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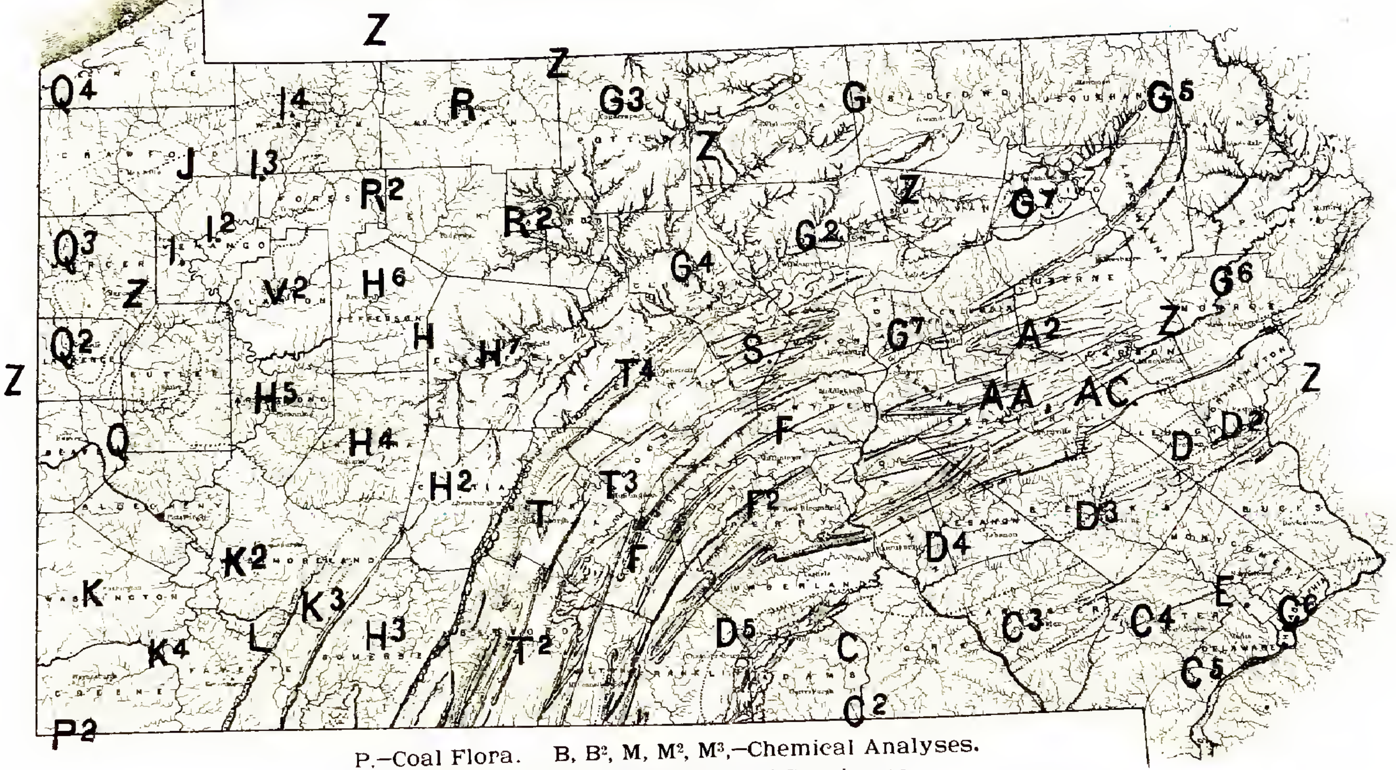

P.–Coal Flora. B, B², M, M², M³,–Chemical Analyses.

N.–Levels. O, O²,–Catalogue of Specimens.

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

REPORT OF PROGRESS X.

A GEOLOGICAL HAND ATLAS

OF THE

SIXTY-SEVEN COUNTIES

OF

PENNSYLVANIA,

EMBODYING THE RESULTS

OF THE

FIELD WORK OF THE SURVEY,

FROM 1874 TO 1884.

BY

J. P. LESLEY.

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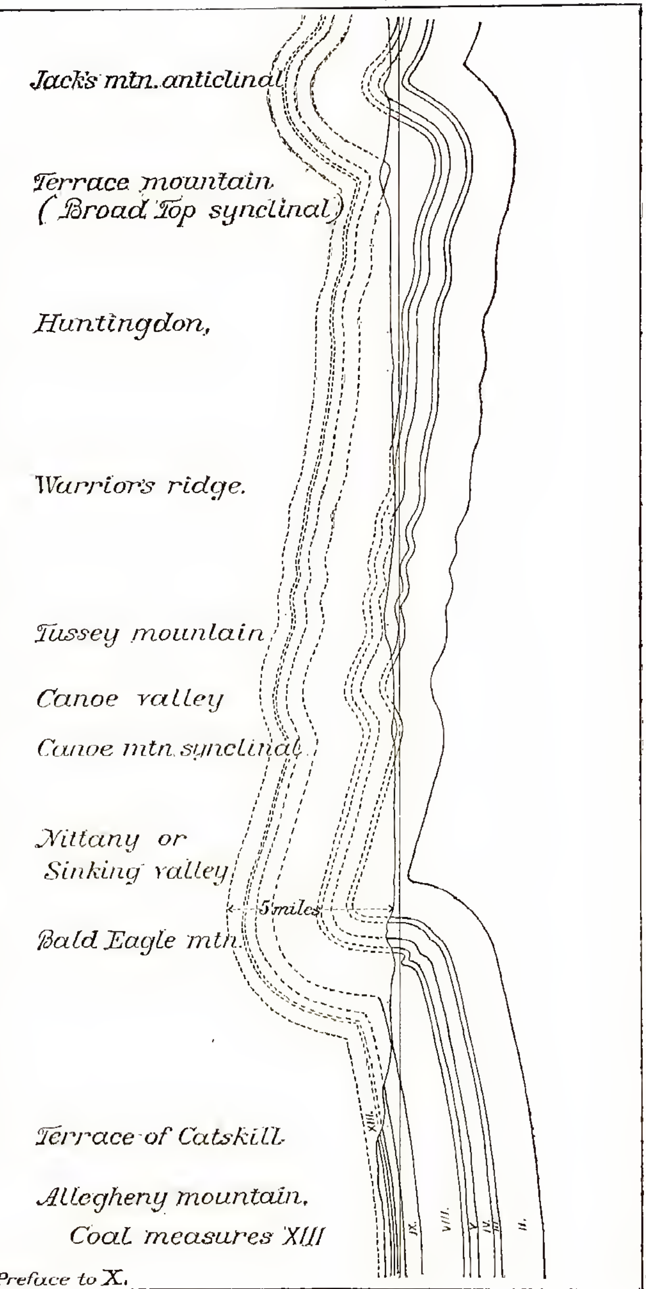
LIST OF COUNTY MAPS IN THE HAND ATLAS.

vi X.



Section of Palæozoic formations along the Little Juniata river.

To face Preface to X.

SHORT EXPLANATION

OF THE

GEOLOGICAL STRUCTURE OF PENNSYLVANIA.

By J. P. Lesley.

Pennsylvania is 150 miles in width between two parallels of latitude, and 290 miles long, measuring from the meridian of the Ohio State line to either one of its two projecting points on the Delaware river, Port Jarvis at the northern angle of New Jersey, or the bend below Trenton. A slight irregularity in its northern line gives it a boundary of 50 miles along Lake Erie; and a circle of 10 miles radius struck from the court-house of New Castle in Delaware takes off a small piece of its south-east corner. Its eastern line follows the course of the Delaware river.

The Allegheny mountain divides it into two nearly equal parts, popularly known as Eastern and Western Pennsylvania, entirely different in geological character and in relief of surface; western Pennsylvania belonging to the Mississippi valley region, and eastern Pennsylvania to the Atlantic seaboard; western Pennsylvania being one unbroken bituminous coal field, while eastern Pennsylvania is partly a labyrinth of parallel and interlocked mountains and valleys of Devonian and Silurian age, and partly an open country of still older Cambrian or Primordial, Azoic or Fundamental strata, across which runs a broad continuous belt of Triassic or Mesozoic brown stone and trap. Cretaceous rocks underlie a narrow strip along the Delaware river below Trenton;* and a mantel of glacial drift covers the surface of the whole northern part of the State as far south as a line drawn nearly straight from Belvedere on the Delaware river to Olean on the New York State line, and another line drawn nearly through Franklin and Beaver to the Ohio State line north of the Ohio river.†

No high mountains exist at present in Pennsylvania; its highest land may be quoted at 2500 feet above tide; and most of its ridges at 1500 to 2000 feet; although a few of the small rounded knobs along the crest of the Allegheny mountain reach 2700 and 2800. The high plateau of the Catskill in southern New York, with numerous summits exceeding 4000 feet, slopes south-westward to the Delaware river, and becomes in Pennsylvania the Pocono plateau only 2000 feet high. In like manner the great Blue Ridge range, which in North Carolina has peaks of over 7000 feet, declines through Virginia and Maryland into the South Mountain range of Pennsylvania, scarcely 2000 feet high, and ends in a point west of Harrisburg. At Reading on the Schuylkill it rises again above the surface,

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* See the special map of Philadelphia, and Report C^6.

† See the maps in Report Z.

with parallel ridges 1000 feet high, and passes on through New Jersey to become the Highlands of the Hudson river, with summits about 3000 feet above tide.

It is noticeable, however, that at least one fourth of the State, comprising the northernmost two tiers of counties from end to end, and the tier of counties back of the Alleghany mountain, has a general surface averaging 2000 feet above the sea, until recently covered with a continuous forest, and subject to a rigorous winter climate. On this table-land the rainfall separates itself into three systems of drainage, and flows northward through the Genesee into Lake Ontario; south-eastward through the Susquehanna river into Chesapeake bay; and south-westward through the Allegheny, Ohio, and Mississippi rivers into the Gulf of Mexico.

In spite of the present nearness of the surface level of the State to the level of the sea such was not always the case. Our mountains were once ten times higher than they are now; and their gradual erosion to their present height by the frosts and rains of past ages, beginning long before the advent of the races of living beings which now inhabit the planet, makes the most interesting chapter in our geological history.

This weathering down of the surface of the State is shown by the coloring of the skeleton State map, which precedes the series of county maps. The black area in the south-west corner of this map marks those portions of Greene, Washington, Fayette, Westmoreland, Allegheny, Indiana, and Somerset counties which still preserve the Pittsburgh coal bed, and its covering of higher rocks. In several places it passes underneath the Monongahela and Youghiogheny rivers; but elsewhere these rivers have cut through it, and left its edges to be mined upon the steep side slopes of their valleys. In like manner this coal bed has been carried away from the divides, and left in long and irregular strips, and a multitude of isolated patches on the hill tops. One small patch of it is preserved in the center of the Ligonier valley in eastern Westmoreland; and several small patches of it still remain in the Salisbury basin in Somerset county.

These relics of the Pittsburgh coal bed show that it once spread over south-western Pennsylvania from the Ohio river to the Allegheny mountain. But it must have spread still farther eastward; for a large area of it is mined between Cumberland and Piedmont in Maryland; and a very small patch of it has been left on the highest summit of the Broad Top mountain in Huntingdon county.* Finally, there are good reasons for identifying one or two of the anthracite beds with the Pittsburgh bituminous coal bed, and therefore for regarding it as a growth of swamp vegetation co-extensive with the State. Its original extent northward towards Lake Erie and New York State cannot be now learned, for it

*The black spot in Huntingdon county represents the entire 80 square miles of Broad Top Coal Measures. The patch of Pittsburgh coal would be represented by the finest needle prick, and must be imagined to lie in the center of the black spot.

has been completely swept away from the whole Allegheny valley region, and from the upper Susquehanna river country.

The white portion of the map surrounding the Pittsburgh coal bed area —embracing Beaver, Lawrence, Mercer, and Crawford counties on the Ohio line; Butler, Armstrong, Clarion, Venango, Forest, Warren, and McKean, on the Allegheny river; Cambria, Indiana, Jefferson, and Elk on its eastern branches; Clearfield, Cameron, and Clinton on the Susquehanna river west of the Allegheny mountain—shows the country which is now denuded of the Pittsburgh coal bed and the beds above it, but still retain the Middle Coal Measures, the coal beds of Freeport, Kittanning, Clarion, Brookville, Mercer, and Sharon, with the great Conglomerate No. XII and the Lower Carboniferous (Pocono Sandstone No. X) down to the top of the upper Devonian, Catskill formation No. IX, which is colored red.

On the county maps it may be seen how the different coal beds, each one in its order, have been eroded away, precisely as in the case of the Pittsburgh bed, so that they now occupy only a part of their original areas. Each one in turn disappears from the soil, going northward, until at length, in McKean, Potter, Lycoming, Bradford, Tioga, Sullivan, and Wyoming, only isolated patches of the lowest workable coal beds maintain a precarious existence on the highest land, or parallel ranges of highest land, and, if the world lasts long enough, will be all slowly washed away by the rain into the sea; their protection thus far being due to the fact that they are overlaid and underlaid by massive sand and pebble rocks which offer a stubborn resistance to erosion, and yield very slowly to the undermining action of the elements operating on the soft deposits beneath them.

Where these carboniferous sandrocks (No. XII and X) have been preserved in geological basins, run the mountain ranges, with patches of coal on their tops; where they were arched, they have been destroyed, and valleys of older, lower, softer, Devonian formations, Catskill (IX) and Chemung (VIII), have taken the place of former much higher mountains. Along the northern border of the map may be seen the extent of the Catskill red rocks, inclosing the preserved patches of carboniferous sandrocks and coal; and the erosion of the Catskill is also shown by a set of white streaks entering from the State of New York, representing valleys of Chemung exposed by the removal of the overlying Catskill. The gradual rise of the whole country north-eastward towards the Hudson river, and the increasing thickness of the Pocono and Catskill formations in that direction, has kept the underlying Chemung rocks safely covered, and this explains the unbroken spread of the red color over Wayne and the greater part of Susquehanna, Lackawanna, Monroe, and Pike counties in the north-east corner of the State.

