gillespie Run | ........... | 132 | 156 | ........... | ........... |
| On road from Cross Creek to Bethel Church | ........... | 141 | 160 | ........... | ........... |
| On road southeast of McCreed Run | ........... | ........... | ........... | ........... | 211 |
| Average | 102 | 138 | 167 | 204 | 213 |

*Redstone coal.*—The Redstone coal is present only as a thin coaly shale throughout the township. Its outcrop was noted on the road from Hanlin to Eldersville and also on the road leading north from the twin tunnels of the Wabash Railroad. The following intervals were measured:

*Distance between base of Pittsburg coal and top of Redstone coal, Jefferson Township, Pennsylvania.*

| | Feet. |
|---|---|
| On road from Hanlin to Eldersville | 77 |
| On road from the twin tunnels northward | 60 |
| Average | 68 |

*Pittsburg coal.*—On the north side of the Eldersville ridge the Pittsburg coal outcrops at an elevation of 1,080 to 1,100 feet. The steep dip of the formation to the southeast reduces this elevation to about 1,020 feet before the coal goes under cover in the side streams which flow northward into Harmon Creek. On McCreed Run the coal outcrops within less than 1 mile southwest from Eldersville and there goes under cover at an elevation of 1,076 feet. On Scott Run the highest outcrop occurs 1¾ miles south of Eldersville at an elevation of 1,010 feet. Along the south edge of the township the coal is halfway up the hillside above Cross Creek at an elevation of about 1,000 feet. The rocks here are nearly level, the coal going under cover at about the same elevation in the ravines on the north side of Cross Creek. Throughout the township the limestone above the Pittsburg coal and the Rider coal bed are absent, being replaced by a heavy brown sandstone (Pittsburg sandstone) whose base is only a foot or so above the main coal.

*Pittsburg limestone.*—The Pittsburg limestone is well developed throughout the township. It is in two beds, each a foot or more in thickness, one being dark blue and the other dove color. The following intervals were determined:

*Distance between top of Pittsburg limestone and base of Pittsburg coal, Jefferson Township, Pennsylvania.*

| | Feet. |
|---|---|
| On road from Hamlin Station to Eldersville | 7 |
| On road from Hamlin Station to Lee schoolhouse | 18 |

From the Pittsburg limestone to the Ames limestone the section consists of shale and sandstone, with a larger percentage of shale than in other sections of the quadrangle.

*Ames limestone.*—In the valley of Harmon Creek the Ames limestone is a bed 2½ feet thick, well filled with crinoid stems. Where this stream leaves the quadrangle the limestone is 40 feet above the stream bed. From this point it can be easily followed up the creek to a point due north of Eldersville, where it goes under cover. Owing to the steep rise of the rocks to the northwest, no reliable measurements of the interval between the Ames limestone and the Pittsburg coal could be obtained. In the adjoining area of the Steubenville quadrangle a measurement of 219 feet was obtained for this interval, and this was assumed to hold for Jefferson Township.

*Intervals.*—By combining all the averages of the previous tables the following general averages are found for the different marking strata above and below the Pittsburg coal in Jefferson Township:

*Distance between marking strata and base of Pittsburg coal, Jefferson Township, Pennsylvania.*

| | Feet. |
|---|---|
| Ames limestone to Pittsburg coal | 219 |
| Pittsburg coal to Sewickley coal | 102 |
| Pittsburg coal to Dinsmore limestone | 138 |
| Pittsburg coal to Bulger limestone | 167 |
| Pittsburg coal to top of Benwood limestone | 204 |
| Pittsburg coal to Uniontown coal | 213 |
| Pittsburg coal to Waynesburg coal | 279 |
| Pittsburg coal to Waynesburg "A" coal | 335 |

*Subsurface stratigraphy.*—Throughout the northern portion of the township the Dunkard sand is found about 420 feet below the Pittsburg coal. In this same area the Lower Kittanning coal, called the Freeport coal, is noted in all the well records at a distance of 600 to 640 feet below the Pittsburg coal. In the southern portion of the township the real Freeport coal is noted in well records at a distance of about 360 feet below the Pittsburg coal, and here the Kittanning coal appears to be absent, as it is not noted in the records. The top of the Salt sand is from 810 to 840 feet below the Pittsburg coal.

The Big Injun sand has a thickness of about 200 feet, with the top averaging about 1,000 feet below the Pittsburg coal. The Squaw sand occurs at 1,300 to 1,330 feet below the Pittsburg coal. The Berea sand, or Thirty-foot shells, as it is called in the records, is from 1,600 to 1,650 feet below the coal and by four measurements occurs from 180 to 205 feet above the Hundred-foot sand. The top of the "red rock" is a little less than 100 feet above the Hundred-foot sand, which is the producing gas sand of the township. This sand is from 9 to 11 feet thick, and occurs 1,780 feet below the Pittsburg coal in the northern part of the township and 1,846 feet below in the southern part.

Few wells have been drilled below the Hundred-foot sand. In the G. Cunningham well (No. 822) the Thirty-foot sand was found 99 feet below the Hundred-foot, the Gordon Stray 171 feet, the Gordon 193 feet, the Fourth 255 feet, and the Fifth as shells 348 feet below the Hundred-foot sand.

### CROSS CREEK AND INDEPENDENCE TOWNSHIPS, WASHINGTON COUNTY.

Cross Creek Township, which includes most of the drainage of Cross Creek, lies to the east of Jefferson, south of Smith, and west of Mount Pleasant townships. Only a part of Independence Township is included in the Burgettstown quadrangle. This lies in the southwest corner, to the south of Jefferson and Cross Creek townships. The surface of Cross Creek and Independence townships is composed mostly of the Monongahela and Washington formations.

*Marking strata above Washington coal.*—The Lower Washington limestone is well developed above the Washington coal. It is the highest bed found in most parts of the township. At and to the north and east of Cross Creek village, however, the dip of the formation into the Cross Creek syncline brings the Jollytown coal and the Upper Washington limestone down to the level of the highest hills.

*Washington coal.*—The Washington coal is the principal geologic marker throughout the greater portion of Cross Creek Township. Apparently the coal is of considerable thickness, showing as a prominent blossom on the roads. In the vicinity of Cross Creek village it is halfway down to valley level east of the village and a hundred feet below town on the west. It is near the summit of the ridge between Middle Fork and North Fork of Cross Creek. Between Middle Fork and the north branch of South Fork it is nearly at the heads of the valleys. On the ridge between the two branches of South Fork the Washington coal is near the summit, but south of the South Fork it is about 100 feet below the summit of the ridge.

In Independence Township the Washington coal is present in all of the high knobs along the southern boundary of the quadrangle.

In the following table are given the measurements obtained by comparing the elevations of the different marking strata of the Washington formation above the Waynesburg coal:

*Distance from top of Waynesburg coal to Waynesburg "A" and Washington coal beds, Cross Creek and Independence townships, Pennsylvania.*

| Locality. | Waynesburg "A" coal. | Washington coal. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Road from West Middletown station to West Middletown | | 99 |
| 1 mile east of Wilson Mills | 49 | |
| 1 mile north of Woodrow | | 109 |
| Near well No. 829 | | 106 |
| Northeast angle of Cross Creek Township | | 106 |
| Average | | 107 |

*Waynesburg coal.*—The Waynesburg coal is from 2 to 2½ feet thick in most of Cross Creek Township. From its position near the summit of the ridges in the western part of the township it dips steeply to the east and is just above valley level at Wilson Mills. Here it has been opened for mining in a number of places. To the east of Wilson Mills the coal rises and shows in outcrop on all of the roads leading away from the valley. The outcrop of this coal is prominent near the twin bridges on South Fork of Cross Creek and can be followed along the railroad cut to the west. It is some distance above the valley floor both north and south of Woodrow and has here been opened for mining. North of the north branch of South Fork of Cross Creek the coal is not so prominent.

It was not possible to obtain much reliable information as to the interval between the Pittsburg coal and the Waynesburg coal in these townships. The following table gives the few measurements made between the Pittsburg and Waynesburg, two of which are from well records:

*Distance between base of Pittsburg coal and Waynesburg coal, Cross Creek and Independence townships, Pennsylvania.*

| | Feet. |
|---|---|
| Average at Pattersons Mill | 268 |
| On road from twin tunnels to Independence | 278 |
| In well No. 829 | 273 |
| In well No. 832 | 265 |
| Average | 271 |

*Uniontown coal, Benwood limestone, and Sewickley coal.*—The Sewickley and Uniontown coals are small and valuable only as markers. The coal beds and intervening limestone outcrop on the hillsides along Cross Creek and its branches. On the north fork of the creek the upper beds of the Benwood limestone go under cover at the road intersection, half a mile west of the village of Cross Creek.

The valley road from this point southward shortly reaches the Dinsmore beds, at which horizon it remains nearly to Pattersons Mill, the formation dipping at about the same rate as the fall of the stream. This condition also exists along the roads from the main valley road to the northwest. Up Middle Fork of Cross Creek the upper bed of the Benwood remains above water level to a point within 2 miles of Cross Creek village. On the main Cross Creek the Benwood limestone is very prominent, the lower half being especially well developed. Many good sections of this member are exposed along the cuts of the Wabash Railroad and in the channel of Cross Creek. At the mouth of South Fork the Uniontown coal is 20 feet above the valley level. Up the main stream the Benwood sinks below surface level under the Wilson Mills syncline, but appears again at the east edge of Cross Creek Township; also on South Fork the Benwood goes entirely under cover and reappears before Mount Pleasant Township is reached.

In Independence Township the Benwood limestone outcrops along the hillsides above Cross Creek and in the canyons of the streams flowing from the south. The upper beds are not so well developed in these areas as to the north, and in many places their identification is difficult. The Uniontown coal shows in good outcrop on the road from the twin tunnels to Independence village at the turn of the road near the crest of the hill.

*Pittsburg coal.*—The Pittsburg coal outcrops along Cross Creek from Pattersons Mill and Avella to the west edge of the quadrangle. The coal maintains a regular thickness of 5 feet. It is overlain by the Pittsburg sandstone, which takes the place of the limestone above the Pittsburg coal and the Rider coal.

In the following table are given the intervals obtained by comparing the elevation of different outcrops of the Benwood limestone and the Sewickley and Uniontown coals with the elevation of the Pittsburg coal:

*Distance between base of Pittsburg coal and top of marking strata of Monongahela formation, Cross Creek and Independence townships, Pennsylvania.*

| Locality. | Sewickley coal. | Dinsmore limestone. | Bulger limestone. | Blue limestone. | Uniontown coal. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| Above So[illegible]thwestern Coal Co.'s mine | .......... | 114 | 166 | 217 | .......... |
| West of [illegible]ryor station | .......... | 149 | 170 | .......... | .......... |
| On ridge road to Eldersville | .......... | 146 | 166 | 220 | 225 |
| At Pattersons Mill, average | .......... | 153 | 173 | .......... | .......... |
| Gillespie hill | 104 | .......... | .......... | .......... | .......... |
| South of twin tunnels | .......... | 140 | .......... | .......... | 220 |
| Average | 104 | 148 | 169 | 218 | 222 |

*Distance between top of Bulger limestone and top of marking strata of Monongahela formation, Cross Creek and Independence townships, Pennsylvania.*

| Locality. | Blue limestone. | Uniontown coal. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Road from West Middleton to Pattersons Mill | 50 | 57 |
| West of Pryor station | | 54 |
| Ridge road to Eldersville | 54 | 55 |
| Average | 52 | 55 |

By combining the measurements given in the foregoing tables the following intervals are found for the different marking strata above the Pittsburg coal in Cross Creek Township:

*Average distances between marking strata and base of Pittsburg coal, Cross Creek Township, Pennsylvania.*

| | Feet. |
|---|---|
| Pittsburg coal to Sewickley coal | 104 |
| Pittsburg coal to Dinsmore limestone | 148 |
| Pittsburg coal to top of Benwood limestone | 220 |
| Pittsburg coal to Uniontown coal | 223 |
| Pittsburg coal to Waynesburg coal | 271 |
| Pittsburg coal to Waynesburg "A" coal | 320 |
| Pittsburg coal to Washington coal | 378 |

## MOUNT PLEASANT TOWNSHIP, WASHINGTON COUNTY.

Mount Pleasant Township lies southeast of Smith and Cross Creek and northwest of Chartiers townships. It occupies most of the southeastern quarter of the quadrangle.

*Washington formation.*—Through the central and southwestern parts of the township the larger portion of the surface is composed of the Washington formation. The Waynesburg "B" coal is especially prominent near Hickory and along the ridge road to the east, also in the vicinity of Miller Run. The Washington coal outcrops at Prospect Church, west of Hickory, and thence southward through all the higher hills on the western side of the township, along the ridge leading to Cross Creek village, at Rankin schoolhouse, and farther east, through the higher hills. The coal makes on all roads a heavy blossom that is easily distinguished by its size and mealy appearance. The high ridge between the waters of Chartiers Creek and Cross Creek reaches through the Washington formation, the Upper Washington limestone showing near the summit.

In the following table are given the measurements obtained by comparing the elevations of different marking strata of the Washington formation with the elevation of the top of the Waynesburg coal:

*Distance between top of Waynesburg coal and top of marking strata of Washington formation, Mount Pleasant Township, Pennsylvania.*

| Locality. | Waynesburg "A" coal. | Waynesburg "B" coal. | Washington coal. |
|---|---|---|---|
| | *Feet.* | *Feet.* | *Feet.* |
| West of Rankin schoolhouse, average | | 56 | 117 |
| West of Prospect Church | | | 115 |
| Southeast of Woodrow | | | 103 |
| One-half mile south of Prospect Church | | | 105 |
| At Prospect Church | 35 | 48 | |
| West end of Hickory | | 61 | |
| 1 mile north of Hickory | | | 95 |
| 1 mile south of Hickory | 39 | | |
| 2 miles east of Hickory, average of 2 measurements | | 55 | |
| 3 miles east of Hickory, average of 4 measurements | | 61 | |
| Four outcrops in hill road to Primrose | | | 116 |
| Average | 37 | 56 | 108½ |

*Monongahela formation.*—The Pittsburg coal outcrops along the northeast edge of the township, on the south side of Robinson Run, at Primrose, also along Westland Run at the south edge of the township. An outcrop of the Redstone coal was found on the road from Westland to Hickory, but in general this coal is not prominent. The Sewickley coal bed makes a very small blossom on the roads leading to the ridges from Chartiers Creek and Westland Run. By far the best marking stratum for geologic purposes throughout the township is the Bulger member of the Benwood limestone. This bed is a pure crystalline limestone, from 1 to 2 feet thick. It is prominent about halfway up the hills above Westland, also in the hills south of Robinson Run. The Bulger limestone remains above water level nearly to the headwaters of Chartiers Creek and all its branches. The east-west structural trough, which passes through the middle of the township, lowers the formation, so that all of the Benwood limestone is below valley level in the vicinity of Rankin schoolhouse and also east and west from that point. The Uniontown coal amounts to little or nothing in this township. The Waynesburg coal is from 1 to 1½ feet thick south of Primrose and through the middle of the township, but in the southeastern part it is only a few inches thick and hard to find. On the headwaters of Cherry Run and Burgetts Fork this coal is a short distance above valley level and is a good geologic guide.

The conditions are not good for determining by the direct comparison of outcrops the distances of the different marking strata of the Monongahela formation above the Pittsburg coal. The best measurements were obtained by comparing the elevations of outcrops of the various strata with elevations of the Pittsburg coal as determined by mine survey and from the reliable records of wells.

The following table shows the measurements obtained in different parts of the township:

*Distances between base of Pittsburg coal and top of marking strata of Monongahela formation, Mount Pleasant Township, Pennsylvania.*

| Locality. | Dinsmore limestone. | Bulger limestone. | Waynesburg coal. |
|---|---|---|---|
| | *Feet.* | *Feet.* | *Feet.* |
| South of Primrose, outcrops compared with mine levels of coal. | 136 | 159 | 260 |
| South of Primrose, outcrops compared with mine levels of coal. | 145 | 162 | ........ |
| North of Miller Run, outcrop compared with record of J. Scott well No. 5 | ........ | 161 | ........ |
| On Burgetts Fork, outcrop compared with record of Lyle well No. 1 | ........ | ........ | 275 |
| On Burgetts Fork, outcrop compared with record of D. C. Miller well No. 1 | ........ | ........ | 264 |
| 1 mile southwest of Hickory, outcrop compared with record of J. M. K. Donaldson well | ........ | 173 | ........ |
| 1 mile west of Hickory, outcrop compared with record of George Kimmond well | ........ | ........ | 275 |
| 1 mile north of Westland, 2 outcrops compared with record of Parkinson well | ........ | 168 | 273 |
| 1 mile southwest of Hickory, outcrop compared with coal test well | ........ | 168 | ........ |
| 2 miles southwest of Woodrow, outcrop compared with record of Walker well No. 1 | ........ | ........ | 273 |
| Average | 140 | 165 | 270 |

By combining the measurements given in the foregoing table the following average measurements are established for the various marking strata above the Pittsburg coal in Mount Pleasant Township:

*Average distance between marking strata and base of Pittsburg coal, Mount Pleasant Township, Pennsylvania.*

| | Feet. |
|---|---|
| Pittsburg coal to Dinsmore limestone | 140 |
| Pittsburg coal to Bulger limestone | 165 |
| Pittsburg coal to Waynesburg coal | 270 |
| Pittsburg coal to Waynesburg "A" coal | 307 |
| Pittsburg coal to Waynesburg "B" coal | 326 |
| Pittsburg coal to Washington coal | 378 |

*Subsurface stratigraphy.*—The information obtained regarding conditions below the surface is shown in the following tables, which are compiled from well records:

*Distance from base of Pittsburg coal to subsurface coals and sands, Mount Pleasant Township, Pennsylvania.*

| Well No. | Farm. | Elevation of Pittsburg coal. | Distance to— Coals. | Salt sand. Top. | Salt sand. Bottom. | Big Injun sand. Top. | Big Injun sand. Bottom. | Hundred-foot sand. |
|---|---|---|---|---|---|---|---|---|
| | | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| 630 | D. C. Miller | 885 | 668 | 873 | ........ | 1,083 | 1,218 | 1,747 |
| 649 | Joseph Lyle | 895 | 660 | 934 | 992 | 1,038 | 1,216 | 1,750 |
| 661 | Parkinson | 1,015 | 517–637 | ........ | ........ | 1,116 | 1,222 | 1,760 |
| 612 | James V. Rea | 980 | ........ | 918 | 1,008 | 1,060 | 1,264 | 1,793 |
| 633 | Mrs. John Cowden | 1,005 | ........ | 863 | ........ | ........ | ........ | 1,800 |
| 796 | Rankin heirs | 863 | ........ | 960 | 1,035 | 1,107 | 1,287 | 1,802 |
| 657 | McGuigan | 920 | ........ | ........ | ........ | ........ | ........ | 1,810 |
| 702 | Kraekemer | 865 | 675 | 775 | ........ | 980 | 1,280 | 1,825 |

*Distance from top of Hundred-foot sand to "red rock" and various oil sands, Mount Pleasant Township, Pennsylvania.*

| Well No. | Farm. | Berea (above). | "Red rock" (above). | Thirty-foot (below). | Gordon (below). | Fourth (below). | Fifth (below). |
|---|---|---|---|---|---|---|---|
| | | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| 630 | D. C. Miller | 204 | 80 | 100 | ........ | ........ | 419 |
| 649 | Joseph Lyle | 216 | 106 | 101 | ........ | 320 | 430 |
| 661 | Parkinson | 233 | ........ | 121 | 225 | ........ | ........ |
| 612 | James V. Rea | 152 | ........ | ........ | 223 | 271 | 332 |
| 633 | Mrs. John Cowden | ........ | ........ | ........ | 193 | 263 | 303 |
| 796 | Rankin heirs | ........ | ........ | ........ | 195 | ........ | 328 |
| 702 | Krackemer No. 1 | 195 | ........ | ........ | 188 | ........ | ........ |
| | Krackemer No. 2 | ........ | ........ | ........ | 211 | ........ | ........ |
| | Average | 212 | 93 | 107 | 205 | ........ | ........ |

The first of these tables shows a good deal of doubt as to the exact position of the top of the Salt sand and also of the Big Injun. The bottom of the Big Injun is more regular in position, being from 615 to 545 feet above the Hundred-foot sand, the average being 532 feet. The second table, which gives the positions of various oil sands above and below the Hundred-foot sand, shows the Berea to average 212 feet above, the Thirty-foot 107 feet below, and the Gordon 205 feet below.

### CHARTIERS TOWNSHIP, WASHINGTON COUNTY.

Only a small portion of Chartiers Township is included in the Burgettstown quadrangle. This portion is in the southeast corner and is bordered on the north and west by Mount Pleasant Township.

*Members of the Washington formation.*—The Waynesburg "A" coal shows as a good blossom fully as prominent as the Waynesburg bed. The Waynesburg "B" coal was identified by the limestone bed above it.

*Members of Monongahela formation.*—The Pittsburg coal outcrops in the Chartiers Creek valley to a point half a mile above the junction of Westland Run. It continues in outcrop up Westland Run beyond the boundary of the township. The Redstone and Sewickley coals both show as blossoms of 8 or 10 inches in thickness. They are easily found on the roads leading to the north and south from Chartiers Creek. The lower half of the Benwood limestone is well developed and prominent. Both the Dinsmore and Bulger limestones are prominent on all roads, the Bulger being resistant enough to form a terrace on the hillsides. The heavy blue bed near the top of the Benwood is also very thick and prominent. The Uniontown and Waynesburg coals show only as blossoms a few inches thick and are hard to identify.

*Intervals.*—In the small portion of Chartiers Township within the quadrangle the formations have so much dip that no good measurement of intervals could be made by comparing the elevation of different outcrops. It was therefore necessary to compare the elevations of outcrops with the elevation of the Pittsburg coal in wells drilled near the outcrop. The following table gives the information obtained in this way:

*Distance between base of Pittsburg coal and marking strata of Monongahela formation, Chartiers Township, Pennsylvania.*

| Locality. | Dinsmore limestone. | Bulger limestone. | Waynesburg coal. |
|---|---|---|---|
| | *Feet.* | *Feet.* | *Feet.* |
| South side of creek at Menden | 128 | ............ | ............ |
| Near Mount Pleasant Township line, outcrop compared with record of T. M. Paxton well No. 2 | ............ | 160 | ............ |
| East border of quadrangle, outcrop compared with record of S. Griffith well No. 1 | ............ | 183 | ............ |
| 1 mile northeast of Westland, outcrop compared with record of Robert Cowden well No. 4 | ............ | 167 | ............ |
| 1 mile northeast of Westland, outcrop compared with record of Robert Cowden well No. 2 | ............ | 182 | ............ |
| Southeast corner of quadrangle, outcrops on road over hill to west | 134 | 178 | 288 |
| Average | 131 | 174 | ............ |

# CHAPTER V.

## WELL LOGS USED IN MAKING THE BURGETTSTOWN CONVERGENCE SHEET.

*Wells Nos. 182 and 205.*—These wells are described on pages 108–109, with reference to the convergence sheet of the Steubenville quadrangle. The distance from the Pittsburg coal to the Hundred-foot sand in these two wells has been assumed to be the distance from the Pittsburg coal to the Berea sand plus 190 feet.

*Well No. 179.*—This well is on the Andrew Stevenson farm. Its mouth is at an elevation of 1,114 feet above the sea and about 100 feet below the Pittsburg coal. A sand was found at a depth of 1,828 feet below the surface, or 1,928 feet below the Pittsburg coal. This distance is believed to be too large for the interval between the Pittsburg coal and the Hundred-foot sand, but corresponds closely with the correct distance to the Gordon sand. Five hundred feet was therefore taken from the measurement, making the distance from the Pittsburg coal to the Hundred-foot sand at this point 1,428 feet.

*Five Points and Florence oil fields.*—In these fields the convergence sheet was not made from records of particular wells. The actual position of the sand was plotted from a number of well records and elevations of the mouths of the wells, and from this the approximate distance of outcrops of the Pittsburg coal above the sand was obtained.

*Well No. 210.*—This well is on the Peterson farm and is owned by the Lawrence Gas Company. The elevation of the mouth of the well is 1,189 feet above the sea. The Pittsburg coal outcrops near by at an elevation of 1,194 feet, or 5 feet above the mouth of the well.

*Log of Peterson well (No. 210).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Conductor | | 14 |
| Coal, Pittsburg | | 630 |
| Sand, Salt | 860 | 930 |
| Sand, Big Injun (water at 1,200 feet) | 1,000 | 1,280 |
| Sand, Squaw | 1,360 | |
| Sand, Bitter Rock | 1,520 | |
| Red rock | 1,736 | |
| Sand, Hundred-foot | 1,836 | 1,848 |
| Total depth | | 1,876 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,836 feet plus 5 feet, or 1,841 feet. Other wells in close proximity give about the same result.

*Well No. 114.*—This well is on the farm of Samuel Witherspoon. Its mouth is at an elevation of 1,148 feet above the sea. No positive data were obtained on the Pittsburg coal close to the well, but the limestone below the Pittsburg coal was found at an elevation that would bring the coal 23 feet below the mouth of the well.

*Log of Samuel Witherspoon well (No. 114).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Conductor | 16 | .......... |
| Coal, Pittsburg | 640 | .......... |
| Sand, Salt | 855 | .......... |
| Sand, Big Injun | 1,030 | 1,340 |
| Sand, Squaw | 1,418 | .......... |
| Red rock | 1,780 | .......... |
| Sand, Hundred-foot | 1,881 | 1,900 |
| Total depth | .......... | 2,039 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,881 feet minus 23 feet, or 1,858 feet.

*Well No. 192.*—This well is on the farm of Thomas Cole, and its mouth is at an elevation of 1,088 feet. The Pittsburg coal outcrops northwest of the well at an elevation of 1,152 feet, which is equivalent to about 1,150 feet at the well, or 62 feet above the mouth.

*Log of Thomas Cole well (No. 192).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal | 540 | 545 |
| Coal | 635 | 640 |
| Sand, Hundred-foot | 1,798 | 1,808 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,798 feet plus 62 feet, or 1,860 feet. The elevations of wells Nos. 190 and 191, near No. 192, were obtained, but no records were procured.

*Well No. 186.*—This well is on the farm of James McNary. The elevation of its mouth is 1,042 feet. The Pittsburg coal at the well lies at an elevation of 1,062 feet, or 20 feet above the mouth. The Hundred-foot sand was struck at a depth of 1,862 feet, with a thickness of 21 feet; it contained oil at 1,865 feet. The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,862 feet plus 20 feet, or 1,882 feet. The James Osbourne well, a short distance to the west, shows the interval to be 24 feet less. The McNary well record was used owing to the better determination of the elevation of the coal.

*Wells Nos. 811, 819, 816, 820, and 823.*—The records of these wells, which were used in the convergence sheet of the Burgettstown quadrangle, have been given in the discussion of the correlation of the Berea oil sand with the sands of Pennsylvania on page 109.

*Well No. 813.*—This well is on the farm of J. S. McCorkle, and its mouth is at an elevation of 1,040 feet. No good outcrop was found close to the well. The position of the Pittsburg coal as noted in the well record was accepted.

*Log of J. S. McCorkle well (No. 813).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Conductor | 10 | .......... |
| Coal, Pittsburg | 70 | 75 |
| Sand, Dunkard | 510 | .......... |
| Coal | 700 | .......... |
| Sandstone | 875 | .......... |
| Sand, Big Injun | 1,070 | .......... |
| Sand, Hundred-foot | 1,855 | 1,865 |
| Total depth | .......... | 1,888 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,855 feet minus 75 feet, or 1,780 feet.

*Well No. 800.*—This well is on the farm of J. S. Hays, the elevation of its mouth being 1,125 feet. The Pittsburg coal is noted in the record at a depth of 95 to 103 feet, which agrees with outcrops in the vicinity of the well.

*Log of J. S. Hays well (No. 800).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 95 | 103 |
| Sand, Salt | 975 | .......... |
| Sand, Squaw | 1,495 | 1,520 |
| Sand, Hundred-foot (gas at 1,971 feet) | 1,970 | 1,984 |
| Total depth | .......... | 2,019 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,970 feet minus 103 feet, or 1,867 feet.

*Well No. 806.*—This well is on the Sankey farm. The elevation of its mouth is 1,365 feet. The Waynesburg "B" coal outcrops near the well at an elevation of 1,343 feet. This shows the well record of coal to be correct.

*Log of Sankey well (No. 806).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Conductor | 18 | .......... |
| Coal, Pittsburg | 350 | 355 |
| Coal, Freeport | 950 | .......... |
| Sand, Salt | 1,185 | .......... |
| Limestone, top Big Injun sand | 1,365 | .......... |
| Sand, Hundred-foot | 2,138 | 2,152 |
| Total depth | .......... | 2,183 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,138 feet minus 355 feet, or 1,783 feet.

*Well No. 826.*—This well is on the farm of L. E. Stewart. Its mouth is at an elevation of 1,207 feet. No outcrops of recognizable horizon were found close to the well. The recorded distance to the third Pittsburg coal has been accepted as correct.

*Log of L. E. Stewart well (No. 826).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Wood conductor | 12 | .......... |
| Coal, First Pittsburg | 228 | .......... |
| Coal, Second Pittsburg | 240 | .......... |
| Coal, Third Pittsburg | 250 | 255 |
| Coal, Freeport | 906 | .......... |
| Sand, Salt (break at 1,125 feet) | 1,052 | .......... |
| Sand, Bitter Rock | 1,530 | .......... |
| Sand, Hundred-foot | 2,036 | 2,043 |
| Sand, Fifth | 2,416 | .......... |
| Total depth | .......... | 2,510 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,036 feet minus 255 feet, or 1,781 feet.

*Well No. 803.*—This well is on the farm of John Studa, its mouth being at an elevation of 1,028 feet. The position of the coal as noted in the well record is accepted.