In a deep trough in the otherwise nearly horizontal outspread of Catskill has been preserved the Coal Measures of Carbondale, Scranton, and Wilkesbarre, across Luzerne county; and so deep is this trough that it has retained not only the lower and middle, but the upper coal beds, above the Pittsburgh bed, and even a remnant of still higher rocks (containing Permian fossils) like those in Greene county, at the extreme opposite corner of the State.

In like manner the large white area on the map embracing southern Luzerne, northern Monroe and Carbon, southern Columbia and Northumberland, and north-eastern Dauphin, and nearly the whole of Schuylkill county, represents the lower carboniferous formations X and XI, lying nearly flat east of the Lehigh river, but west of that river folded into a large number of parallel arches, and an equal number of troughs, or elongated basins, in which have been preserved the Coal Measures of Hazleton and Drifton, Mahanoy and Shamokin, Tamaqua, Pottsville, Minersville, Donaldson and Wiconisco, &c. in some places to a depth of 3000 feet. These are the anthracite coal beds of eastern Pennsylvania, corresponding in all respects, except that of hardness, to the bituminous beds of western Pennsylvania, and no doubt originally united with them in continuous sheets over the length and breadth of the State.

The red color on the map forms a narrow zigzag border around this whole anthracite region. This represents the upturned edge of the Catskill formation, No. IX, which underlies the whole; the outward points representing the synclinal basins and the reëntering angles the anticlinal arches which separate the several coal fields. A multitude of smaller secondary plications are shown on the county maps, but cannot be given on the scale of the skeleton State map.

The anthracite beds rise steeply to the soil at the edge of each basin, and may be followed in imagination through the air, arching thousands of feet above the spectator's head and descending again into the next basin, to sink 2000 feet or more beneath the level of the sea. It is evident that the aërial arch between two neighboring basins represents that amount of destruction or erosion of the strata underlying the coal, and of the Coal Measures themselves; and a glance at the little map will convince the eye that, whereas our mining operations are wasting 50 per cent of the anthracite coal still left at our command, the frosts and rains of all the ages since the Coal Era have wasted for man, before men were created, at least a hundred tons of the original deposit for every ton which they have spared.

The bituminous Coal Measures lie practically in their originally horizontal condition. The waves which traverse Western Pennsylvania and divide it into six grand basins are so gentle that the rocks seldom dip more than 2° or 3°. Consequently, the erosion of bituminous coal has amounted to a waste of only 70 or 80 per cent of the original quantity, and so, whereas our anthracite coal fields must be exhausted in two or three centuries, the share which Pennsylvania owns in the great Appalachian coal area—apart from those portions which lie in West Virginia, Ohio, Kentucky, Tennessee, and Alabama—can satisfy the wants of the growing population of the country for several thousand years.

The skeleton State map is colored to show why there is no coal in Middle Pennsylvania, except in eighty square miles of Broad Top.

The red Catskill formation, No. IX, crops out from beneath the lower Carboniferous escarpment of the Allegheny mountain—through Somerset, Cambria, Blair, Centre, Clinton and Lycoming counties—as a noble terrace or range of short, knob-like spurs from the front of the mountain. In the long, narrow Bald Eagle valley, at the foot of the mountain, crop up the underlying Chemung, Portage, Genessee, Hamilton, and Marcellus formations which together make No. VIII, the Oriskany No. VII, the Lower Helderberg No. VI, and the Onondaga and Clinton No. V,* at angles increasing from 15° or 20° up to 80° and 90°. The Clinton forms the west side of the Bald Eagle mountain, the two crests of which are made by the two outcrops of the next lower sand-rock formations, the Medina and Oneida, No. IV. The east slope of this mountain is made by the Loraine (Hudson river) slate formation No. III; and from beneath this rises, in the Nittany valley, the Trenton, Chazy, and Calciferous limestone formations, No. II. (See cross section along the Little Juniata river on page vi.)

Passing on eastward across the Nittany valley, the limestones (II) turn over and go down again; then III in Tussey mountain; IV makes its crest, and V its eastern slope; then VI, VII, and VIII descend; and finally the Catskill (IX) reappears sinking eastward into Terrace mountain. Thus from the top beds of the Catskill in the Allegheny mountain to the top beds of the Catskill in Terrace mountain an arch in the air may be drawn, which, if the measured thicknesses of all of the above-mentioned Devonian and Silurian formations be added together, must have been, along its keystone line, 2560′+6520′+50′+900′+1330′+2900′+900′+6600′=21,760 feet, or a little more than *four miles high.* That it was a solid arch is shown at its northern and southern ends, where one formation after another from II up to IX sinks slowly beneath the present surface; and that it was much higher than the 21,760 feet above given is shown by the fact that the same conglomerate, red shale, iron-ore, limestone and coal beds are recognizable on the Allegheny mountain and on Broad Top, with opposite dips, twenty miles apart; and since the Pittsburgh coal bed is presewed in Broad Top, although it has been eroded from the Allegheny table-land of Cambria county, we have a right to add to the height of the arch the whole thickness of the three Carboniferous formations overlying the Catskill: *i. e.* 2500′±; 283′, and 240′, say 5000′; making the total original height of the arch *five miles.*

This gigantic rock-wave extended from Sullivan county to Cambria, a distance north-east and south-west of 125 miles. Another, to the south of it, extended from Luzerne county 165 miles into Fulton county. As the highest part of the first wave was over Nittany valley so the highest part of the second was over Kishacoquillis valley in Mifflin county. Between the two were shorter arches of nearly equal height, now marked by Brush and Penn valleys in Centre county. A third great arch commencing in Columbia county extended 120 miles to the Maryland line; but its height over Shade valley in Snyder county, and over Black Log valley in Juniata county, was less than 20,000 feet. A fourth extended

*The Oriskany is the base of the Devonian and the top of the Silurian systems.

from Schuylkill county about 100 miles along the county lines of Snyder, Juniata, and Franklin, into Maryland, being at its greatest height over Path valley, where it was broken so that its western side sank several hundred feet. Between the third and fourth long wave was a short one, in Fulton county, at least 20,000 feet high, but broken lengthwise so that its western side dropped about 8000 feet, making the McConnellsburg fault, where the rocks of No. VIII abut against the limestones of No. II. A fifth arch started in Schuylkill county between the two lobes of the fishtail at the west end of the Pottsville coal basin, and extended through Perry, Cumberland, and Franklin counties to the Maryland line, being more than 20,000 feet high in its southern course.

All these long waves had a majestic curvilinear course from east-north-east to south-south-west, and between them lay deep basins of rumpled rocks which still preserve along their middle lines more or less of their Devonian and Silurian formations. But as neither the arches nor the basins were regular and symmetrical in form, but undulated lengthwise, more or less, the lines of outcrop on the present surface which reveal their shape form a curious labyrinth of zigzags throughout the middle region of the State, as shown upon the little map. But as, on the whole, the great arches and basins all declined together from the Juniata region eastward to the anthracite region, the result of their even erosion to the present surface-level has been to confine the blue color (Silurian) mainly to the country west of the Susquehanna, and the red color and overlying white and black to the country east of that river.

The same effect has been produced by the erosion of the corrugated mass as is obtained by planing smooth a log of gnarled wood; and the color-lines upon the map may be considered as imitating the natural graining of a piece of furniture. To produce its full effect upon the eye and to avoid confusion, only the formations Nos. VI, III, and II have been colored; No. VI (the Lower Helderberg) being a thin blue line representing a multitude of low ridges, carrying valuable limestone beds, iron-ore and glass sand; No. III, gray, representing the *inside* slope of a large number of the mountains of No. IV inclosing the Silurian limestone valleys of No. II. These valleys are colored broadly blue, and serve to mark (1) the ancient summits of the great rock waves, *i. e.* the extreme heights in the air at which the top strata of the upper coal measures rolled from one great basin over into another, (2) the most fertile and longest settled secluded farming lands of the interior of the State, and (3) its most famous native iron-ore districts, studded as they are with open quarry-mines of brown hematite, deposited in the sink holes and caverns of the present limestone surface.

Beside the five principal rock waves described above as dominating the plicated structure of the middle mountain belt of the State, two others in western and two in eastern Pennsylvania deserve special attention; the former because they sub-divide the bituminous coal region into its 1st, 2d and 3d basins and connect our geology with that of West Virginia; the latter because they have determined the remarkable long straight southern edge of the anthracite coal region, and connect our geology with that of northern New Jersey.

The only distinct mountain ranges in western Pennsylvania are those of Laurel Hill along the top of which runs the county line between Somerset and Fayette, and of Chestnut Ridge in Fayette, Westmoreland, and Indiana counties. The broadly rounded crests of these two mountains run N. E. and S. W. parallel with each other, and ten miles apart, inclosing between them the Ligonier valley. The rainfall of the highland back of the Allegheny mountain crest in Cambria and northern Somerset collects in the Conemaugh river at Johnstown and cuts a gate-like gap through Laurel Hill, crosses the Ligonier valley, and cuts another gate through Chestnut ridge at Blairsville. In like manner the rainfall of southern Somerset collects in Castleman's river, joins the Youghiogheny coming from Virginia, and cuts two similar gaps through the two mountains at Confluence and Connellsville. In the vertical walls of these four gaps, each measuring from 1200 to 1300 feet from mountain top to river bed, the Devonian rocks are seen rising in low arches, overlaid by higher arches of Carboniferous strata (X, XI, XII), and casting off the lowest workable coal beds from their opposite sides into the three great coal basins. Unlike the mountains of middle Pennsylvania, these two mountains have nearly the shape of the anticlinal arches which produced them; but they have nevertheless shared in the general erosion of the State to the extent of more than 2000 feet, for not even the lowest coal bed remains upon their tops for a length of 60 miles north from the Virginia line. In Clearfield county, and further on north-eastward, however, the productive coal measures pass over both these arches from the 1st into the 2d, and from the 2d into the 3d basin, owing to the decline in height of the arches in that direction, while the surface level of the country is maintained, and even increased. In Virginia these rock waves increase in height going south, and separate the coal basins more widely, allowing the underlying formations to take possession of the present surface. The wonderful straightness of these rock-waves for 150 miles from Fayette to Lycoming county—their parallelism with each other and with the crest of the Allegheny mountain representing the Nittany Valley anticlinal—their equable height along such extensive lines, preventing the appearance of the Devonian rocks at the present surface until they reach Clinton county—and their extreme flatness, preventing the formation of such valleys as abound in the middle belt of the State—are all features of great geological importance. And, in discussing the astonishing fact that these two anticlinal waves have only lost at the most 3000 feet of their original height in the same length of time that the Nittany anticlinal, for example, has lost 25,000 feet, we can recognize the extraordinary violence and rapidity of the first stages of the erosion of the State in those districts of it which then stood as high above the sea as do the Alps, Andes, and Himalaya mountains of to-day.

Negro mountain, which enters Somerset from West Virginia, and is cut by Castleman's river, is similar to the two just described; but its rock arch is comparatively low, and passes on into the high flat Allegheny mountain table-land of Cambria county in a direct line with the Nittany Valley anticlinal, of which it seems to be a virtual continuation.

The two rock-waves of eastern Pennsylvania, south of the anthracite region, are shorter and lower than the great anticlinals of middle Pennsylvania, but have a still more important effect in modifying the practical geology of the State. One of them crosses the Delaware river at Walpack bend, traverses Monroe and Carbon counties, crosses the Lehigh river at Weissport, and the Little Schuylkill below Tamaqua, and makes two of the sharp folds in the Pottsville coal basin at New Philadelphia. The other one is confined to southern Schuylkill county, and crosses the Schuylkill river at Schuylkill Haven. They are alike in straightness and direction and in shape, having moderate dips to the south and a very steep or vertical plunge northward. Both of them run at a low angle diagonally to the strike of the outcrops and make a series of zigzags across the valley formations, and of hooks and spurs in the mountain ridges, as the county maps show. But the most important feature common to both is the vertical descent from a vast original height in the air to a profound depth beneath the present surface, of the whole series of Devonian and Carboniferous formations, in the northern leg of each arch. At Schuylkill Haven the pinched top fold of No. VI appears in the bed of the river. From this point up to Pottsville about 15,000 feet of No. VIII, IX, X, XI, and XII, with many hundred feet of the productive coal measures, are cut through by the Schuylkill river. This makes the original height of the arch over Schuylkill Haven about three miles. As the lowest coal bed sinks to more than 2,000 feet beneath Pottsville, the limestone of Schuylkill Haven (No. VI) must lie about 17,000 feet beneath Pottsville; while the added thicknesses of the Silurian formations from No. VI downward will place the Potsdam sandstone No. I beneath Pottsville at a depth of about 26,000 feet, or nearly five miles.

This vertical plunge of the Palæozoic series of formations from a great height in the air to a great depth beneath the present surface begins in Carbon county and continues through Schuylkill, Lebanon, Dauphin, and Cumberland into Franklin county, although it is not produced by the two arches above described further west than the Swatara river. From the Swatara to the Susquehanna river, and so onward, it is referable to other more southern and parallel folds which operate with even greater effect, for in the gaps of the Susquehanna above Harrisburg all the formations from No. XII down to No. III—strata measuring at least 16,000 feet—are seen thrown over on their faces at an angle of 20° *beyond the vertical*, and the only suspicion of a break in the arch is suggested by the absence of about 1,000 feet of Nos. V, VI, VII and the lower part of VIII, which may be equally well ascribed to an original absence of the missing strata from the deposits of the ancient sea at the close of the Silurian ages.

As Western Pennsylvania, with its present surface of Carboniferous rocks, is limited in front by the great curved line of the Allegheny mountain wall, 175 miles long, and of an even height of 2000 feet above the sea—so Middle Pennsylvania, with its labyrinth of Devonian and Silurian ridges and valleys, is limited in front by the continuous but minutely crenulated line of the Kittatinny, Blue or North mountain wall, 170 miles long, with its narrow rocky crest, and of an almost perfectly uniform height of 1500 feet above the sea.* Through five gates in this otherwise unbroken wall the rainfall of Eastern New York and Northern and Middle Pennsylvania finds its way to the seaboard, as rivers named in the following order from east to west; the Delaware, the Lehigh, the Schuylkill, the Swatara, and the Susquehanna. The Potomac river makes a distant sixth gap in Maryland, but receives little of the drainage of our State. Middle Pennsylvania is chiefly drained by the Juniata river. The Lehigh river drains only parts of Carbon and Monroe; the Schuylkill drains the rest of the southern anthracite coal basins; the Swatara is scarcely to be named, although its water gap is like the others; the Delaware only drains Wayne, Pike, and Monroe counties in our State; but the Susquehanna spreads its immense water tree over the whole country extending from the Mohawk valley in New York to Clearfield, Indiana, and Cambria counties in Western Pennsylvania.

In front of the Blue mountain, like a broad moat at the outside foot of a castle wall, lies the Great Valley of the earlier settlers, known by many names, such as the Lehigh, Lebanon or Cumberland valley in Pennsylvania, the Winchester or Shenandoah valley in Virginia, the valley of East Tennessee, and in the other direction the Kittatinny valley in New Jersey, and the Newburgh valley in New York—extending as it does from the Hudson river to the middle of Alabama, behind the Highlands and South mountains of the north, and the Blue Ridge and the Smoky mountains of the Southern States, which along its course of 700 miles seclude it from the Atlantic seaboard country. Its width in Pennsylvania varies from ten to twenty miles, and is about equally divided into two belts of soil, slate next the Blue mountain, and limestone next the South mountain; the former representing the outcrop of from 3000 to 6000 feet of formation No. III, the latter from 2000 to 3000 feet of formation No. II, crimpled into numerous small sharp folds, some of which, however, are large enough to produce alternate strips of II and III upon the map, especially in Franklin county. The gray and blue color belt on the small skeleton State map shows the position, shape and size of the Great Valley; and at its south-western end indicates with convincing clearness the relationship of its slate and limestone formations to those of the smaller interior valleys of the middle region of the State. Additional proof of their identity and underground continuity is afforded by the iron ore deposits and the Lower Silurian, or Siluro-Cambrian fossils common to both. Species of *Murchisonia* and *Orthoceras* are found in the Canoe valley of Huntingdon county, and in the Lehigh valley of Northampton county; and Trenton fossils abound in

*If the measurement be made by following the crest around the hooks, and up and down Path valley, it will amount to more than 260 miles in Pennsylvania alone.

Nippenose valley of Lycoming county, as along the center line of the Great Valley at Chambersburg and Carlisle.

That the limestone formation No. II was originally deposited over all south-eastern Pennsylvania is plainly shown by the patches and strips of its blue color on the little skeleton map; for, although it has been eroded from the higher parts of the Reading-Easton hills in Northampton, Lehigh and Berks counties, it has been preserved in Durham, Saucon and Oley valleys which lie among them; and is seen going down beneath the Mesozoic strata (colored brown) along its northern edge, and rising again to the surface at its southern edge. That it once in like manner overspread the South mountain range west of the Susquehanna river is proved by the preservation of a strip of it in the valley of Mountain creek at Pinegrove furnace. Its outspread southward is shown by its appearance at the surface in Lancaster county, where a triangular piece of the Mesozoic overlying formation has been eroded through; and in Bucks county, where an upthrow seven miles long from the Delaware river south-westward, brings it to the surface, with its fossils and its companion the underlying Potsdam sandstone No. I. The garden of the State is Lancaster county, and why it is the garden of the State is explained by the large area of blue color on the map around the city of Lancaster, extending itself westward through York and Adams counties as the Codorus valley, and eastward into Chester county as the Conestoga valley behind, and the Downingtown valley in front of the (white) area of the Welsh mountain region. There can be no doubt that the Lancaster county limestone formerly covered the whole of northern Chester; and that it was removed from it by gradual erosion before the deposit of Mesozoic sediments; for there is no appearance of the limestone at the present edge of the Mesozoic area along French creek, and there is ample evidence that the Mesozoic itself originally covered the district beyond its present limits. That the limestone formation No. II once overspread southern Lancaster, southern Chester and Delaware counties and the northern part of the State of Delaware also, is shown by the relics of it left at various places, along parallel lines marked in blue upon the map; and in all such places it is accompanied by its underlying Potsdam sandstone No. I.

The lowest Palæozoic formation in Pennsylvania, No. I, logically identified with the Potsdam sandstone of northern New York, makes its appearance along the edges of the limestone No. II at the north foot of the Azoic mountain range between Bethlehem and Reading in Lehigh and Berks counties; in Mulbaugh hill on the Lebanon county line; in Chicques ridge on the Susquehanna above Columbia; in the Welsh mountain in northern Chester, and in the North Valley hill which stretches for 60 miles from the heart of Lancaster to the Bucks-Montgomery county line north of the city of Philadelphia. Its only fossil as yet discovered is a *Scolithus*, but its position next beneath the Calciferous limestone is too well marked to admit of doubt. Formerly it entirely covered the mountain districts north and south of the Schuylkill river, because it still spreads in sheets upon their sides, and in many places makes their summits, lying unconformably upon the gneiss.

The South mountains proper, which separate Cumberland from York, and Franklin from Adams county, do not thus exhibit the fundamental gneiss covered by a coating of Potsdam, but are composed of peculiar sandstone and slate strata several thousand feet thick which occupy the place of the Potsdam in the series but cannot certainly be identified with it. They may be considered the equivalents of the Ocoee and Sewanee strata of East Tennessee.

These rocks when followed south are seen to be cut off by a cross fault along the line of the Chambersburg and Gettysburg turnpike, which has shifted a whole block of the earth crust (north of the pike) westward several miles. South of the fault the sandstone reappears along the western side of the mountain mass, but most of the ground becomes occupied by red and gray schists and porphyries carrying traces of copper, supposed to represent the Huronian system of western Canada. These rocks cross Maryland, and are finely exposed along the Potomac between Harper's Ferry and the Point of Rocks; thence onward they make the Blue Ridge of Virginia, flanked by the sandstones, slates, and conglomerates of so-called Potsdam age. We may consider our South mountain rocks therefore, those lying north of the turnpike fault, as of Cambrian age. At the Carlisle end of the mountain range they seem to be thrown into a series of five anticlinal waves; but along their Cumberland and Franklin county flank they dip eastward instead of westward, *i. e.*, from over the limestone of the valley, instead of towards and under it; so that a long fault must be supposed to follow the foot of the mountain as far south as the turnpike. South of the turnpike synclinals and anticlinals, vertical dips and offsets to the east complicate the structure and require long investigation.

The geology of southern Adams, York, Lancaster, and Chester is still obscure—a region of metamorphic rocks—mica-schists, chlorite schists, and gneiss of various kinds, interrupted by belts of serpentine and marble, and carrying deposits of Kaolin and chrome iron sand. Where the Susquehanna river crosses Mason and Dixon's line a belt of roofing-slate is extensively quarried, and a multitude of plant-like fossils have been found, pronounced by competent authority to be a *Buthrotrephis* of Hudson river age, which looks as if the roofing-slate formation of Northampton and Lehigh county once extended over southern Pennsylvania; and this idea has been carried so far as to suppose that the talcose and micaceous and garnetiferous serpentine-bearing schists which form a wide border to the Chester county limestone valley from York eastward, along the South Valley hill, and across the Schuylkill to Chestnut hill in Philadelphia, instead of being sub-Calciferous, Potsdam, sub-Potsdam, or Cambrian strata, are really metamorphosed Hudson river strata, overlying the limestones of the valley, the top layers of which would then be Trenton beds, turned to white marble.

Immediately south of the belt of these more or less magnesian schists of the South Valley hill, gneiss of much older-looking kind shows itself at the surface, and occupies considerable areas in Delaware county. Similar gneiss occupies the edge of the Mesozoic for several miles west of the Delaware at Trenton. The same older gneiss appears in northern Chester county; is brought up by an arch of the rocks on the Susquehanna river at the mouth of Tocquan creek, fifteen miles below Columbia; forms most part of Mulbaugh hill at the south-east corner of Lebanon county; constitutes the core of the mountain ridges from Reading eastward to the Delaware river; appears in two isolated hills from beneath the limestone west and east of Allentown in Lehigh county, and in Chestnut hill north of Easton in Northampton county; spreads through northern New Jersey and southern New York in ranges of mountains which make the finest scenery of the Hudson river, and is there recognized by northern geologists as typical Canadian or Laurentian gneiss, the fundamental rock formation of the continent.

Finally, south of the line of this old hornblendic gneiss, in Delaware county, which crosses the Schuylkill river at Conshohocking, and ends in a point at the Wissahickon creek, range the mysterious Philadelphia rocks, which dip at various angles southward towards the Delaware river, seem to be 10,000 or 15,000 feet thick, consist of thin-bedded gneiss and mica-schists with serpentine and garnets, the age of which is as yet not certainly known. Their surface is covered by the older gravels, sands, and brick clays deposited in the Delaware river valley when it was an estuary of the sea, and by the more recent mud of the river at its present level. On the New Jersey side run the outcrops of the lower Cretaceous formation, which, however, occupy the corner of Pennsylvania between Bristol and Trenton.

After this short survey of the geology of the State as sketched to the eye by the little skeleton map it only remains to give the history and explain the purpose of this hand atlas.

In 1839 I joined the corps of the First Geological Survey; and in 1841, by direction of Prof. H. D. Rogers, compiled the Geological State Map (published by him in Edinburgh in 1858) from all the data furnished by the field work of the corps during the six preceding years. That map has now been under the closest critical examination by my colleagues of the Second Geolooical Survey, since 1874, and has been found to be in all essential particulars a correct representation of the topographical and geological structure of the State, but both deficient and defective in a multitude of details, which have now been in great part supplied and defined in the colored geological county maps published during the last nine years with the Reports of Progress of the Second Survey, as it advanced in its reëxamination of the whole ground.

Of the sixty-seven counties of the State, fifty-seven such maps, on a uniform scale of two miles to an inch, have been published; five others have been printed, and await publication; five others remain to be prepared. Were a new State map compiled from these county maps, it would be a great improvement on my map of 1841 (1858) in the case of the counties lying between the Allegheny mountain and the Ohio line;

while it would be little more than a reproduction of the old map as to Middle and Eastern Pennsylvania, so excellently were these studied and portrayed by the geologists of the First Survey; and this, not merely in a geological sense, but in regard to geographical correctness; for in the interval between the two surveys, an interval of thirty-three years, private geographical surveys were made, and private county maps and atlases of township maps published, covering the whole area of the State. These have been used by the geologists of the Second Survey, and constituted an improved basis for their geological mapping. But the errors discovered in these county and township maps in following the outcrops of the geological formations from stream to stream and from road to road are innumerable, and, in a multitude of places, large. As the township survey plottings were more or less distorted in the process of forcing them together within the boundaries of each county map, and as the county boundaries have never been properly located in the area of the State, it is impossible to compile a State map without employing the same vicious method of forcing the counties together by distorting their boundary lines, and superposing thus a new network of errors upon the old one. And this state of things respecting the geography of Pennsylvania must continue to stand in the way until the State has been properly triangulated and new township and county surveys made, starting from the corners of the triangles,—a costly and tedious undertaking, but one worthy of a great and wealthy Commonwealth.

Anticipating the difficulties in the progress of the Survey towards the production of a geographically correct State map, the Board of Commissioners approved my plan of providing a small county atlas of the State for the use of geological field-workers, prospectors, engineers, and travelers in general, by reproducing on a much smaller scale, *six miles to an inch*, the geological county maps as fast as they were prepared for the Reports of Progress of the Survey. This I began to do in 1875, and colored by hand one county after another, in successive years, completing in the spring of 1884 the whole series, including counties of which maps on the *two-mile scale* had not been made. This atlas is therefore a virtual second edition of my map of 1841 (1858) improved by the Second Survey, but not presented on a single sheet.

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The elaborate topographical work of the Second Survey in McKean, Blair, Huntingdon, Mifflin, Centre, Snyder, Berks, Lehigh, and Northampton counties (published in the atlases to Reports R, T, and D^3, and awaiting publication in S) is represented on the maps of those counties in this atlas; but the topographical work done in the South mountains was not in form for use when the maps of York, Adams, Franklin, and Cumberland were colored. The map of Perry county was printed before the revision of that county (with a special study of its faults and trap-dykes) was made by Prof. Claypole, as published in Report F^2. The maps of Schuylkill, Carbon, Lehigh, Luzerne, Lackawanna, Columbia, and Northumberland represent the anthracite basins only approximately, but their accurate delineation can be learned by consulting the large sheets of the anthracite survey.

A SHORT ACCOUNT

OF THE

CHARACTERISTIC FEATURES OF EACH COUNTY.

1. ADAMS.—Area, 530 square miles; population in 1880, 32,455. Two thirds of the county consist of Mesozoic soft sandstone and shale, traversed by extensive trap-dykes. Its western townships rise upon the South mountain massif of Azoic rocks, resembling the Huronian series in Canada, very siliceous and porphyritic, carrying some copper ores, as yet unproductive. The York county limestone belt of the Codorus valley spreads over Conowago township and parts of Oxford and Union, as far as Littlestown, and is bordered on the south-east by the mica-schist belt; the chlorite-schist belt just enters the south-east corner of the county. Extensive outcrop-fragments of quartzite indicate the presence of the Potsdam sandstone No. I in Berwick township, along the continuation of the Pigeon hills of York county; and several thousand feet of rocks assignable to No. I make up the mountain ridges of Menallen and Franklin townships, north of the Chambersburg turnpike. The county is wholly agricultural; the inhabitants are descendants of early German settlers; and on the trap hills overlooking its seat of justice, Gettysburg, was fought the decisive battle of the civil war in 1863. (See Report C.)