*Log of John Studa well (No. 803).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 65 | 70 |
| Sand, Salt (water at 955 feet) | 870 | 955 |
| Sand | 1,050 | ,075 |
| Sand, Big Injun | 1,235 | 1,295 |
| Sand | 1,385 | 1,425 |
| Red rock | 1,760 | 1,810 |
| Sand | 1,810 | 1,825 |
| Slate | 1,825 | 1,865 |
| Sand, Hundred-foot | 1,865 | 1,874 |
| Total depth | .......... | 1,874 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,865 feet minus 70 feet, or 1,795 feet.

*Well No. 824.*—This well is on the Pressley Leech farm near Pattersons Mill, at an elevation of 935 feet. The Pittsburg coal outcrops near by at an elevation of 940 feet, or 5 feet above the mouth of the well.

*Log of Pressley Leech well (No. 824).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Wood conductor | 16 | |
| Sand, Salt | 820 | |
| Limestone | 1,048 | |
| Sand, Big Injun | 1,100 | |
| Water in Squaw sand | 1,338 | |
| Sand, Hundred-foot | 1,825 | 1,829 |
| Total depth | | 1,941 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,825 feet plus 5 feet, or 1,830 feet.

*Well No. 847.*—This well is on the Buchanan farm. The elevation of its mouth is 1,050 feet. From outcrops of the Waynesburg and Washington coals in this vicinity the Pittsburg coal should be 260 feet below the mouth of the well. This does not agree with the record by 18 feet, but is accepted as a more reliable determination.

*Log of Buchanan well (No. 827).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal | 278 | |
| Red rock | 450 | |
| Sand, brown | 617 | |
| Limestone, gray | 675 | |
| Sand | 686 | |
| Sand, First | 715 | |
| Sand, Second | 913 | |
| Sand | 1,627 | |
| Sand | 1,910 | |
| Red rock | 2,000 | |
| Sand (gas) | 2,090 | |
| Sand (gas and little oil) | 2,260 | |
| Red rock | 2,492 | |
| Sand, brown | 2,825 | |
| Sand | 3,055 | |
| Sand (oil) | 3,600 | |
| Sand | 3,750 | |
| Red rock | 3,960 | |
| Soapstone | 4,010 | |
| Sand | 4,160 | |
| Sand, Bradford | 4,303 | |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,090 feet less 260 feet, or 1,830 feet.

*Well No. 657.*—This well is on the McGuigan farm. The elevation of its mouth is 1,145 feet. It is known as the "great McGuigan gas well." From outcrops of the Waynesburg coal in the vicinity the Pittsburg coal should be 225 feet below the mouth of the well.

*Log of McGuigan well (No. 657).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal | 180 | 185 |
| Coal | 285 | 300 |
| Red rock | 470 | .......... |
| Sand | 730 | .......... |
| Sand, First | 762 | 802 |
| Sand, Second | 865 | 900 |
| Sand | 920 | .......... |
| Shell | 982 | .......... |
| Sand, Third | 988 | 1,028 |
| Sand, Fourth | 1,100 | 1,155 |
| Sand, Fifth | 1,266 | 1,500 |
| Break of slate | 1,350 | 1,365 |
| Sand | 1,578 | 1,588 |
| Sand | 1,850 | 1,855 |
| Red rock | 1,965 | .......... |
| Soapstone | 1,995 | .......... |
| Sand, Hundred-foot | 2,035 | 2,040 |
| Sand, Gordon (gas) | 2,245 | .......... |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,035 feet less 225 feet, or 1,810 feet.

*Well No. 612.*—This well is on the farm of J. V. Rea, and the elevation of its mouth is 1,032 feet. The base of the Pittsburg coal is 55 feet below the mouth of the well.

*Log of J. V. Rea well (No. 612).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | .......... | 50 |
| Sand, Salt (water at 1,050 feet) | 970 | 1,060 |
| Sand, Big Injun (little gas at 1,205 feet) | 1,112 | 1,326 |
| Sand, Thirty-foot | 1,693 | 1,752 |
| Sand, Gantz (Hundred-foot) | 1,845 | 1,860 |
| Sand, Fifty-foot | 1,864 | 1,900 |
| Sand, Gordon (gas at 2,078 feet) | 2,068 | 2,087 |
| Sand, Fourth | 2,116 | 2,130 |
| Sand, Fifth (gas at 2,188 feet) | 2,177 | 2,192 |
| Total depth | .......... | 2,224½ |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,845 feet less 55 feet, or 1,795 feet.

*Well No. 661.*—This well is on the Parkinson farm. Its mouth is at an elevation of 1,228 feet. The position of the Pittsburg coal as given in the well record agrees with the position as determined by outcrops of the Bulger limestone near the well.

*Log of Parkinson well (No. 661).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Limestone, gray | 30 | 37 |
| Shale | 37 | 75 |
| Limestone and slate | 75 | 90 |
| Sand | 90 | 100 |
| Limestone | 100 | 130 |
| Slate | 130 | 145 |
| Sand | 145 | 160 |
| Slate | 160 | 185 |
| Coal, Pittsburg, and black slate | 185 | 215 |

*Log of Parkinson well (No. 661)*—Continued.

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Limestone and slate | 215 | 285 |
| Slate | 285 | 315 |
| Sand | 315 | 430 |
| Shale | 430 | 645 |
| Sand and limestone | 645 | 665 |
| Shale | 665 | 715 |
| Sand | 715 | 730 |
| Coal | 730 | 735 |
| Slate | 735 | 827 |
| Sand | 827 | 840 |
| Slate | 840 | 850 |
| Sand (trace of coal) | 850 | 860 |
| Slate | 860 | 960 |
| Sand | 960 | 970 |
| Slate | 970 | 990 |
| Sand | 990 | 1,005 |
| Shale (trace of coal at bottom) | 1,005 | 1,131 |
| Sand | 1,131 | 1,155 |
| Shale | 1,155 | 1,218 |
| Sand | 1,218 | 1,250 |
| Slate | 1,250 | 1,260 |
| Limestone, Big lime | 1,260 | 1,302 |
| Sand, Keener | 1,302 | 1,312 |
| Slate | 1,312 | 1,329 |
| Sand, white, Big Injun | 1,329 | 1,435 |
| Slate | 1,435 | 1,441 |
| Sand (layers of slate) | 1,441 | 1,468 |
| Shale | 1,468 | 1,495 |
| Sand | 1,495 | 1,502 |
| Shale | 1,502 | 1,555 |
| Sand (trace of limestone) | 1,555 | 1,580 |
| Shale | 1,580 | 1,740 |
| Sand, Bitter Rock | 1,740 | 1,750 |
| Shale | 1,750 | 1,835 |
| Sand, Berea, hard, trace of limestone | 1,835 | 1,848 |
| Shale | 1,848 | 1,910 |
| Shale, red | 1,910 | 1,973 |
| Sand, Hundred-foot | 1,973 | 2,015 |
| Shale | 2,015 | 2,198 |
| Sand, Gordon | 2,198 | 2,205 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,973 feet less 215 feet, or 1,758 feet.

*Well No. 633.*—This well is on the farm of Mrs. John Cowden. The elevation of its mouth is 1,172 feet. The position of the Pittsburg coal as given by the well record is accepted.

*Log of Mrs. John Cowden well (No. 633).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 136 | .......... |
| Water (salt) | 1,000 | .......... |
| Sand, Salt | 1,030 | .......... |
| Gas | 1,055 | .......... |
| Sand, Fifty-foot | 1,967 | .......... |
| Gas in Gordon Stray sand | 2,160 | .......... |
| Oil in Gordon sand | 2,230 | .......... |
| Sand, Fourth, dry | 2,270 | .......... |
| Total depth | .......... | 2,401 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,967 feet less 161 feet, or 1,808 feet.

*Well No. 702.*—This well is No. 1 on the Krackemer farm, and the mouth is at an elevation of 1,135 feet above sea level. The position of the Pittsburg coal as given by the well record is accepted. The measurement to the Hundred-foot sand is not accepted, however. Other wells on the same farm show that the distance between the Hundred-foot and Gordon sands is 211 feet, which is very close to the average distance between these sands. It is believed a better result is obtained by taking the measurement to the Gordon sand and subtracting 210 feet.

*Log of Krackemer well No. 1 (No. 702).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Limestone | 25 | |
| Coal, Pittsburg | 265 | |
| Coal, Freeport | 945 | |
| Sand, Salt | 1,045 | |
| Sand, Big Injun (gas) | 1,250 | 1,550 |
| Sand, Berea | 1,900 | |
| Sand, Hundred-foot | 2,095 | 2,101 |
| Sand, Gordon (gas and oil at 2,285 feet) | 2,278 | 2,296 |
| Total depth | | 2,296 |

The depth to the Gordon sand, 2,278 feet less 210 feet, gives 2,068 feet as the assumed depth of the Hundred-foot sand. The distance between this sand and the Pittsburg coal at this point is therefore 2,068 feet less 270 feet (the depth of the base of the Pittsburg coal, 265 feet plus 5 feet), or 1,798 feet.

*Well No. 649.*—This well is on the farm of J. R. and Joseph Lyle. Its mouth is at an elevation of 1,161 feet. The depth to the Pittsburg coal as given in the record is accepted. It will be noticed that the distance between the Hundred-foot and Gordon sands is 320 feet.

*Log of J. R. and Joseph Lyle well (No. 649).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Limestone | 15 | 156 |
| Coal, Pittsburg | 256 | 266 |
| Coal, Freeport | 926 | 932 |
| Sand, Salt (salt water at 1,215 feet) | 1,200 | 1,258 |
| Sand, Big Injun | 1,304 | 1,482 |
| Shell, Thirty-foot (Berea) | 1,800 | 1,865 |
| Red rock | 1,910 | 1,932 |
| Sand, Hundred-foot (steel-line measurement) | 2,016 | 2,031 |
| Sand, Blue Monday (Thirty-foot) (gas at 2,224 feet, steel-line measurement) | 2,217 | 2,226 |
| Sand, Gordon | 2,336 | 2,340 |
| Sand, Fifth | 2,446 | 2,450 |
| Total depth | | 2,474 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,016 feet less 266 feet, or 1,750 feet.

*Well No. 630.*—This well is No. 1 on the farm of D. C. Miller, and its mouth is at an elevation of 1,111 feet above sea level. The depth to the Pittsburg coal as given in the well record is accepted. No Gordon sand was found in the well. The Fifth sand is 419 feet below the Hundred-foot sand, nearly a hundred feet more than the average distance.

*Log of D. C. Miller well No. 1 (No. 630).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Limestone | 128 | 143 |
| Coal, Pittsburg | 217 | 227 |
| Coal, Freeport (little gas) | 895 | .......... |
| Sand, Salt | 1,100 | .......... |
| Sand, Big Injun (little water at 1,430 feet) | 1,310 | 1,445 |
| Shells, Thirty-foot (Berea) | 1,770 | 1,830 |
| Red rock | 1,894 | 1,934 |
| Shells, Hundred-foot (gas at 1,976–1,980 feet) | 1,974 | 1,990 |
| Sand, Blue Monday | 2,074 | .......... |
| Sand, Fifth | 2,393 | 2,418 |
| Total depth | .......... | 2,454 |

The distance between the Hundred-foot shells and the Pittsburg coal at this point is therefore 1,974 feet less 227 feet, or 1,747 feet.

*Well No. 717.*—This well is No. 11 on the Berry heirs farm, and its mouth is at an elevation of 1,145 feet above sea level. The position of the Pittsburg coal as noted in the record is accepted.

*Log of Berry heirs well No. 11 (No. 717).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 246 | .......... |
| Sand, Gordon | 2,294 | 2,320 |
| Sand, Fifth | 2,430 | 2,453 |
| Total depth | .......... | 2,461 |

In this record the Hundred-foot sand is not noted, but in this part of the township the average distance between the Hundred-foot and Fifth sands is 330 feet. If this amount is subtracted from 2,430 feet, the remainder, 2,100 feet, is the assumed depth of the top of the Hundred-foot sand. The distance between this and the Pittsburg coal is 2,100 feet less 251 feet (the coal bed being assumed to be 5 feet thick), or 1,849 feet.

*Well No. 737.*—This well is No. 9 on the farm of James Scott, and the elevation of the mouth is 1,100 feet. The position of the Pittsburg coal as noted in the record is accepted.

*Log of James Scott well No. 9 (No. 737).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 160 | .......... |
| Sand, Gordon | 2,260 | .......... |
| Sand, Fifth | 2,385 | 2,410 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,385 feet less 495 feet (165 plus 330 feet), or 1,890 feet.

*Well No. 750.*—This well is No. 3 on the farm of J. G. Berry. The position of the Pittsburg coal as noted in the well record is accepted.

*Log of J. G. Berry well No. 3 (No. 750).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 258 | .......... |
| Sand, Gordon | 2,375 | 2,400 |
| Sand, Fifth | 2,493 | 2,515 |
| Total depth | .......... | 2,520 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,493 feet (depth of Fifth sand) less 593 feet (330 feet plus 263 feet), or 1,900 feet.

*Well No. 832.*—This well is on the farm of Abram Pry. Its mouth is at an elevation of 1,262 feet. The well record is accepted and the distance taken directly from it.

*Log of Abram Pry well (No. 832).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil and clay | .......... | 10 |
| Rock | 10 | 16 |
| Slate | 16 | 60 |
| Coal (filled up full of water) | 60 | 63 |
| Slate and limestone | 63 | 160 |
| Coal | 160 | 164 |
| Slate and limestone | 164 | 420 |
| Coal, Pittsburg | 420 | 425 |
| Slate, limestone, and red rock | 425 | 850 |
| Sand, Hurry-up, first streak | 850 | 875 |
| Slate and limestone | 875 | 1,000 |
| Sand, Hurry-up, second streak | 1,000 | 1,025 |
| Slate | 1,025 | 1,170 |
| Sand | 1,170 | 1,190 |
| Slate | 1,190 | 1,210 |
| Sand, Gas, hard, white (very little gas) | 1,210 | 1,235 |
| Slate | 1,235 | 1,250 |
| Sand, Salt | 1,250 | 1,300 |
| Slate | 1,300 | 1,306 |
| Sand | 1,306 | 1,346 |
| Sand and shell | 1,346 | 1,407 |
| Sand, Big Injun (water at 1,460 feet) | 1,407 | 1,610 |
| Slate | 1,610 | 1,700 |
| Sand, Squaw | 1,700 | 1,725 |
| Slate and limestone shells | 1,725 | 2,088 |
| Red rock and slate | 2,088 | 2,173 |
| Sand, Hundred-foot | 2,173 | 2,186 |
| Slate | 2,186 | 2,190 |
| Total depth | .......... | 2,190 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,173 feet less 425 feet, or 1,748 feet.

*Well No. 585.*—This well is No. 9 on the William Russell farm, and its mouth is at an elevation of 1,193 feet above sea level.

*Log of William Russell well No. 9 (No. 585).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 352 | |
| Sand, Big Injun | 1,410 | 1,635 |
| Sand, Hundred-foot (small show of oil at 2,165 feet) | 2,160 | 2,171 |
| Sand, Thirty-foot, streak of | 2.270 | |
| Total depth | | 2,287 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,160 feet less 357 feet, or 1,803 feet.

*Well No. 589.*—This well is No. 7 on the Buchanan farm. The elevation of the mouth is 1,223 feet.

*Log of Buchanan well No. 7 (No. 589).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 345 | |
| Sand, Salt | 1,230 | 1,340 |
| Sand, Big Injun | 1,380 | 1,580 |
| Shell, Thirty-foot | 1,860 | 2,000 |
| Red rock | 2,060 | 2,120 |
| Sand, Hundred-foot (oil at 2,161 feet) | 2,160 | 2,174 |
| Sand, soft | 2,170 | |
| Total depth | | 2,175 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,160 feet less 350 feet, or 1,810 feet.

*Well No. 494.*—This well is No. 5 on the William Russell farm. Its mouth is at an elevation of 1.220 feet above sea level.

*Log of William Russell well No. 5 (No. 494).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 345 | |
| Sand, Salt | 1,200 | 1,340 |
| Sand, Big Injun | 1,390 | 1,630 |
| Sand, Squaw | 1,700 | 1,720 |
| Shell, Thirty-foot | 1,900 | 2,060 |
| Red rock | 2,080 | 2,140 |
| Sand, Hundred-foot (oil at 2.172 feet) | 2,170 | 2,186 |
| Total depth | | 2,189 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,170 feet less 350 feet, or 1,820 feet.

*Well No. 537.*—This well is No. 11 on the Scott heirs farm, and the elevation of its mouth is 1,134 feet above the sea.

*Log of Scott heirs well No. 11 (No. 537).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 200 | .......... |
| Sand, Salt | 1,100 | 1,170 |
| Sand, Big Injun | 1,300 | 1,550 |
| Sand, Hundred-foot (oil at 2,077 feet) | 2,070 | 2,091 |
| Total depth | .......... | 2,093 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,070 feet less 205 feet, or 1,865 feet.

*Well No. 515.*—This well is No. 5 on the farm of Alexander Hays. Its mouth is at an elevation of 1,002 feet above sea level.

*Log of Alexander Hays well No. 5 (No. 515).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 7 | 13 |
| Sand, Big Injun | 1,087 | 1,367 |
| Sand, Hundred-foot | 1,913 | 1,928 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,913 feet less 13 feet, or 1,900 feet.

*Well No. 577.*—This well is No. 1 on the farm of J. S. Vance. The elevation of its mouth is 1,204 feet above sea level.

*Log of J. S. Vance well No. 1, (No. 577).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 328 | 336 |
| Sand, Salt | 1,195 | .......... |
| Sand, Hundred-foot | 2,152 | 2,162 |
| Sand, Thirty-foot | 2,253 | .......... |
| Sand, Gordon | 2,312 | .......... |
| Total depth | .......... | 2,318 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,152 feet less 336 feet, or 1,818 feet.

*Well No. 569.*—This well is No. 2, on the farm of M. M. Atcheson, and the mouth is at an elevation of 1,015 feet above sea level.

*Log of M. M. Atcheson well (No. 569).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg Rider | 105 | .......... |
| Sand, Salt | 950 | .......... |
| Sand, Bitter Rock, dry | .......... | .......... |
| Sand, Big Injun | 1,160 | .......... |
| Sand, Hundred-foot (oil at 1,968 feet) | 1,962 | 1,975 |
| Total depth | .......... | 1,983 |

The Rider bed usually occurs about 15 feet above the main Pittsburg coal. This would make the base of the Pittsburg coal at a depth of 120 feet. The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,962 feet less 120 feet, or 1,842 feet.

*Well No. 500.*—This well is No. 1, on the farm of John Moore. Its mouth is at an elevation of 1,188 feet above sea level. The Pittsburg coal outcrops in the vicinity, and its leveled elevation agrees closely with its position as noted in the well record.

*Log of John Moore well, No. 1 (No. 500).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 145 | .......... |
| Sand, Hurry-up | 355 | .......... |
| Sand, Salt | 1,080 | .......... |
| Sand, Big Injun | 1,230 | 1,467 |
| Sand, Bitter Rock | 1,620 | .......... |
| Red rock | 1,965 | .......... |
| Sand, Hundred-foot | 2,050 | .......... |
| Total depth | .......... | 2,200 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,050 feet less 150 feet, or 1,900 feet.

*Well No. 115.*—This well is No. 2, on the farm of Taylor Brothers. The elevation of its mouth is 1,201 feet above sea level. The Pittsburg coal outcrops on both sides of the well, and its leveled elevation agrees with the position shown in the well record.

*Log of Taylor Brothers well No. 2 (No. 115).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Pittsburg | 138 | 148 |
| Sand, Salt | 1,050 | 1,100 |
| Limestone | 1,180 | 1,160 |
| Sand, Big Injun | 1,200 | .......... |
| Slate | 1,375 | .......... |
| Sand, Squaw | 1,580 | 1,560 |
| Sand, Bitter Rock | 1,640 | .......... |
| Sand, Hundred-foot | 2,044 | 2,064 |
| Sand, Thirty-foot | 2,158 | 2,180 |
| Total depth | .......... | 2,180 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2, 044 feet less 148 feet, or 1,896 feet.

*Well No. 106.*—This is well No. 1 on the farm of John Dunbar, and the elevation if its mouth is 1,099 feet. The Pittsburg coal outcrops close to the well at an elevation of 4 feet above the mouth.

*Log of John Dunbar well No. 1 (No. 106).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Salt | 940 | 1,050 |
| Sand, Big Injun | 1,085 | .......... |
| Sand, Hundred-foot | 1,925 | .......... |
| Sand, Thirty-foot | 2,040 | .......... |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,925 feet plus 4 feet, or 1,929 feet.

*Well No. 118.*—This is well No. 1 on the farm of Mrs. J. E. Bell, and its mouth is at an elevation of 1,120 feet above sea level. The Pittsburg coal outcrops 45 feet above the mouth of the well.

*Log of Mrs. J. E. Bell well No. 1 (No. 118).*

| | Top | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Freeport | 570 | .......... |
| Sand, Salt | 785 | .......... |
| Sand, Hundred-foot | 1,863 | 1,881 |
| Sand, Thirty-foot | 1,983 | 1,993 |
| Total depth | .......... | 2,017 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,863 feet plus 45 feet, or 1,908 feet.

*Well No. 414.*—This well is No. 3 on the farm of W. S. Bailey. Its mouth is at an elevation of 1,122 feet. The elevation of the Pittsburg coal is 1,180 feet, or 58 feet above the mouth of the well.

*Log of W. S. Bailey well No. 3 (No. 414).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Salt | 800 | .......... |
| Sand, Big Injun | 1,010 | .......... |
| Sand, Bitter Rock | 1,440 | .......... |
| Sand, Hundred-foot | 1,860 | .......... |
| Sand, Thirty-foot | 1,975 | .......... |
| Sand, Gordon | 2,065 | .......... |
| Sand, Fourth | 2,125 | .......... |
| Sand, Fifth | 2,180 | .......... |
| Total depth | .......... | 2,234 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,860 feet plus 58 feet, or 1,918 feet.

*Well No. 413.*—This well is No. 1 on the John McCalmont farm. The elevation of its mouth is 1,120 feet above sea level. The elevation of the Pittsburg coal at this point is 1,154 feet, or 34 feet above the mouth of the well.

*Log of John McCalmont well No. 1 (No. 413).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Salt | 900 | |
| Gas | 950 | |
| Sand, Big Injun | 1,120 | |
| Sand, Fifty-foot (gas) | 1,700 | |
| Sand, Hundred-foot | 1,900 | |
| Sand, Gordon | 2,121 | |
| Sand, Fourth | 2,175 | |
| Total depth | | 2,235 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,900 feet plus 34 feet, or 1,934 feet.

*Well No. 427.*—This well is No. 2 on the farm of R. S. Stevenson. Its mouth is at an elevation of 1,162 feet above the sea. The Pittsburg coal at this point is 11 feet above the mouth of the well.

*Log of R. S. Stevenson well No. 2 (No. 427).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Hurry-up | 310 | |
| Coal, Freeport | 654 | |
| Sand, Salt | 925 | |
| Sand, Big Injun | 1,045 | 1,360 |
| Sand, Bitter Rock | 1,500 | |
| Sand, Hundred-foot | 1,911 | 1,940 |
| Total depth | | 1,940 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,911 feet plus 11 feet, or 1,922 feet.

*Well No. 447.*—This is well No. 1 on the farm of Levi Gregg, and the elevation of its mouth is 1,132 feet above the sea. The Pittsburg coal outcrops at an elevation of 1,135 feet, or 3 feet above the mouth of the well.

*Log of Levi Gregg well No. 1 (No. 447).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Coal, Freeport | 675 | |
| Sand, Salt (gas at 1,045 feet; water at 1,050 feet) | 875 | 1,100 |
| Sand, Big Injun | 1,138 | 1,400 |
| Sand, Bitter Rock | 1,490 | 1,512 |
| Sand, Berea | 1,738 | |
| Red Rock | 1,859 | |
| Sand, Hundred-foot Stray | 1,924 | |
| Sand, Hundred-foot | 1,934 | 1,948 |
| Sand, Thirty-foot | 2,048 | 2,059 |
| Total depth | | 2,080 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 1,934 feet plus 3 feet, or 1,937 feet.

*Well No. 662.*—This well is No. 14 on the farm of K. N. McDonald. The elevation of its mouth is 1,023 feet. The Pittsburg coal at this point is at an elevation of 1,080 feet, or 57 feet above the mouth of the well.

*Log of K. N. McDonald well No. 14 (No. 662).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Gordon | 2,095 | 2,117 |
| Sand, Fifth | 2,222 | 2,232 |
| Total depth | ........ | 2,255 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,098 feet less 210 feet for the interval between the Gordon and Hundred-foot sands, plus 57 feet for the distance of the well mouth below the coal, or 1,942 feet.

*Well No. 906.*—This is well No. 36 on the farm of K. N. McDonald, and its mouth is at an elevation of 1,047 feet. The Pittsburg coal outcrops in the vicinity at an elevation of 1,077 feet, or 37 feet above the mouth.

*Log of K. N. McDonald well No. 36 (No. 906).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Gordon | 2,120 | 2,142 |
| Total depth | ........ | 2,148 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,120 feet, less 210 feet for the interval between the Gordon and Hundred-foot sands, plus 30 feet for the distance of the Pittsburg coal above the well mouth, or 1,940 feet.

*Well No. 674.*—This well is No. 11 on the farm of Ed. McDonald. Its mouth is at an elevation of 1,006 feet above sea level. The Pittsburg coal at this point is at an elevation of 1,038 feet, or 32 feet above the mouth of the well.

*Log of Ed. McDonald well No. 11 (No. 674).*

| | Top. | Bottom. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand, Gordon | 2,098 | 2,116 |
| Sand, pay | 2,100 | ........ |
| Total depth | ........ | 2,132 |

The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,098 feet, less 210 feet for the interval between the Gordon and Hundred-foot sands, plus 32 feet for the distance of the Pittsburg coal above the well mouth, or 1,920 feet.

*Well No. 776.*—This well is No. 1 on the W. C. Campbell farm. Its mouth is at an elevation of 1,280 feet above sea level. The record of the well does not show the position of the Pittsburg coal, but from the contoured map of the surface structure, the coal is probably at an elevation of 1,027 feet, or 253 feet below the mouth of the well. In this well the Gordon sand lies at a depth of 2,383 feet and has a thickness of 15 feet. The distance between the Hundred-foot sand and the Pittsburg coal at this point is therefore 2,383 feet, less 210 feet for the interval between the Gordon and Hundred-foot sands, less 253 feet for the depth of the Pittsburg coal below the surface, or 1,920 feet.

# CHAPTER VI.

## DETAILED GEOLOGY OF THE CLAYSVILLE QUADRANGLE.

### INDEPENDENCE TOWNSHIP, WASHINGTON COUNTY.

The lowest depression in the structure of the rocks in Independence Township is about 1 mile north of the junction of Dutch Fork and Buffalo Creek. This point is approximately the center of a low, spoon-shaped basin in the bottom of the Burgettstown syncline. From this point the rocks rise very steeply to the northwest, a little less so to the southeast, and still less to the northeast and southwest along the bottom of the synclinal trough, the rise being smallest to the southwest. The beds exposed in this township are the lower portion of the Greene, all of the Washington, and the upper part of the Monongahela formation.

*Upper and Middle Washington limestones and Jollytown coal.*—The Upper Washington limestone is found in outcrop near the tops of the highest hills from West Middletown along the pike toward Independence, the last outcrop noted being on the road to the south about one-half mile from Manchester schoolhouse. Westward the steep rise of the rocks brings the horizon of this bed above the hills, but to the south along the ridge road between Haynon and Sugarcamp runs the dip is sufficient to keep the limestone under cover to the center of the structural basin west of Acheson. The Middle Washington limestone has an unusual thickness in this township. It is exposed over about the same territory as that given above for the Upper Washington, but on account of its position lower in the series it is not so badly eroded as the upper bed. This limestone is easily identified by a heavy yellow bed near its center from which all measurements of interval have been taken. The smaller layers at the top are more easily disintegrated and rarely show distinctly in outcrop. The Jollytown coal appears to be present wherever the Middle Washington limestone occurs, but it is thin, and being embedded in reddish shale is easily overlooked. The interval between this coal and the Middle Washington limestone does not remain constant, and hence the former is of little value as a geologic marker.

*Washington coal.*—This coal is widespread in outcrop. On the points of the hills north of Buffalo Creek it is a little more than 100 feet above the stream. In all the small tributaries coming into the creek from the north this coal bed is fully 5 feet thick, and by its great thickness and the accompanying exposure of the Lower Washington limestone a few feet above and the Little Washington coal about the same distance below it is very easily recognized. The coal outcrops on both sides of Haynon Run from its mouth to its source, being well up toward the tops of the hills at the head of this stream. It also shows in outcrop on the east side of Sugarcamp Run along its whole length. A narrow belt along the top of the ridge between this stream and Indian Camp Run is underlain by this coal. From that point northwestward the rocks rise so steeply that only the highest points along the ridge catch this horizon. The last outcrop of the coal in Independence Township in this direction is on the high point just north of the village of Independence.

*Waynesburg and Waynesburg "A" and "B" coals.*—This group of coal beds comes to the surface along Buffalo Creek a little west of the mouth of Buck Run. West of this point the rocks dip more steeply than the bed of the stream, so that the Waynesburg coal is under cover to the edge of the quadrangle, but the "A" and "B" beds are above the level of the creek. From the mouth of Brush Run eastward all the coals are in continuous outcrop along Brush Run, also for three-fourths of a mile up Haynon Run, where the Waynesburg is first to go under cover. On Brush and Haynon runs the Waynesburg coal has been opened for mining in several places. It is at least 4 feet thick here and apparently of a much better grade than elsewhere. Up Haynon Run the "B" coal passes below water level a short distance from the John Wilson well. On Sugarcamp Run the first outcrop of the Waynesburg is halfway between the mouth of Indian Camp Run and the edge of the quadrangle. Northward on both sides of these runs the beds rise more abruptly than the bottoms of the valleys, and may be found in outcrop on the sides of the hills as far as the northern edge of the quadrangle.

On Sugarcamp Run the Waynesburg coal appears in several small layers, divided in places by as much as 15 feet of yellowish shale. Its appearance is so similar to that of the "A" and "B" coals that some difficulty was experienced in distinguishing between them. From the point where Sugarcamp Run leaves the quadrangle northward the "B" coal is most prominent. At the east end of Independence this coal, together with its accompanying black shale, is at least 6 feet thick. On the road to the south a short distance from this point coal "A" goes under cover in an unusually heavy outcrop. On the Middletown pike from Independence this group of coals crops out in a number of places, the "A" and "B" beds being even more prominent than the Waynesburg itself. None, however, are of economic value.

## HOPEWELL TOWNSHIP, WASHINGTON COUNTY.

The Burgettstown syncline, which passes a short distance east of West Middletown, crosses the northwest corner of Hopewell Township. Eastward from this trough the rocks rise in a broad dome-shaped anticlinal nose, which juts out from the crest of the Claysville anticline. The exposed rocks have a thickness of about 325 feet, ranging from the Benwood limestone to a horizon a few feet above the Upper Washington limestone.

*Middle Washington and Lower Washington limestones and Washington coal.*—In this township the steep rise of the rocks from the south and west brings these beds high above the valleys of the principal streams. On the east fork of Haynon Run the Washington coal crops out a short distance below the schoolhouse, half a mile from West Middletown and also at several places on the road down this run as far as Dunkle Run. Its outcrop line encircles the hillsides of the large tributary to Haynon Run which heads south of West Middletown, and the coal goes under cover on this run a short distance south of the road crossing its headwaters. On Dunkle Run this group of beds is exposed as far as the Washington-Middletown pike, along which there are numerous exposures of the Lower Washington limestone. On the ridge south of Dunkle Run the Washington coal crops out at the heads of the numerous tributaries to Brush Run. East of Buffalo village and north of the Washington-Buffalo pike the Washington coal has been opened west of the run. It also outcrops just west of the village and on the Buffalo-Middletown pike well up toward the tops of the hills on the west side of the run. At the head of Dunkle Run the coal is in fine outcrop. On the Samuel Donaldson farm, at the headwaters of Cross Creek, one-third of a mile west of the corner of Hopewell, Mount Pleasant, and Canton townships, this coal has been mined. It is approximately 5 feet thick, but owing to the condition of the opening no detailed section could be obtained. South of Buffalo village it outcrops on the point of the hills overlooking Brush Run, about 135 feet above the stream. The Little Washington coal is everywhere present, from 10 to 15 feet below the Washington coal. The Lower Washington limestone is of average thickness and has the same general appearance as described elsewhere. In most places it is overlain by the small coal found in Blaine Township, though this coal is very thin, being at no place over 1 foot thick.

*Waynesburg and Waynesburg "A" and "B" coals.*—On Brush Run the easternmost outcrop of the Waynesburg coal is at the road forks at the corner of Hopewell, Buffalo, and Canton townships. Northwest of this point it is exposed on the Buffalo-Washington pike, near the foot of the hill east of the schoolhouse, the Washington coal being just west of the schoolhouse and 112 feet above the Waynesburg coal. Westward along the hillside the outcrop line of these coals is almost on a level with the Buffalo-Taylorstown road. Up a tributary to Brush Run from the north, a short distance west of this road, the Waynesburg goes under cover before the first road crossing is reached. On this road, uphill to the west from this tributary, an unusually thick outcrop of the Waynesburg "A" coal occurs 90 feet below the Washington coal. At the point where this run crosses the Middletown-Buffalo pike the "A" coal has been opened, exposing at least 4 feet of coal. Accurate measurement shows it to be 89 feet below the Washington coal. The steep westward dip of the rocks carries these coal beds lower and lower on the hillsides to the north of Brush Run until, at the mouth of Haynon Run, the Waynesburg coal is not over 30 feet above the valley, and a short distance north of the mouth of Dunkle Run this bed is stripped in the bottom of the run and is also opened by entry. The "A" and "B" coals outcrop for half a mile farther upstream. On the south side of Dunkle Run, near its mouth, the "A" seam has been opened, but was soon abandoned. Up this run the last outcrop of this group is about three-fourths of a mile south of the Middletown-Buffalo pike.

*Uniontown coal and Benwood limestone.*—The only exposures of these beds in the township occur on the north side of Brush Run, a few feet above the stream, from a point 1 mile east of its mouth to a point within about the same distance of the corner of Buffalo, Blaine, and Hopewell townships. The beds show the same general relations as in Blaine Township, to the south.

*Middle Washington limestone and Jollytown coal.*—In Hopewell Township the Middle Washington limestone attains its maximum thickness of about 25 feet. Near West Middletown it is present in the tops of the hills, and on the ridge road south to Acheson its exposure is several yards wide on the hillside above Haynon Run. The limits of the bed are not clearly marked, but from all appearances it is at least 25 feet thick, the Jollytown coal being exposed more than 110 feet above the Washington coal. This point lies fairly in the center of the Burgettstown syncline, and from it the outcrop line of these beds rises in all directions except to the south and southwest. The Jollytown coal outcrops at the forks of the road on the Independence and West Middletown pike at the township line. It also occurs a short distance east of this point, the Middle Washington limestone outcropping below. The Jollytown coal crops out on the West Middletown-Buffalo pike at the summit of the first hill west of Buffalo, with the Middle Washington limestone in fine outcrop below. The lower beds of this limestone are exposed at the cross-roads in Buffalo and a short distance to the north of this village. The Jollytown coal also occurs on the first road east of this point opposite the lane to the east. Here it is broken up into several small layers, separated by shale. (See section, p. 156.) From this place the outcrop line of these beds encircles the headwaters of Brush Run, the heavy ledges of the limestone being well exposed on the points of the hills. In this vicinity the Jollytown coal is overlain by a laminated sandstone several feet in thickness, which in places is rather massive. This is the bed which juts out so prominently on the hillsides and which farther to the north, in Mount Pleasant Township, strews the tops of the hills with enormous bowlders.

*Upper Washington limestone and Upper Washington coal.*—The Upper Washington limestone and coal are present along the higher portions of the watershed between Buffalo and Cross creeks. The outcrop encircles the high points to the north and northwest of West Middletown and the hilltop upon which the village stands, and extends eastward for a mile or more to the forks of the road going north to Wilson Mills. The steep rise of the rocks from this point to the Canton Township line brings these beds to the highest points of the ridge. The Upper Washington limestone is here exposed, though its lower section is somewhat thinner than it is farther south. The Upper Washington coal is represented by less than a foot of soft shale, carrying thin layers of coal. The Donley limestone and Finley coal were not found in outcrop, though it is possible that they are both present.

## CHARTIERS AND SOUTH STRABANE TOWNSHIPS, WASHINGTON COUNTY.

Only the southwestern part of Chartiers Township and the western part of South Strabane Township are included in this quadrangle. The axis of the Finney syncline lies along the west edge of South Strabane and passes through the middle of Chartiers. The rocks dip from all points toward this line. Rocks from a horizon about 35 feet above the Pittsburg coal to one about the same distance above the Washington coal outcrop over this area.

*Washington formation.*—The Waynesburg "A" and "B" coals are present over most of this area, but are of no importance. The Washington coal outcrops in South Strabane Township near the top of the high ridge north of Washington. In Chartiers Township it was found only in one or two places along the high ridge between Chartiers Creek and Chartiers Run.

*Monongahela formation.*—In these townships the Waynesburg coal is thin and unimportant both for mining and as a geologic marker. It outcrops a few feet above Catfish Run in the town of Washington, and from this point northward it encircles the hills east of Chartiers Creek to the boundary of the quadrangle. On the north side of Chartiers Creek the crop line of this bed rises higher and higher on the hillsides to the borders of the quadrangle.

The Uniontown coal is represented by a few inches of coal or carbonaceous shale.

The Benwood limestone outcrops along both sides of Chartiers Creek from the edge of the quadrangle to Oak Grove, where the steep westward dip carries it under cover. It is exposed on both sides of the northern tributary to Chartiers Creek to a point half a mile above Arden Mines. On this run, a short distance below Arden Mines, a coal a few feet below the Benwood limestone was once opened for mining. This is probably the Sewickley coal, since it lies between 130 and 140 feet above the Pittsburg coal.

The Pittsburg coal comes to the surface in the valley of Chartiers Creek a quarter of a mile east of the quadrangle boundary, in the Amity quadrangle, where it is extensively mined. This coal is opened by shaft at Arden Mines, but to the southwest along Chartiers Creek it dips steeply to the bottom of the Finney syncline west of Woodell.

## CANTON TOWNSHIP, WASHINGTON COUNTY.

The axis of the Finney syncline enters Canton Township near the southwest corner, the rocks along the trough lying almost horizontal to the vicinity of Woodell, whence the axis of the syncline swings sharply to the north, passing into Chartiers Township 1 mile north of the mouth of Georges Run. At this point the key rock is about 190 feet higher than it is at Woodell. From the bottom of this trough the rocks rise steeply in all directions. The thickness of the outcropping beds is about 500 feet, that portion of the geologic column exposed including the rocks from the Benwood limestone up to the Claysville limestone.

*Upper Washington limestone and coal, Donley limestone, and Sparta coal.*—This group is not found in Canton Township north of the Buffalo-Washington pike unless a few scattering bowlders on the crest of Garrett Hill belong to the Upper Washington limestone. On the ridge south of this pike the Upper Washington limestone is in fine outcrop at the township line east of North Buffalo Church. From this point eastward a rather broad strip along the ridge is underlain by these beds to a point within a mile of Wolftown. Farther east small isolated patches of the Upper Washington limestone occur under the higher points. Southward along the higher ridge between Canton and Buffalo townships the outcrop line of the Upper Washington limestone sinks abruptly to the trough of the Finney syncline. At the tunnel on the Baltimore and Ohio Railroad under Sugar Hill this limestone is only a few feet above the track, the heavy ledges of what is probably the Donley limestone being above the roof of the tunnel. Here the Upper Washington coal lies directly above the top beds of the Upper Washington limestone, as similarly noted in the tunnel east of Claysville. At this point the bed is over 100 feet lower than on the ridge west of Wolftown. On the north side of the National pike south of Woodell this limestone is extensively quarried for road material. It is at least 25 feet thick, the layers being rather massive and lying close together. Here it is about 65 feet above the exposure at the tunnel. On the road uphill westward from Woodell the white ledges of this bed outcrop opposite the second house to the south, where it is 40 feet below the exposure on the National pike and 158 feet above an outcrop of the Washington coal near the schoolhouse on this road at the foot of the hill. The Upper Washington coal is everywhere present as a small, shaly coal from 4 to 10 inches thick. What is thought to be the Donley limestone was noted only at the tunnel under Sugar Hill, though it may probably be part of the heavy beds of limestone quarried on the National pike south of Woodell. The Finley coal shows in outcrop east of North Buffalo Church 32 feet above the Upper Washington limestone, and it is probably present at other places still farther east.

*Washington and Little Washington coals and Lower Washington limestone.*—Along the Baltimore and Ohio Railroad from Woodell station to Washington one or more of these beds are exposed in each cut. The lowest point at which the Washington coal was found in outcrop is at the sandstone quarry one-fourth mile west of Woodell station. Northward the steep rise of the rocks soon carries this coal well up toward the tops of the hills. It outcrops on the road uphill west of Wolftown near the top of the ridge, where it is 125 feet above the valley. On the Washington-Buffalo pike it is exposed at the top of the divide between Chartiers Creek and Brush Run. On the ridge road northwest from Wolftown the first outcrop of this coal occurs at a sharp bend in the road on the high point south of the residence of McClain Johnson, 110 feet higher than the outcrop west of Wolftown. Half a mile farther on the coal shows again at least 8 feet thick in front of the first house to the north of Mr. Johnson's. The bluish-white to cream-white limestone called by Stevenson [a] the *Ib* is here in fine outcrop 37 feet below the Washington coal. The Lower Washington limestone is also exposed in a normal outcrop about 30 or 35 feet above the coal. Along this ridge to the north the Washington coal underlies a narrow strip to the township line, and from this point northward along the eastern side of the ridge to the Mount Pleasant line west of Gretna. Its last outcrop in this direction is on the high ridge road three-fourths of a mile west of this village.

*Middle Washington limestone and Jollytown coal.*—A fine outcrop of the Middle Washington limestone occurs on the ridge road from

[a] Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, 1876, p. 55.

Buffalo to Gretna one-half mile north of the corner of Hopewell, Mount Pleasant, and Canton townships, just north of the crossroads. The following section, taken at this place, is typical:

*Section of Middle Washington limestone on road from Buffalo to Gretna.*

| | Ft. | In. |
|---|---|---|
| Coal, Jollytown, shaly | | 6 |
| Shale and sandstone | 3 | |
| Limestone, yellow | | 3 |
| Sandstone, reddish, and shale | 10 | |
| Shale, soft, cream colored | 5 | |
| Limestone, hard, blue | 1 | |
| Limestone, slabby, white | 1½ | |
| Shale | 3 | |
| Limestone, gray, hard, and tough, fracturing flesh color | 2 | |
| Shale | 3 | |
| Limestone, single heavy yellowish bed, fracture flesh color, with calcite crystals | 2 | |
| Shale | 2 | |
| Concealed. | | |

*Waynesburg and Waynesburg "A" and "B" coals.*—The southwesternmost outcrop of these beds is in the valley of Chartiers Creek near the Baltimore and Ohio Railroad, where the "B" coal is exposed in the bed of the creek. Northward from this point the steep rise of the beds soon brings both the "A" bed and the Waynesburg to the surface. The outcrop line of these beds encircles the sides of the valley traversed by the Washington-Buffalo pike, well up toward the head of the stream, the rise of the rocks being about equal to that of the bed of the creek. The Waynesburg coal outcrops at several places along this pike west of Wolftown. On the ridge road northwest of Wolftown this group outcrops in a number of places between that village and the top of the hill. The "B" coal, with a creamy limestone from 6 to 10 feet above, is the most prominent of the three. In this vicinity the main Waynesburg bed is much thinner than elsewhere. Toward the north the coal crops out again in three places within half a mile, the last outcrop in this direction occurring just south of the residence of McClain Johnson. Northeast of Wolftown these coals are hard to recognize. On the ridge road just west of Gretna the Waynesburg is soft and shaly, with a total thickness of not over 14 inches. A little farther up the hill near the sharp bend to the west the "B" coal is exposed in a shaly bed less than 1 foot thick, with its accompanying limestone above. At this point the "B" coal is about 65 feet below the Washington coal. On the road west from Georges Run the Waynesburg coal, exposed at the foot of a steep hill, is less than 2 feet thick. At this point the distance to the Washington coal above is not less than 115 feet.

*Uniontown coal and Benwood limestone.*—This group of rocks outcrops in a small area in Canton Township, in Chartiers Valley north of Oak Grove, and up Georges Run almost to Gretna. The rise of the rocks in that direction is just about equal to that of the valley, the upper portion of the Benwood limestone being at water level for almost the entire distance. On the first road turning to the west north of Oak Grove occurs the only outcrop of the Uniontown coal bed known in the township. The following section, taken along this road, shows the stratigraphic position and general appearance of the beds:

*Section on road west of the mouth of Georges Run.*

| | Ft. | In. |
|---|---|---|
| Limestone above Waynesburg "B" coal | 6 | |
| Coal "B," with a thin layer of bluish fire clay above and below | 2 | 6 |
| Shale and sandstone carrying one or two tiny coal smuts | 30 | |
| Coal "A," mostly shale | | 6 |
| Shale, yellow, and thin-bedded reddish sandstone | 36 | |
| Coal, Waynesburg, mostly shale | 1 | 2 |
| Sandstone, thin-bedded, shaly looking, micaceous | 10 | |
| Shale, black (horizon of stray coal bed) | 1 | |
| Clay shale, yellow, and thin-bedded sandstone | 40 | |
| Shale, black, very coarse | | 4 |
| Shale, brown | 3 | |
| Coal, Uniontown, coarse, black shale, with carbonaceous shale at bottom | | 6 |
| Limestone, Benwood: | | |
| Limestone, yellowish white, very hard, fractures dark blue | 1 | 4 |
| Shale, yellowish | 2 | |
| Limestone, yellow and hard, very impure | 2 | 6 |
| Limestone, yellowish white, fractures steel gray | | 6 |
| Shale, yellow | 8 | |
| Limestone, yellow | | 3 |
| Shale, yellowish | 8 | 6 |
| Limestone, blackish, fractures buff, very hard | 2 | 6 |
| Sandstone, thin bedded | 3 | |
| Limestone in several beds, reddish white, fractures steel gray, top bed pimply, bottom bed weathers in grooves and fantastic forms | 3 | |
| Clay and shale below to bed of run. | | |

## BUFFALO TOWNSHIP, WASHINGTON COUNTY.

The Finney syncline crosses the southwest corner of Buffalo Township, in which a shallow basin occurs northeast of Coffeys Crossing. Southward along the bottom of the trough from the rim of this basin the rocks dip 50 feet to the south edge of the township. Northwestward from this syncline the rocks rise to the Claysville anticline, the crest of which roughly parallels the west border of the township. The rocks exposed include those from the Waynesburg coal upward through the Washington formation and about 225 feet of the Greene.

*Prosperity and Claysville limestones.*—The highest rocks in the geologic column of this township occur on the high ridge a short distance north of the Sugar Hill tunnel. This is practically in the center of the Finney syncline. The Claysville limestone occurs in a small area occupying the high knob at the water tank. The exact thickness of this bed was not determined, but limestone was seen outcropping through a vertical distance of more than 20 feet, some of the layers being 1 foot or more in thickness. The Prosperity limestone is much thinner and occurs in a very poor exposure about 40 feet below the Claysville limestone.

*Upper Washington limestone and coal and Donley limestone.*—This group of beds lies from 80 to 90 feet above the Middle Washington limestone at most of the locations mentioned above. In the northern portion of the township the Upper Washington limestone shows at North Buffalo Church and on the ridge road both to the east and west of this place, also at the road forks east of the township line three-fourths of a mile southwest of the church, and again well up toward the top of the hill east of the road forks at the head of Pleasant Valley. This limestone also outcrops on the Buffalo and Coffeys Crossing road at the top of the hill east of Pleasant Valley. At this place the Upper Washington coal appears to be in two sections, at 3 and 15 feet above the limestone. Opposite the pump house on the Washington and Coffeys Crossing pipe line some of the white beds of the Upper Washington limestone show, and at the foot of the hill the Jollytown coal and Middle Washington limestone are poorly exposed. A good section of the Upper Washington limestone and associated beds may be seen near the west end of the tunnel under Sugar Hill and also on the road southward from Coffeys Crossing. Southward from this point the outcrop lines of these beds rise to the Washington anticline and are exposed on the road south of South Buffalo Church and on the road leading to Lagonda up the middle fork of Buffalo Creek near the top of the divide. In the southwestern portion of the township the Upper Washington limestone outcrops at the tunnel east of Claysville and on the road northward from the National pike 1 mile east of town.

*Jollytown coal and Middle Washington limestone.*—On the road to the north from North Buffalo Church the heavy yellow layer of the Middle Washington limestone is prominent in outcrop, and it is also exposed on the road to the east from the head of Pleasant Valley. At both these places the Jollytown coal is in two benches of 6 or 8 inches, separated by 15 feet of yellowish shale. The coal is 94 feet above the Washington coal and about 58 feet below the Upper Washington limestone. In Pleasant Valley these beds cross the Buffalo and Coffeys Crossing road about 125 feet above the stream. The Middle Washington limestone is present on both sides of the valley of the middle fork of Buffalo Creek to its source. On the west fork of Buffalo Creek these beds are exposed to the township line, and on the first road to the west north of the National pike on this creek a good outcrop of the Middle Washington limestone occurs at the sharp bend in the road about three-fourths of a mile west of the railroad. Along this stretch of road the Washington coal and its associated beds outcrop in several places.

*Lower Washington limestone and Washington and Little Washington coals.*—On Buffalo Creek the heavy layer in the Lower Washington limestone is at least 2 feet thick and is very yellow, closely resembling the yellow layer in the Middle Washington limestone. These beds go under cover on the middle fork of Buffalo Creek just south of the "S" Bridge on the National pike, on the east fork at Coffeys Crossing, and on the west fork 200 yards south of the National pike. At a cut on the Baltimore and Ohio Railroad west of Taylorstown station these beds are finely exposed, and also on the road to the west just south of this place. Downstream from these points the Washington coal rises to the crest of the Claysville anticline at Taylorstown. Up Pleasant Valley it crops out from the Blaine Township line to the forks of the road at the head of the stream. At several places along this valley the coal has been opened, but no mining is done at the present time. On the road to the north from North Buffalo Church the coal is being worked at the Imhoff bank. It is apparently of a somewhat better quality here than elsewhere, though an analysis of a carefully selected sample from this mine shows a high percentage of sulphur. On the road to the west from North Buffalo Church the Washington coal is exposed about halfway down the hill, at an interval of 112 feet from the Waynesburg coal, which outcrops at the forks of the road at the bottom of the hill.

*Waynesburg and Waynesburg "A" and "B" coals.*—The Waynesburg coal comes to the surface only along the south side of Brush Run at the north edge of the township. The "B" bed of this group is the only one exposed on the hillsides above Pleasant Valley. At the point where the Buffalo and Coffeys Crossing road intersects this valley it outcrops but a few feet above the stream in a bed 18 inches thick and 37 feet below the limestone called by Stevenson the I*b*.

## BLAINE TOWNSHIP, WASHINGTON COUNTY.

The principal structural feature of Blaine Township is the Washington anticline, which crosses the southwestern part in the vicinity of Taylorstown, having at this point a northeast-southwest trend. North of the village the crest of the anticline is unusually narrow, with a long, steep dip to the southeast and a very abrupt dip for a short distance to the west, beyond which the rocks for a long distance are almost horizontal. Just south of Taylorstown the crest of the anticline pitches to a low, flat saddle, from which it rises to the dome north of Claysville. From this saddle a broad, flat, cross syncline, which narrows and deepens to the west, pitches off to the bottom of the deep basin in Donegal and Independence townships west of Acheson. Northeastward from this trough, which roughly follows the valley of Buffalo Creek, the rocks rise at a fairly uniform rate to the line of Hopewell Township. The rocks exposed are about 300 feet thick, ranging from the upper beds of the Benwood limestone to a stratum a few feet above the Upper Washington limestone.

*Upper Washington limestone and coal.*—These beds underlie a few small areas within this township. One is along the high ridge west of Taylorstown, another along the high crest north and east of the Neely schoolhouse. There are also small areas of these rocks on the highest points to the northwest and southwest of the lower portion of Pleasant Valley and a doubtful exposure in one or two places near the west end of the ridge between Buffalo Creek and Brush Run. In most places the Upper Washington coal is represented by a few inches of black shale which locally carries a thin bed of coal. The Upper Washington limestone is somewhat thinner than it is in the townships to the south, but its characteristic milk-white layers are in general prominently exposed. The following section on the road to the west from Taylorstown shows the relative position and prominence of the beds from the Little Washington coal to the Upper Washington limestone above:

*Section on road uphill west of Taylorstown.*

| | Ft. | In. |
|---|---|---|
| Sandstone, thin-bedded, micaceous, to top of hill | 20 | |
| Shale, black (Upper Washington coal) | | 6 |
| Sandstone, thin, and shale | 6 | |
| Limestone, Upper Washington | 9 | |
| Sandstone, yellowish, and shale | 9 | |
| Concealed | 13 | |
| Limestone, buff colored, in two layers | 1 | 6 |
| Shales, black and reddish | 5 | |
| Sandstone, thin; shale and concealed | 10 | |
| Limestone, yellowish, very impure | | 6 |
| Shale and sandstone | 36 | |
| Limestone, Middle Washington: | | |
| Limestone, two beds, brownish to gray | 1 | 8 |
| Shale, brown to blue | 4 | |
| Limestone, thick yellow ledge | 2 | 6 |
| Shale, light blue to red | 1 | |
| Limestone, pink, weathers ox-blood red | | 3 |
| Shale and clay above heavy bed of laminated sandstone, below which is yellow shale, total | 31 | |
| Shale, black, locally carries coal | 4 | |
| Limestone, Lower Washington: | | |
| Limestone, cherty, crumbly, with 1 foot of thin layers below | 3 | |
| Limestone, light gray, very hard | 2 | |
| Sandstone, thin; black shale and yellow clay | 6 | |
| Limestone, blue, very impure, reddish streaks | 1 | 2 |

| | Ft. | In. |
|---|---|---|
| Limestone, Lower Washington—Continued. | | |
| Clay, blue, and shale | 10 | |
| Limestone, steel blue | | 6 |
| Shales, black and blue | 2 | |
| Coal, Washington: | | |
| Coal | | 4 |
| Shale, blue | 1 | |
| Coal | | 5 |
| Shale, brown and black | | 3 |
| Coal | 4 | |
| Shale, coaly | | 4 |
| Clay or shale | 1 | |
| Sandstone, thin, and shale, containing bits of bituminous matter | 16 | |
| Coal, Little Washington | | 8 |
| Clay or shale | 1 | |
| Sandstone and shale below. | | |

*Jollytown coal and Middle Washington limestone.*—The Jollytown coal bed is from 10 to 12 inches thick north of Buffalo Creek, but in the area to the south of this stream it seems to be represented by only a few inches of black friable shale. The heavy yellow bed of the Middle Washington limestone may be found from 72 to 78 feet above the Washington coal at all points in the township where this horizon is exposed. The bed is not so prominent as it is in Hopewell and Independence townships, and in some places the top section seems to be wanting, though the heavy yellow bed characteristic of this member can always be found.

*Lower Washington limestone and Washington and Little Washington coals.*—The Washington coal and associated beds form the most prominent group outcropping in the township. They are characteristically exposed at the sharp bend in the road uphill west of Taylorstown. On the top of the hill 1 mile west of Taylorstown a ridge road branches northward to Buffalo Creek, on which this coal outcrops near its north end about 130 feet above the stream. The following section taken along this road gives a fair idea of the associated beds:

*Section on road to north from ridge road west of Taylorstown.*

| | Ft. | In. |
|---|---|---|
| Shale, black | 1 | |
| Limestone in several heavy beds | 10 | |
| Sandstone, thick laminated, and shale | 10 | |
| Coal | | 4 |
| Shale | | 6 |
| Coal | 2 | 6 |
| Shales, black and red | 2 | |
| Limestone, brown, in single heavy bed | 3 | |
| Sandstone, thin, and shale | 15 | |
| Coal, Washington | 6 | |
| Sandstone, thin, and shale below, the Little Washington coal being concealed by rock mantle. | | |

The coal bed noted in this section is evidently directly above the Lower Washington limestone, though the heavy bed of limestone above may be the upper section of the Lower Washington. Westward from this road the Washington coal next appears on the road up Polecat Hollow near the sharp bend to the west. From this point it encircles the northern face of the hills to the township line. Southwestward from the outcrop at Taylorstown the coal dips gently to the next exposure, which occurs on the road to the south from the ridge road west of Taylorstown, about halfway from the top of the ridge to the forks of the road. On the run to the south the outcrop line leaves the township at the road forks near its head, where the Little Washington coal and the Lower Washington limestone were found in fine outcrop.

On the north side of Buffalo Creek the Washington coal outcrops on the road to Buffalo opposite the residence of V. M. Blaney and shows in another fine exposure one-fourth mile farther north. Westward the outcrop line of the coal encircles the hills well up toward their summits. The coal underlies a narrow strip along the crest of the ridge between Buffalo Creek and Brush Run as far west as a point opposite the mouth of Haynon Run and outcrops on each side of Pleasant Valley, being about 150 feet above the stream at the Buffalo Township line.

*Waynesburg and Waynesburg "A" and "B" coals.*—These coal beds are somewhat prominent in Blaine Township, being in continuous outcrop on Brush Run for the whole length of the township, with the Waynesburg coal from 20 to 80 feet above the stream. These beds also outcrop along Buffalo Creek from the mouth of Brush Run to a point a mile east of the mouth of Polecat Hollow, where for a distance of half a mile the Waynesburg goes under cover, reappearing just west of the pumping station and remaining above the valley from this point to Taylorstown. This bed has been opened for mining in a number of places in both valleys, but owing to the poor quality of the coal few of these mines are now in operation.

South of Taylorstown the Waynesburg coal goes under cover, but coal "A" outcrops on each side of Pleasant Valley almost to the township line. The outcrop of coal " B " on the hillsides above passes into Buffalo Township. This bed also comes to the surface for a short distance along the township line 1 mile southwest of Taylorstown.

*Uniontown coal and Benwood limestone.*—These beds crop out along the base of the hills in the valley of Buffalo Creek from the mouth of Brush Run to a point a short distance east of the mouth of Polecat Hollow. At this run the Uniontown coal is about 8 inches thick, hard and blocky, and it is separated from the upper beds of the Benwood limestone by about 1 foot of black shale. Along Brush

Run from its mouth these beds are probably under cover for less than a mile. The rise of the rocks in this direction is much greater than that of the stream bed. At the fork of the roads on this stream the coal outcrops in the bluff a few feet above the road. East of this point the group is exposed at many places along the valley road to a point within a mile of the township corner. At no other place in the township does it show, except for a short distance in the bed of Buffalo Creek at Taylorstown, where the crest of the Claysville anticline brings it to the surface.

## DONEGAL TOWNSHIP, WASHINGTON COUNTY.

Donegal Township lies along the western slope of the Claysville anticline. The bottom of the Burgettstown syncline crosses its extreme northwest corner. Southwestward from this point the rocks rise steeply, culminating in a dome about 1½ miles north of Claysville. From this dome a broad anticlinal nose juts out to the west, crossing Dutch Fork about a mile south of Budaville. Southward from this anticline the rocks dip at a high angle, reaching the north end of a shallow trough near Dutch Fork, 1 mile northwest of Coon Island. From this point the bottom of the trough appears to extend a little west of south, leaving the quadrangle a short distance north of Wheeling Run. Recognizable outcrops are so scanty that with the time allotted to the work it was not possible to determine precisely the lay of the rocks in this locality. From the bottom of this trough eastward the rocks rise to the Claysville anticline, the crest of which crosses Dutch Fork about 1 mile west of Claysville, with a general northeast-southwest trend. The rocks exposed range from the Uniontown coal upward through the Washington formation and include about 300 feet of the lower part of the Greene formation.