2. ALLEGHENY.—Area, 760 square miles; population in 1880, 355,869. In its center, Pittsburgh, the chief city of Western Pennsylvania, at the head of the Ohio river, occupies the space between the Allegheny and Monongahela rivers, having Allegheny City opposite to it on the triangular flood-plain of the Ohio west of the Allegheny, and South Pittsburgh stretching along the southern river bank. The three rivers flow in narrow valleys sunk at least 400 feet beneath the level of the county; and along the upper part of the steep slopes crops out the Pittsburgh bed, about six feet thick, nearly horizontal, and penetrated by colliery workings, the produce of which is lowered on inclined-planes to the railroads and river pools, for transportation in flat boats down the Ohio and Mississippi rivers. The bed extends beneath the southern townships into Washington county, its outcrop gradually, but not uniformly, falling lower and lower on the Monongahela slopes, until it passes beneath water level at Bridgeport, 56 miles above Pittsburgh. But in the other direction, northward, the bed creeps into the very hill tops, and the only

relics of it that have been preserved from erosion, in the townships north of the Ohio river and west of the Allegheny river, are a few small spots in Ross and Indiana townships, three others on the highest summits along the Franklin township lines, and the last solitary outlier in Pine township. Between the Allegheny and Monongahela rivers, however, the higher lands east of Pittsburgh preserve large areas of the bed, more or less separated by valleys of erosion. A description of 200 collieries, with 76 sections of the coal bed, showing the gradual increase in size of its lower workable portion from about 6 feet at Pittsburgh, to 9 feet higher up the river, will be found in Mr. Wall's Report of Progress, K[1]. At Pittsburgh the bed lies 330 feet above low river water; 13 feet beneath it a 10-foot bed of limestone; several other thin limestones and coal beds too small to work crop out on the hill sides, but no workable bed exists down to the Freeport upper coal, which lying more than 200 feet beneath the city of Pittsburgh, makes its appearance at water level in the Allegheny river valley 2 miles above Springfield in East Deer township, and thence northward takes the place of the Pittsburgh coal bed in the mining operations of the valley. The Pittsburgh coal is of the finest cokeing quality, ranging in solid carbon from 59 to 64 per cent; volatile matters, from 30 to 34 per cent; from 3 to 6 per cent ash, about 1 per cent water, and 1 per cent sulphur. Its value was known to the French before Fort Duquesne became the English Pittsburgh, and its abundance has made this city the principal center of the iron manufacture of the United States. Whether or not the new fuel—natural gas from deep wells—shall replace the solid coal in the furnaces of Pittsburgh for any length of time, the pool made by the new dam at Davis Island (four miles below the city) must always be the starting-point for fleets of boats loaded with Monongahela Valley coal and Connellsville coke for the Western and South-western States. Coal and gas, with a little limestone, much excellent building stone, and salt water flowing from wells, are the only minerals of the county. No productive oil wells have been got, and the iron-ore deposits of the coal measures are insignificant. The soil is everywhere good, except along the more massive sandstone outcrops. (See Reports K, K[2], K[1], and Q.)

3. ARMSTRONG.—Area, 610 square miles; population in 1880, 47,641. The whole surface is sculptured in all directions by the erosion of the Barren Measures, lying almost horizontally, although several wide and gentle rolls traverse it from north-east to south-west, bringing the Lower Productive coal measures above water level along the Allegheny river and its great branches from the east, the Kiskiminitas, Crooked, Cowanshannock, Pine, Mahoning, and Redbank creeks; and on the western side, along Buffalo creek, Glade run, and other small streams descending from Butler county. The Pittsburgh coal bed occupies only a short and narrow basin in the south-east corner of the county. The Barren measures are 600 feet thick, including the Mahoning Sandstone at the bottom, the long horizontal outcrops of which edge all the valleys of the county with cliffs, and rough their steep slopes with fallen rocks. Two coal beds, each with a limestone bed beneath it, are mined near water level

at Freeport, and rise slowly northward until they merely cap the highest hills. The three next coals are mined at Kittanning, the highest one having a limestone bed under it, and the lowest one, overlying the Ferriferous Limestone, which appears at the surface in southern Armstrong only where Crooked creek is crossed by the Paddy's Run axis. It has isolated outcrops from 3 to 5 miles long at Greendale on Cowanshannock; on both forks of Pine creek from Echo to Pine P. O., and near Goheenville; and an unbroken outcrop along both sides of the Allegheny river and Mahoning and Redbank creeks from Kittanning northward. It varies from 4 to 18 feet in thickness, and carries the famous "buhrstone" brown hematite iron-ore on which ran in early years the old Rock, Bear Creek, Allegheny, Buffalo, Ore Hill, Cowanshannock, Mahoning, America, Phœnix, Pine Creek, Olney, Stewardson, Monticello, and Great Western cold-blast charcoal furnaces (with their forges and rolling mills,) some of which were changed to hot-blast coke furnaces. The two Clarion coal beds (beneath the limestone) only appear above water level in the northern townships; and the Pottsville Conglomerate No. XII shows its upper massive layers where the anticlinal lines cross the principal river valleys; but nearly the whole formation (300 feet thick) has been cut through by the river at Parker City, where the Clarion oil belt crosses the valley. Here on the flat beneath its vertical cliffs and on the terraces above, hundreds of derricks once stood, thick as trees in a forest, draining the Third Oil Sand from a depth of 800 feet beneath the river. At Brady's Bend this third oil sand lies 1,000 feet beneath the river. In all other parts of this county the wells, some of them 2,000 feet deep, have yielded no petroleum. (See Report H^5.)

4. BEAVER.—Area, 450 square miles; population in 1880, 39,605. The Ohio river makes a great sharp bend across this county, the Beaver river meeting it at the point of the bend, after cutting a long straight gorge through nearly horizontal (gently south dipping) Pottsville Conglomerate No. XII massive sand-rock strata, supporting an upland of Lower Productive coal measures, of which the Freeport and Kittanning coal beds, the Ferriferous limestone, and the Clarion fire-clay, are the most valuable layers. All the hill-tops north of the Ohio river are of the Barren measures. South of the river the country is made by the 600 feet of Barren measures; but the Pittsburgh coal bed is left in a few of the highest hill-tops near the Washington county line. The outcrop of the Ferriferous limestone appears above water level at Freedom and extends down the Ohio and up the Beaver to the county lines; and up Connoquenessing creek for three miles. At Darlington the Middle Kittanning coal becomes nearly 20 feet thick, by the conversion of a part of its roof shales into cannel coal. Before the discovery of petroleum in 1859, oil was manufactured from these shales; and they have yielded to Mr. Mansfield's intelligent and zealous research an incredible number of fine plant-forms described in the Coal Flora, Report P, by Leo Lesquereux, and of crustaceans described in Report P^3, by James Hall. A considerable amount of petroleum was at one time obtained, by wells near the State line, both from the Conglomerate No. XII, the top of

which is near river level, and from oil sands at the greater depths of 500 and 600 feet. Glacial drift covers the north-western corner of the county, the great Terminal Moraine passing north of Galilee along the highland north of the Little Beaver. The drift materials were swept into the deep slackwater pool of the Ohio and Beaver valleys during the continuance of the Cincinnati ice-dam; and relics of the deposit have been preserved in four lines of gravel, sand, and brick-clay terraces, at heights of 30, 80, 125, and 215 feet above the river bed at New Brighton; these support a large manufacture of pottery and fire-brick. (See Report Q.)

5. BEDFORD.—Area, 1000 square miles; population in 1880, 34,929. It is divided into three parallel belts of almost exactly equal width, 10 miles each, by two long straight mountains of Medina No. IV. Nearly the whole palæozoic system is represented, viz: 1200 feet of coal measures, 250′ of Pottsville Conglomerate XII, 1100′ of Mauch Chunk red shale XI, 1400′ of Pocono sandstone X, 3000′ of Catskill old red IX on Yellow creek (2000′ on Wills creek), 3600′ of Chemung and Portage, 200′ of Genessee, 800′ of Hamilton, 800′ of Marcellus (total for VIII, 5400′), 200′ of Oriskany VII, 1250′ of Lower Helderberg VI, 275′ of Salina and Niagara, 900′ of Clinton (total for V, 1175′), 1600′ of Medina and Oneida (very thin) IV, 700′ of Hudson river and Utica III, and 4520′ of Trenton, Chazy, and Calciferous (visible) in Snake Spring township; making a total of 3950′ Carboniferous, 8600′ Devonian, and 9520′ Silurian rocks= 22,070 feet in total thickness from the highest stratum on Broad Top to the lowest rock visible on the Juniata river before Bedford. The higher rocks of the series crop out along the two opposite county lines in Ray's hill on the east and the Allegheny mountain on the west, both crests running evenly along at about 2000 feet above tide. Towards these two sides, the lower formations dip both ways from the central belt, which is one grand anticlinal wave, with numerous folds in its back. Consequently the eastern and western belts are broad zones of Devonian hills, very much broken up by cross valleys and ravines descending from the crest of the Allegheny mountain. Along the west flank of Wells mountain and Dunning's mountain, and along the east flank of Tussey mountain, the whole length of the county, run two outcrops of the Clinton (V) fossil iron-ore beds, mined at many points. Close to each belt of iron ore runs a ridge of Oriskany sandstone and Lower Helderburg limestone, a broad central strip of which turns in to the central belt north of Bedford Springs and stretches thence south into Maryland. The great limestone formation No. II with its border mountain of Medina IV, terraced by the slates of III, makes the floor of the three "coves"—Morrison's, Friends' and Milliken's—renowned for their fertility. A large part of the Broad Top coal field lies in the north-east corner of the county, and several considerable collieries work the Lower Productive coal beds of Six Mile and Sandy runs for export to the seaboard. The coal of the Kelly bed shows 74 per cent of solid carbon, 19 per cent of gas, 5½ of ash, 1 of sulphur and almost no water; is highly esteemed for steam engines and puddling furnaces; and its coke is successfully used in the Hopewell and Riddlesburg blast furnaces, which are stocked from

the fossil-ore mines in West Providence, Bedford and Hopewell townships, mixed occasionally with brown-hematite ores obtained from the outcrops of the Marcellus, the Lower Helderburg and the Calciferous formations. No permanent and copious supply of iron ore can be obtained in the county from any of the formations except the Clinton, although they all contain it. No coal beds are available on the crest of the Allegheny mountain; and the way the west county line has been run across from it to the northern end of Savage mountain excludes the Cumberland coal field of Somerset and Maryland from Bedford county. Bedford Springs has been a great resort for many years. (See Report T^2.)

6. BERKS.—Area, 900 square miles; population in 1880, 122,597. The Schuylkill river crosses this county from north to south; and two large streams, Maiden creek draining the northern, and Tulpehocken creek draining the western townships, in the Great Valley, fall into it above and opposite to the large city of Reading, one of the principal centers of iron manufacture in the State. The eastern townships cover a low mountain region (1000′–1200′ above tide) of gneiss, covered with patches and belts of Potsdam quartzite and slate No. I, one or two hundred feet thick, and inclosing the Oley limestone valley of II. Mulbaugh hill, on the west county line, is another summit of the floor-gneiss of the State, carrying Potsdam on its northern slope. Between the two gneiss areas a gate ten miles wide, mostly closed with Potsdam, lets the limestone of the great valley out southward; but it immediately sinks beneath the great belt of Mesozoic new red country; rising again however to the surface at the southern corner of the county. All along the south slope of the mountains east of Reading the limestone is seen descending beneath the Mesozoic, and undoubtedly forms its floor under the southern townships. Extensive outbursts of trap form high hills along the northern edge of the Mesozoic, and a peculiar conglomerate, called Potomac marble, finely exposed in the cuttings of the railroad at the bend of the river below Reading, has been shot into the new red estuary by torrents from the north at the close of the Mesozoic age. The thickness of the whole new red brown sandstone and shale deposit on the Delaware seems to be at least 30,000 feet, but in Berks county it cannot be 10,000 feet, even if the dip be not false-bedding. The Great Valley, between the gneiss mountains and the Kittatinny or Blue mountain, along the crest of which (1500′ A. T.) runs the north county line, is divided into two belts: one, of the limestones of II (2000′? thick) at the foot of the gneiss mountain; the other, of the slates of III (5000′? thick) extending to the Blue mountain and far up its slope. The limestone belt is famous for its levelness and fertility, and for its numerous local and isolated deposits of brown-hematite ore. The slate belt is elevated about 200′ above the limestone belt; is sculptured into innumerable vales; contains some rofiong slate and flag-stone beds of good quality, especially in Albany and Greenwich townships; contains no other minerals of value; and although the soil is good, is still in an inferior state of cultivation. These two great formations are excessively crimpled by side

pressure, and the whole valley is a labyrinth (underground) of sharp, small anticlinal and synclinal folds, all pressed over to the north and collapsed, so that the dips exposed along the Schuylkill river from Reading up to the Port Clinton gap (17 miles in a straight line) are all steep to the south; whereas the limestone *as a whole* passes down northward under the slate, and the slate *as a formation* dips northward under the Medina sandstone of the Blue mountain. Another consequence of the plication is, that strips of slate run lengthwise in the limestone belt, marking sharp downward folds or narrow basins; and strips of limestone run lengthwise in the slate belt, marking the sharp tops of upward folds, or compressed arches eroded off at the present surface. In the northern corner of the county, ten such folds traverse the slate, and show themselves in as many spurs of the Blue mountain on the Little Schuylkill side in Schuylkill county. The great fold in front of the gap broke, and its northern limb was thrust vertically upward several thousand feet in the air, as is shown by the attitude of the Medina and Clinton strata in the gap. Besides the brown-hematite deposits of the valley limestone (the principal of which is the great old Moselem bank on its northern edge) there are important magnetic-iron mines at Boyertown and Siesholtzville, and the Jones mine in the southern corner of the county. (See Report D^3, Vol. 2.)