*Prominent beds of the Greene formation.*—In the southern part of Donegal Township, along the high ridges dividing the headwaters of Dutch Fork, Wheeling Creek, and Robinson Run, several thin beds of limestone have been noted. The most prominent of these limestone beds in East and West Finley townships is about 265 feet above the Upper Washington limestone and usually shows as a single dark rusty ledge at least 15 inches thick. It occurs at the road forks on top of the first ridge south of the National pike and about 1 mile from the west border of the quadrangle. At the first road to the south on the ridge west of Coon Island the Claysville limestone outcrops in several small white ledges that closely resemble those of the Upper Washington limestone. The Claysville limestone, together with a thinner bed about 30 feet above, also shows in a number of places on the ridges southeast of the above-mentioned location, the rise of the rocks in that direction keeping them well up toward the crest line.

*Donley and Upper Washington limestones.*—The tops of the Donley and Upper Washington limestones are from 40 to 55 feet apart in Donegal Township. They underlie a narrow strip along the top of the ridge between Buck Run and Dutch Fork, from the high bluff south of Buffalo Creek to the top of the dome north of Claysville. West of Dutch Fork, owing to the westerly dip of the rocks, these beds outcrop lower down on the hillsides, and are present under a considerable area along the west border of the quadrangle from Dog Run to the Baltimore and Ohio Railroad, both beds going under cover near the point where the railroad crosses the west boundary of the quadrangle. At Coon Island the outcrop line of the Upper Washington is about 165 feet above the village. It encircles the head of the southern tributary of Dutch Fork, caps the high hill to the southeast of the village, and outcrops along the heads of both the northern and southern tributaries of Dutch Fork eastward to the tunnel at the divide beyond Claysville. At this tunnel the Upper Washington coal lies directly above the top layers of the Upper Washington limestone, and but 10 or 15 feet of blue and brown shale lies between this coal and the Donley limestone above.

*Jollytown coal and Middle and Lower Washington limestones.*—The Jollytown coal in this township consists of less than a foot of coal and shale, and occurs from 5 to 25 feet above the Middle Washington limestone. The Middle Washington limestone is much thinner and the individual beds are less massive here than in Independence and Hopewell townships. In several places the limestone does not show, and in only a few exposures could it be positively identified. The Lower Washington limestone occurs in two benches separated by 1 to 5 feet of shale, each bench being made up of one heavy layer from 1 to 2 feet thick, accompanied by one or two thin layers, the total thickness of the bed varying from 5 to 20 feet. This limestone overlies the Washington coal at a distance of 15 to 35 feet, and is always present where this coal outcrops.

*Washington coal.*—The outcrop line of the Washington coal extends on the hillsides well up toward the heads of the small tributaries of Buck Run, Buffalo Creek, and Dutch Fork. In Dog Run, southeast of Dunsfort, the coal goes under cover at a small waterfall made by projecting ledges of the Lower Washington limestone. At this outcrop the Washington coal, which is about 5 feet thick, is broken only by relatively thin partings of shale and appears to be of a better quality than usual. This is the general condition of the bed at all points at which it was examined on Buffalo Creek and Buck Run. South of Budaville, on Dutch Fork, the coal occurs in two benches, divided by 3 to 5 feet of yellowish shale. About 1 mile north of Coon Island the coal has been opened in a number of places and its condition is about the same as on Dog Run. From this point the rise of the rocks toward Coon Island is sufficient to keep the coal a few feet above the stream, and in the road opposite the slaughterhouse it occurs in two benches, with several feet of shale between. Less than a mile south of Coon Island the coal goes under the bed of the run and does not show at any point to the south in the Claysville quadrangle. Up Dutch Fork, toward Claysville, the coal rises at about the same rate as the bed of the run. The last outcrop noted on this stream is near a short lane to the north from the National pike, 1 mile west of Claysville. It probably goes under cover in the bed of the run a short distance west of the steel plant. At all outcrops noted on this run from Coon Island eastward, the coal occurs in two or more benches separated by black or reddish shale, and it does not appear to be of economic value.

*Waynesburg and Waynesburg "A" and "B" coals.*—For a mile or more west of the mouth of Buck Run the Waynesburg coal outcrops along the base of the hill to the south of Buffalo Creek, but the steep westerly dip carries it under cover before the first crossing is reached. On Buck Run it outcrops on both sides of the valley to a point within three-fourths of a mile of Donley, where it goes under cover. This coal is prominent and has been opened in several places for mining, though most of the mines have since been abandoned owing to the poor quality of the coal. On Dutch Fork the anticlinal nose crossing south of Budaville brings the Waynesburg coal to the surface for a mile or more, but the dip of the rocks in both directions from the axis soon carries the coal under cover. The Waynesburg "A" and "B" coals have the same general distribution in the township as the Waynesburg, though, being above this coal, they are exposed over a larger area. On the south side of Buffalo Creek, west of the mouth of Dutch Fork, these coals outcrop in a continuous line to the edge of the quadrangle.

*Uniontown coal and Benwood limestone.*—The Uniontown coal barely comes to the surface in the bed of Buck Run, about 100 yards south of its mouth. It is directly underlain by the Benwood limestone. These beds occur along Buck Run for half a mile, but beyond that place go under cover.

## EAST AND WEST FINLEY TOWNSHIPS, WASHINGTON COUNTY.

The geologic conditions are so nearly identical in East and West Finley townships that it is thought advisable to discuss them together. The trough of the Finney syncline passes through the center of this area, having a northeast-southwest trend. The bottom of this trough is uneven, being lowest at the south border between Robinson and Templeton runs. One-half mile south of Hair schoolhouse, in this syncline, the bottom of a small shallow basin is 80 feet higher. Northward from this point the trough is broader and very flat, leaving East Finley township at the point where the north line of the township crosses Buffalo Creek. From this trough the rocks rise eastward to the Washington anticline and westward to the Claysville anticline. On Wheeling Creek, west of the Claysville anticline, the rocks dip steeply to a trough which heads in Donegal township, northwest of Coon Island. In this area the rocks, though wrinkled, have a maximum difference of level of less than 200 feet. The rocks exposed at the surface include a vertical section extending upward from the base of the Middle Washington limestone for a distance of about 550 feet.

*Prominent beds of the Greene formation.*—In this connection will be considered only those beds that are prominent enough to be of value as geologic markers over rather extensive areas, a detailed description of the areal distribution of each outcropping bed not being within the scope of this paper. A limestone bed that is somewhat prominent lies about 100 to 120 feet above the Upper Washington limestone, and is here called the Prosperity limestone. Its maximum thickness is 8 or 10 feet. Ledges of this bed weather cream to bluish gray, resembling somewhat the Upper Washington limestone. The thickness changes greatly from place to place, but the bed is recognizable over most of East and West Finley townships.

In the higher points along the Claysville-Burnsville pike from Fargo to the south border of the quadrangle and on the divide between Robinson and Wheeling runs, a persistent bed of limestone occurs in two or three thick rusty-black layers, somewhat resembling the Donley limestone, and at all points easily distinguishable from the associated beds. This bed is about 260 feet above the Upper Washington limestone.

*Upper Washington limestone and coal, Donley limestone, and Sparta coal.*—These beds are exposed only along the sides of the deeper valleys. On Rocky Run the Upper Washington limestone outcrops in the village of Gale, and the other beds of the group are exposed on both sides of the valley. These outcrops form a belt on both sides of the valley to its mouth, the dip in the rocks being a little less than the fall of the creek bed. On Templeton Run this belt of outcrop encircles the base of the hills on each side of the valley from the south border of the quadrangle to the road forks 1¼ miles south of Pleasant Grove, near which place the Upper Washington limestone goes under cover.

On Robinson Run at the south border of the quadrangle the Upper Washington limestone outcrops on the sides of the valley 125 feet above the stream, but at Good Intent it is at the foot of the hill. Upstream the rise of the rocks increases for some distance, the Upper Washington limestone going under cover in the run about 1 mile beyond the township line between East and West Finley, near the Bell and McDonald wells. The Upper Washington coal disappears between this point and the first road to the north. This coal is 18 inches thick and was once opened on the south side of the run. In a very small way this bank is yet operated from time to time, the total production from it, however, being very small. This coal bed shows on northern tributaries of Robinson Run. On the first road to the north, near the township line, it has been opened both by entry and by stripping. The section is as follows:

*Section of Upper Washington coal near Robinson Run.*

| | Ft. | In. |
|---|---|---|
| Shale, black | 4 | |
| Coal, hard and blocky | 1 | |
| Clay, dark blue | | 4 |
| Coal, shaly | | 6 |

On Beham Run in the extreme southwest corner of the quadrangle this group of limestones and coals outcrops on both sides of the valley for about a mile from the south border. At the point where the Donley and Upper Washington limestones go under cover on the west fork of this run these beds present the following section:

*Section of rocks on Beham Run.*

| | Ft. | In. |
|---|---|---|
| Sandstone and shale | | |
| Limestone, Donley, single dark lichen-covered ledge, very tough, flesh colored on fresh fracture, coarse grained, with crystals of calcite | 3 | |
| Sandstone, coarse, yellowish, thin bedded | 3 | |
| Clay, yellowish to blue | 4 | |
| Shale, black | | 3 |
| Coal (Upper Washington), with thin shale partings | | 12 |
| Shale, black and coarse | 2 | |
| Clay and thin sandstones and shale alternating | 3 | |
| Limestone, Upper Washington: | | |
| Limestone, white, dark gray on fresh fracture, very brittle | 1 | 6 |
| Limestone, light yellowish, light gray on fresh fracture, fine grained | 1 | 2 |
| Clay or shale, gray | 1 | |
| Limestone, very white, brittle, breaks in thin layers, light bluish gray | 1 | 6 |
| Sandstone, thin bedded, reddish, micaceous, and shale | 8 | |
| Limestone (poorly exposed), in several heavy dark-blue layers, very hard and tough | 8–9 | |

The Donley limestone usually occurs in two beds having a total thickness of 3 to 5 feet. Otherwise the section given above is characteristic of the beds in this vicinity. Between 25 and 30 feet above the Donley limestone is the Sparta coal, which is from 12 to 18 inches thick. The coal was not seen at this point, however, its horizon being covered by a mantle of loose rock.

On Wheeling Run the Upper Washington limestone comes to the surface three-fourths of a mile northwest of Elvilla. From this point the rocks dip westward so steeply that at the schoolhouse on the road to the south the Upper Washington limestone (with the Upper Washington coal 8 feet above) is 60 feet lower than at the first outcrop mentioned. The Donley limestone and Sparta coal occur at their regular intervals above the Upper Washington limestone.

In the northeast corner of East Finley Township, in the basin of Buffalo Creek, this group of beds outcrops well up toward the heads of the tributaries of this stream. One-half mile north of Pleasant Grove, on the road to Claysville, the Donley limestone outcrops halfway down the hill. About 200 yards farther north, opposite the first house to the east, the lower section of the Upper Washington limestone appears. The rocks dip to the northeast, north, and northwest from this point. Northwestward the rocks dip to the bottom of the Mansfield syncline, where the Upper Washington limestone occurs in the bed of Sawhill Run half a mile west of the Sawhill schoolhouse. From this point northward the rocks rise gently to the next outcrop noted, which is on the road to Claysville, 200 yards north of the Sawhill schoolhouse. Within the limits of the Claysville quadrangle to the south of Rocky Run this group of coals and limestone comes to the surface in a small area along the bottom of the deeper valleys. On the western fork of the road to the south from East Finley the Upper Washington limestone outcrops in the road on the boundary line of the quadrangle and in the bed of the stream a short distance north of this point. The white layer at the top of this bed is 14 inches thick, and on fresh fracture shows the characteristic black mottled color. Neither the Donley limestone nor the coal beds are exposed here. On Rocky Run the Sparta coal is unusually thick. It has been opened for mining in a number of places, but because of the great variations in thickness and quality of the coal, all of these banks have long since been abandoned. On the road to the north, one-eighth of a mile from East Finley, in an entry driven 80 feet into the hill, this coal is said to have varied from 6 inches to 3½ feet in thickness. Those who have used it say that the best is somewhat rusty in color, makes a hot fire, and leaves a small amount of white ash. Where noted in outcrop the bed is from 6 to 18 inches thick and very friable, with a number of shale and clay partings.

*Jollytown coal and Middle Washington limestone.*—These beds come to the surface in only a few places in these townships. On the road to the west from Buffalo Creek at the north boundary of East Finley Township the Middle Washington limestone is only a few feet above the creek valley. The Jollytown coal, which outcrops in several places along the road for half a mile, rises steeply to the west. Southward along Buffalo Creek from the township line the Middle Washington limestone is barely above the creek. It outcrops at the road forks near the mouth of Sawhill Run and in the west bank of the creek at the next fork of the road to the south. On the road to the southeast from this point the limestone again outcrops at the next road forks. On Robinson Run the Middle Washington limestone does not outcrop north of Good Intent, but at the forks of this run just west of the point where it crosses the township line between East and West Finley the Jollytown coal barely comes to the surface in the road at the south end of the bridge. The coal here is unusually thick for this bed, showing the following section:

*Section of Jollytown coal on Robinson Run.*

| | Ft. | In. |
|---|---|---|
| Shale, yellow | 10 | |
| Coal | | 6 |
| Shale, blue and yellow | | 6 |
| Coal | | 6 |
| Clay, red | | 2 |
| Coal | 1 | |

On the creek road to the south of Good Intent a section of the rocks from the Donley limestone to about the horizon of the Middle Washington limestone was obtained, as follows:

*Section on side of valley south of Good Intent.*

| | Ft. | In. |
|---|---|---|
| Limestone, Donley | 3 | 6 |
| Sandstone, thin bedded | 15 | |
| Shale, black (probably Upper Washington coal) | 2 | |
| Shale or clay, blue | 3 | |
| Limestone, Upper Washington (top section) | 8 | |
| Shale and clay, with 1 foot of black shale at bottom | 15 | |
| Limestone, Upper Washington (lower section) | 6–8 | |
| Sandstone and shale | 44 | |
| Limestone in two or three thin layers, embedded in blocky brown shale; limestone whitish in color, dark gray to steel blue on fresh fracture | 1 | 6 |
| Shale below to creek bed. | | |

Just beyond the south boundary of the quadrangle, below the junction of Templeton and Rocky runs, the Middle Washington limestone outcrops in the stream bed. On Wheeling Creek a coal bed, doubtfully considered the Jollytown, was opened years ago on the south side of the run about three-fourths of a mile from the west border of the quadrangle, near the east edge of the Frazer farm, but at no other point in this basin was either of these beds found in outcrop.

## NORTH AND SOUTH FRANKLIN TOWNSHIPS, WASHINGTON COUNTY.

The western half of North and South Franklin townships is traversed from northeast to southwest by the Washington anticline. The bottom of the Nineveh syncline, toward which the rocks in that half dip steeply, is just off the area to the southeast. The outcropping rocks range from the Washington coal to a bed about 60 feet above the Claysville limestone.

*Prosperity and Claysville limestones.*—These limestones are exposed in small areas along the higher points of the watershed east of the basin of Chartiers Creek, from Point Lookout to Van Buren. They also occur in one or two places on the high ridge between Chartiers and Tenmile creeks. West of Tenmile Creek they outcrop in several places along the western side of the townships. The Prosperity limestone is the heavier in this area, has a bluish appearance, and shows dark blue on fresh fracture. The Claysville is thinner and whiter, some of its beds resembling the Upper Washington limestone. Few good measurements of the intervals between these beds and the Upper Washington limestone were obtained, as it was not necessary to use them in determining the structure of these townships.

*Upper Washington limestone and coal, Donley limestone, and Sparta coal.*—A typical outcrop of the Upper Washington limestone as it occurs in this vicinity is exposed near the tollgate on the cemetery hill southwest of Washington. At this point the Donley limestone crops out in one or two heavy ledges at the highest point of the pike over this hill. The outcrop lines of these beds are clearly marked by quarries around the hillsides for some distance to the west, and also to the south as far as reservoir No. 3. On the east side of Chartiers Creek from reservoir No. 3 southward the beds dip gently, going under cover near the head of the stream. They reappear on top of the divide between Tenmile and Buffalo creeks, where all the members of this group are exposed, the Donley limestone only 25 feet above the Upper Washington limestone, with the Upper Washington coal between. The Donley is directly overlain by a few inches of shaly coal, which may possibly be all that remains of the Sparta bed, though this coal may outcrop still higher on the hillside to the west. To the south, along the western slope of Tenmile Creek, the beds dip slightly for a distance, then rise slowly over the Washington anticline, then dip again steeply to the southeast. On the east side of the hill east of Tenmile Creek the Upper Washington limestone is finely exposed and has been quarried for road material. On the road from Pleasant Grove to Lagonda, one-fourth mile northeast of Tenmile Creek, the Upper Washington limestone is well exposed just east of the residence of Mr. Tannis, where the

Upper Washington coal is less than 6 inches thick. Near the first road fork northeast of this location the Upper Washington limestone crops out on the road to the west, and also on the road to the east toward Van Buren. About half a mile east of this point the Upper Washington limestone has been quarried on the east side of the valley just above the road. Here it is 42 feet lower than at the last outcrop mentioned. Farther south it is exposed on both sides of this run to a point a little beyond Van Buren, where the dip to the south is so abrupt that it is carried under cover near the township line. At the Crossroads schoolhouse, 2 miles east of Van Buren, the white ledges of the Upper Washington limestone, which show black to dark mottle on fresh fracture, are only a few feet above the run, the top of the Donley limestone being 22 feet higher. Up the run to the northeast from this location the Upper Washington limestone rises at about the same rate as the bottom of the run to the first road forks, where it goes under cover. Just west of the Plymire well the Sparta coal shows 18 inches thick in the bed of the run. On the first road directly north of this point it occurs at the foot of the hill with at least as great a thickness. From the Crossroads schoolhouse northward up the valley road the Upper Washington and Donley limestones outcrop at the first road to east. Farther upstream both the Upper Washington coal and the Sparta coal show in a number of places as far as the Andrews well, south of Point Lookout.

On the first road to the west from the Prosperity pike just south of Lagonda the Upper Washington limestone crops out at almost the highest point on the road, and at the first road forks on the township line to the north the Donley limestone is exposed. Half a mile farther north the Upper Washington limestone and coal outcrop on the crest of the ridge, the coal being 13 feet above the limestone. From this point the outcrop line swings around the heads of the tributaries to Chartiers Creek to the exposure in Canton Township at the rock quarry south of Woodell. Good exposures of these beds are so numerous over this township that it is not necessary to describe all of them. A sufficient number of those in the basins of Chartiers and Tenmile creeks have been mentioned to admit of their identification.

*Jollytown coal and Middle Washington limestone.*—This group outcrops on the Prosperity and Pleasant Grove road on the hillside west of Tenmile Creek in front of the third house to the north. The coal is 18 feet above the heavy yellow bed of the Middle Washington limestone. On the Prosperity-Claysville road west of Tenmile Creek the heavy yellow bed shows at the head of the little run, where this road starts up the hill. The Jollytown coal was not seen at this place, but on the next road to the north it crops out 95 feet above the exposure of the Washington coal at the brick schoolhouse in the valley. In the basin of Chartiers Creek these beds outcrop at the foot of the hill north of Point Lookout, near the head of reservoir No. 3. From this point the outcrop of the Middle Washington limestone and Jollytown coal encircles the hills in a continuous line on the east side of the creek southward to a point on the Prosperity pike opposite the third road to the west, south of Lagonda. On the west side of the valley the heavy yellow bed of the Middle Washington limestone, with the Jollytown coal from 15 to 25 feet above, is present on all the roads leading to the west.

*Lower Washington limestone and Washington and Little Washington coals.*—This group of beds shows on both sides of Chartiers Valley from West Washington to a point 3 miles south of Lagonda. The Lower Washington limestone is rather heavy and at many places is overlain by a stray coal bed from 6 to 14 inches thick. Where the Washington anticline crosses the headwaters of Tenmile Creek the Washington coal is brought to the surface for a mile or more. It occurs at the road forks east of the Mannon oil well about 25 feet above the valley. To the north it goes under cover in the bed of the run just south of the brick schoolhouse. At this point it is only 12 feet lower than at the Mannon well. South of this well the coal is exposed as far as the first road to the west leading to Pleasant Grove. Up this road it outcrops at the junction of the first road to the south. Down the valley road to Prosperity the stray coal above mentioned, overlying the Lower Washington limestone, is exposed in several places. The coal is at least 1 foot thick, embedded in 2 or 3 feet of black shale. The Lower Washington limestone occurs in unusually heavy beds along this valley and closely overlies the Washington coal.

In the valley of Chartiers Creek, 1 mile south of Lagonda, the steep dip to the southeast soon carries the Washington coal under cover, but to the northwest its outcrop line extends some distance up the tributaries of Chartiers Creek. This coal is about 5 feet thick, including several shale partings, and has been opened in several places along the creek, but it is of so inferior a quality that most of the banks have been abandoned. The Little Washington coal invariably accompanies this coal. At some places it is 16 inches thick, hard and blocky, and remarkably free from shale partings.

## MORRIS TOWNSHIPS, WASHINGTON AND GREENE COUNTIES.

It will be noted by examining the map (Pl. X, pocket) that the Washington and Greene County line, which separates the two Morris townships, enters the Claysville quadrangle about 1 mile southwest of Old Concord. From that point it has an easterly direction to the top of the high ridge, half a mile south of that village, and thence follows the crest line of this watershed, leaving the quadrangle on its east border half a mile south of Dunns Station. Only that portion of Morris Township, Greene County, included in the quadrangle to the south of this line will be discussed.

The axis of the Nineveh syncline enters the quadrangle from the south, about 1 mile west of West Union, trends north-northeastward to the eastern boundary of the quadrangle, near the Crossroads schoolhouse. The rise of the rocks from this trough is steep in both directions, the greatest ascent being toward the dome on the Washington anticline lying southeast of Pleasant Grove, near the corner of East Finley, Morris, and South Franklin townships. The maximum difference in level of the key rock within the area is about 285 feet. The geologic section outcropping ranges from a bed a few feet below the Middle Washington limestone upward through the remainder of the Washington formation and about 500 feet of the Greene formation.

*Nineveh limestone and coal.*—At a number of places on the high ridge between Washington and Greene counties a foot or more of coal and black shale, from 10 to 15 feet above a rather heavy bed of white to cream-colored limestone, was found well up toward the top of the hill. Owing to the ease with which these beds are recognized and their frequency of outcrop in an east-west line, they make valuable geologic markers. The distance of the coal above the Upper Washington limestone can not be very accurately determined, but it is approximately 325 feet. This is about the horizon of the Nineveh coal and the Nineveh limestone, though this correlation is by no means positive. North of Tenmile Creek the high ridge from Lindleys Mill to Van Buren catches these beds only at the point where it is crossed by the trough of the Nineveh syncline. The coal was noted at the forks of the road to the north of the schoolhouse on this ridge and again near the first forks of the road about the same distance to the south of this schoolhouse. At both places the bluish to cream-colored beds of the Nineveh limestone were seen.

*Upper Washington coal, Donley limestone, and Sparta coal.*—The Upper Washington coal is usually represented by thin layers of black shale containing streaks of coal. It is subject to abrupt changes, however, and at the forks of the road near the Hogue well, one-half mile east of Old Concord, it is as much as 14 inches thick. Near the head of Crafts Run one outcrop of this coal 3½ feet thick was noted. This is the maximum measurement obtained in the Claysville quadrangle. The outcrop of the Donley limestone is everywhere closely associated with that of the Upper Washington limestone. In this region the beds are not over 35 feet apart. Along Short Creek the Donley limestone is separated from the Sparta coal by a massive sandstone bed from 10 to 25 feet thick. The Sparta coal comes to the surface only along the sides of the valleys of Short and Tenmile creeks and at the head of Rocky Run east of Gale. Just north of Sparta, on the Day farm, it is 18 inches thick and has been mined in a small way by stripping. As a rule, however, the coal is thin and its quality so poor that extensive operations are unprofitable. This coal outcrops on the road from Sparta to Mount Zion Church, at the point where the road leaves the valley to ascend to the top of the ridge. It probably outcrops on both sides of the valley from Sparta to Old Concord and is the bed exposed at several places along the road from Old Concord to Gale.

*Upper Washington limestone.*—At no point within the portion of Greene County shown on the map does this bed come to the surface, but in Washington County it outcrops on both sides of the valley of Tenmile Creek from its source to the east edge of the quadrangle. The trough of the Nineveh syncline crosses this stream near its junction with Short Creek, where the Upper Washington limestone lies in the bed of the creek. Here the bottom of the trough is wide and for half a mile both up and down the stream the rocks are practically level. At Lindleys Mill the limestone is 60 feet higher. From this place to Prosperity it barely keeps above the bottom of the valley, but from that point to the north, northwest, and west the rise is so steep that at the township line on Tenmile Creek the limestone is 100 feet above the stream, and near the sharp bend in the road to the south from Crafts Run near the old McDowell mill site it is about 110 feet above the valley. From this outcrop westward the strike of the rock is almost parallel with the course of the stream, the limestone being exposed in the valley a short distance northeast of the Joint schoolhouse. On Short Creek the Upper Washington limestone is barely under cover from its mouth to the village of Sparta, where it shows in the bed of the stream for a few hundred yards. Halfway from Sparta to Old Concord the Hogue well shows this limestone 13 feet from the surface. On the road to the north, near the parsonage at Old Concord, a limestone outcrops, which is probably the Upper Washington. On the road to Mount Zion Church from Sparta the limestone goes under cover in the run opposite the second house to the west of the road. Here the black mottled ledges of this bed are finely exposed. To the north of Tenmile Creek the Upper Washington limestone does not outcrop again in Morris Township, unless it comes to the surface in the bed of the run for a few hundred yards at the township line south of the Crossroads schoolhouse and also for a short distance on the next run to the south.

*Middle Washington limestone and Jollytown coal.*—At the point where Tenmile Creek crosses the north boundary of Morris Township, Washington County, the Middle Washington limestone is only a few feet above the valley. The southward dip carries this bed under cover a short distance south of this point. Up Crafts Run to the west the limestone comes to the surface just east of the first road to the north. Here the massive yellow ledge characteristic of this bed is finely exposed. These are the only exposures of the Middle Washington limestone noted in both townships. No outcrop of the Jollytown coal was seen, though its horizon is doubtless exposed wherever the Middle Washington limestone comes to the surface. The coal is probably present, but at the points examined it is concealed by a mantle of loose rock.

# APPENDIX.

The following tables give a description of the points used for bench marks, with the original and adjusted elevation. The numbers agree with those printed in red on the surface structure maps of each quadrangle. The red crosses show the general location of the benches. The numbers and elevations printed in italic denote the bench marks on primary lines. Bench marks established on secondary lines are given with two elevations, the original and adjusted, the adjusted being the elevation corrected for the error of closure between two points of a primary line, or between a primary line and a previously adjusted secondary line.

*Bench marks in Steubenville quadrangle.*

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| *1* | Aluminum tablet at southeast corner of court-house | | *714.58* |
| *2* | Chiseled square on southeast corner of coping stone, stone arch over Fourth street | | *715.43* |
| *3* | Chiseled square on rock above spring | | *697.40* |
| *4* | Top of south rail opposite station, Mingo Junction | | *674.50* |
| *5* | Chiseled square on south side of stone bridge No. 47 | | *671.70* |
| *6* | Chiseled square on northeast corner of coping, stone bridge No. 48 | | *675.84* |
| *7* | Cross cut on lower stone, south side, east end of tunnel | | *709.63* |
| *8* | Top of south rail, opposite New Alexandria station | | *740.70* |
| *9* | Bronze tablet in top stone of northwest abutment of bridge | | *751.29* |
| *10* | Top of north rail at road crossing | | *771.20* |
| *11* | Railroad bench mark at north end of arch culvert, 600 feet east of Fernwood station | | *777.14* |
| *12* | Chiseled square on northeast abutment of iron bridge over Cross Creek | | *781.18* |
| *13* | Top of north rail at road crossing | | *786.76* |
| *14* | Railroad bench mark on northeast abutment of bridge No. 51 | | *801.28* |
| *15* | Railroad bench mark on northeast corner of coping stone of bridge No. 52 | | *810.66* |
| *16* | Railroad bench mark on northeast coping stone of bridge No. 53 | | *828.48* |
| *17* | Railroad bench mark on northeast coping stone of bridge No. 54 | | *836.48* |
| *18* | Top of stone corner post at end of stone wall | | *1,023.89* |
| *19* | Aluminum tablet in southeast corner of foundation of Wintersville Church | | *1,255.78* |
| *20* | Cross cut in stone on east side of road at junction | | *1,258.77* |
| *21* | Cross cut in southeast corner of bridge | | *1,134.41* |
| *22* | Aluminum tablet in stone abutment of bridge to waterworks | | *662.70* |
| *23* | Cross cut in stone step of schoolhouse | | *1,163.96* |
| *24* | Cross cut in stone at southwest corner of crossroads, Pekin | | *1,150.29* |
| *25* | Bronze tablet in southwest pier of bridge over Island Creek | | *787.68* |
| *26* | Cross cut in stone step of Island Creek Church | | *1,282.96* |
| *27* | Aluminum tablet in southeast corner of stone foundation of Knoxville Church | | *1,279.66* |
| 28 | Top of post on north side of road | 1,284.18 | |
| *29* | Cross cut in stone at southeast corner of crossroads | | *1,172.48* |
| *30* | Cross cut in bottom tier of stone, northeast abutment of bridge over road | | *653.22* |
| *31* | Chiseled triangle in stone in center of road | | *1,185.73* |
| *32* | Bronze tablet in northeast corner of stone foundation of brick church | | *1,249.13* |
| *33* | Cross cut in stone at southeast corner of road intersection | | *1,195.29* |
| *34* | South end of platform, 2 feet east of track, Lazearville | | *666.04* |
| *35* | Top bolt at southeast corner of iron bridge over Cross Creek | | *656.38* |
| *36* | Bolt at south end of supporting board to platform, Cross Creek station | | *673.23* |
| *37* | Top of north side of stone culvert No. 4 | | *669.43* |
| *38* | Top of post marked "E 2" | | *671.31* |

*Bench marks in Steubenville quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| *39* | Top of post marked "D 1" | | *694.01* |
| *40* | Bolt on supporting board to sand sidewalk | | *713.61* |
| *41* | Northwest corner of bridge No. 41 | | *672.08* |
| *42* | Southeast corner of stone abutment of wagon bridge | | *672.40* |
| *43* | Chiseled crowfoot in northwest corner of covered bridge over Cross Creek | | *722.18* |
| *44* | Cross cut in bowlder 100 feet north of schoolhouse | | *753.49* |
| *45* | Cross cut in rock on east side of road at intersection | | *1,139.29* |
| *46* | Stone in center of road | | *1,008.73* |
| 47 | Ground at foot of telephone pole | 1,238.76 | |
| 48 | Ground at foot of telephone pole | 1,196.16 | |
| *49* | Aluminum tablet in northwest abutment of railroad bridge at Colliers Station | | *823.60* |
| *50* | Bolt in northeast corner of bridge to pumping station | | *776.56* |
| *51* | Cross cut in coping stone in southeast corner of bridge No. 39 | | *741.90* |
| 52 | Cross cut in stone on northwest pier of iron bridge over Kings Creek | | *693.58* |
| 53 | Stone in road at northwest corner of Kings Creek station | | *669.81* |
| 54 | Bronze tablet in large bowlder 100 feet south of church | | *703.72* |
| 55 | Cross cut in stone at fork of roads | | *1,016.42* |
| 56 | Ground at foot of mail-box post | 816.77 | |
| 57 | Cross cut in southeast corner of bridge over Kings Creek | | *753.39* |
| 58 | Cross cut in stone at intersection of roads | | *1,165.70* |
| 59 | Cross cut in southwest abutment of covered bridge over Cross Creek | | *754.35* |
| 60 | Aluminum tablet in southwest corner of bridge over Cross Creek | | *784.02* |
| 61 | Cross cut in stone at northeast corner of road intersection | | *1,159.47* |
| 62 | Cross cut in stone at road intersection | | *1,242.36* |
| 63 | Cross cut in stone at road intersection | | *1,230.77* |
| 64 | Cross cut in stone on north side of road | | *1,229.76* |
| 65 | Cross cut on stone milepost at Fowlersville | | *1,236.73* |
| 66 | Cross cut in stone at crossroads | | *1,198.67* |
| 67 | Aluminum tablet in stone horse block | | *1,000.94* |
| 68 | Root of beech tree on east side of road | 978.33 | 978.09 |
| 69 | Painted spot on north end of bridge | 1,041.56 | 1,041.32 |
| 70 | Painted spot on stump on south side road, 10 feet east of junction | 1,064.87 | 1,064.63 |
| 71 | Nail in bar post on north side of road, 500 feet east of brick house | 1,098.80 | 1,098.56 |
| 72 | Nail in foot of mail-box post in center of grassplot | 1,049.94 | 1,049.70 |
| 73 | Painted spot on southeast wing wall of iron bridge | 786.69 | 786.45 |
| 74 | Painted spot on southeast wing wall of iron bridge | 730.04 | 729.80 |
| 75 | Painted spot on northeast abutment of stone arch of railroad bridge | 698.53 | 698.29 |
| 76 | Nail in foot of signboard post | 1,289.98 | 1,289.75 |
| 77 | Painted spot on end of tile culvert | 1,220.63 | 1,220.30 |
| 78 | Nail in post at junction of private road | 1,204.11 | 1,202.58 |
| 79 | Top of mail-box post | 1,248.64 | 1,247.10 |
| 80 | Painted spot on stone opposite brick house | 1,230.86 | 1,230.62 |
| 81 | Painted spot on south end of wooden culvert | 1,219.76 | 1,219.52 |
| 82 | Painted spot on horse block | 1,171.84 | 1,171.60 |
| 83 | Painted spot on south end of stone culvert | 1,195.93 | 1,195.69 |
| 84 | Painted spot on stone culvert | 1,229.90 | 1,229.66 |
| 85 | Painted spot on root of locust tree | 1,181.02 | 1,180.78 |
| 86 | Painted spot on culvert at road intersection | 748.55 | 748.31 |
| 87 | Top of water plug at glass company's plant | 715.88 | 715.64 |
| 88 | Frog in street railroad opposite park entrance | 733.74 | 733.51 |
| 89 | Painted spot at south end of road crossing | 682.18 | 681.94 |
| 90 | Top of rail at road crossing | 677.94 | 677.71 |
| 91 | Painted spot at junction of roads | 1,040.57 | 1,040.34 |
| 92 | Stone at foot of fence post | 1,166.21 | 1,166.96 |
| 93 | Root of large oak tree on summit | 1,147.78 | 1,148.78 |
| 94 | Painted spot on large stone at road intersection | 876.58 | 877.88 |
| 95 | Painted spot on small bridge near road intersection | 811.13 | 812.53 |
| 96 | Painted spot on southeast abutment of bridge | 738.24 | 739.74 |
| 97 | Ground at foot of mail-box post | 1,177.26 | 1,177.02 |
| 98 | Ground at foot of telephone pole | 1,217.54 | 1,217.30 |
| 99 | Ground at foot of mail-box post | 1,228.36 | 1,228.12 |
| 100 | Painted spot on west end of wooden culvert | 1,192.66 | 1,192.43 |
| 101 | Root of locust tree | 1,199.70 | 1,199.46 |
| 102 | Painted spot on lower board of gatepost | 1,212.59 | 1,212.36 |
| 103 | Stone at foot of mail-box post | 1,160.44 | 1,160.21 |
| 104 | Painted spot on south end of bridge at coal bank | 1,086.49 | 1,086.26 |
| 105 | Top of stake at foot of signboard post | | 1,272.53 |
| 106 | Top of fence post | 851.08 | 849.18 |
| 107 | Ground at foot of signboard post | 1,205.11 | 1,203.21 |
| 108 | Painted spot on bridge | 1,129.90 | 1,128.00 |
| 109 | Ground at foot of signboard post | 1,067.84 | 1,065.94 |
| 110 | Painted spot on lower board of fence opposite schoolhouse | 1,106.41 | 1,104.51 |
| 111 | Nail in post near watering trough | 1,183.76 | No tie. |
| 112 | Spot on stone under southeast corner of wagon shed | 1,158.43 | No tie. |
| 113 | Painted spot on small bridge | 1,018.10 | No tie. |
| 114 | Painted spot on end of log at road intersection | 1,095.57 | 1,095.33 |
| 115 | Painted spot on stone at road intersection | 1,198.74 | 1,198.50 |
| 116 | Ground at foot of F. Dickey's mail-box post | 1,267.86 | 1,267.62 |

*Bench marks in Steubenville quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 117 | Ground at foot of mail-box post | 1,260.88 | 1,260.64 |
| 118 | Painted spot on lower board of fence at corner | 1,157.73 | 1,157.50 |
| 119 | Top of stone step of south door of Two Ridge Church | 1,262.10 | 1,261.87 |
| 120 | Ground at foot of J. Bremer's mail-box post | 1,247.85 | 1,247.62 |
| 121 | Ground at foot of mail-box post | 1,241.20 | 1,240.97 |
| 122 | Painted spot on stone in center of grassplot | 1,244.77 | 1,244.54 |
| 123 | Ground at foot of mail-box post opposite church | 1,224.94 | 1,224.70 |
| 124 | Top of stone (Survey mark) at private road | 1,130.12 | 1,129.89 |
| 125 | Painted spot on abutment of iron bridge | 813.80 | 813.56 |
| 126 | Painted spot on east end of wooden culvert | 1,053.92 | 1,053.42 |
| 127 | Painted spot on stone culvert at road intersection | 1,197.42 | 1,196.62 |
| 128 | Ground at foot of mail-box post | 1,144.67 | 1,143.67 |
| 129 | Root of large oak, 300 feet north of house | 1,146.33 | 1,144.88 |
| 130 | Painted spot on culvert | 1,059.93 | 1,058.53 |
| 131 | Painted spot at road intersection, opposite schoolhouse | 994.53 | 992.78 |
| 132 | Root of wild cherry on west side of road | 1,096.94 | 1,095.04 |
| 133 | Ground at foot of mail-box post | 1,086.30 | 1,084.20 |
| 134 | Nail in signboard post | 1,142.61 | 1,140.41 |
| 135 | Painted spot on end of wooden culvert | 1,069.50 | 1,067.20 |
| 136 | Painted spot on northwest abutment of iron bridge | 1,000.54 | 998.10 |
| 137 | Ground at foot of mail-box post | 1,125.94 | 1,123.50 |
| 138 | Painted spot on top of stump at bend of road | 1,074.97 | 1,072.57 |
| 139 | Ground at foot of telephone pole | 1,222.85 | 1,222.45 |
| 140 | Painted spot on east end of tile culvert | 1,240.50 | 1,240.05 |
| 141 | Painted spot on small wooden bridge | 1,032.36 | 1,031.89 |
| 142 | Ground at foot of foundation post of corn crib | 1,172.00 | 1,171.53 |
| 143 | Ground at foot of marked fence post | 1,239.35 | 1,238.81 |
| 144 | Painted spot on stump on west side of road | 1,247.74 | 1,247.13 |
| 145 | Ground at foot of mail-box post at schoolhouse | 1,220.60 | 1,220.00 |
| 146 | Painted spot on lower board of fence at southeast corner of road intersection | 1,178.85 | 1,178.17 |
| 147 | Ground at foot of mail-box post | 1,182.07 | 1,181.32 |
| 148 | Painted spot on small bridge | 921.26 | 920.44 |
| 149 | Painted spot on top of stump at northwest fence corner | 1,217.97 | 1,217.01 |
| 150 | Ground at foot of mail-box post | 1,174.84 | 1,173.88 |
| 151 | Stepping block in front of house | 1,157.19 | 1,156.09 |
| 152 | Ground at foot of markéd post at sharp turn | 955.06 | 953.96 |
| 153 | Painted spot on stone at stream crossing | 892.22 | 891.12 |
| 154 | Root of locust tree at northeast corner of road intersection | 1,165.99 | 1,164.89 |
| 155 | Root of locust tree at northwest corner of road intersection | 1,188.21 | 1,187.11 |
| 156 | Painted spot on large ledge of sandstone | 917.36 | 916.26 |
| 157 | Painted spot on wooden culvert | 836.48 | 836.24 |
| 158 | Painted spot on small bridge near intersection of roads | 880.57 | 880.33 |
| 159 | Painted spot on wooden bridge | 738.99 | 738.59 |
| 160 | Painted spot on bridge over Island Creek | 688.32 | 687.92 |
| 161 | Painted spot on small bridge | 696.91 | 696.51 |
| 162 | Painted spot on end of culvert | 977.14 | 976.54 |
| 163 | Top of east rail at road crossing | 698.21 | 697.97 |
| 164 | Painted spot on lower board of fence in southeast corner | 946.89 | 946.64 |
| 165 | Ground at foot of signboard post | 993.31 | 993.65 |
| 166 | Painted spot on small bridge | 1,104.11 | 1,103.76 |
| 167 | Painted spot on lower rail of fence | 1,211.01 | 1,210.61 |
| 168 | Ground at foot of signboard post | 1,226.44 | 1,226.02 |
| 169 | Painted spot on rock | 1,162.45 | 1,162.00 |
| 170 | Painted spot on top of big stump | 1,209.64 | 1,209.16 |
| 171 | Painted spot on small bridge | 1,125.52 | 1,125.02 |
| 172 | Stone at foot of telephone pole | 1,196.79 | 1,196.19 |
| 173 | Painted spot on west end of small wooden bridge | 1,220.38 | 1,219.75 |
| 174 | Painted spot on end of wooden culvert | 1,199.43 | 1,198.70 |
| 175 | Ground at foot of telephone pole | 1,146.43 | 1,146.68 |
| 176 | Ground at foot of marked telephone pole | 1,226.89 | 1,226.09 |
| 177 | Ground at foot of marked fence post | 1,161.20 | 1,160.38 |
| 178 | Painted spot on southeast abutment of covered bridge | 835.65 | 834.75 |
| 179 | Painted spot on large stone | 1,184.90 | 1,183.90 |
| 180 | Ground at foot of mail-box post | 1,221.60 | 1,220.60 |
| 181 | Painted spot on fence board | 1,222.07 | 1,221.00 |
| 182 | Painted spot on west end of retaining wall opposite church | 1,243.84 | 1,242.72 |
| 183 | Ground at foot of mail-box post | 1,141.84 | 1,140.60 |
| 184 | Painted spot on northwest abutment of covered bridge over Kings Creek | 863.19 | 861.89 |
| 185 | Painted spot on rock at junction of streams | 836.91 | 835.00 |
| 186 | Root of large tree | 825.04 | 823.72 |
| 187 | Painted spot on second board of fence at private road | 829.69 | 828.36 |
| 188 | Painted spot on large rock at road intersection | 804.43 | 803.10 |
| 189 | Painted spot on rock at approach to foot bridge | 776.25 | 774.92 |
| 190 | Painted spot on southeast abutment of iron bridge over Kings Creek | 742.25 | 740.90 |
| 191 | Ground at foot of telephone pole, private road to east | 757.03 | 755.68 |
| 192 | Painted spot on rock at stream crossing | 848.63 | 847.28 |
| 193 | Painted spot on rock at road intersection | 966.28 | 964.93 |
| 194 | Painted spot on west end of tile culvert | 817.90 | 816.55 |
| 195 | Painted spot on stone at road intersection | 674.29 | 674.04 |
| 196 | Ground at foot of telephone pole | 698.47 | 698.22 |
| 197 | Root of oak tree at sharp turn in road | 873.98 | 873.73 |

*Bench marks in Steubenville quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 198 | Painted spot on small bridge at road intersection | 848.21 | 847.96 |
| 199 | Painted spot on large rock | 907.13 | 906.88 |
| 200 | Painted spot on rail of fence | 1,165.58 | 1,165.33 |
| 201 | Painted spot on stone at root of large oak tree | 1,189.67 | 1,189.42 |
| 202 | Painted spot on stump at private road | 1,261.92 | 1,261.67 |
| 203 | Painted spot on fence board at private road | 1,117.25 | 1,117.00 |
| 204 | Painted spot on end of fence board | 1,128.24 | 1,127.99 |
| 205 | Painted spot on end of tile culvert | 1,081.21 | 1,080.96 |
| 206 | Ground at foot of mail-box post | 1,205.34 | 1,205.09 |
| 207 | Ground at foot of mail-box post | 1,087.07 | 1,086.82 |
| 208 | Ground at foot of mail-box post at road intersection | 1,122.94 | 1,122.69 |
| 209 | Painted spot on stump | 920.61 | 920.36 |
| 210 | Ground at foot of mail-box post | 1,184.57 | 1,184.32 |
| 211 | Ground at foot of mail-box post at road intersection | 1,191.38 | 1,191.13 |
| 212 | Painted spot on end of rail at private road | 1,269.07 | 1,268.82 |
| 213 | Painted spot on end of fence at crossroads | 1,200.93 | 1,200.68 |
| 214 | Painted spot on stump in center of grass plot | 1,208.89 | 1,208.44 |
| 215 | Painted spot on stump at entrance to house | 1,124.24 | 1,124.00 |
| 216 | Painted spot on southeast abutment of covered bridge | 903.16 | 902.91 |
| 217 | Painted spot on rail opposite road in woods | 1,083.65 | 1,083.40 |
| 218 | Ground at foot of telephone pole | 1,211.16 | 1,210.04 |
| 219 | Ground at foot of telephone pole, 600 feet east of road to north | 1,213.94 | 1,212.82 |
| 220 | Root of large oak tree opposite schoolhouse | 1,110.22 | 1,109.10 |
| 221 | Top of post in center of grass plot | 1,212.06 | 1,210.94 |
| 222 | Painted spot on top of stump | 1,186.12 | 1,185.00 |
| 223 | Ground at foot of telephone pole at private road | 1,047.10 | 1,045.98 |
| 224 | Ground at foot of telephone pole at road to north | 780.40 | 779.78 |
| 225 | Ground at foot of signboard post | 708.26 | 707.14 |
| 226 | Painted spot on stone on east end of culvert | 781.15 | 780.90 |
| 227 | Ground at foot of gatepost at private road | 834.11 | 833.86 |
| 228 | Painted spot on end of culvert at road intersection | 888.12 | 887.87 |
| 229 | Painted spot on rock at junction of roads | 1,191.66 | 1,191.41 |
| 230 | Ground at foot of telephone pole | 1,195.54 | 1,195.29 |
| 231 | Painted spot on rock at road intersection | 1,212.97 | 1,212.72 |
| 232 | Painted spot on stone at road intersection | 938.62 | 938.37 |
| 233 | Painted spot on rail of fence | 1,185.11 | 1,184.80 |
| 234 | Root of tree on north side of road, east of private road | 944.49 | 944.41 |
| 235 | Painted spot on east end of culvert | 897.92 | 895.83 |
| 236 | Ground at foot of gatepost, entrance to barn | 1,191.90 | 1,190.78 |
| 237 | Painted spot on foundation of small building at road intersection | 1,214.55 | 1,213.43 |
| 238 | Painted spot on large rock at road intersection | 1,140.73 | 1,139.61 |
| 239 | Root of locust tree 100 feet east of road intersection | 790.17 | 789.05 |
| 240 | Painted spot on end of overhead bridge | 818.94 | 817.82 |
| 241 | Ground at foot of gatepost | 1,148.76 | 1,147.64 |
| 242 | Ground at foot of gatepost at turn in road | 1,170.30 | 1,169.18 |
| 243 | Root of triplet tree at junction of roads | 1,233.90 | 1,232.70 |
| 244 | Ground at foot of marked fence post at corner | 1,200.53 | 1,200.12 |
| 245 | Painted spot on board of fence 400 feet south of house | 1,198.33 | 1,197.73 |
| 246 | Painted spot on east end of culvert at crossroads | 957.67 | 958.01 |
| 247 | Painted spot on lower board of fence at private road | 1,164.00 | 1,161.34 |
| 248 | Root of locust tree | 1,089.02 | 1,089.36 |
| 249 | Painted spot on stone at private road | 887.49 | 887.83 |
| 250 | Painted spot on small bridge 300 feet west of house | 782.81 | 783.15 |
| 251 | Painted spot on large rock at private road | 838.72 | 838.47 |
| 252 | Ground at foot of telephone pole on summit | 902.86 | 902.61 |
| 253 | Ground at foot of gatepost at private road | 770.18 | 768.93 |
| 254 | Top of north rail at Crawfo.d crossing | 723.41 | 723.16 |
| 255 | Top of east rail 300 feet south of station | 700.79 | 700.54 |
| 256 | Painted spot on east side of road | 923.08 | 922.38 |
| 257 | Ground at foot of gatepost | 1,016.89 | 1,016.19 |
| 258 | Painted spot on end of log by stream | 857.70 | 857.00 |
| 259 | Root of large oak tree opposite small house | 1,018.12 | 1,016.52 |
| 260 | Painted spot on lower board of fence | 1,151.50 | 1,149.90 |
| 261 | Painted spot on foundation log at southwest corner of barn | 1,227.09 | 1,225.49 |
| 262 | Painted spot on northwest abutment of covered bridge | 858.88 | 858.63 |
| 263 | Painted spot on iron pipes opposite oil well | 973.10 | Bad tie; 7.14 feet low. |
| 264 | Ground at gatepost | 1,020.32 | |
| 265 | Painted spot on large stone at road intersection | 1,005.32 | |
| 266 | Root of large oak tree at road intersection | 1,129.34 | |
| 267 | Painted spot on large stone | 1,043.42 | |
| 268 | Top of post at road intersection | 917.43 | |
| 269 | Ground at foot of post at private road | 925.85 | 925.60 |
| 270 | Painted spot on stone by watering trough | 1,033.16 | 1,032.91 |
| 271 | Painted spot at junction of roads | 1,125.58 | 1,125.33 |
| 272 | Painted spot on southwest end of bridge | 790.67 | 789.55 |
| 273 | Painted spot on small bridge at turn in road | 1,023.30 | 1,022.70 |
| 274 | Painted spot on lower board of fence at road intersection | 1,213.86 | 1,212.66 |
| 275 | Root of large locust tree at road intersection | 1,197.54 | 1,196.24 |
| 276 | Painted spot on culvert at private road | 1,052.60 | 1,051.10 |
| 277 | Painted spot on culvert at schoolhouse | 1,032.12 | 1,030.52 |
| 278 | Painted spot at sharp turn in road | 1,115.03 | 1,113.33 |
| 279 | Painted spot on lower fence rail on summit | 1,245.80 | 1,245.57 |

*Bench marks in Steubenville quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 280 | Painted spot on small bridge | 863.26 | 863.03 |
| 281 | Painted spot on stone at private road | 1,189.05 | 1,188.55 |
| 282 | Painted spot on small bridge | 909.03 | 908.53 |
| 283 | Ground at foot of guy pole to telephone pole | 1,217.87 | 1,216.75 |
| 284 | Ground at foot of telephone pole at private road | 811.34 | 811.00 |
| 285 | Painted spot on large rock on east side of creek | 686.08 | 687.08 |
| 286 | Root of tree at sharp turn in road | 880.89 | 882.39 |
| 287 | Ground at foot of fence post at northeast corner of road intersection | 1,028.55 | 1,030.35 |
| 288 | Ground at foot of telephone pole at road intersection | 1,225.94 | 1,228.00 |
| 289 | Painted spot on stone at road to south | 1,227.61 | 1,227.38 |
| 290 | Painted spot on stone culvert at road to south | 1,237.21 | 1,236.98 |
| 291 | Ground at foot of corner post at road to north | 1,226.99 | 1,226.76 |
| 292 | Painted spot on end of culvert at road to south | 1,145.95 | 1,145.72 |
| 293 | Painted spot on lowest rail of fence at road to south | 1,227.94 | 1,227.71 |
| 294 | Ground at foot of telephone pole opposite cemetery | 1,235.29 | 1,235.06 |
| 295 | Ground at foot of telephone pole at road to north | 1,262.00 | 1,261.77 |
| 296 | Root of stump near house | 1,262.06 | 1,262.56 |
| 297 | Ground at foot of marked fence post | 1,199.82 | 1,200.59 |
| 298 | Ground at foot of large elm, 300 feet west of house | 1,203.46 | 1,203.23 |
| 299 | Painted spot on flat stone at road to south | 1,149.75 | 1,149.52 |
| 300 | Painted spot on end of culvert opposite house | 1,176.97 | 1,176.74 |
| 301 | Root of walnut tree at sharp turn | 1,160.07 | 1,159.67 |
| 302 | Root of elm tree at bend in road | 981.13 | 980.63 |
| 303 | Painted spot on stone at junction of roads | 904.93 | 904.33 |
| 304 | Ground at foot of fence post opposite church | 1,099.84 | 1,099.14 |
| 305 | Painted spot on foot log over stream | 1,001.52 | 1,002.52 |
| 306 | Painted spot on stump at private road | 1,017.39 | 1,017.16 |
| 307 | Ground at foot of signboard post at junction of roads | 840.83 | 840.70 |
| 308 | Painted spot on stone at footbridge opposite house | 797.40 | 797.27 |
| 309 | Painted spot on small bridge opposite brick house | 963.59 | 963.46 |
| 310 | Root of large oak tree | 941.27 | 941.04 |
| 311 | Ground at foot of fence post at road intersection | 846.26 | 846.00 |
| 312 | Root of large cherry tree at road intersection | 1,231.01 | 1,230.71 |
| 313 | Painted spot on end of rail opposite private road | 1,237.82 | 1,237.42 |
| 314 | Painted spot on stone at road to south | 1,257.38 | 1,257.15 |
| 315 | Ground at foot of fence post at turn in road | 1,161.20 | 1,160.97 |
| 316 | Painted spot on stone culvert at private road | 1,006.48 | 1,006.25 |
| 317 | Painted spot on culvert at sharp turn in road | 958.67 | 958.44 |
| 318 | Ground at foot of electric-light pole | 754.46 | 754.23 |
| 319 | Painted spot on street crossing | 736.26 | 736.03 |
| 320 | Painted spot on southeast end of small bridge at junction of roads | 901.61 | 901.38 |
| 321 | Painted spot on stump at crossroads | 1,132.22 | 1,132.00 |
| 322 | Top of step at schoolhouse | 1,155.70 | 1,155.47 |
| 323 | Painted spot on end of wooden culvert at junction of roads | 1,144.23 | 1,144.00 |
| 324 | Painted spot on stone at road intersection | 777.78 | 777.55 |
| 325 | Cross cut on southeast corner of iron bridge seat | 737.36 | 737.13 |
| 326 | Ground at foot of gatepost at junction of roads | 1,178.82 | 1,178.59 |
| 327 | Painted spot on stone culvert at road intersection | 1,062.87 | 1,062.64 |
| 328 | Ground at foot of fence post at road intersection | 986.69 | 986.46 |
| 329 | Painted spot on stone at road intersection | 1,077.06 | No tie. |
| 330 | Painted spot on stone culvert at road intersection | 1,181.15 | No tie. |
| 331 | Ground at foot of mail-box post at junction of roads | 1,128.45 | No tie. |
| 332 | Root of oak tree at road intersection | 964.72 | No tie. |
| 333 | Root of walnut tree at junction of roads | 1,128.19 | No tie. |
| 334 | Painted spot on second rail of fence at road intersection | 1,097.89 | No tie. |
| 335 | Top of stake at road intersection | 726.16 | 725.96 |
| 336 | Ground at foot of marked fence post | 905.77 | 705.57 |
| 337 | Painted spot on northwest end of iron bridge | 729.88 | 729.68 |
| 338 | Painted spot on southeast end of dividing wall of railroad bridge | 781.30 | 781.10 |
| 339 | Painted spot on large rock at road intersection | 793.83 | 793.63 |
| 340 | Painted spot on southeast corner of iron bridge | 821.87 | 821.67 |
| 341 | Painted spot on stump at private road | 1,001.31 | 1,003.08 |
| 342 | Ground at foot of mail-box post | 1,207.51 | 1,209.28 |
| 343 | Root of large oak tree by schoolhouse | 1,184.11 | 1,185.84 |
| 344 | Painted spot at road intersection | 1,236.35 | 1,238.12 |
| 345 | Ground at foot of locust tree at road intersection | 1,162.75 | 1,162.55 |
| 346 | Root of large oak tree at private road | 1,131.05 | 1,130.85 |
| 347 | Cross cut in stone at southwest corner of bridge | 671.31 | 671.31 |
| 348 | Painted spot on southwest corner of iron bridge by schoolhouse | 843.33 | 843.33 |
| 349 | Painted spot on stone on summit | 1,198.08 | 1,198.08 |
| 350 | Root of tree at private road | 763.33 | 763.33 |
| 351 | Root of large oak tree at road intersection | 1,114.12 | 1,113.88 |
| 352 | Painted spot on small bridge | 1,130.77 | 1,130.53 |
| 353 | Painted spot on end of rail at road intersection | 1,139.54 | 1,139.30 |
| 354 | Painted spot on north end of stone culvert | 813.11 | 812.89 |
| 355 | Painted spot on southeast foundation log of coal platform | 971.32 | 971.10 |
| 356 | Painted spot on stump at junction of roads | 973.36 | 973.14 |
| 357 | Root of large oak tree | 1,240.23 | 1,240.01 |
| 358 | Painted spot on stump on west side of road | 777.08 | 776.85 |
| 359 | Root of oak tree on north side of road at intersection | 1,133.71 | 1,133.48 |
| 360 | Painted spot on large stump on south side of road at intersection | 979.88 | 979.65 |
| 361 | Ground at foot of mail-box post | 1,103.37 | 1,103.14 |

*Bench marks in Steubenville quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
| --- | --- | --- | --- |
| | | *Feet.* | *Feet.* |
| 362 | Painted spot on northwest corner of iron bridge | 866.24 | 866.00 |
| 363 | Painted spot on end of rail | 1,152.09 | |
| 364 | Root of large oak tree at junction of roads | 1,073.83 | |
| 365 | Ground at foot of mail-box post | 1,088.71 | |
| 366 | Painted spot on south end of culvert west of junction of roads | 766.60 | |
| 367 | Painted spot on stump at road intersection | 714.80 | |
| 368 | Painted spot on large sand rock | 971.97 | |
| 369 | Ground at foot of signboard post | 705.60 | |
| 370 | Painted spot on small wooden bridge | 755.40 | |
| 371 | Painted spot on stone on west side of road | 797.84 | |
| 372 | Painted spot on end of rail fence | 976.46 | |
| 373 | Ground at foot of mail-box post | 1,015.16 | |
| 374 | Root of oak tree on west side of road | 882.58 | |
| 375 | Painted spot on small bridge | 886.67 | |
| 376 | Ground at foot of signboard post at road intersection | 807.71 | |