7. BLAIR.—Area, 510 square miles; population in 1880, 52,740. The Allegheny mountain (2000′ to 2500′ A. T.) is the boundary on the north-west, and its many short, deep ravines, all containing the lowest Productive coal beds at their upper ends, issue, between short projecting knobby spurs of Catskill and Pocono rocks, and lower down as Chemung and Hamilton vales, into the long transverse water bed of the Little Juniata flowing along the soft Marcellus outcrop, from Altoona (1178′ A. T.) north-eastward to Tyrone city (896′ A. T.) Here, reënforced by the similarly arranged Bald Eagle creek, coming from Centre county, it turns and gaps the mountain, exposing VII, VI, IV, and III, and crosses Sinking creek valley to the end of Canoe mountain. The drainage of the south-west townships is more complicated. The mountain ravines here pour their rainfall into the Juniata through a hatchet-shaped synclinal basin; from which it issues by the Williamsburg gap through Canoe mountain to traverse the Canoe valley limestone rocks to the gap in Tussey mountain. Canoe valley opens southward into Morrison's Cove, which is drained backward through McKee's gap in Dunning mountain into the river above Holidaysburg. The vast anticlinal arch of Nittany valley dies southward up Sinking Creek valley; while the equally huge arch of Morrison's Cove dies northward against it at Frankstown. Thus the important Lower Helderberg limestone No. VI outcrop, and the still more valuable Clinton ore beds No. V, not only run the whole length of the county, but fold back into the Frankstown cove, greatly increasing the exposure of ore and flux. Immense holes along the limestone outcrop of No. VI (as at Blair furnace) have been filled with brown-hematite; while in Canoe valley at Springfield, and elsewhere, and in Morrison's Cove on Roaring Spring run, still larger deposits of pipe and ball ore

(occupying ancient caverns in the limestone of No. II long since uncovered by erosion) once stocked the first small furnaces of Dr. Shoenberger, and still support in whole or part the Rodman, Holladay, Martha, Frankstown, Bennington, Springfield, Ætna, Rebecca, and Sarah furnaces. some using coke and others charcoal. The Pennsylvania railroad tunnel through the crest of the Allegheny mountain (2126′ A. T.) cuts through the Freeport upper coal bed (5′ thick) with a westward dip of 1°, the railroad gradient upwards in that direction being also 1°. Below it are six other coal beds from 2 to 4 feet thick, which crop out around the heads of all the ravines along the mountain wall for many miles. The Mahoning sandstone makes the range of knobs along the summit of the mountain; and the thickness of coal measures under it is 350′; descending we have exposed, at first with gentle and then with steeper and steeper dips until they become quite vertical in the Bald Eagle mountain, the following formations: Conglomerate XII, 220′; red shale XI, 280′; gray sandstone X, 1240′; old red sandstone, &c., IX, 2560′; middle and lower Devonian VIII, 6520′; Oriskany sandstone VII, 50′; limestone VI, 900′; red shale and fossil ore V, 1330′; the three sandrock divisions of the Bald Eagle mountain IV, 2900′; the dark slates of III, say 900′; and a measured thickness of Canoe valley limestone strata II, 6600′ without reaching the Potsdam No. I, which nowhere appears; *i. e.* 23,316 feet of Palæozoic strata, all of them exposed in detail at many points in the county. The original height of the great rock arches over Sinking creek, Canoe valley, and Morrison's cove must have been nearly five miles above the present surface; and the lowest limestone strata visible at Birmingham, Springfield, and Bloomfield must plunge vertically under Altoona to an equal depth beneath the Allegheny mountain. The Nittany arch is broken between Birmingham and Tyrone city by a fault, and the Morrison Cove arch by a similar fault along the east foot of Dunning mountain. Two small transverse cracks throw the Bald Eagle rocks westward north of Tyrone city; and Canoe mountain is still more apparently dislocated by a diagonal fault just north of Williamsburg. The range of picturesque roofed and unroofed caverns through which Sinking creek finds its way in a straight line for three or four miles to the Little Juniata are fine examples of the combined chemical and mechanical erosion of past ages, still going on, which has removed the great Palæozoic arches from over the present surface. The Springfield ore bank in Canoe valley, and the Blloomfield ore bank in Morrison's Cove, are two of the largest and richest in the State. The great ore deposit in Leathercracker Cove near the Bedford county line is peculiar, because at the upper edge of the limestone next the slates of No. III, at the foot of Tussey mountain. (See descriptions and local maps in Report and Atlas T.)

8. Bradford.—Area, 1160 square miles; population in 1880, 58,541. An open, rolling country of nearly horizontal Catskill (IX) and Chemung (VIII) brown sandstone, red and olive shales, with some calcareous breccias, and one well-marked conglomerate (supposed to represent the Third Oil Sand of the western counties) is traversed from north to south by the wide meandering channel valley of the North Branch Sus-

quehanna river. Three well-marked anticlinal rolls traverse its northern, middle, and southern districts. Between these lie two synclinal troughs, arranged in the same E. N. E. and W. S. W. direction. The southern trough, filled with Pocono sandstone (X) in mountain form, occupies most of Monroe Barclay, Leroy, and Overton townships. Towanda creek flows along the north foot of the mountain; Shrader branch splits the mountain lengthwise into two, and the south branch cuts through its eastern end. A long plate of Pottsville Conglomerate, 100 feet thick and nearly solid, makes the broad flat top of the northern mountain, supporting isolated patches of the Lower Productive coal measures, one bed of which, from 6 to 10 feet thick, of excellent semi-bituminous coal, has been extensively mined for the markets of New York State. Although the coal lies so flat, the south dips become steeper descending to Towanda creek, until in the small gorges at Leroy the Chemung rocks stand nearly vertical, and have supplied the local cabinet of Mr. Lilley with a multitude of fossil forms—*Spirifer*, *Productella*, *Strophomena*, *Grammysia*, *Ambocoelia*, *Pterinea*, *Loxonema*, *Bellerophon;* beds containing these molluscs, *Tentaculites*, an *Orthoceras*, fish scales and crinoidal fragments together; with thin, solid, limestone layers; red and green shales; gray sandstone and conglomerate beds; 1855 feet in one consecutive section.* At the west line of the county rises a similar synclinal mountain of X, which in Tioga county is crowned by XII and holds the Blossburg coal basin. In the space between the two mountains just at the south-west corner of the county, Towanda creek flowing east and Lycoming creek flowing south head together in a swamp in Chemung rocks, covered (as all the county is more or less) with glacial drift. The Mansfield fossil iron ore beds (VIII) of Tioga county range in two outcrops through this open space; and an exceptional limestone bed of Chemung age (VIII) becomes 40 feet thick in the quarries east of Burlington, a nearly solid mass of shells. Opposite Towanda is an outcrop of Chemung sandstone 300 feet thick crowded with carbonized plant stems. Where the Wysox-Standing Stone township line meets the river an interesting slip fault is exposed; and in the bend below Towanda a curious example of a single corrugated layer of rock between perfectly undisturbed strata above and beneath it. (See Report G.)

9. Bucks.—Area, 590 square miles; population in 1880, 68,656. This long and narrow county bordering on the Delaware river, stretches from the old gneiss ridges of the Northampton county South mountain to the Cretaceous outcrop at Burlington, N. J., but most of its surface is a gently rolling, highly cultivated country of Mesozoic new red sandstone and shale, all dipping north-westward at angles varying from 5° to 15°, for 33 miles (in a straight line) along the river, giving to the formation an apparent total thickness of say 30,000 feet, which seems incredible for several reasons; especially seeing that at half way of the distance, across Solebury and Buckingham townships, a straight NE.-SW. fault, 10 miles long, brings the sandstone No. I and limestone No. II floor

*See Proc. A. P. S., Philadelphia, December 7, 1883, page 304.

up to the present surface with so little disturbance of the topography that the amount of upthrow cannot be considered large. The whole surface of Mesozoic country has been reduced by erosion several hundred feet, and the upper deposits must have once overspread the Potsdam-covered gneiss ridge at the northern county line, for they still rise nearly to its top (1000′ A. T.), although they dip north towards it, and there is no evidence for a fault; but why no trace of it exists in the Great Valley cannot be explained, except on the supposition that the surface of the valley has been lowered by erosion at least a thousand feet since Mesozoic times; and this fact is proved at Hummelstown in Dauphin county. The Mesozoic formation is of the same character throughout, an alternation of hard and soft layers of reddish sand and mud, some fit for building purposes, some conglomeritic, a few calcareous, and some (near the middle of the formation) fossiliferous, containing numerous bones of large sea-lizards, shells and plants. A range of trap four miles long in Rockhill township forms a hill parallel with the strike; the east ends of two other trap hills enter Bucks from Montgomery county near the north-western corner; another in Southampton township; an isolated mass of trap forms "Haycock Mountain;" and two others occur back of Newhope and Brownsville. These traps may be interbedded with the New Red strata. At the southern edge of the formation, its lowest strata lie upon the Trenton range of gneiss and appear to be made up of fragments of the older rock. At its northern edge, its uppermost strata are also in places a cemented conglomerate of quartzite and limestone fragments brought by mountain torrents from the once higher lands of Northampton and Lehigh county. The limestone valley of Durham creek at the north end of Bucks county, lying being two ridges of gneiss and Potsdam quartzite, has furnished much brown-hematite iron ore to the Durham blast furnaces. Prehistoric animal bones were obtained from one of its numerous caverns, now quarried away. The same iron ore has been mined along the limestone upthrow east of Doylestown. The southern end of Bucks county is occupied by a belt, 5 miles wide, of Philadelphia rocks, micaceous gneisses and mica-schists of unknown age, dipping very gently northward and covered with gravels of recent but various ages, ending with the present river mud. A remarkable, very straight and very steep outcrop of the Edge Hill (itacolumite) sandstone runs along the south edge of the older gneiss, separating it everywhere from the Philadelphia gneisses and schists. (See Report and Special Map C^6.)

10. BUTLER.—Area, 820 square miles; population in 1880, 52,536. The county would be an oblong square but that its north-west corner is cut off. It occupies the high divide between the Allegheny river (which its north-east corner touches at Emlenton and its south-east corner touches at Freeport) and the Beaver river valleys; its rainfall being cast off eastward through short, deep, rocky dells into the Allegheny, and westward through the long, wide, many branched water-ways of Crooked and Connoquenessing creeks into the Beaver; the flat divide itself having scarcely distinguishable summits in the north of about 1500 feet above

tide, while the river bed at Emlenton is about 950′ and at Freeport about 750′. The southern part of the county filled with higher rocks is lower in elevation, R. R. grade at Butler being 1010′ A. T. The Barren Coal Measures cover the southern half of the county, and, rising gently northward, occupy smaller and smaller patches of highest land until no traces of them remain north and east of Crooked creek. The Lower Productive Coal measures, nearly horizontal, crop out along the main valley of Connoquenessing creek and its larger branches, and (rising gently northward) take possession of the middle and northern townships; but are in their turn cut through by the many-branched valley of Crooked creek, along the steep side-slopes of which the Conglomerate series (No. XII) crops out with its two little Mercer coal beds and limestones, its little Quakertown coal bed, and its Sharon coal bed (of no importance in this county.) The Ferriferous limestone, carrying its "buhrstone iron ore," crops out on both sides of Muddy creek for 3 miles; all along the Crooked creek and all its branches; and along the valley slopes descending to the Allegheny river in Parker, Allegheny, and Venango townships. The limestone, varying from 4′ to 25′ in very short distances, but averaging from 12′ to 15′, is very fossiliferous, furnishing different species of the genera *Spirifer*, *Productus*, *Hemipronites*, *Chonetes*, *Euomphalus*, *Pleurotomaria*, *Bellerophon*, *Nucula*, *Nuculana*, *Macrocheilus*, *Astartella*, *Polyphemopsis*, *Aviculo-pecten*, *Athyris*, *Solenomya*, *Aviculopinna*, *Nautilus*, *Platyceras*, *Synocladia*, *Lophophyllum*, *Orthoceras*, *Zeacrinus*, &c. Its overlying concretionary and cherty ore sometimes replaces the limestone and is then of equal thickness. At Millerstown is a locally workable coal bed in the Mahoning sandstone at the top of the Lower Productive coal series. The Freeport upper coal bed is generally thin and sometimes absent in northern Butler, and the F. lower coal is also irregular and unreliable; the two limestones under these beds are persistent but feeble. The three Kittanning coal beds are much alike, persistent, about 3 feet thick, of good quality, and analyzing 43 to 55 p. c. fixed carbon, 36 to 41 p. c. vol. mat., 4 to 12 p. c. ash, 1.5 to 2.5 water, and 1 to 4 sulphur. The Clarion coal bed, (below the Ferriferous limestone,) 4 feet thick, and very sulphurous, is largely mined near Parker and Martinsburg for oil wells; and its upper bench when separated by many feet of rock is called the Scrubgrass coal bed. Most of the county is free from glacial drift; but the line of the Terminal Moraine may be traced near its N. W. boundary, from Harrisville to Centreville and Mechanicsburg and so into Lawrence county. The underground petroleum deposits of Butler county have been extraordinarily productive along a narrow belt—so narrow as to be a mere line upon the State Map—crossing the river at Parker and running S. W. towards Butler. Petrolia, Karn's city, Modoc, and many other towns sprung into existence along its route. The 1st, 2d, and 3d oil sands of Venango county are in Butler county overlaid by a fourth oil sand, which the Butler drillers called of course their 1st. The Venango 1st and 2d they called their 2d and 3d. It was long before they could be induced to seek the most productive and deepest Venango 3d, which ever since has been called the Butler 4th sand. These oil sands lie at a remarkably constant depth beneath the Ferriferous limestone; at Greece, for example, 910′, ——, 1189′, 1234′; at Fairview, 919′, ——, 1129′, 1189′, &c. Six wells at Petrolia, arranged in an oval 18,000′ long by 3000′ wide, were measured with extreme care; and while the Ferr. Lime. (base) sank south-westward from 1060′ to 1019′ A. T. the top of the 3d oil sand sank from —105′ to —110′ A. T. Some of the most violent gas wells have been got in Butler county; and although gas is not absolutely confined to any special rocks of the series, the Butler 1st sand is so noted for its copious yield that it is called by drillers "the gas sand," although many wells go through it without blowing gas. The famous Burns, Delemater, and other wells blow from the 4th sand. Outside the main oil belt and south of Butler lay a pool of oil under high gas pressure until 1884, when it was tapped by the Thorn creek wells, one of which gushed at the rate of 10,000 or 12,000 barrels a day, while neighboring wells were dry. (See Reports Q, V, and Oil Region Map in R^3.)