*Bench marks in Burgettstown quadrangle.*

| No. | Description. | Original elevation. | Adjusted elevation. |
| --- | --- | --- | --- |
| | | *Feet.* | *Feet.* |
| 1 | Square cut on northeast abutment of bridge No. 29, Pennsylvania Railroad | | 1,005.59 |
| 2 | Copper nail on root of large oak tree on east side of road | | 1,026.51 |
| 3 | Square cut on southeast abutment of iron bridge | | 946.63 |
| 4 | Copper nail in root of white oak tree on east side of road 150 feet south of forks | | 990.93 |
| 5 | Painted spot on rock at southwest corner of crossroads in Bavington | | 976.42 |
| 6 | Aluminum tablet on east end of south abutment of bridge | | 920.87 |
| 7 | Square cut on northeast end of bridge seat | | 901.94 |
| 8 | Square cut on northeast abutment of small iron bridge | | 900.96 |
| 9 | Painted spot on rock at east end of sewer | | 957.86 |
| 10 | Copper nail on root of large sugar tree on east side of road | | 978.42 |
| 11 | Painted spot on root of white oak tree to east at road intersection | | 933.25 |
| 12 | Bronze tablet on northeast abutment of iron bridge | | 877.08 |
| 13 | Square cut on rock on east side of road | | 885.89 |
| 14 | Copper nail on root of white oak tree on south side of road | | 1,158.11 |
| 15 | Copper nail on stump of small oak tree on south side of road | | 1,153.28 |
| 16 | Copper nail on root of black oak tree at northeast corner of crossroads | | 1,196.87 |
| 17 | Copper nail on root of white oak tree on south side of road, 500 feet east of crossroads | | 1,248.62 |
| 18 | Top of small bridge at foot of hill | | 1,107.28 |
| 19 | Standard B. M. Frankfort: Aluminum tablet on north foundation wall of A. Vance's heirs' brick dwelling | | 1,185.60 |
| 20 | Floor of small bridge at foot of hill | | 1,051.84 |
| 21 | Top of stump on east side of road at forks to west by schoolhouse | | 1,196.49 |
| 22 | Copper nail on root of large white oak tree in field on west side of road | | 1,214.05 |
| 23 | Top of stone under mail box at forks to west | | 1,153.49 |
| 24 | Standard B. M. Florence: Aluminum tablet in east foundation wall of O. K. Simpson's dwelling | | 1,282.58 |
| 25 | Wire nail on gatepost at forks to east | | 1,185.16 |
| 26 | Nail in root of large white oak tree 40 feet east of road | | 1,025.98 |
| 27 | Copper nail on root of wild cherry tree on north side of road on summit | | 1,181.54 |
| 28 | Painted spot on horse block at northeast corner of crossroads at Cork | | 1,174.31 |
| 29 | Square cut on rock on west side of road | | 1,136.96 |
| 30 | Copper nail in root of white oak tree on south side of road at top of hill | | 1,183.84 |
| 31 | Bronze tablet on southeast corner of foundation wall of J. E. McCullough's store | | 1,233.88 |
| 32 | Aluminum tablet in south foundation wall of Burgettstown National Bank | | 999.18 |
| 33 | Square cut on limestone rock at west side of road | | 1,021.98 |
| 34 | Aluminum tablet on northeast wing wall of covered bridge | | 1,036.77 |
| 35 | Copper nail on root of white oak tree on east side of road opposite schoolhouse | | 1,079.45 |
| 36 | Top of rock at small bridge | | 1,083.71 |
| 37 | Painted spot on culvert at crossroads | | 1,131.23 |
| 38 | Square cut on large rock on north side of road | | 1,130.11 |
| 39 | Copper nail in root of black walnut tree on north side of road | | 1,208.70 |
| 40 | Copper nail in root of white oak stump on south side of road | | 1,294.49 |
| 41 | Aluminum tablet in south wall of J. M. Griffith's dwelling | | 1,302.80 |
| 42 | Top of rock to north at road to east | | 1,231.14 |
| 43 | Copper nail on root of elm tree on south side of road | | 1,113.33 |
| 44 | Painted spot on east end of sewer at road to north | | 1,084.97 |
| 45 | Top of rock at northwest corner of forks of road to west | | 1,058.37 |
| 46 | Bronze tablet on east end of abutment of railroad bridge south of coal mine | | 1,024.79 |

*Bench marks in Burgettstown quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 47 | Copper nail in south end of station platform at Menden | ............ | *996.71* |
| 48 | Copper nail in south end of station platform at McConnell's mills | ............ | *997.41* |
| 49 | Top of south rail at private crossing | ............ | *1,196.20* |
| 50 | Square cut on east end of north abutment of bridge | ............ | *1,170.58* |
| 51 | Bronze tablet on south end of west abutment of bridge over road | ............ | *1,134.62* |
| 52 | Square cut on rock north side of track | ............ | *1,096.29* |
| 53 | Square cut on south end of east abutment of bridge over road | ............ | *1,087.50* |
| 54 | Square cut on bridge seat of bridge over wagon road | ............ | *1,046.98* |
| 55 | Square cut on south end of east abutment of bridge over Cross Creek | ............ | *1,026.28* |
| 56 | Square cut on south end of east abutment of bridge over Cross Creek | ............ | *1,008.23* |
| 57 | Top of rail at road crossing | ............ | *984.08* |
| 58 | Square cut on southwest corner of bridge seat over road | ............ | *956.70* |
| 59 | Square cut on top of south end of west abutment of large iron bridge | ............ | *912.97* |
| 60 | Bronze tablet on north end of east abutment of railroad bridge over Cross Creek | ............ | *904.83* |
| 61 | Spike in northeast corner of overhead bridge support | ............ | *875.27* |
| 62 | Aluminum tablet on north end of east abutment of bridge No. 25 over road | ............ | *1,110.67* |
| 63 | Railroad bench mark on south end of east abutment of bridge No. 24 | ............ | *1,024.10* |
| 64 | Bronze tablet on coping at northeast corner of bridge No. 32 | ............ | *942.18* |
| 65 | Bronze tablet in southeast corner of foundation wall of Freshwater's house | ............ | *1,149.92* |
| 66 | Painted spot on northwest corner of covered bridge | ............ | *987.07* |
| 67 | Copper nail on root of large white oak tree | ............ | *1,083.73* |
| 68 | Ground at foot of telephone pole at corner of schoolhouse lot | 1,211.90 | 1,211.70 |
| 69 | Ground at foot of telephone pole opposite Doorman's house | 1,207.75 | 1,207.55 |
| 70 | Ground at foot of signboard post at road intersection | 1,254.61 | 1,254.41 |
| 71 | Painted spot on root of oak tree at road to south | 1,290.09 | 1,289.89 |
| 72 | Ground at foot of telephone pole at road to north | 1,259.23 | 1,259.03 |
| 73 | Stone at foot of telephone pole at road to Hanlan | 1,264.65 | 1,264.55 |
| 74 | Painted spot on stone at corner of fence at road intersection | 1,234.49 | 1,234.49 |
| 75 | Stone at foot of telephone pole at road going south | 1,215.55 | 1,215.55 |
| 76 | Painted spot on small bridge near private road | 1,090.76 | 1,090.70 |
| 77 | Painted spot on end of log at small culvert near house | 1,109.09 | 1,109.00 |
| 78 | Painted spot on end of culvert | 971.03 | 971.00 |
| 79 | Painted spot on northwest abutment of covered bridge | 942.79 | 942.69 |
| 80 | Painted spot on south end of small bridge | 1,021.05 | 1,020.85 |
| 81 | Stone at foot of gatepost on north side of road at summit | 1,188.68 | No tie. |
| 82 | Block at foot of fence post at road intersection | 1,188.33 | 1,188.13 |
| 83 | Stone at foot of gatepost at road intersection | 1,196.73 | 1,196.53 |
| 84 | Painted spot on bridge | 1,022.53 | 1,022.23 |
| 85 | Painted spot on stone at foot of black oak tree at road intersection | 1,210.10 | 1,209.70 |
| 86 | Painted spot on gas pipe at northwest corner of road intersection | 1,215.00 | 1,214.45 |
| 87 | Ground at foot of corner fence post | 1,261.34 | 1,260.74 |
| 88 | Painted spot on end of log over culvert | 1,168.89 | 1,168.89 |
| 89 | Painted spot on southwest abutment of covered bridge | 1,047.27 | 1,047.62 |
| 90 | Painted spot on southeast abutment of wooden bridge | 1,022.22 | 1,022.62 |
| 91 | Top of north rail at Dinsmore station | 1,060.06 | No tie. |
| 92 | Painted spot on stone at junction of road | 1,112.11 | No tie. |
| 93 | Painted spot on east end of wooden culvert at road intersection | 981.33 | 981.33 |
| 94 | Stone at foot of gatepost near yellow house | 943.43 | 943.43 |
| 95 | Painted spot on southwest corner of bridge | 893.96 | 893.96 |
| 96 | Painted spot on small wooden bridge at road intersection | 875.95 | 876.20 |
| 97 | Stone at foot of telephone pole at junction of roads | 1,018.79 | 1,018.94 |
| 98 | Painted spot on stone at foot of flag pole at schoolhouse | 1,084.21 | 1,084.21 |
| 99 | Painted spot on stone at foot of telephone pole at road to south | 1,274.26 | 1,274.00 |
| 100 | Painted spot at foot of fence post by mail-box post | 1,267.35 | 1,267.15 |
| 101 | Painted spot on stone at foot of mail box post at road intersection | 1,263.48 | 1,263.30 |
| 102 | Painted spot on stone at foot of telephone pole at road intersection | 1,262.97 | 1,262.97 |
| 103 | Painted spot on stone at foot of telephone pole at road to north | 1,346.73 | 1,346.06 |
| 104 | Ground at foot of guy post at northwest corner of crossroads | 1,316.39 | 1,315.62 |
| 105 | Ground at foot of mail-box post at road to south | 1,170.17 | 1,170.17 |
| 106 | Ground at foot of telephone pole at road to Independence | 1,288.35 | 1,288.35 |
| 107 | Southeast end of covered bridge 2½ miles east of Eldersville | 1,074.28 | 1,074.28 |
| 108 | Southeast abutment of covered bridge | 1,051.62 | 1,051.62 |
| 109 | Small bridge ¼ mile west of crossroads | 1,107.30 | 1,107.30 |
| 110 | Stone at foot of telephone pole opposite church | 1,290.39 | 1,290.39 |
| 111 | Stone at foot of signboard post at junction of roads | 1,305.20 | 1,305.20 |
| 112 | Root of large oak tree at road to north | 1,228.00 | 1,228.25 |
| 113 | Painted spot on southeast abutment of iron bridge over Raccoon Creek | 992.11 | 992.61 |
| 114 | Painted spot on iron bridge 800 feet south of schoolhouse | 982.90 | 983.65 |
| 115 | Southeast abutment of covered bridge over Raccoon Creek | 970.70 | 971.65 |
| 116 | Root of oak tree at junction of roads | 1,161.64 | 1,161.64 |
| 117 | Painted spot on bridge | 995.16 | 995.16 |
| 118 | Root of dead tree opposite house | 1,171.98 | 1,171.98 |
| 119 | Painted spot on log at culvert at road intersection | 1,083.07 | 1,083.07 |
| 120 | Ground at foot of gatepost opposite house | 1,166.53 | 1,166.73 |
| 121 | Painted spot on stone at junction of roads | 969.64 | 969.84 |
| 122 | Painted spot on northeast abutment of covered bridge | 923.41 | 922.54 |
| 123 | Painted spot on northeast abutment of iron bridge | 953.22 | 952.37 |
| 124 | Stone between two trees at junction of roads | 1,173.70 | 1,172.86 |
| 125 | Stone at foot of signboard post at road to south | 1,227.17 | 1,226.33 |

*Bench marks in Burgettstown quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 126 | Painted spot on southeast abutment of covered bridge | 1,026.31 | 1,025.48 |
| 127 | Root of stump opposite pump station | 1,180.10 | 1,179.27 |
| 128 | Stone at foot of telephone pole at road intersection | 1,138.83 | 1,138.00 |
| 129 | Stone at foot of post at northeast corner of fence at crossroads | 1,204.77 | 1,203.95 |
| 130 | Ground at foot of telephone pole at private road | 1,142.69 | 1,141.88 |
| 131 | Ground at foot of gatepost at private road | 1,151.83 | 1,151.53 |
| 132 | Painted spot on small bridge | 1,013.35 | 1,013.35 |
| 133 | Painted spot on limestone on east end of culvert | 1,094.25 | 1,095.00 |
| 134 | Ground at foot of signboard post at road intersection | 1,053.06 | 1,053.66 |
| 135 | Square cut on southwest abutment of covered bridge | 969.04 | 969.54 |
| 136 | Ground at foot of guy post in grass plot | 1,048.65 | 1,049.05 |
| 137 | Painted spot on small bridge | 1,106.60 | 1,106.80 |
| 138 | Painted spot on small culvert | 1,038.26 | 1,038.06 |
| 139 | Ground at foot of signboard post at road intersection | 1,145.71 | 1,146.11 |
| 140 | Painted spot on floor of iron bridge | 913.52 | 914.52 |
| 141 | Ground at foot of corner fence post of schoolhouse yard | 1,210.64 | 1,210.54 |
| 142 | Painted spot on culvert at turn in road | 1,152.34 | 1,152.20 |
| 143 | Painted spot on small bridge | 1,039.37 | 1,039.17 |
| 144 | Painted spot on stone on west side of road at road to east | 1,000.50 | No tie. |
| 145 | Root of oak tree ⅛ mile east of junction of roads | 1,053.21 | 1,053.21 |
| 146 | Ground at foot of mail-box post | 1,098.51 | 1,098.51 |
| 147 | Root of large oak tree at junction of roads | 1,117.66 | 1,117.66 |
| 148 | Painted spot at root of oak tree at junction of roads | 1,099.13 | 1,099.13 |
| 149 | Painted spot on west end of small bridge | 964.42 | 963.42 |
| 150 | Root of oak tree at junction of roads | 967.96 | 967.41 |
| 151 | Stone at foot of oak tree at crossroads | 964.18 | 963.68 |
| 152 | Small wooden bridge 0.7 mile north of breast of dam | 1,007.59 | 1,006.84 |
| 153 | End of culvert at entrance to house on east side of road | 1,167.80 | 1,167.05 |
| 154 | End of culvert at junction of roads | 1,055.96 | 1,055.21 |
| 155 | Ground at center of grass plot at road to north | 1,193.59 | 1,192.84 |
| 156 | Ground at center of grass plot at road to east | 1,204.70 | 1,204.00 |
| 157 | Ground at foot of post, private road to east | 1,253.51 | 1,252.81 |
| 158 | Small log at end of culvert at crossroads | 1,095.87 | 1,095.17 |
| 159 | Painted spot on end of culvert at North Star Jersey farm | 1,111.85 | 1,111.15 |
| 160 | Ground at foot of northeast corner post of fence at crossroads | 1,167.29 | 1,166.79 |
| 161 | Painted spot on root of oak tree at road to east | 1,135.52 | 1,135.00 |
| 162 | Small bridge at junction of roads | 1,063.31 | 1,062.91 |
| 163 | Ground at corner of stable at road to north | 1,186.43 | 1,186.43 |
| 164 | Large oak tree at road to west | 1,231.15 | 1,231.15 |
| 165 | Root of oak tree at crossroads | 1,205.41 | 1,205.41 |
| 166 | Root of oak tree opposite schoolhouse at junction of roads | 1,196.07 | 1,186.54 |
| 167 | Painted spot on iron bridge at Virsoix post-office | 1,008.38 | 998.85 |
| 168 | Square cut on stone at junction of roads | 956.84 | 956.64 |
| 169 | Painted spot on end of stone cribbing near bridge opposite house | 930.12 | 929.87 |
| 170 | Painted spot on root of oak tree at road to south | 1,116.79 | 1,116.39 |
| 171 | Ground at foot of fence post back of milk platform | 1,230.92 | 1,230.52 |
| 172 | Painted spot on root of oak tree by schoolhouse at junction of roads | 996.86 | 996.36 |
| 173 | Ground at fence post at road to west | 1,076.51 | 1,075.81 |
| 174 | Painted spot on stump at private road to west | 1,239.00 | 1,238.15 |
| 175 | Painted spot on culvert at road to east | 1,227.10 | 1,226.10 |
| 176 | Painted spot on stone in center of grass plot at road to north | 1,079.51 | 1,080.31 |
| 177 | Painted spot on stone at foot of southeast corner post at crossroads | 1,183.71 | 1,184.51 |
| 178 | Painted spot on stone at foot of fence post opposite schoolhouse | 1,130.21 | 1,130.21 |
| 179 | Head of copper nail in root of oak tree | 1,133.91 | 1,134.61 |
| 180 | Stone in center of grass plot at junction of roads | 1,190.23 | 1,189.83 |
| 181 | Painted spot on stone at foot of guy post at junction of roads | 1,246.45 | 1,247.05 |
| 182 | Painted spot on small bridge | 1,078.97 | 1,078.70 |
| 183 | Painted spot on bridge at crossroads | 1,106.97 | 1,106.37 |
| 184 | Stump at coal tipple | 1,133.88 | 1,133.23 |
| 185 | Small bridge at railroad crossing 1 mile north of Midway | 1,074.44 | 1,073.79 |
| 186 | Painted spot on small bridge at junction of roads | 1,065.70 | 1,065.10 |
| 187 | Stone in center of grass plot at junction of roads | 1,197.13 | 1,196.53 |
| 188 | Stone in center of grass plot at crossroads | 1,074.65 | 1,074.05 |
| 189 | Small bridge opposite schoolhouse | 1,097.41 | 1,096.81 |
| 190 | Stone at fence, junction of roads | 1,173.08 | 1,172.48 |
| 191 | Root of small locust tree at junction of roads | 1,192.03 | 1,192.03 |
| 192 | Painted spot on root of large tree at junction of roads | 1,213.98 | 1,213.48 |
| 193 | Painted spot on ground at foot of mail-box post at private road | 1,159.82 | 1,159.00 |
| 194 | Painted spot on stone at corner of barn at junction of roads | 1,174.49 | 1,174.59 |
| 195 | Painted spot on floor of small bridge at junction of roads | 1,056.61 | 1,056.41 |
| 196 | Stone in center of grass plot at junction of roads | 1,040.88 | 1,040.58 |
| 197 | Small bridge near junction of roads | 1,047.27 | 1,046.92 |
| 198 | Copper nail in root of tree at road intersection | 1,013.55 | 1,013.20 |
| 199 | Painted spot on end of culvert at road intersection | 1,006.28 | 1,006.48 |
| 200 | Painted spot on stump in grass plot | 1,080.70 | 1,081.00 |
| 201 | Painted spot on small bridge near road intersection | 1,040.21 | 1,040.50 |
| 202 | Painted spot on small bridge near gristmill | 1,098.88 | 1,098.88 |
| 203 | Stone in center of grassplot at intersection of roads | 1,185.17 | 1,185.00 |
| 204 | Painted spot on small bridge near crossroads | 961.08 | 960.78 |
| 205 | Painted spot on stone at fence corner opposite schoolhouse | 1,198.14 | 1,197.54 |
| 206 | Copper nail in root of tree in center of grassplot at junction of roads | 1,107.16 | 1,106.56 |
| 207 | Copper nail in root of oak tree at crossroads | 1,202.57 | 1,201.77 |

*Bench marks in Burgettstown quadrangle.*—Continued

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 208 | Painted spot on end of tile culvert at road intersection | 1,120.25 | 1,119.00 |
| 209 | Painted spot on small bridge | 1,079.63 | 1,078.33 |
| 210 | Painted spot on end of iron pipe at gate at road intersection | 1,068.18 | 1,068.22 |
| 211 | Painted spot on end of small bridge | 1,071.60 | 1,070.60 |
| 212 | Painted spot on survey stone at crossroads | 1,099.30 | 1,098.00 |
| 213 | Painted spot on small culvert | 1,167.02 | 1,166.82 |
| 214 | Limestone on south side of road | 1,258.64 | 1,258.34 |
| 215 | Copper nail in root of large oak tree at road to north | 1,217.27 | 1,216.77 |
| 216 | Copper nail in root of oak tree on north side of road | 1,225.87 | No tie. |
| 217 | Bridge near junction of roads | 1,057.88 | No tie. |
| 218 | Painted spot on stone in center of grassplot at junction of roads | 1,075.57 | 1,075.07 |
| 219 | Ground at foot of mail-box post at entrance to house to west of road | 1,163.82 | 1,163.62 |
| 220 | Painted spot on small bridge | 1,107.83 | 1,107.73 |
| 221 | Small bridge at junction of roads | 1,069.70 | 1,069.40 |
| 222 | Copper nail in root of oak tree at junction of roads | 1,111.95 | 1,111.55 |
| 223 | Culvert near turn in road | 1,148.08 | 1,147.08 |
| 224 | Culvert leading to barn | 1,181.98 | 1,181.98 |
| 225 | Painted spot on culvert in valley | 1,039.79 | 1,039.89 |
| 226 | Painted spot on northeast corner of small bridge at road to north | 1,006.66 | 1,006.86 |
| 227 | Copper nail in root of large oak tree at southeast corner of crossroads | 1,205.46 | 1,205.81 |
| 228 | Stone at foot of mail-box post opposite large brick house | 1,219.21 | 1,219.62 |
| 229 | Ground at foot of gatepost at entrance to oil well | 1,236.45 | 1,236.85 |
| 230 | Ground at northeast corner of foundation stone of schoolhouse | 943.57 | 943.57 |
| 231 | Painted spot on top of culvert | 1,081.03 | 1,080.93 |
| 232 | Copper nail in root of oak tree at junction of roads | 1,247.72 | 1,247.52 |
| 233 | Copper nail in small bridge by private road | 1,134.34 | 1,134.04 |
| 234 | Painted spot on stone under corner of fence at road intersection | 1,220.18 | 1,220.10 |
| 235 | Painted spot on stone by stone bridge | 1,071.14 | 1,071.00 |
| 236 | Painted spot on end of culvert at road intersection | 1,094.33 | 1,094.20 |
| 237 | Painted spot on stone at road intersection | 1,138.86 | 1,138.70 |
| 238 | Nail in root of elm tree 150 feet south of house | 1,014.10 | 1,014.00 |
| 239 | Copper nail in root of oak tree 300 feet east of house | 1,126.68 | 1,126.48 |
| 240 | Copper nail in root of large oak tree at crossroads | 1,249.24 | 1,249.04 |
| 241 | Ground at foot of fence post at corner at sharp turn in road | 1,217.81 | 1,217.52 |
| 242 | Copper nail in root of locust tree at junction of roads | 1,126.65 | 1,127.15 |
| 243 | Painted spot on floor of small bridge | 1,064.56 | 1,064.76 |
| 244 | Copper nail in telephone post opposite coal works | 1,028.77 | 1,028.97 |
| 245 | Painted spot on bridge at junction of roads | 1,026.16 | 1,026.26 |
| 246 | Painted spot on small bridge | 1,055.22 | 1,055.42 |
| 247 | Painted spot on stone culvert | 1,097.31 | 1,097.56 |
| 248 | Copper nail in root of oak tree | 1,189.63 | 1,190.00 |
| 249 | Painted spot on white limestone at foot of telephone pole | 1,242.51 | 1,242.71 |
| 250 | Stone in center of grassplot at road intersection | 1,161.77 | 1,162.17 |
| 251 | Painted spot on end of small culvert | 1,077.19 | 1,077.29 |
| 252 | Painted spot on wooden culvert | 1,228.83 | 1,228.83 |
| 253 | Copper nail in root of oak tree | 1,304.58 | 1,304.58 |
| 254 | Stone in center of grassplot | 1,252.70 | No tie. |
| 255 | Painted spot on small culvert | 1,108.18 | No tie. |
| 256 | Painted spot on stone at end of culvert | 1,174.22 | No tie. |
| 257 | Copper nail in root of locust tree | 1,271.70 | No tie. |
| 258 | Painted spot on stone | 1,261.06 | No tie. |
| 259 | Painted spot on small bridge | 983.78 | 982.78 |
| 260 | Painted spot on small bridge | 1,039.80 | 1,038.80 |
| 261 | Painted spot on small bridge | 1,073.59 | 1,073.59 |
| 262 | Ground at foot of mail-box post at private road | 1,210.94 | 1,209.84 |
| 263 | Painted spot on small bridge | 1,037.96 | 1,036.56 |
| 264 | Painted spot on small bridge 25 feet east of road intersection | 1,092.60 | 1,091.20 |
| 265 | Copper nail in root of maple tree at road intersection | 1,233.46 | 1,232.00 |
| 266 | Ground at foot of mail-box post | 1,178.85 | 1,178.35 |
| 267 | Copper nail in small bridge | 1,037.55 | 1,036.60 |
| 268 | Cross cut in stone in center of grassplot | 1,335.40 | 1,335.40 |
| 269 | Painted spot on stone | 1,338.53 | 1,338.43 |
| 270 | Copper nail in root of hickory tree at crossroads | 1,255.34 | 1,255.14 |
| 271 | Cross cut in survey stone at junction of road to east | 1,258.99 | 1,258.49 |
| 272 | Painted spot on end of iron pipe at stream | 957.63 | 956.63 |
| 273 | Ground at foot of mail-box post at private road | 1,142.30 | 1,141.30 |
| 274 | Copper nail in bridge in valley | 1,090.69 | 1,089.70 |
| 275 | Painted spot on pipe line at stream crossing | 1,030.17 | 1,031.17 |
| 276 | Painted spot on small bridge in valley | 974.78 | 974.98 |
| 277 | Nail in small bridge | 1,082.93 | 1,081.18 |
| 278 | Ground at foot of mail-box post in front of house | 1,194.28 | 1,194.53 |
| 279 | Painted spot on bolthead of iron bridge | 982.03 | 982.03 |
| 280 | Square cut on southeast abutment of iron bridge | 969.46 | 969.46 |
| 281 | Square cut on southwest abutment of covered bridge | 926.87 | 926.68 |
| 282 | Copper nail in root of oak tree at private road to south | 1,239.58 | 1,239.18 |
| 283 | Root of oak tree opposite house at road intersection | 1,226.68 | 1,225.93 |
| 284 | Root of oak tree at road intersection | 1,233.92 | 1,232.91 |
| 285 | Cross cut on stone at crossroads near schoolhouse | 1,257.72 | 1,256.42 |
| 286 | Painted spot on small bridge in valley | 1,012.11 | 1,012.11 |
| 287 | Painted spot on iron bar at intersection of private road | 1,183.18 | 1,183.20 |
| 288 | Cross cut in stone at road intersection | 1,228.26 | 1,228.00 |
| 289 | Painted spot on west end of culvert | 1,019.31 | 1,019.31 |

*Bench marks in Burgettstown quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 290 | Painted spot on end of culvert at private road to west | 1,198.95 | 1,198.95 |
| 291 | Painted spot on east end of culvert | 1,060.90 | 1,060.90 |
| 292 | Ground at center of road opposite private road | 1,257.05 | 1,257.05 |
| 293 | Ground at foot of mail-box post at road to west | 1,299.73 | 1,299.73 |
| 294 | Painted square on head of spike in bridge | 1,119.21 | 1,118.70 |
| 295 | Painted spot on bridge at junction of roads | 1,091.76 | 1,091.16 |
| 296 | Stone in center of grassplot | 1,314.14 | 1,313.34 |
| 297 | Copper nail in root of oak tree | 1,366.30 | 1,365.20 |
| 298 | Copper nail in root of oak tree | 1,345.14 | 1,343.84 |
| 299 | Painted spot on floor of small bridge | 1,066.85 | 1,066.85 |
| 300 | Painted spot on limestone | 1,286.46 | 1,286.46 |
| 301 | Painted spot on end of stone at culvert | 1,187.86 | 1,187.86 |
| 302 | Square cut in stone in grassplot | 1,101.48 | 1,101.48 |
| 303 | Copper nail in end of wooden culvert | 1,337.18 | 1,336.08 |
| 304 | Square cut in stone on north side of road | 1,316.10 | 1,314.80 |
| 305 | Painted spot on stone at foot of telephone pole | 1,316.45 | 1,315.10 |
| 306 | Painted spot on floor of small bridge | 1,070.90 | 1,070.90 |
| 307 | Square cut in northeast abutment of covered bridge | 1,039.33 | 1,039.33 |
| 308 | Cross cut on stone | 1,077.78 | 1,077.78 |
| 309 | Copper nail in southwest abutment of covered bridge | 1,067.90 | 1,067.90 |
| 310 | Cross cut on southeast abutment of covered bridge | 1,084.08 | 1,084.08 |
| 311 | Square cut in stone | 1,149.82 | 1,150.07 |
| 312 | Painted spot on end of culvert | 1,315.92 | 1,346.00 |
| 313 | Painted spot on large limestone | 1,138.75 | 1,138.00 |
| 314 | Square cut in stone | 1,139.44 | 1,139.24 |
| 315 | Copper nail in root of oak tree | 1,236.23 | 1,236.23 |
| 316 | Painted square on small bridge | 1,130.18 | 1,130.32 |
| 317 | Painted spot on rail fence on west side of road | 1,278.06 | 1,278.20 |
| 318 | Copper nail in small bridge | 1,161.28 | 1,161.03 |
| 319 | Stone in center of grassplot | 1,124.42 | 1,124.12 |
| 320 | Painted spot on northwest abutment of iron bridge | 1,094.79 | 1,094.49 |
| 321 | Copper nail in root of tree | 1,268.68 | 1,268.23 |
| 322 | Painted spot on small bridge | 1,246.23 | 1,245.78 |
| 323 | Nail in end of culvert | 1,125.19 | 1,125.19 |
| 324 | Painted spot on small bridge | 1,150.05 | 1,150.05 |
| 325 | Painted spot on end of log at entrance to barn | 1,268.68 | 1,268.68 |
| 326 | Copper nail in end of culvert | 1,129.74 | 1,129.74 |
| 327 | Copper nail in root of oak tree | 1,297.69 | 1,297.69 |
| 328 | Stone in center of grassplot | 1,311.62 | 1,311.62 |
| 329 | Stone in center of grassplot | 1,266.91 | 1,266.91 |
| 330 | Painted spot on end of culvert | 1,111.46 | 1,111.16 |
| 331 | Ground at foot of mail-box post | 1,270.76 | 1,270.56 |
| 332 | Copper nail in west end of wooden culvert | 1,318.20 | 1,317.80 |
| 333 | Painted spot on limestone | 1,113.41 | 1,112.76 |
| 334 | Square cut in northeast abutment of covered bridge | 1,018.84 | 1,018.14 |
| 335 | Painted spot on small culvert | 1,052.33 | 1,051.53 |
| 336 | Copper nail in small bridge | 1,086.90 | 1,086.00 |
| 337 | Painted spot on small bridge | 1,127.60 | 1,126.60 |
| 338 | Painted spot on stone under rail fence | 1,230.32 | 1,230.32 |
| 339 | Floor of small bridge | 1,165.60 | 1,165.40 |
| 340 | Cross cut in stone at road intersection | 1,184.28 | 1,183.83 |
| 341 | Copper nail in root of oak tree | 1,278.89 | 1,278.89 |
| 342 | Ground at foot of mail-box post | 1,164.98 | 1,164.98 |
| 343 | Copper nail in root of oak tree | 1,058.60 | 1,058.40 |
| 344 | Painted spot on end of wooden culvert | 1,149.72 | 1,149.72 |
| 345 | Cross cut in stone at road intersection | 1,034.43 | 1,034.13 |
| 346 | Square cut in southeast abutment of covered bridge | 1,019.51 | 1,019.11 |
| 347 | Copper nail in root of locust tree | 1,188.79 | 1,188.79 |
| 348 | Ground at foot of mail-box post | 1,241.14 | 1,241.14 |
| 349 | Painted spot on stone at road intersection | 1,099.81 | 1,099.81 |
| 350 | Copper nail in root of oak tree | 1,057.89 | 1,057.89 |
| 351 | Painted spot on stump in center of grassplot | 1,193.59 | 1,193.39 |
| 352 | Painted spot on large rock | 1,289.79 | 1,289.04 |
| 353 | Copper nail in root of tree | 1,344.41 | 1,343.41 |
| 354 | Copper nail in root of tree | 1,040.57 | 1,039.72 |
| 355 | Painted spot on southeast abutment of covered bridge | 1,002.30 | 1,001.55 |
| 356 | Square cut on iron bridge | 1,064.18 | 1,063.60 |
| 357 | Painted spot on small wooden bridge | 1,046.47 | 1,045.00 |
| 358 | Painted spot on floor of small bridge | 1,197.33 | 1,196.93 |
| 359 | Ground at foot of post of milk stand at road intersection | 1,244.55 | 1,244.55 |
| 360 | Root of oak tree at private road | 1,242.42 | 1,242.42 |
| 361 | Painted spot on end of foundation log of schoolhouse | 1,061.02 | 1,061.02 |
| 362 | Foot of mail-box post at private road | 1,252.19 | 1,252.19 |
| 363 | Ground at foot of telephone pole at junction of roads | 1,249.78 | 1,249.78 |
| 364 | Copper nail in fence post on summit | 1,263.02 | 1,263.02 |
| 365 | Copper nail in end of log at junction of roads | 1,092.04 | 1,092.04 |
| 366 | Painted spot on limestone at junction of roads | 1,084.33 | 1,084.33 |
| 367 | Ground at foot of fence post at road to north | 1,133.96 | 1,133.96 |
| 368 | Ground at foot of telephone pole at junction of roads | 1,097.58 | 1,097.38 |
| 369 | Ground at foot of twin walnut tree at turn in road | 1,218.19 | 1,217.89 |
| 370 | Bridge opposite schoolhouse at junction of roads | 1,036.46 | 1,036.26 |
| 371 | East end of culvert at north end of wood | 1,079.64 | 1,079.64 |