11. CAMBRIA.—Area, 670 square miles; population in 1880, 46,811. Four fifths of this lozenge-shaped district, lying immediately behind the crest of the Allegheny mountain, and at a general elevation of 2000 feet above tide, have a surface of the Barren coal measures, filling the whole of the first and part of the Second Bituminous coal basins. Along the Allegheny mountain the Lower Productive coal measures rise eastward at an angle of 1° or 2°, and several of the coal beds are mined at numerous points; especially where the Pennsylvania railroad crosses the mountain and descends the Conemaugh south-westward to Johnstown, with a gradient exactly equal to the diagonal slope of the Freeport upper coal bed; and also at the upper end of the Bell's Gap railroad, on the waters of Clearfield creek, flowing north. It is a noteworthy fact that the crest of the Allegheny mountain in this part of its course is half made up of knobs of Mahoning sandstone, separated by outlooking intervals of coal measures, and fronted by a considerable lower bluff of the Pottsville conglomerate XII, under which runs the outcrop of Mauch Chunk red shale XI, reduced in thickness to 200 feet. Laurel hill, separating the two great coal basins, is about as high as the Allegheny mountain, and runs nearly parallel with it, at a distance of 18 miles in the south and 15 in the north. Its broad crest is made of Conglomerate half across the county; the other (northern) half, coal measures cap the mountain; and, near the Clearfield county line, Barren measures. The dip from the anticlinal eastward into the 1st basin is at most 10°, and westward into the 2d basin somewhat more, but both dips rapidly flatten upwards and downwards. The 1st basin is subdivided into two by the Viaduct anticlinal, the axis of which, running 5 miles distant from that of Laurel hill, rises into Somerset county, and declines and flattens northward on Chest creek waters. The narrow wall of Mauch Chunk red shale No. XI cut through by the railroad (here 1456′ A. T.) with the river on the west side of it 80 feet deeper than on the east side of it,—the vertical cliffs and fallen masses of beautifully false-bedded Pocono sandstone No. X,—and the three-mile circle which the river has made, make this spot remarkable. After crossing the second

sub-basin, and receiving Stoney creek from the south at Johnstown, the Conemaugh cuts through Laurel Hill, exposing arches of Pocono (X), Mauch Chunk (XI), and Pottsville (XII) in a fine arch of vertical cliffs, projecting from precipitous slopes 1200 feet high above the river, which is here 1100′ A. T. Nine miles further north Laurel hill is gapped by Black Lick creek in a similar manner, but only deep enough to show XI on the crest of the arch. The Siliceous limestone at the contact of X and XI in the gap of the Conemaugh is nearly 50 feet thick, and in spite of its flinty appearance burns and slakes well, and makes a snow-white mortar which needs no sand. The Cambria Iron Works at Johnstown are among the largest in the world; mining, coking and roasting their own coal and ore on the spot, but also importing Lake Superior red hematite, and Juniata Valley brown-hematite and fossil ores in large quantities for mixture. The elaborate vertical section of the measures at Johnstown, made by Mr. John Fulton, shows the Johnston ore bed, 2′ thick, underlying 248′ of Barren measures; another ore bed 10″ thick, 22′ beneath it; then, 49′ lower, the Freeport Upper coal bed (E) 3′ thick; 21′ lower, kidney ore 10″ thick; 33′ lower, coal bed D′ 2′ 6″ underlaid by a limestone 3′ thick; 42′ lower coal bed D 3′ 6″ thick, with its underlying limestone 5′ thick; 80′ lower (with two small coal beds in the interval) coal bed B 6′ thick; 60′ lower, coal bed A 6′ 10″ thick, overlying 65′ of various strata belonging to the Pottsville Conglomerate series, No. XII. Analyses show these coals to hold from 17 to 27 p. c. of volatile matter, and 1 p. c. water; the ash varies from 4 to 14 p. c., but commonly runs from 4 to 6 p. c. (See Report H^2.)

12. CAMERON.—Area, 380 square miles; population in 1880, 5,159. This irregular district of rough and wooded mountain land is traversed lengthwise by the Sinnemahoning branch of the West Branch Susquehanna river, with the lower reaches of the First Fork from the north, and Bennett's Branch from the west. Innumerable deep, narrow, winding ravines traverse the county in all directions, cutting down from a general table land of 2000′ A. T. to a main river channel bed, which itself descends from about 1220′ at Beechwood station (Philadelphia & Erie R. R.) to about 750′ at Grove Station at the eastern boundary line.* The upper Chemung rocks (VIII) nowhere appear except along the main valley for 2 miles below and 4 miles above Emporium; for 6 miles up West creek; and for 5½ miles up the Portage fork, northward. Every where else the Catskill red rocks (IX) supporting the gray Pocono sandstones (X) form the walls of the valleys and ravines. The isolated strings and patches of highland are faced on top with Pottsville Conglomerate (XII), around the rough edges of which comes out, in a ring around each summit, the Mauch Chunk red shale (XI.) The coal measures have been eroded from all the summits of the south-eastern half of the county; but the lowest coal beds are still left upon the pretty continuous highland west of Stirling and north of Cameron, an extension north-eastward of the Caledonia bituminous coal basin of Elk county;

* R. R. grade at Driftwood junction with Bennett branch R. R. 816′ A. T.

and also on the highlands in the north-western corner of the county, an extension north-eastward of the Little Toby creek basin in Elk county. (See Report R².) The Cameron coal basin, bounded by Boon's mountain on the west, is 13 miles wide; but the strip of coal measures left in it is less than 2 miles wide; and north-east of the Sinnemahoning they occupy only the summits. Hunt's and Hick's runs also cut down through into No. XI; but Stirling run and its many branches penetrate the coal area in all directions and furnish ample opportunities for mining. At Emporium the top of the Chemung rocks (VIII) is 300′ above water, but sinks below water in less than a mile; the summit south of Emporium (2080′ A. T.) holds 200′ of Pocono rocks (X); all between is Catskill (IX.) The Conglomerase (XII) 3 miles S.E. at the Cameron Coal Co.'s is 1300′ A. T. showing a dip of over 300′ per mile. Here the section reads: Drift 4½′; sandstone 27′; black slate 15′; *Dagus coal bed* 3′; fire-clay 2½′; gray slate and shale 27′; *Sulphur coal bed* 3′; gray slate and shale 52′; *Clermont coal bed* 5′; fire-clay and thin soft JOHNSON RUN SANDSTONE and shale 27′; *Star-vein rider-coal* 1′; black and gray slate and shale 7′; *Star coal bed* 2⅔′; fire-clay 3½′; slate 1½′; fire-clay 5′; *Bogus cannel coal* and underlying slate 5′; coal 1¼′; slate 19′; KINZUA CREEK CONGLOMERATE, *Marshburg coal bed*, and OLEAN CONGLOMERATE, together, 125′. The sandstone and two conglomerates make up No. XII.

13. CARBON.—Area, 400 square miles; population 1880, 31,923. From the Pocono plateau (2000′ A. T.) in the north-eastern part of the county the Lehigh river descends in a wide curve, and cuts a long, picturesque gorge through nearly flat-lying Carboniferous and upper Devonian rocks nearly to Mauch Chunk; passes here the east end of the Southern Anthracite coal field, lying in a deep basin; and then cuts south through the vertically upturned outcrops of XI, X, IX, and VIII to Weissport; where VIII rolls over the anticlinal axis to form the shallow Parryville (or Wire hill) basin holding a long, isolated strip of Catskill (IX) which stretches from the Monroe line westward nearly to the Schuylkill county line. The river then traverses the recovered north dip of VIII, VII, VI, and V, and makes the superb Lehigh Water Gap through the Medina and Oneida rocks of the Blue mountain (No. IV.) This is one of the longest and finest rock sections on exhibition to geologists in our State, and after repeated measurements may be thus described: Productive coal measures, 975′; Pottsville conglomerate, XII, 880′; Mauch Chunk red shale, XI, 2170′; Pocono gray sandstone, X, 1255′; Catskill red sands and shales, IX, 7145′; Chemung shales and Portage flags, 1290′; Genessee slates, 290′; Hamilton sands and shales, 760′; Marcellus shales, 800′ (=VIII, 3140′); Oriskany sandstone, VII, 340′; Lower Helderberg limestone and shales, 295′; Onondaga and Clinton red and gray shales and marls, say 2000′; Medina sandstone, 665′; Oneida Conglomerate, 460′; in all 19,325 feet of Carboniferous, Devonian, and Silurian rocks, stretching their parallel outcrops east and west across the county. With the exception of excellent limestone and hydraulic cement quarried extensively on the front face of the Devil's Wall or Steinberg ridge facing the Water Gap, the only useful mineral of the county is Anthracite coal,

preserved in two groups of long, narrow, tightly compressed basins or rock folds, the one ending in a point on the top of the mountain at Mauch Chunk, and the other ending in a similar mountain spur west of the Oxbow Bend of the Lehigh river. The first-mentioned is the eastward extension of the Southern or Pottsville-Tamaqua coal field; the other is a virtual extension eastward of the Middle or Shamokin-Mahanoy coal field. The first is now known as the Panther creek basin; the other comprehends (inside of Carbon county) most of the Beaver Meadow basin, and a small part of the Silver Brook basin. Careful recent measurements at Lansford make out the following section: Shales—; slates and sandstone 300′; *coal* 1′;—69′; *coal* 4′;—59′; *coal* G, 6′;—160′; *coal F* (red ash) 16′;—9′; *coal* 2′;—52′; *coal* 1′;—63′; *coal* 1′;—68′; *Mammoth coal bed* 50′;—29′; *coal* 3′;—34′; *Buck mountain coal* 11′;—40′; *coal* 1′;—68′; *coal* 1′; Pottsville conglomerate No. XII, 770′; total 1855′. The Mammoth bed was first quarried on the top of the mountain, (in 1792) where it lies flat, and consists of 21 separate layers of coal, aggregating 40′ 3″, separated by 20 layers of slate, aggregating 12′ 10″; the whole bed being, therefore, 53 feet thick; but its average thickness east of Nesquihoning colliery is estimated at 29′, and from Rhume run to the Schuylkill county line at 55′ (with only 27′ of coal.) The *Red ash bed* averages 13′ (9′ of coal) east, and 9′ (5′ of coal) west of Rhume run. Mr. Ashburner estimates that of the 293,000,000 tons of Mammoth coal in Panther creek basin in Carbon county, only 56,943,000 have thus far been mined out; of 50,000,000 tons Red Ash bed, only 5,178,000; of 120,000,000 all other beds, only 572,000; *i. e.*, of 463,000,000 tons in all, only 62,693,000 have been mined out. Of the mined areas, only from 51 to 60 per cent of the coal has been won (since 1820,) but this waste has decreased from 10 to 15 per cent since 1881. The Nesquehoning mountain, between the two coal fields, is a great anticlinal roll of Pocono sandstone X, underneath which can be seen in the gorge of the Lehigh the red Catskill strata rolling in several low and broad rock waves; consequently, all search for workable coal in this mountain must result in disappointment. The absence of the Upper Helderberg limestone, Cauda-galli grit and Schoharie sandstone formations (at the bottom of VIII) in Carbon county should be observed. The numerous folds of the thick and soft Mauch Chunk red shale formation XI is a striking feature in this as in the neighboring counties. (See Report AA.)

14. CENTRE.—Area, 1230 square miles; population in 1880, 37,922. This large and important county presents all the most interesting features of the Palæozoic geology of the State on a grand scale—a wide expanse of mountain upland, with important coal areas on its top, in the western townships—an uninterrupted Devonian and Silurian valley crossing its middle townships—great anticlinal waves bringing up to the present surface hundreds of square miles of Siluro-Cambrian magnesian limestones, charged with superb deposits of brown hematite iron ore—long parallel symmetrical synclinal ranges of Medina-Oneida mountains separating the limestone valleys—and a labyrinth of these mountains in the south-eastern townships, formed by numerous close rock-waves and faulted

in several places. Most of the Allegheny mountain plateau has been denuded of its former covering of coal measures; but considerable minable areas of them are preserved along the center line of the First Bituminous basin, viz: a continuous belt 2 or 3 miles wide and 16 miles long, along the Moshannon river in Rush township; another 3 miles wide by 9 miles long, around Snowshoe, Moshannon, Pine Glen, and Germania, stretching west to the Susquehanna river; and seventeen other smaller patches along the headwaters of Beech creek, and on Hays run, along the Burnside-Snowshoe township line, and in Curtin township. The Snowshoe coal beds, first mined in the early part of the century, are now extensively worked. The Freeport upper coal, 5′ thick, caps the highest knobs, Askey hill, &c., covered with the last remaining blocks of the great Mahoning sandstone. The Freeport lower coal, so important at Karthaus, is thin in Centre county. The Kittanning upper coal is the bed of the region, from 5 to 7 feet thick, in three benches, with a coarse cannel roof. Numerous small downthrow faults are met in the mines. Analyses show 70 per cent carbon, 25 gas, 3 ash, 1 sulphur, less than 1 water, and good coke is made of it. Four other beds, 3′ or 4′ thick, exist; and several limestone beds, one of which, the Freeport lower limestone, is the key-rock of the district, from which all measurements are made and the coal beds identified. The Pottsville conglomerate, XII, 250′ thick, makes the crest of the Allegheny mountain* and the rocky sides of innumerable ravines. Under it the Mauch Chunk red shale, XI, 150′ thick, appears; and is also brought up in the bed of the Susquehanna, below Salt Lick, at the west end of Burnside township, and along both sides of Beech Creek valley, in Curtin township, everywhere topped by a plate of carbonate of iron, "the red ore bed," of variable thickness, never exceeding 4′. The Pocono sandstone, X, is more than 600′ thick, and forms a bold, straight, forest-covered ridge of coarse, and often conglomerate white sandstone, covered with bowlders. and keeping a pretty regular height of 2200′ A. T. The Catskill rocks, IX, form a broad, flat terrace in front of the Allegheny mountain its whole length, which can be well studied in Worth township, where the old turnpike to Philipsburg runs along it; they are 2600′ thick. The Chemung and Hamilton formations form the foot hills, and the Marcellus dark shales (800′) the bottom of the Bald Eagle valley; in all more than 6000′ thick of middle and lower Devonian measures, rising from beneath the Coal regions at increasing angles from 10° to 60°. The astonishing straightness of the Bald Eagle valley (N. 45° E.) across the county is explained by the vertical attitude of the rocks of the Bald Eagle mountain, at the west foot of which runs the low ridge of Oriskany sandstone VII, and Lower Helderburg limestone VI. At the Clinton county line VII is 130′ thick, but thins southward to nothing a few miles south of Milesburg, and has

*2236′ A. T. at middle summit; 2281′ northern summit Three Springs at head of Moshannon; 2614′ highest ground one mile further east; 2043 at railroad grade at Emig's gap; 1735′ in the notch where the Snowshoe R. R. crosses it; level of Snowshoe 1572.

been seen after that at only one place; it furnishes inexhaustible quantities of the finest glass sand, is excessively fossiliferous, but seems to offer no iron ore. The limestone VI is finely developed in Centre county, 1020′ thick, and has been quarried in the neighborhood of the charcoal iron furnaces. It is both argillaceous and cherty, and, as usual, quite fossiliferous. No. V (Onondaga and Clinton) 1040′ thick, makes the west slope of Bald Eagle mountain, but its fossil ore beds are scarcely recognizable; one thin layer was formerly mined a little at Howard. "Paint Springs" issue from its outcrop. The Bald Eagle mountain rocks stand vertical; the west crest made by Medina white sandstone (938′,) the east crest by Oneida white sandstone (710′,) and the interval by Medina red rocks (774′,) in all 2425 feet thick, containing neither useful minerals nor any fossils, except a few casts of a sea weed called *Arthrophycus harlani*. This triple formation (IV) makes all the other mountains of the county: Nittany, Brush, Penns, Tussey, and Seven mountains; but as their dips are not vertical, their crests are made by the upper (Medina) division, while bold and beautiful terraces are made by the lower (Oneida), cut into short lengths by innumerable ravines heading in the softer outcrops of the middle division. No. III, Loraine (Hudson river) and Utica slates, 1000′ thick, make the foot slope of the terrace, and in front of it spreads the fertile but waterless rolling plain of the great valley limestone formation No. II (at least 6000′ thick) the bottom of which is nowhere to be seen. Innumerable caverns lie concealed, through which flow streams, fed through sink-holes in the surface. One of these caverns is the channel-way for a considerable stream which sinks in Brush valley and rises in a great spring in Nittany valley, passing beneath Nittany mountain at a depth of at least 4000 feet. Another sinks into a cave near the end of Brush mountain, and rises in the "Fathomless spring" as Penn's creek. Big Hollow, along which the Bellefonte and Buffalo Run railroad runs, is the floor of an ancient cavern five miles long, the roof of which has been long since carried away, and sink holes along its course show that a new cavern has been found beneath it. Caverns filled with iron ore, on Sinking creek near Egg hill in Potter township, prove that the great brown hematite pipe ore deposits of Centre county fill depressions in the limestone which were once roofed like other caverns. Of these immense ore beds the largest and most famous is that of Pennsylvania furnace, in the southern corner of the county, the open excavations extending 1500 feet in length by 500′ wide and 60′ deep, the ore being known to be 30′ or 40′ deeper. Seven groups of these deposits, embracing more than fifty banks, are described by Mr. d'Invilliers, in Report T^4.

15. Chester.—Area, 760 square miles; population in 1880, 83,481. A perfectly straight valley, two miles wide on the Montgomery county line at the Schuylkill river, and less than one mile wide near the Lancaster county line, separates the northern from the southern townships. The Siluro-Cambrian limestones of No. II, which occupy this "Chester county" or "Downingtown valley," dip generally 30° to 50° southward, although small anticlinal rolls run diagonally across their general strike,

and the white-marble strata, confined to its southern edge, stand quite vertical. The *North valley hill* is made by the Potsdam sandstone, No. I, rising northward from beneath the lowest limestones, and spreading in sheets and patches over a considerable gneiss region, embracing Honeybrook, E. and W. Nantmeal, W. Vincent, E. and W. Pikeland, Charlestown, Upper Uwchlan, E. and W. Brandywine, and parts of W. Caln and Sadsbury townships; and it is plain that the fundamental gneiss area now exposed was formerly entirely covered by both the Potsdam quartzite and the overlying limestone. The *South valley hill*, on the contrary, is the edge of a low table-land, (500′ to 600′ A. T.) composed (1) of a belt of magnesian-mica slate; also, vertical or dipping at the highest angles southward, *apparently* in contact and conformity with and *over* the marble beds of the south edge of the valley, but *possibly* overturned and *beneath* the marble, in which latter case the valley is a synclinal trough, and the slates south of it are equivalent to the quartzite north of it; or else a fault runs along the south edge of the valley. The belt of South Valley Hill slate is only 2 miles wide at the Schuylkill end; widens westward to three miles at West Chester; 4½ at the West Branch Brandywine; and then spreads over E. and W. Fallowfield, Highland, Londonderry, Upper and Lower Oxford, and E. and W. Nottingham townships into Lancaster county; (2) a belt of older and newer gneisses and mica-schists occupying all the townships to the south and east. Isolated areas of limestone, however, occur in this belt near West Chester, Doe Run, Kennett's Square, Avondale, Landenburg, &c.; and Potsdam quartzite seems to be preserved around London Grove and at points on the Delaware State line. A long range of serpentine separates the two belts in E. Goshen and Williston townships, and another still more extensive serpentine belt ranges along the Maryland line into Lancaster county, and carries deposits of chrome-iron sand. A trap dyke enters from Delaware county at the south edge of the slate belt, and extensive outspreads of trap bowlders occur along the Berks county boundary in the north; other local exhibitions of trap being numerous in various parts of the county. Between the Schuylkill river and French creek the country is wholly of Mesozoic brown sandstone and shale; and in the tunnel at Phœnixville through these rocks a large collection of fossil plants and reptiles was made by Dr. C. M. Wheatley. Copper, lead, and zinc veins have long been mined to a small extent along the contact line of the Mesozoic and Gneissic rocks. The large magnetic iron mines of Warwick, connected with both trap and New Red rocks, but really belonging to the underlying Azoic floor, are still worked. Small quantities of brown hematite ore have also been obtained from the valley limestone. The white marble quarries are numerous, but none of them large. (See Report C[4].) The extensive *Kaolin mines* in New Garden township are pictured with those of Delaware county in Report C[5].

16. Clarion.—Area, 570 square miles; population in 1880, 40,328. Forty-six separate hill tops in the five southern townships are capped by small patches of Mahoning sandstone. All the rest of the surface of the southern half of the county, that is south of the Clarion river, consists

of the Productive coal measures; and these also make the hills of the other half except near the Forest county line, where the Conglomerate occupies the whole ground. The conglomerate crops out along the whole course of the Clarion; along Piney creek and both its main branches; along Mill creek and all its branches; along Turkey run, Beaver creek, Canoe creek, Deer creek and its two Paint creek branches, and along Toby creek and Tom's run; makes, in fact, the whole county a labyrinth of wild and rocky glens, sunk in a tableland of coal measures, the general upper surface of which ranges between 1400′ and 1500′ A. T. (the Allegheny Valley railroad at Emlenton being 905′, the Clarion railroad bridge 1098′, (water 1042′,) and the three railroad summits between Emlenton and Clarion, 1499′, 1466′, and 1435′.) The greater erosion of the coal measures from the northern half of the county has been caused by a general elevation of the surface, and of the rocks also, north-eastward as shown by the fact that levels for a railroad from Shippensburg to Kane begin with 1235′, read 1539′ at Jamestown, and then show successive gradient summits of 1665′, 1704′, 1788′, 1813′, 1823′, and 1909′ at the Elk county line. This gradual rise of the conglomerate lets the underlying shales of XI come to the surface in the Clarion river bed 2 miles east of Clarion, and continue above water level up the river into Forest county. Five slight but well-defined anticlinal rolls, and five very shallow basins cross the county in a N.E.–S.W. direction, the anticlinal axes running through Millerstown, Brady's Bend, Kellersburg, Anthony's Bend, and Brookville. The Freeport Upper coal varying from 2½ to 4¾ feet thick has been largely mined for the iron furnaces. Its limestone, 2′ to 5′ thick, is sometimes absent. A stratum of iron ball ore below the limestone has been extensively mined near W. Freedom. The Freeport Lower coal, a fine bed 5½ to 6½ feet thick, unfortunately does not extend far into this county, but has been extensively mined at several points; its carbon ranging from 51 to 56 p. c., its gas from 35 to 40, its ash from 2.6 to 6.2, its sulphur from 1 to 2, and its water from 1.3 to 4.7 p. c. Its underlying "flag" limestone, 1′ to 6′ thick, is seldom seen. The great Freeport Lower sandstone, hard, massive, often coarse, 75′ thick, is grandly exposed at Brady's Bend, but also forms crags and bluffs along the vales of the southern townships. The Kittanning Upper coal is every where either too thin or too poor, and is destitute of its upper cannel coal bench; and its underlying "Cement" limestone, 3′ thick, exposed at Fairmount on Middle run, is really an iron ore (Carb. lime 25, Carb. iron 37.) The Kittanning Middle coal is seldom workable, but the Kittanning Lower coal extends far and wide, and is an excellent workable steam-coal bed, 3½ to 5′ thick, cokes well, its vol. mat. ranging from 36 to 41 p. c. Fifteen feet under it spreads the Ferriferous limestone over two thirds of the county, 5′ to 15′ thick, carrying almost everywhere the rich "buhrstone" iron ore, which is merely the more or less metamorphosed uppermost layer of the whole deposit; is ordinarily only from 6 to 14 inches thick, but sometimes swells to 2, 3, 4, and even 6 feet, and with it is always obtained a variable amount of ball ore from the overlying shale. By reason of the extensive outcrop of this ore Clarion county possessed thirty charcoal iron furnaces—Ca Pike, Wildcat, Black Fox, St. Charles, Prospect, Buchanan, Sligo, I son, Martha, Monroe, Washington, Limestone, Clarion, Richland, ley, Jefferson, Eagle, Tippecanoe, Beaver, Shippenville, Mary Ann, Creek, Elk, Lucinda, Hemlock, Clinton, Licking, Helen, and Cc (or Mt. Pleasant,) most of them now abandoned for want of wood or inability to compete with great establishments elsewhere. The Cl coal bed, where its two benches are united, is 4′ or even 6′ thick, bu benches separate as much as 25′, the upper bench gradually risi touch the underside of the Ferriferous limestone. The Brookville 40 feet lower, is worthless, except along the border of Jefferson co and even there is of poor quality. The conglomerate is triple and tains the Mercer coal, thin and poor; and the Mercer ball ore, mi little. The Lower (*i. e.* Southern) oil belt crossing the river from E county at Parker City, runs straight N. 30° E. to St. Petersburg curving to N. 45° E. before reaching Shippenville where it pract ends. As first developed, it was very narrow, but in 1877 several pools were discovered. The total area including the pools is 20,000 a the actual productive belt underlies only 7,000 acres. The 3d oil sa oil rock proper, lies (the top of it) at Shippenville 370′ and at Parke above ocean level (a S. W. fall of 310′ in 15 miles.) The top of tl oil sand is 280′ beneath the top of the 1st oil sand, and 1100′ be the Ferriferous limestone. The presence of 40′ of red rock mid-wa tween the 1st and 3d oil sands is a marked feature of the well rec The annual production commenced in 1866 with 3,000 barrels, ro 1871 to 182,500, and in 1872 to 1,100,000, and culminated in 1877 2,372,500, declining in 1879 to 730,000.

17. CLEARFIELD.—Area, 1130 square miles; population in 1880, 4: The Laurel Hill anticlinal ranges up the eastern side—the Chestnut I anticlinal through the western half—and a third great anticlinal the extreme north-west corner of this county, which, therefore, sp across the Second and Third Bituminous Coal basins of western I sylvania, holding not only the whole Lower Productive coal series extensive uplands of the great Mahoning sandstone and the lower of the Barren measures. The whole county is very elevated—15 2000′ A. T.—the Susquehanna river flowing north-east through it, gorge-like valley, and Clearfield creek flowing north from Cambria co meet at an elevation of 1144′; and the Moshannon creek, which northward along the east boundary of the county, meets the river a A. T. Steep and often vertical cliffs, 500′ high, wall in these water nels, and those of their innumerable tributary streams. The Cong erate No. XII occupies the bed and sides of the whole length of the quehanna river, except for a short distance in Bell township; C field creek from Knox township north; the Moshannon from Morri north; all the valleys on the north side of the river; a belt of high 3 or 4 miles wide from the north-east corner of Bloom township n eastward into Elk county; and most of northern Girard, and norl Covington and Karthaus townships. The shales of XI and the u

most sandstones of X appear in the water beds of Morris, Graham, and Bloom, and where the head waters north of Clearfield cut through the Chestnut ridge axis. The quantity of coal preserved to Clearfield county in the two Freeport coal beds lying, here, only from 25′ to 40′ feet apart, and in the four Kittanning coal beds, occupying a space of only 70′ or 80′, is immensely large; but the Clarion series is not productive. The Freeport lower coal is the famous "Moshannon bed" of the First Basin, outside of which it is small. The other principal bed is the Kittanning lower coal, with a regular fire-clay under its thin top bench. The Freeport upper limestone is thin, often absent, or only represented by ball ore shales. The F. lower limestone varies from 2′ to 4′; is occasionally 6′ or 8′ thick; and is often wanting. The Johnstown Cement bed, underlying the K. upper coal runs from 1½′ to 2½′, and is persistent. The Ferriferous limestone is hardly to be found. Iron ore shales occur, but have remained unmined; the red carbonate iron stone, under the Conglomerate, presents its outcrop here and there. The fire-clay beds worked at Sandy ridge, Blueball, Woodland, and Clearfield are rich and important, lying at the base of the Productive coal series, on top of the Conglomerate No. XII. It is remarkable that this clay contains 2½ per cent of titanic acid. The clay bed at Clearfield is 13′ thick. (See Reports H, and H⁷.)