*Bench marks in Burgettstown quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 372 | Painted spot on stone on east end of culvert | 1,052.99 | 1,052.59 |
| 373 | Cut on sandstone at end of culvert at crossroads | 1,244.66 | 1,244.26 |
| 374 | Painted spot on small bridge in valley | 1,093.91 | 1,093.21 |
| 375 | Painted spot on culvert | 1,118.07 | 1,118.07 |
| 376 | Copper nail in root of oak tree at junction of roads | 1,000.84 | 1,000.84 |
| 377 | Ground at foot of mail-box post on summit opposite house | 1,186.00 | 1,184.70 |
| 378 | Small culvert in turn in road | 1,155.88 | 1,154.58 |
| 379 | Ground at foot of post at junction of roads | 1,345.18 | 1,343.88 |
| 380 | Copper nail in end of culvert at junction of roads | 967.28 | 967.28 |
| 381 | Ground at foot of mail-box post at private road | 1,152.57 | 1,152.57 |
| 382 | Painted spot on stone at entrance to private road | 1,256.71 | 1,256.21 |
| 383 | Painted spot on stone at stream crossing | 1,112.91 | 1,112.61 |
| 384 | Painted spot on small culvert at private road to west | 1,063.04 | 1,062.14 |
| 385 | Block of wood at mail-box post at junction of roads | 1,042.34 | 1,041.54 |
| 386 | Top of culvert in saddle | 1,017.39 | 1,016.59 |
| 387 | Top of stone stepping block at junction of roads | 1,015.81 | 1,015.01 |
| 388 | Small bridge at road to west | 1,033.58 | 1,032.58 |
| 389 | End of culvert at road to west | 1,014.49 | 1,013.29 |
| 390 | Southwest abutment of covered bridge | 942.23 | 940.20 |
| 391 | Painted spot on floor of small bridge | 1,116.61 | 1,115.51 |
| 392 | Small iron pipe on summit | 1,361.20 | 1,360.20 |
| 393 | Copper nail in root of tree at junction of roads | 1,304.46 | 1,303.46 |
| 394 | Painted spot on ground at foot of mail-box post at crossroads | 1,265.93 | 1,264.73 |
| 395 | Copper nail in root of oak tree at junction of roads | 1,281.75 | 1,281.50 |
| 396 | Root of tree at entrance to house on summit | 1,226.00 | 1,225.40 |
| 397 | Ground at foot of corner post of fence at junction of roads | 1,272.57 | 1,272.57 |
| 398 | Root of tree at junction of roads | 1,308.43 | 1,308.43 |
| 399 | Small bridge at junction of roads | 985.95 | 985.75 |
| 400 | End of culvert at coal bank | 1,074.54 | 1,074.54 |
| 401 | End of culvert at road to east | 1,063.49 | 1,063.49 |
| 402 | Stone near oak tree at crossroads | 1,200.15 | 1,200.15 |
| 403 | Painted spot on wooden bridge | 965.90 | 965.90 |
| 404 | Ground at foot of mail-box post at junction of roads | 1,210.89 | 1,210.89 |
| 405 | Painted spot on top of summit | 1,314.69 | 1,314.13 |
| 406 | Northwest abutment of covered bridge in valley | 1,021.97 | 1,021.67 |
| 407 | Small bridge opposite house east of road | 1,069.62 | 1,068.62 |
| 408 | Painted spot on stone at foot of signboard post at road to west | 1,156.15 | 1,155.35 |
| 409 | Copper nail in stump of post on northwest corner of junction of roads | 1,253.82 | 1,253.32 |
| 410 | Painted spot on small bridge | 1,004.79 | 1,004.04 |
| 411 | Stone at junction of roads | 1,241.40 | 1,240.90 |
| 412 | Ground at foot of mail-box post at junction of roads | 1,205.88 | 1,205.88 |
| 413 | Northeast abutment of iron bridge in valley | 821.75 | 821.75 |
| 414 | Painted spot on stone at junction of roads | 1,047.13 | 1,047.13 |
| 415 | Stone under rail of fence at junction of roads | 1,307.85 | 1,306.65 |
| 416 | Small culvert at house | 1,090.62 | 1,089.22 |
| 417 | Small bridge | 1,100.39 | 1,099.00 |
| 418 | Bolt of wire fence at junction of roads | 1,326.48 | 1,324.98 |
| 419 | Stone in center of grassplot at junction of roads | 1,331.58 | 1,330.08 |
| 420 | Ground at foot of mail-box post at junction of roads | 1,203.48 | 1,203.48 |
| 421 | Copper nail in root of oak tree at junction of roads | 1,277.08 | 1,277.08 |
| 422 | End of culvert at junction of roads | 1,234.03 | 1,234.03 |
| 423 | Copper nail in root of walnut tree at junction of roads | 1,292.53 | 1,292.53 |
| 424 | Copper nail in top of stump at junction of roads | 1,241.72 | 1,241.72 |
| 425 | Copper nail in root of oak tree at junction of roads | 1,246.34 | 1,246.34 |
| 426 | Root of walnut tree at private r ad to south | 1,116.45 | 1,116.45 |
| 427 | Ground at foot of signboard post at junction of roads | 1,012.34 | 1,012.34 |
| 428 | Painted spot on end of culvert opposite church | 1,201.88 | 1,201.88 |

*Bench marks in Claysville quadrangle.*

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| *1* | Bronze tablet in northeast foundation of M. M. Hemphill's brick residence, West Middletown | *1,332* | *1,332.105* |
| *2* | Copper nail in root of hickory tree northwest of road forks | *1,081.2* | *1,081.36* |
| *3* | Copper nail in root of sugar tree east of road opposite Barr's coal bank | *944.4* | *944.63* |
| *4* | Bench cut on rock at west side of road at forks | *916.6* | *916.85* |
| *5* | Bronze tablet on large rock on east side of road 360 feet south of bridge over Brush Run | *903* | *903.410* |
| *6* | Bronze tablet on southwest abutment of covered bridge over Brush Run | *1,028* | *1,027.910* |
| *7* | Copper nail in root of sugar tree on west side of road at summit | *1,301.4* | *1,301.75* |
| *8* | Bronze tablet at northeast corner of bridge abutment | *975* | *975.814* |
| *9* | Square cut on northwest corner of bridge abutment | *981.3* | *981.73* |
| *10* | Square cut on northeast abutment of covered bridge at Taylorstown | *987* | *987.42* |
| *11* | Spike in milepost at Crothers; post reads "43 miles from Pittsburg" | | *1,049.61* |

*Bench marks in Claysville quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| *12* | Bronze tablet in northeast abutment of railroad bridge over Buffalo Creek | *1,011* | *1,010.798* |
| *13* | Bronze tablet at corner of southwest foundation of E. T. Boone's residence north of station | *1,190* | *1,189.809* |
| *14* | Spike in telegraph pole south of railroad opposite line connection of Baltimore and Ohio and Pennsylvania railroads | *1,067* | *1,067.512* |
| *15* | Square cut on bridge No. 31 of Pennsylvania Railroad near junction of connecting lines | ............ | *1,006.946* |
| *16* | Copper nail in root of large sugar tree on east side of road | *1,144.3* | *1,144.71* |
| *17* | Bronze tablet in southeast corner of foundation of H. W. Leech's residence, Buffalo | *1,307* | *1,307.752* |
| *18* | Aluminum tablet in foundation wall of public school | *1,127* | *1,126.972* |
| *19* | Square cut on abutment of culvert at road forks | *1,375.5* | *1,375.55* |
| *20* | Square cut on south end of culvert; house to south | *1,424* | *1,424.22* |
| *21* | Bronze tablet on culvert abutment on east side of road near road forks. | *1,466* | *1,465.680* |
| *22* | Square cut on rock on west side of road | *1,200.4* | *1,200.39* |
| *23* | Bronze tablet on west abutment of covered bridge at forks of road | *1,092* | *1,092.307* |
| *24* | Square cut on limestone on west side of road south of watering trough. | *1,072.4* | *1,072.43* |
| *25* | Square cut on northwest abutment of covered bridge at crossroads | *1,047* | *1,046.93* |
| *26* | Bronze tablet in sandstone ledge to north of road house | *1,037* | *1,037.377* |
| *27* | Bronze tablet on step of entrance to church at Old Concord | *1,118* | *1,117.920* |
| *28* | Square cut in stone wall in front of J. L. Parkinson's residence, Sparta. | *1,052.7* | *1,052.59* |
| *29* | Square cut on southwest abutment of covered bridge near crossroads | *1,008.5* | *1,008.46* |
| *30* | Bronze tablet on abutment at northeast corner of covered bridge over Tenmile Creek | *983* | *992.984* |
| *31* | Top of iron plug opposite pumping station | *1,030.4* | *1,030.38* |
| *32* | Square cut on northwest wing wall of iron bridge over Chartiers Creek. | *1,038* | *1,037.90* |
| *33* | Bronze tablet in east wall of brick schoolhouse | *1,076* | *1,075.986* |
| *34* | Bolt in telegraph pole on west side of road opposite watering trough | *1,124* | *1,124.04* |
| *35* | Copper nail in south end of watering trough on east side of road | *1,210.2* | *1,210.35* |
| *36* | Bronze tablet in foundation at southeast corner of Bethel Church | *1,325* | *1,325.510* |
| *37* | Square cut on northwest corner of small stone bridge | *1,144* | *1,144.17* |
| *38* | Square cut on limestone ledge on east side of road | *1,060* | *1,059.78* |
| *39* | Square cut on curb at foot of signpost "Hotel Day" | *1,032.3* | *1,032.50* |
| *40* | Square cut on southwest abutment of covered bridge at forks | *984.3* | *984.57* |
| *41* | Square cut on southeast abutment of covered bridge at forks | *977* | *977.19* |
| *42* | Square cut at northeast corner of railroad bridge No. 162 and road | *1,070* | ............ |
| *43* | Square cut on rock at south side of track at east end of cut | *1,170* | ............ |
| *44* | Painted spot on southwest capstone of railroad bridge No. 165 over county road | *1,050.6* | ............ |
| *45* | Bronze tablet in southwest capstone of railroad bridge No. 166 at Vienna station | *1,000* | *1,000.192* |
| *46* | Square cut on southwest abutment of iron bridge | *978* | *978.02* |
| *47* | Copper nail in root of large sycamore tree 180 feet east of road forks | *938.9* | *938.96* |
| *48* | Bronze tablet in northwest abutment of iron bridge near schoolhouse | *917* | *917.376* |
| *49* | Square cut on rock on south side of road 300 feet from crossroads | *1,433* | *1,433.05* |
| *50* | Bronze tablet at southeast corner of foundation of schoolhouse | *1,052* | *1,052.228* |
| 51 | Painted spot on bridge near road forks | 1,120 | 1,120.2 |
| 52 | Painted spot on heavy limestone ledge north of road | 1,226 | 1,226.44 |
| 53 | Painted spot on stone at sharp bend in road | 1,244 | 1,244.15 |
| 54 | Top of corner stone near forks of road | 1,346 | 1,346.41 |
| 55 | Painted spot on stone north of road at forks | 1,276 | 1,276.98 |
| 56 | Painted spot on culvert at forks of road south of pumping station | 1,067 | 1,066.98 |
| 57 | Painted spot on culvert at forks of road just north of township corners. | 1,106 | 1,106.01 |
| 58 | Top of corner stone northwest of road forks | 1,193 | 1,193.67 |
| 59 | Painted spot on limestone ledge on south side of road | 1,282 | 1,282.09 |
| 60 | Painted spot on limestone ledge west of road forks | 1,368 | 1,368.19 |
| 61 | Painted spot on sandstone bowlder at northwest corner of road forks | 1,386 | 1,386.17 |
| 62 | Painted spot on stone south of road forks | 1,346 | 1,346.19 |
| 63 | Painted spot on wooden bridge (primary line) | 994 | ............ |
| 64 | Painted spot on wooden bridge | 1,050 | 1,049.53 |
| 65 | Painted spot on wooden culvert | 1,102 | 1,102.21 |
| 66 | Painted spot on corner of southwest foundation of schoolhouse | 1,297 | 1,297.50 |
| 67 | Painted spot on culvert west of Samuel Davidson's residence | 1,136 | ............ |
| 68 | Ground at foot of milepost northwest of crossroads | 1,321 | 1,321.07 |
| 69 | Painted spot on small wooden culvert at road forks | 1,144 | 1,143.79 |
| 70 | Painted spot on floor of wooden bridge 150 yards south of schoolhouse | 1,066 | 1,065.67 |
| 71 | Painted spot on limestone ledge opposite schoolhouse | 1,192 | 1,191.84 |
| 72 | Painted spot on covered bridge 60 feet south of crossroads | 948 | 948.15 |
| 73 | Painted spot on bridge floor near crossroads | 1,104 | 1,104.67 |
| 74 | Painted spot on southeast corner stone of carriage house | 1,110 | 1,109.69 |
| 75 | Ground at foot of fence post 50 feet east of road to south | 1,248 | 1,248.48 |
| 76 | Painted spot on stone west of road forks | 1,065 | 1,064.73 |
| 77 | Painted spot on small culvert south of crossroads | 1,093 | 1,093.96 |
| 78 | Root of large oak tree 40 feet west of road to north | 1,046 | 1,045.74 |
| 79 | Painted spot on stone by mail box at road forks | 1,212 | 1,211.80 |
| 80 | Ground at foot of fence post on which the elevation is painted | 1,356 | 1,355.88 |
| 81 | Painted spot on stone 40 feet southwest of small house | 1,339 | 1,339.23 |
| 82 | Painted spot on sandstone bowlder at southwest corner of crossroads | 1,368 | 1,367.76 |
| 83 | Painted spot on wing wall of culvert on pike | 1,070 | 1,070.20 |
| 84 | Painted spot on wooden bridge 100 yards west of road crossing | 1,083 | 1,082.77 |
| 85 | Painted spot on small bridge 20 feet northwest of road forks | 1,244 | 1,244.36 |

*Bench marks in Claysville quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 86 | Ground in front of gatepost southwest of road forks | 1,129 | 1,128.84 |
| 87 | Painted spot on bottom plank of fence west of road forks | 1,311 | 1,311.48 |
| 88 | Ground at foot of telegraph pole at east side of road forks | 1,364 | 1,364.17 |
| 89 | Painted spot on stone at forks of road | 978 | 977.88 |
| 90 | Painted spot on stone on north side of road at forks | 940 | 939.77 |
| 91 | Painted spot on stone southwest of road forks | 1,264 | 1,264.19 |
| 92 | Painted spot on stone west of road forks | 1,181 | 1,180.90 |
| 93 | Top of Washington coal | 1,171 | ........... |
| 94 | Ground in front of telephone pole at road forks | 1,037 | 1,037.24 |
| 95 | Painted spot on base plank of fence east of road forks | 1,041 | 1,041.30 |
| 96 | Painted spot on lower plank of fence opposite of road forks | 1,009 | 1,008.83 |
| 97 | Painted spot on plank of fence on west side of road at forks | 1,259 | 1,259.47 |
| 98 | Painted spot on small bridge south of road forks | 1,118 | 1,117.61 |
| 99 | Top of coal in east bank of road east of schoolhouse | 1,282 | ........... |
| 100 | Ground at foot of fence post northeast of road forks | 1,085 | 1,084.79 |
| 101 | Top of Washington coal | 1,050 | 1,050.09 |
| 102 | Painted spot on small culvert on National pike at road forks | 1,094 | 1,094.33 |
| 103 | Painted spot on plank of fence at road forks | 1,292 | 1,291.87 |
| 104 | Painted spot on wooden bridge at road forks near tollgate | 1,051 | 1,050.90 |
| 105 | Painted spot on plank of fence north of road forks | 1,099 | 1,099.33 |
| 106 | Square cut on sandstone at road forks | 1,322 | 1,322.53 |
| 107 | Painted spot on top of fence post at road forks | 1,350 | 1,349.86 |
| 108 | Painted spot on stone pillar in corner of foundation of barn | 1,320 | 1,320.61 |
| 109 | Ground at foot of telegraph pole on which elevation is painted | 1,320 | 1,319.83 |
| 110 | Ground at foot of telephone post on which elevation is painted | 1,068 | 1,068.02 |
| 111 | Painted spot on plank of fence northwest of road forks north of church | 1,333 | 1,333.20 |
| 112 | Top of coal at road forks | 1,200 | 1,199.67 |
| 113 | Painted spot on coping stone of bridge southwest of crossroads | 1,037 | 1,037.46 |
| 114 | Ground on foot of post on which elevation is painted | 1,324 | 1,323.98 |
| 115 | Painted spot on root of red oak tree at road forks | 1,358 | 1,358.12 |
| 116 | Ground at foot of post on which elevation is painted | 1,334 | 1,334.25 |
| 117 | Painted spot on fence plank south of road forks | 1,101 | 1,100.56 |
| 118 | Painted spot on small wooden culvert at road forks | 1,074 | 1,073.96 |
| 119 | Top of limestone ledge | 1,149 | ........... |
| 120 | Painted spot on root of hickory tree 40 feet east of church | 1,368 | 1,367.12 |
| 121 | Painted spot on stone wall east of road forks | 1,356 | 1,355.47 |
| 122 | Painted spot on bowlder at road forks | 1,395 | 1,394.58 |
| 123 | Painted spot on sandstone bowlder at road forks | 1,145 | 1,144.70 |
| 124 | Painted spot on root of oak lane to west | 1,308 | 1,307.94 |
| 125 | Painted spot on wing wall of covered bridge | 1,099 | 1,098.95 |
| 126 | Painted spot on rail of fence at road forks | 1,391 | 1,391.10 |
| 127 | Painted spot on top plank of fence at road forks | 1,162 | 1,161.51 |
| 128 | Painted spot on sandstone bowlder by roadside opposite house | 1,223 | 1,223.36 |
| 129 | Painted spot on sandstone bowlder at road forks | 1,187 | 1,187.30 |
| 130 | Painted spot on bowlder at road forks near signpost | 1,134 | 1,134.18 |
| 131 | Painted spot on stump at road forks | 1,278 | 1,278.35 |
| 132 | Painted spot on small wooden culvert | 1,291 | 1,290.93 |
| 133 | Painted spot on sandstone bowlder northeast of road forks | 1,063 | 1,063.22 |
| 134 | Painted spot on small bowlder at road forks | 1,164 | 1,163.76 |
| 135 | Ground at foot of signpost | 1,386 | 1,386.35 |
| 136 | Painted spot on sandstone bowlder at road forks | 1,082 | 1,081.71 |
| 137 | Ground at foot of telephone pole at road forks | 1,398 | 1,397.93 |
| 138 | Painted spot on sandstone bowlder at corner of yard | 1,071 | 1,071.26 |
| 139 | Ground at corner post of yard northeast of road forks | 1,436 | 1,436.26 |
| 140 | Painted spot on plank of fence opposite road forks | 1,028 | 1,027.56 |
| 141 | Painted spot on small wooden bridge 100 feet west of crossroads | 1,151 | 1,151.16 |
| 142 | Painted spot on sandstone bowlder at road forks | 1,304 | 1,304.25 |
| 143 | Painted spot on gas pipe on north side of road at forks | 1,298 | 1,298.45 |
| 144 | Ground at foot of signpost at road forks | 1,119 | 1,118.11 |
| 145 | Painted spot on culvert at crossroads | 1,282 | 1,281.53 |
| 146 | Painted spot on limestone by oak tree east of crossroads | 1,301 | 1,301.41 |
| 147 | Painted spot on rock at forks west of Mount Hope Church | 1,252 | 1,251.93 |
| 148 | Painted spot on abutment of small bridge | 883 | 883.03 |
| 149 | Center of road at top of rise | 1,237 | ........... |
| 150 | Painted spot on limestone ledge at road forks | 1,099 | 1,099.58 |
| 151 | Copper nail in stump at road northeast of Manchester schoolhouse | 1,304 | ........... |
| 152 | Painted spot on root of water oak tree at road forks | 1,031 | 1,031.74 |
| 153 | Painted spot on small bridge north of road forks | 979 | 979.20 |
| 154 | Painted spot on abutment of stone arch bridge | 1,070 | 1,069.49 |
| 155 | Top of derrick floor, oil well | 1,039 | 1,039.27 |
| 156 | Painted spot on limestone ledge | 1,251 | 1,251.28 |
| 157 | Top of rise at center of road south of schoolhouse | 1,250 | ........... |
| 158 | Painted spot on root of white oak tree at road forks | 939 | 938.66 |
| 159 | Painted spot on stump at road forks | 1,222.6 | 1,222.62 |
| 160 | Painted spot on stone at road forks | 1,285 | 1,285.53 |
| 161 | Painted spot on plank of fence by barn at road forks | 1,321 | 1,321.30 |
| 162 | Painted spot on small wooden bridge | 997 | 997.38 |
| 163 | Painted spot on bridge south of road forks | 979 | 978.74 |
| 164 | Painted spot on large sandstone under fence corner | ........... | ........... |
| 165 | Painted spot on sandstone by corner of fence at road forks | 1,316 | 1,316.44 |
| 166 | Painted spot on large sandstone by gate opposite schoolhouse | 1,309 | 1,308.63 |
| 167 | Painted spot on large limestone in middle of crossroads | 1,251 | 1,250.59 |

*Bench marks in Claysville quadrangle*—Continued.

| No. | Description. | Original elevation. | Adjusted elevation. |
|---|---|---|---|
| | | *Feet.* | *Feet.* |
| 168 | Painted spot on large limestone by gate on south side of road forks | 1,295 | 1,295.52 |
| 169 | Painted spot on large sandstone on north side of crossroads | 1,043 | 1,042.64 |
| 170 | Painted spot on stump by yard fence at crossroads | 1,262 | 1,261.78 |
| 171 | Painted spot on gas pipe at road forks | 1,333 | 1,333.15 |
| 172 | White spot on bridge | 1,084 | 1,084.06 |
| 173 | White spot on large square stone opposite old tollgate at road forks | 1,311 | 1,311.45 |
| 174 | Painted spot on small culvert at road forks | 1,289 | 1,289.23 |
| 175 | Painted spot on small culvert at road forks | 1,045 | 1,044.71 |
| 176 | Ground at foot of signpost in grass plot at road forks | 1,033 | 1,031.65 |
| 177 | Ground at foot of telegraph pole at road forks | 1,102 | 1,101.07 |
| 178 | Ground at foot of post on which elevation is painted | 1,380 | 1,379.12 |
| 179 | Painted spot on small stone at junction of roads | 1,319 | 1,319 |
| 180 | Ground at foot of mail box west of road forks | 1,339 | 1,339.10 |
| 181 | Painted spot on gas pipe at road forks | 1,043 | 1,043.12 |
| 182 | Painted spot on stone by watering trough near road forks | 1,268 | 1,268.58 |
| 183 | East rail of Washington and Waynesburg Railroad at road crossing at Dunns Station. | 1,052 | 1,051.55 |
| 184 | Center of road at top of hill | 1,276 | 1,276 |
| 185 | Painted spot on west end of bridge over railroad at West Union | 1,263 | 1,263.05 |
| 186 | Painted spot on stone at road forks | 1,135 | 1,135.27 |
| 187 | Painted spot on sandstone ledge at road forks | 1,433 | 1,433.12 |
| 188 | Painted spot on bridge between road forks | 1,074 | 1,074.43 |
| 189 | Ground at foot of signpost at crossroads | 1,341 | 1,340.63 |
| 190 | Painted spot on plank of fence at road forks | 1,394 | 1,394.18 |
| 191 | Ground at foot of Ross's mail-box post at crossroads | 1,442 | 1,441.69 |
| 192 | Ground at foot of fence post on which elevation is painted | 1,206 | 1,206.40 |
| 193 | Ground at foot of telephone pole opposite schoolhouse | 1,250 | 1,250.37 |
| 194 | Ground at foot of thick post north of road forks | 1,390 | 1,389.60 |
| 195 | Ground at foot of telephone pole south of road forks | 1,119 | 1,119.03 |
| 196 | Top of coal bed opposite schoolhouse | 1,076 | 1,076 |
| 197 | Painted spot on small stone on ground at foot of fence post | 1,329 | 1,329.31 |
| 198 | Painted spot on floor of bridge | 1,160 | 1,160.32 |
| 199 | Painted spot on floor of bridge | 1,102 | 1,102 |
| 200 | Painted spot on large sandstone at road forks | 1,325 | 1,325.12 |
| 201 | Painted spot on stone at foot of fence post at road forks | 1,062 | 1,061.62 |
| 202 | Painted spot on sandstone at road forks opposite big red barn | 1,323 | 1,323.04 |
| 203 | Painted spot on stone at road forks | 1,416 | 1,416.34 |
| 204 | Painted spot on top of fence post at road forks | 1,402 | 1,402.33 |
| 205 | Ground at foot of telephone pole at road forks | 1,369 | 1,368.75 |
| 206 | Painted spot on root of red-oak tree at road forks | 1,146 | 1,145.97 |
| 207 | Painted spot on ground at gatepost | 1,374 | 1,373.69 |
| 208 | Painted spot on ground at foot of telephone pole at road forks | 1,133 | 1,132.77 |
| 209 | Painted spot on stone step of Plant's store | 1,105 | 1,105.19 |
| 210 | Painted spot on floor of bridge | 1,195 | 1,194.77 |
| 211 | Painted spot on bridge near house of George Sprowls | 1,059 | 1,058.69 |
| 212 | Painted spot on limestone bowlder in road forks | 1,150 | 1,150.30 |
| 213 | Painted spot on foundation stone at corner of barn | 1,332 | 1,331.74 |
| 214 | Painted spot on plank of fence west of road forks | 1,337 | 1,337.18 |
| 215 | Painted spot on bridge | 1,095 | 1,094.70 |
| 216 | Painted spot on stone south of road forks | 1,415 | 1,414.69 |
| 217 | Painted spot on ground by post on which elevation is painted | 1,238 | 1,237.63 |
| 218 | Painted spot on wing wall of bridge | 1,016 | 1,016.33 |
| 219 | Painted spot on top of post at road forks | 1,106 | 1,105.70 |
| 220 | Painted spot on stump at road forks | 1,372 | 1,372.38 |
| 221 | Painted spot on fence plank northwest of road forks | 1,393 | 1,392.68 |
| 222 | Painted spot on plank north of road forks | 1,407 | 1,406.76 |
| 223 | Painted spot on stump at road forks | 1,348 | 1,347.66 |
| 224 | Painted spot on stone wall at road forks | 1,096 | 1,096.47 |

# INDEX.

# CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 318.]

The publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

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THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

AUGUST, 1907.

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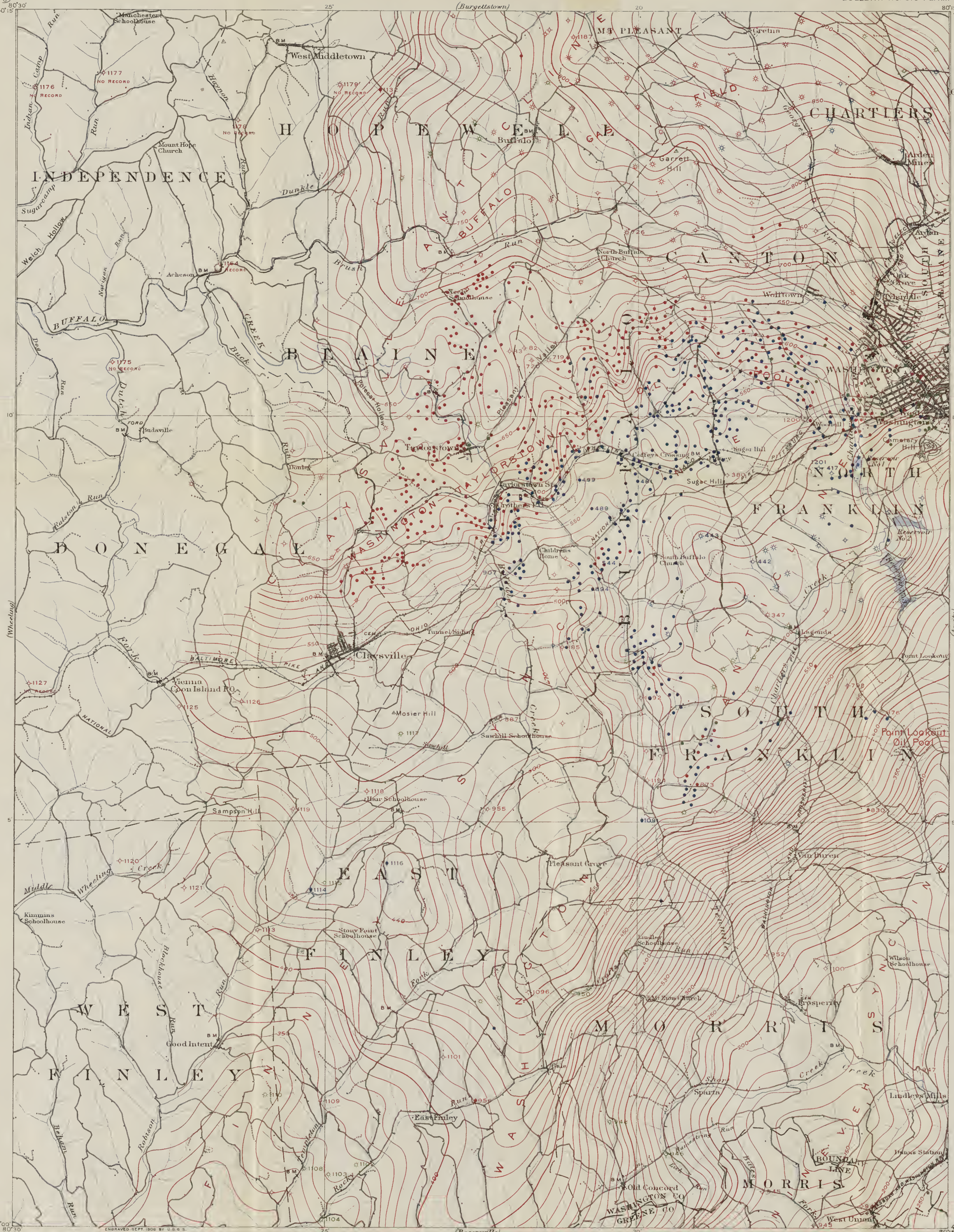



## LEGEND

Contours on top of Gordon sand. Datum plane is 2000 feet below sea level

Oil wells

Show of oil

Gas wells

Dry holes

NOTE: Green color represents oil or gas wells getting their product from or above the Gantz sand.

Red color represents all wells getting their product below the Gantz, to and including the Gordon sand, also numbers for wells discussed in text, all dry holes and wells concerning whose production no information was obtained.

Blue color represents wells getting their product below the Gordon sand.

Numbered wells are referred to in the text.

H. M. Wilson, Geographer
Robt D. Cummin, in charge of section
Topography by M. J. Munn, Assistant, E. W. McCrary
Control by D. H. Baldwin and B. J. Green
Surveyed in 1904 and 1905

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA

# MAP OF CLAYSVILLE QUADRANGLE, PA., SHOWING OIL WELLS, GAS WELLS, AND STRUCTURE CONTOURS ON TOP OF GORDON SAND

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 miles

1 ½ 0 1 2 3 4 5 kilometers

Geology by M. J. Munn under the direction of M. R. Campbell

1907


## LEGEND

Contours on top of Upper Washington limestone. Datum is sea level

Elevation above sea level of top of Upper Washington limestone

Number of bench mark corresponding to list in appendix

NOTE: At points on map indicated by green crosses the elevation in feet of the top of the Upper Washington limestone above sea level is shown by the accompanying numbers in green. These elevations are determined by spirit level, either directly upon this bed or upon others having a known distance above or below it.

The numbers in red correspond to the numbers of bench marks described in the appendix of the accompanying bulletin, from which the elevations on the limestone were secured.

ENGRAVED SEPT 1906 BY U.S.G.S.

H. M. Wilson, Geographer.
Robt D. Cummin, in charge of section.
Topography by M. J. Munn, Assistant, E. W. McCrary.
Control by D. H. Baldwin and B. J. Green.
Surveyed in 1904 and 1905.
SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA

# MAP OF CLAYSVILLE QUADRANGLE, PA., SHOWING BENCH MARKS AND STRUCTURE CONTOURS ON TOP OF UPPER WASHINGTON LIMESTONE

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 miles

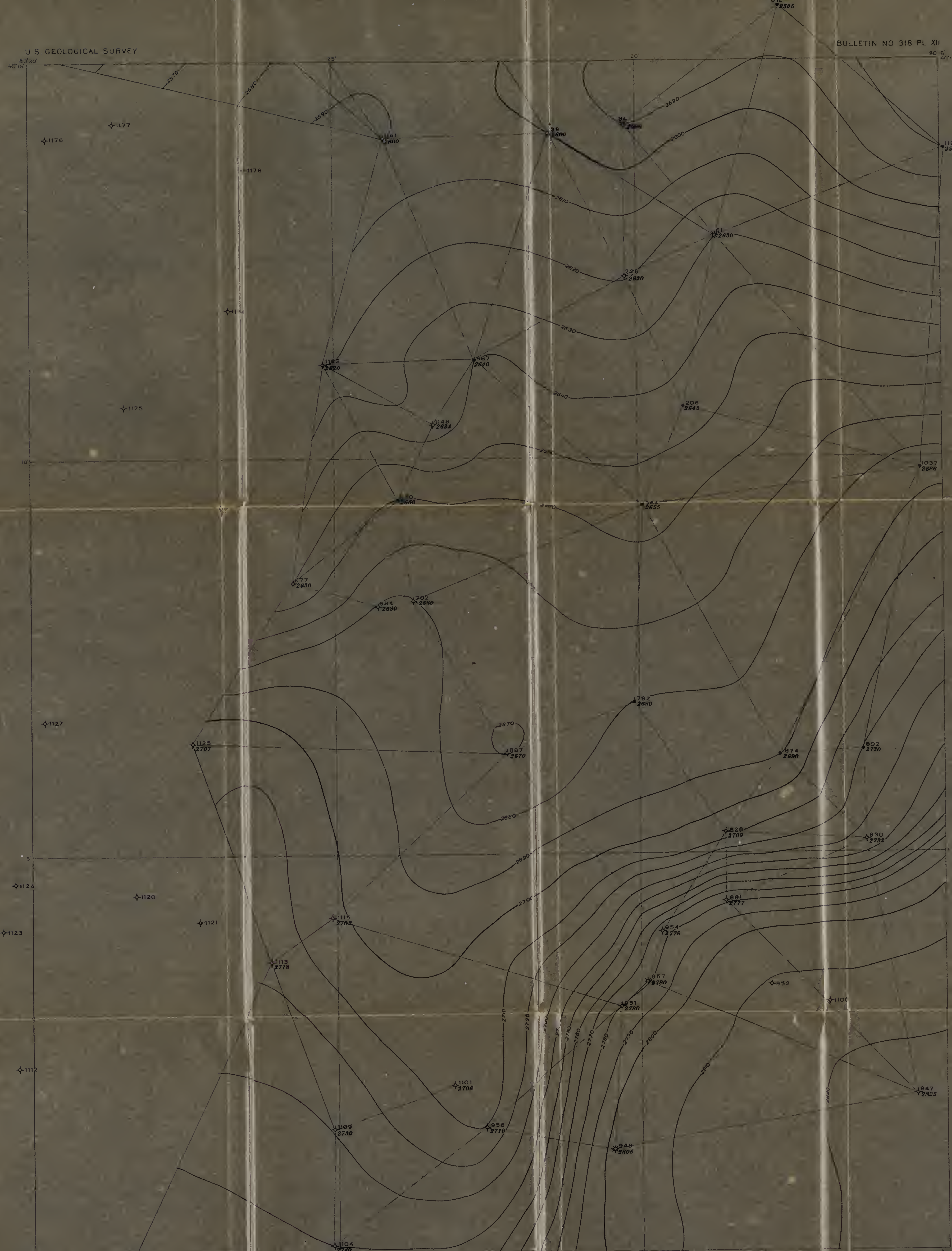
1 ½ 0 1 2 3 4 5 kilometers

Surface contour interval 20 feet.

*Datum is mean sea level.*

1907

Geology by M. J. Munn under the direction of M. R. Campbell




NOTE: The object of this drawing is to show graphically the amount of variation in the distance between the surface beds and the oil sands. The smaller numbers, ranging from 34 to 1178, indicate wells represented on Pl. XIII to which reference has been made in the text. The larger numbers show the measured distance in feet at these wells between the top of the Upper Washington limestone and the top of the Gordon sand. The straight lines radiating from these wells are lines on which the variations between wells are indicated. The sinuous lines are supposed to pass through points of equal distance between these beds. Wells to which no lines have been drawn are ones that could have been used to great advantage, had their records been preserved.

To find the approximate distance to the Gordon sand from any outcrop of the Upper Washington limestone first locate the outcrop on Pl. XIII, then place this sheet over Pl. XIII and note the distance at the located point, as indicated by the sinuous lines on this sheet.

## CONVERGENCE SHEET OF CLAYSVILLE QUADRANGLE, PENNSYLVANIA

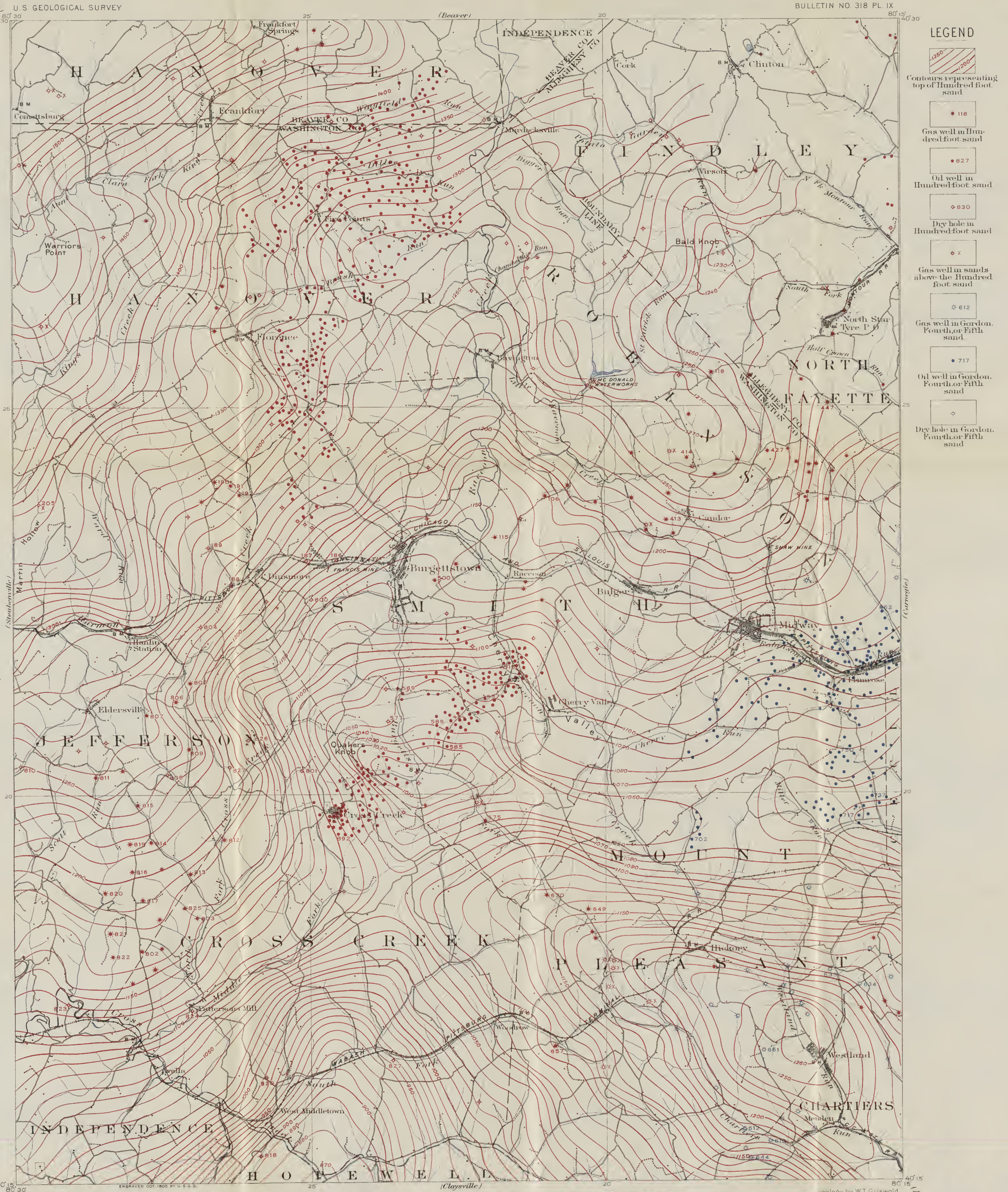
showing distance from top of Upper Washington limestone to top of Gordon sand

• Oil well    ⟡ Dry hole    ✲ Gas well

**2805** Distance from top of Upper Washington limestone to top of Gordon sand

948 Well numbers

Geology by M. J. Munn under the direction of M. R. Campbell




H. M. Wilson, Geographer
R. D. Cummin, in charge of section
Topography by M. J. Munn. Assistants, E. W. McCrary and J. H. Wilkie
Control by D. H. Baldwin and W. T. Griswold
Surveyed in 1904.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA

## MAP OF BURGETTSTOWN QUADRANGLE, PA., SHOWING OIL WELLS, GAS WELLS, AND STRUCTURE CONTOURS ON TOP OF HUNDRED FOOT SAND

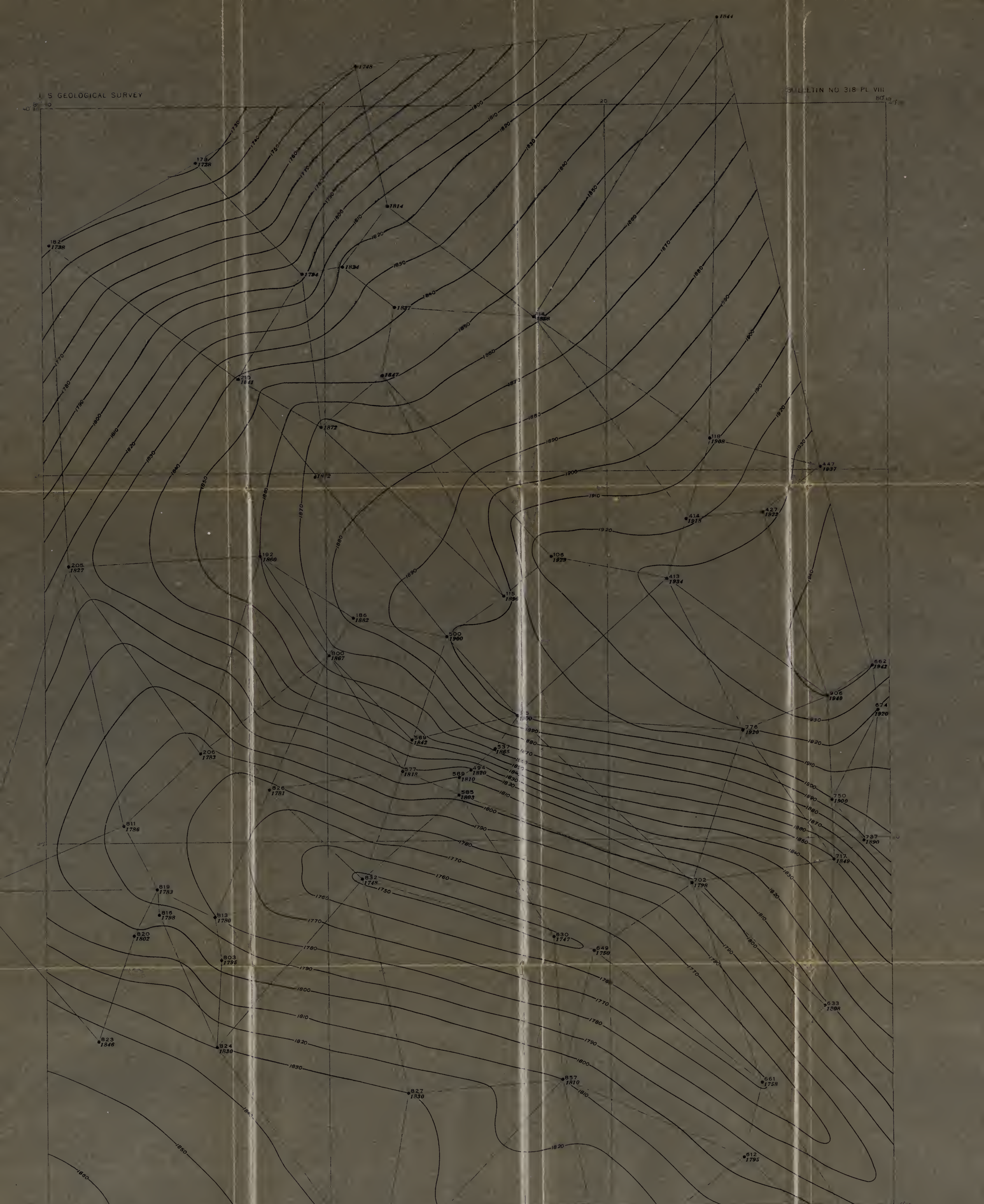
Geology by W. T. Griswold, under the direction of M. R. Campbell

Scale 1/62500

1 ½ 0 1 2 3 4 miles

1 ½ 0 1 2 3 4 5 kilometers

1907



# CONVERGENCE SHEET OF BURGETTSTOWN QUADRANGLE, PENNSYLVANIA

showing distance from base of Pittsburg coal to top of Hundred-foot sand

• Oil wells

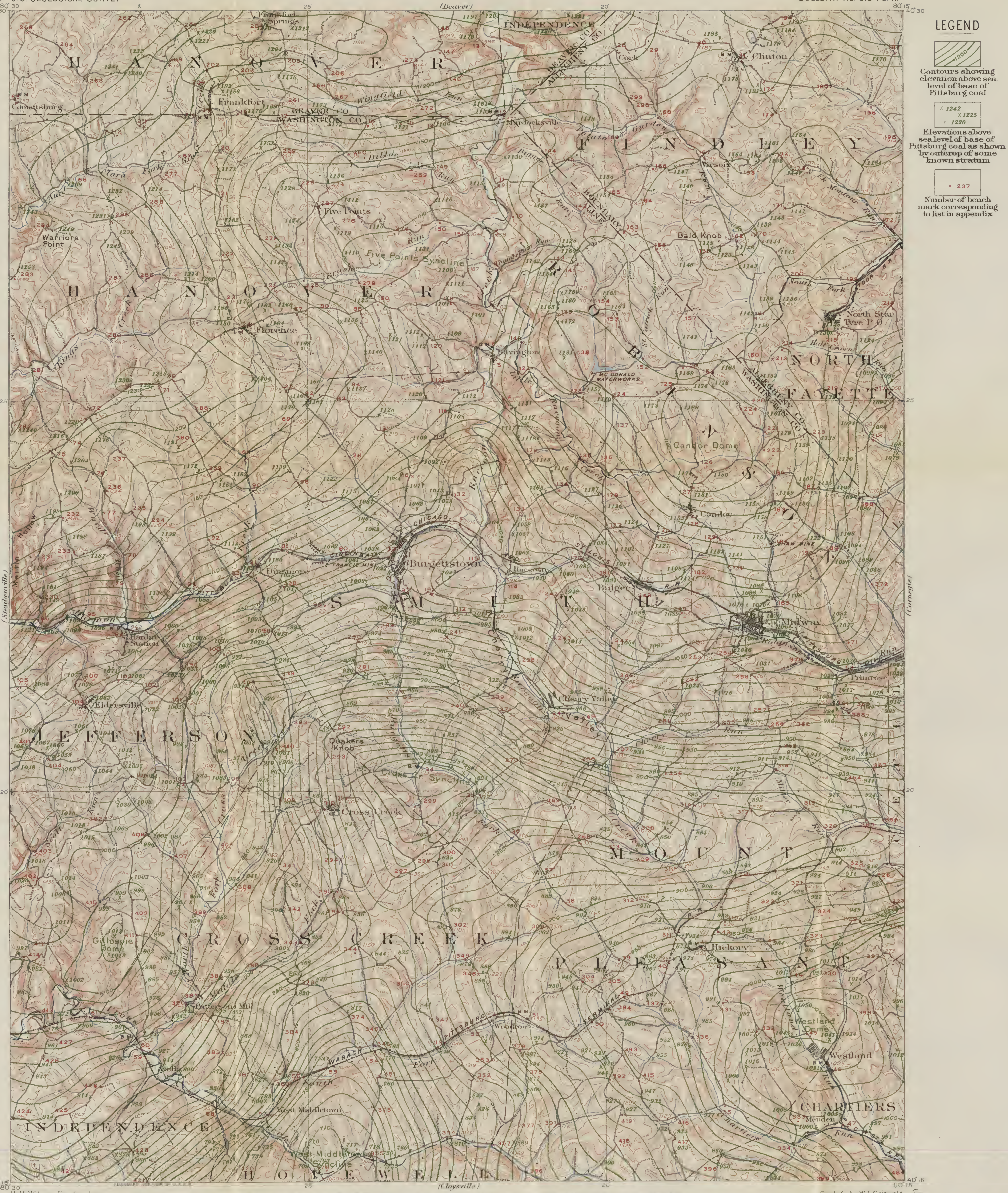
*1830* Distance from base of Pittsburg coal to top of Hundred-foot sand

827 Well numbers

Geology by W. T. Griswold, under the direction of M. R. Campbell

NOTE: The object of this drawing is to show graphically the amount of variation in the distance between the surface beds and the oil sands. The smaller numbers, ranging from 114 to 906, indicate wells represented on Pl. IX to which reference has been made in the text. The larger numbers show the measured distance in feet at these wells between the base of the Pittsburg coal and the top of the Hundred-foot sand. The straight lines radiating from these wells are lines on which the variations between wells are indicated. The sinuous lines are supposed to pass through points of equal distance between these beds.

To find the approximate distance to the Hundred-foot sand from any outcrop of the Pittsburg coal, first locate the outcrop on Pl. IX then place this sheet over Pl. IX and note the distance at the located point, as indicated by the sinuous lines on this sheet.




MAP OF BURGETTSTOWN QUADRANGLE, PA., SHOWING KEY HORIZON (BASE OF PITTSBURG COAL) AND LOCATION OF BENCH MARKS

H. M. Wilson, Geographer.
R. D. Cummin, in charge of section.
Topography by M. J. Munn, Assistants, E. W. McCrary and J. H. Wilkie.
Control by D. H. Baldwin and W. T. Griswold.
Surveyed in 1904.

SURVEYED IN COOPERATION WITH THE STATE OF PENNSYLVANIA

Geology by W. T. Griswold, under the direction of M. R. Campbell.

Scale 1/62500

Surface contour interval 20 feet

*Datum is mean sea level*

1907


# MAP OF STEUBENVILLE QUADRANGLE, OHIO W.VA.-PA., SHOWING OIL WELLS, GAS WELLS, AND STRUCTURE CONTOURS ON TOP OF BEREA OIL SAND

Jno. H. Renshawe, Geographer in charge.
Triangulation by W. T. Griswold.
Topography by Chas. E. Cooke

SURVEYED IN 1902 IN COOPERATION WITH THE STATES OF OHIO, WEST VIRGINIA AND PENNSYLVANIA

Geology by W. T. Griswold under the direction of M. R. Campbell

Scale $\frac{1}{62500}$

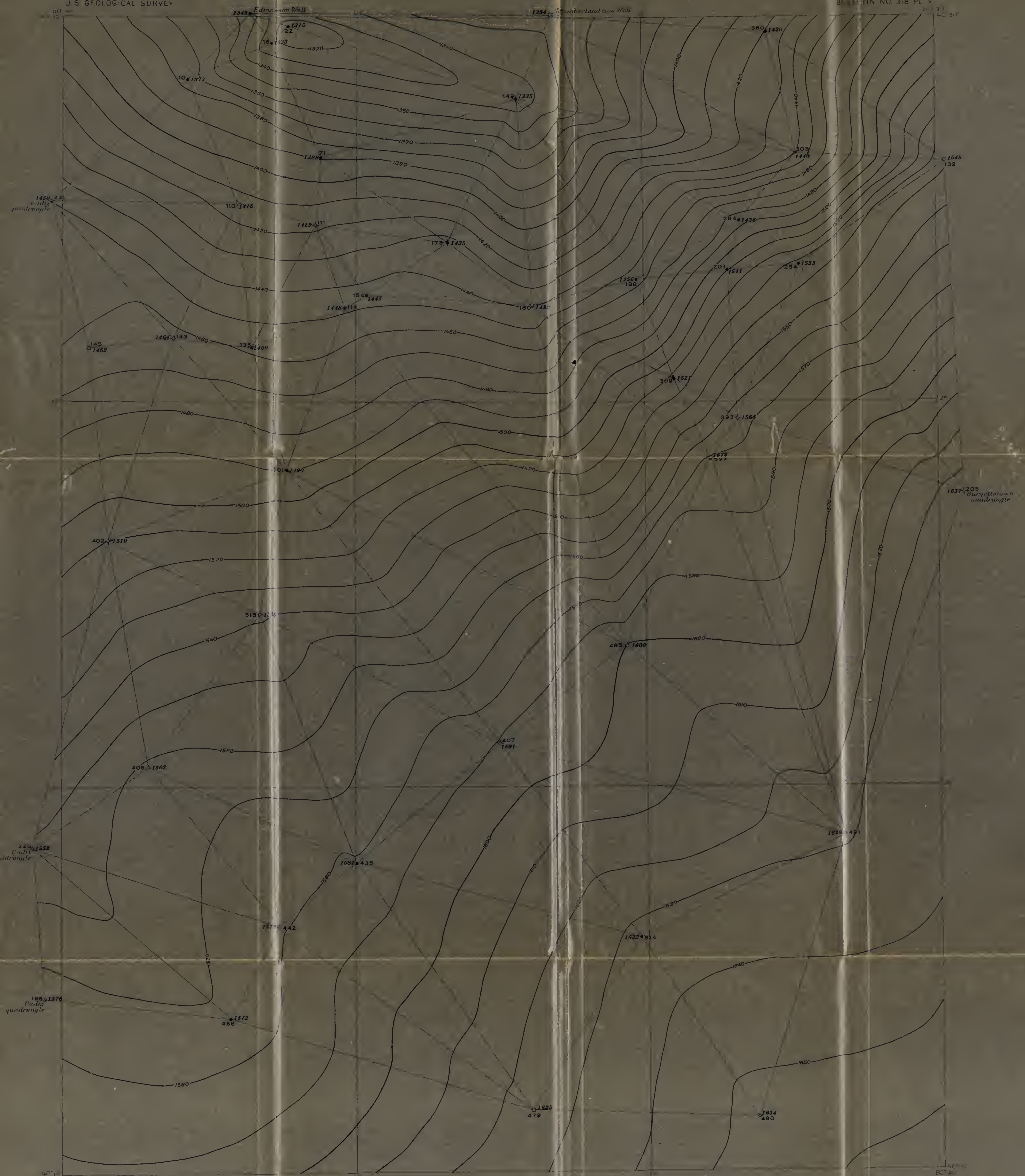
1 ½ 0 1 2 3 4 miles

1 ½ 0 1 2 3 4 5 kilometers

Surface contour interval 20 feet

*Datum is mean sea level*

1907




NOTE: The object of this drawing is to show graphically the amount of variation in the distance between the surface beds and the oil sands. The smaller numbers, ranging from 10 to 514 indicate wells represented on Pl. VI to which reference has been made in the text. The larger numbers show the measured distance in feet at these wells between the base of the Pittsburg coal and the top of the Berea oil sand. The straight lines radiating from these wells are lines on which the variations between wells are indicated. The sinuous lines are supposed to pass through points of equal distance between these beds. Wells to which no lines have been drawn are ones that could have been used to great advantage, had their records been preserved. To find the approximate distance to the Berea oil sand from any outcrop of the Pittsburg coal, first locate the outcrop on Pl. VI, then place this sheet over Pl. VI and note the distance at the located point, as indicated by the sinuous lines on this sheet.

# CONVERGENCE SHEET OF STEUBENVILLE QUADRANGLE, OHIO W.VA.PA.

showing distances from base of Pittsburg coal to top of Berea oil sand

• Oil well ✧ Dry hole ✲ Gas well ♦ Show of oil

*1654* Distance from base of Pittsburg coal to top of Berea oil sand

490 Well numbers

Geology by W T Griswold, under the direction of M R Campbell


LEGEND

Contours on base of Pittsburg coal. Datum is mean sea level

⚒ 1052

Mines
*(Numbers show elevation of Pittsburg coal above sea level)*

› 1056

Prospects
*(Numbers show elevation of Pittsburg coal above sea level)*

× 210

Number of bench mark corresponding to list in appendix

*Note: Where symbols are underscored the elevations are measured directly on the Pittsburg coal. All others are computed from other beds*

Jno. H. Renshawe, Geographer in charge
Triangulation by W. T. Griswold
Topography by Chas. E. Cooke

SURVEYED IN 1902 IN COOPERATION WITH THE STATES OF OHIO, WEST VIRGINIA, AND PENNSYLVANIA

MAP OF STEUBENVILLE QUADRANGLE, OHIO-W. VA.-PA., SHOWING
KEY HORIZON (BASE OF PITTSBURG COAL) AND LOCATION OF BENCH MARKS

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 miles

1 ½ 0 1 2 3 4 5 kilometers

Surface contour interval 20 feet

*Datum is mean sea level*

1907

Geology by W. T. Griswold, under the direction of M. R. Campbell