18. CLINTON.—Area, 860 square miles; population in 1880, 26,278. Two thirds of this county spreads itself over the Allegheny mountain plateau (2000′ A. T.,) and is profoundly trenched by the winding gorges of the Susquehanna river and its branches; Tangascootac creek, Holland's, Backer's, Hall's, McSherry's, Fish Dam, and Burns' run entering it from the west; Queen's, Lick, Rattlesnake, McGingley's, and Hyner's runs from the east; Youngwoman's creek, Paddy's, Drury's, Shintown, and Cook's runs, and Kettle creek from the north; and Grove, Birch Island, and Loop runs from the north-west. The Nine-mile cañon of Kettle creek is one of the grandest pieces of river erosion through horizontal sandstone strata in the State. Very little of the coal-measure beds has escaped destruction, and only in small isolated patches on the very highest mountain divides, a thousand feet above the river beds. Although they look to be scattered at random about the map, they are in reality arranged along lines or belts, representing three very shallow basins, which cross the county from S. W. to N. E. In the walls of all these mountain valleys crop out the horizontal edges of Formations XII, XI, X, and IX, and even the Chemung No. VIII is exposed in the bend at Youngwomanstown. The southern third of the county presents a very different scene. In front of the Allegheny mountain wall, crowned by XII, and terraced by X and IX, with foot hills of VIII (Chemung, Portage, Genessee, Hamilton, Marcellus,) lies the deep valley of the Bald Eagle creek, excavated along the outcrops of the Lower Helderberg limestone VI, and Onondaga and Clinton shales V. Into this valley the mighty Susquehanna river breaks through a noble gap, turns east, and flows away in broad meanders towards Williamsport. The valley is hemmed in on the south by the vertical rocks of IV (Media and Oneida sandstone,) making the straight

Bald Eagle mountain, through a gap in which flows (northward) Fishing creek, draining the head of Nittany valley; and through another gap, McElhattan's run. The gap through which Nippenose valley is drained lies in Lycoming county. Wayne, Greene, and Crawford townships make a broad flat arch of No. IV, uniting the Bald Eagle and Nittany mountains, between which Nittany valley lies, with its side slopes of No. III slates; and its floor of No. II limestone; and its middle ridge of barrens, charged with brown hematite-iron-bearing sands and clays. The west of Nippenose valley projects into Clinton county, and is the exact equivalent of Nittany valley. Sugar valley, an anticlinal repetition of Nittany valley, runs along the southern county line. The intermediate valley of Cherry run, on the contrary, is a synclinal trough in which a strip of No. V has been preserved.

19. COLUMBIA.—Area, 480 square miles; population in 1880, 32,409. Fishing creek and its branches—Huntington, Greene, Little Fishing, Spruce, and Hemlock creeks—drain the northern nine townships southward to the bend of the Susquehanna river between Bloomsburg and Catawissa—a rolling country of Catskill, Chemung, and Hamilton rocks (IX and VIII) spreading in front of the Allegheny mountain plateau, the edge of which is here called the North mountain. A broad and gentle anticlinal arch elevates a wedge of Hamilton rocks, the base of which on the Montour county line is six miles wide, and its eastern point reaches to within four miles of the Luzerne county line. The broad belt of Catskill-Chemung hills north of the wedge has a general height of 800′ to 900′ A. T. The Hamilton wedge itself is less elevated, and is bordered on the south also by a synclinal belt of Catskill-Chemung hills, along the center line of which Pocono sandstone rocks (X) make a long straight mountain (1500′ A. T.) ending in a sharp point overlooking Orangeville, and affording a magnificent view of the county. Four miles from its point the mountain top begins to split, the two crests gradually become two separate mountains, the southern (N. dipping) called Lee's mountain, the northern (S. dipping) Shickshinny mountain, inclosing a narrow valley of red shale (XI) which, in Luzerne county, continues to widen until it takes in the Northern Anthracite coal field. The upper end of the little valley is choked with drift, and the great Terminal moraine of the Ice age ascends Lee's mountain from the south-east, descends Huntington mountain westward to Fishing creek, which it follows northward through Benton and Sugar Loaf townships, ascends to the top of the North mountain and passes on its course through Sullivan county. The two curious notches in the crest of Lee's mountain and the moraine dam at Cole's creek P. O. are described in Report Z. The middle belt of townships, bordering the river, is traversed lengthwise by the north and south dipping outcrops of Oriskany sandstone VII, Lower Helderberg limestone VI, and Onondaga (Salina) and Clinton shales V elevated by the Montour Ridge anticlinal. The great red shale, lower division of the Onondaga (Salina) formation is finally exposed in the river banks at Bloomsburg, from which place it has received its name. Fishing creek cuts square across the rock arch, affording fine exposures with dips of

45°, and here an abundance of Silurian, and Lower and Middle Devonian fossils may be collected. (See Report G^7.) The Stony Brook group of strata in the upper part of the Chemung formation is specially remarkable. Forms characteristic of the Tully limestone of New York seem to be absent. Vast quantities of *Halysites catenulata* of the Niagara formation occur in the Lower Helderberg limestone (VI) at Manser's quarry. A south dipping belt of VIII and IX lies south of the river from Catawissa eastward, and these formations spread over Roaring creek, Locust, and Franklin townships, brought to the surface by the broad and rumpled Selinsgrove anticlinal, which, in Schuylkill county, separates the Mahanoy coal field from that of the Beaver Meadows. The rumples in this great arch are represented on the map by the zig-zags of Catawissa mountain, towards which the western ends of the Eastern Middle Anthracite coal basins point. The elbow of the mountain, overlooking Catawissa, is a double synclinal, and runs on eastward as Nescopec mountain (S. dipping,) gapped at Mainville by Catawissa creek, bringing out the drainage of the broad and winding red shale valley which surrounds the Anthracite mountains. McCauley's mountain, in Beaver township, a canoe-shaped fragment of the Conglomerate XII, holding the lowest coal beds, stands alone in the Conyngham red shale valley (XI,) on one of the two synclinal lines which come through the Catawissa mountain elbow. N. Conyngham township is a square piece of the Western Middle Anthracite coal field, included in Columbia county, with its Hartville and Centralia collieries. This south end of the county is crossed by Big and Little mountains (X and XII,) with a narrow, straight, and deep red shale (XI) valley between them, through which flows the south branch of Roaring creek, which turns at the S. W. county corner, breaks through Little mountain (Pocono X,) and flows north across the great rock arch to the Susquehanna below Catawissa; the main creek drains the triangular area between the Catawissa mountain spurs and the Little mountain. The iron works at Bloomsburg were established on the numerous mines of Clinton fossil ore once worked extensively in Scott township; the exhaustion of the softer outcrop ore, and the leanness of the deeper unchanged portions of the beds, have compelled the use of foreign stock brought from Lake Superior, northern New York, northern New Jersey, and eastern Pennsylvania. A little lead and zinc ore has been found in the limestone of VI, near the west line of Center township, but the attempt to mine it was abandoned.

20. CRAWFORD.—Area, 1000 square miles; population in 1880, 68,607. The last remnants of the lowest workable coal bed along the Lake Erie outcrop of the Carboniferous system, slowly rising north-north-westward at the average rate of less than twenty feet to the mile, are seen in the southern townships of this county, along the low flat summits of somewhat higher land between French creek and the branches of Sugar creek on the one side, flowing south-eastward and into the Allegheny river at Franklin, and Crooked and Shenango creeks further west, flowing south into the Beaver river. These long and narrow divides are composed of

Pottsville conglomerate (XII,) between the middle and lowest sub-divisions of which lies the important "block coal bed" of Sharon in Mercer county, so extensively mined in the State of Ohio; but in Crawford county this bed is almost everywhere too poor to work, except in East Fallowfield township, where some of its areas have been exhausted. In James McEntire's mine (1330′ A. T.) the bed varied from 4′ to nothing, and was covered by impure cannel or bituminous roof slate, sometimes 6′ thick. At Byhm's shaft, east of French creek, (1445′ A. T.,) the northern glacier had crushed it into an unminable condition, and left it covered up beneath 50′ of drift. In Wright's well in Mead township (1545′ A. T.) it was similarly crushed and covered with 25′ of drift. Crawford county is, therefore, practically destitute of coal. The lowest member of No. XII is here called the "Sharon conglomerate." This rock increases in thickness eastward, and becomes the "Garland conglomerate" of Warren county, and the "Olean conglomerate" of McKean county, the outlying outcrop patches of which make those magnificent "rock cities" along the State line. It is the first of the series of *round-pebble* deposits of Carboniferous age. All the gravel deposits beneath it ("Sub-Olean conglomerate," &c.; Pocono, X) have *flat pebbles*. The far end of one of the patches of Sharon conglomerate caps the hill overlooking Meadville, the upper 35′ being good building stone layers, the lower 10′ a conglomerate mass of round quartz pebbles; and in all exposures in the county what pebbles there be in the mass are more abundant and larger at the bottom of it. The frequent honey-combed aspect of the upper layers has been produced by the decomposition of great quantities of the erect stems of sea-weeds, and they contain also fish scales and bones in a fragmentary condition. All round the edges of the patches of Sharon conglomerate crop out on the hill slopes in a descending order: Shenango shales, 50′; Shenango sandstone, 25′; Meadville shales, (including the Meadville *upper* fish-bed limestone, 1′ thick,) 65′; Sharpsville flags, (including the Meadville *lower* limestone, 2′ thick,) 60′; Orangeville shale, 75′; Corry sandstone, 20′; Cussewago shales, (including a 2′ limestone,) 35′; Cussewago sandstone (Butler Co. 1st oil sand,) 25′; Riceville shales, 80′; Venango Co. 1st oil sand, 20′; blue shale, 100′; Venango Co. 2d oil sand, 20′; red shales, 15′; blue shales, 125′; Venango Co. 3d oil sand, 30′= TOTAL, 745′; divisible into an upper group of 435′ of Lower Carboniferous (Pocono X and perhaps Catskill IX,) and a lower group of 310′, Mr. Carll's "Oil Sand Group" (perhaps Catskill, perhaps Chemung, but probably partly both,) as shown by separate colors on the map. The hill at Meadville is (1548′—1080′ R. R. station) less than 500 feet high, so that the Oil Sand group only comes to the surface along the valleys of French, Cussewago, and Conneaut creeks in the north-western townships; and the undoubted Chemung strata (VIII,) underlying the Oil Sand group, only appears at the surface along Conneaut creek north of Conneautville. Although the Oil Sands underlie all the rest of the county, and a multitude of wells have been bored for oil, the only productive area has been the extreme corner around Titusville. On the flats of Oil creek, just outside the county line, Col. Drake bored his famous first well in 1859;

and on the flats of Pine creek, near the Warren county line, Jonathan Watson, under "spiritual guidance," bored his equally famous dry well, 3500′ deep, stopping (according to a very unreliable report) in the Genessee (?) or Marcellus (?) black shales. A good deal of heavy oil was obtained in the vicinity of Titusville. The 3d sand lies about 400′ beneath the flats. The curious "grasshopper excitement" of 1877 is described in Report I[3] Carll, 1880, pp. 422–429, caused by a discovery that about 12,000 barrels of oil had leaked from the rocks into the drift deposit of the flats. Oil creek, like most of the other streams of this region, now flows upon the upper surface of a deep sand gravel and bowlder deposit which was left by the northern ice in its retreat. The whole county is covered with such Glacial drift; and the ancient valleys, which formerly drained northward into Lake Erie, have been filled up to heights varying from 50′ to 350′, so as to reverse the entire drainage of North-western Pennsylvania, and send the rain-fall into the Gulf of Mexico. There are no minerals of value in Crawford county, except building stone and brick clay. Several lakes or ponds produced by dams of drift thrown across the valleys have become partially filled with a mossy vegetation, underlaid by a deposit of fresh-water shell marl. The marl which Mr. Whiting mines above Harmonsburg to a depth of 6′ or 8′ is known to be at least 22′ deep. Mr. Brown finds peat *beneath* his marl. Conneaut lake surface has sunk 25′ below the level of the peat bog, and retired from it to the distance of 1½ miles. Its greatest depth is 100′; its surface lies 497′ above that of Lake Erie and 1070′ A. T.

21. CUMBERLAND.—Area, 550 square miles; population in 1880, 45,977. The Medina sandstone (IV) crest of the Blue or North mountain carries the northern county line from the Susquehanna river westward, 40 miles (in a straight line) to the Franklin county corner. Two pot-hooks in the course of the line are caused by two of the Perry county anticlinals passing through the mountain and running on south-westward, past Bloserville, through the slate country north of Newville. The stratification in the mountain is everywhere very steep, (northward,) becomes vertical going east, and is finally *overturned* as much as 20° beyond the vertical, so as to dip 70° *southward*, in the gap of the Susquehanna river 4 miles above Harrisburg. The Cumberland valley is drained lengthwise by the Connedogwinet creek, the many horseshoe bends of which are most remarkable, and can only be explained by the fact that the channel of the creek is confined to the Slate belt (III), and that the southern points of the bends touch or just enter the northern margin of the limestone belt (II), while both the slates and the limestones are closely crumpled, and squeezed over northward, so that nearly every exposure in both belts shows a *south dip*, although the limestone formation creeps down northward underneath the slate formation, and the slate formation gets down beneath the Blue mountain. The bends in the creek show a number of close folds in the lower division of the Slate formation; a part of it, which is very calcareous, forming a *transition series of lime slates* in the place occupied by the Utica formation of New York. Along the northern margin of the limestone belt the strata belong to the Trenton formation,

and are in some places very fossiliferous. Synclinal prongs of slate project into the limestone at Kingston, Plainfield, and Newville, which aid in proving that the slate formation overlies the limestone; and additional evidence is offered by an area of slate surrounded by limestone stretching from Sheppardstown to the river two miles below Harrisburg. Yellow Breeches creek heads at the Big pond on the Southampton township line, and flows eastward 33 miles (in an air-line) to the Susquehanna 2 miles below Harrisburg. As the Connedogwinet flows along the bottom rocks of III, so the Yellow Breeches flows along the bottom rocks of II, at the foot of the South mountains; and while it receives the Mountain creek and a score of smaller streams descending from the highland, it is also fed by underground channels with the rainfall of the valley, which issues to the surface in the Boiling Spring, Bigpond Spring, &c., powerful enough to turn mill-wheels. The whole limestone belt is honey-combed with concealed caverns, in some of which brown hematite iron ore deposits are no doubt now being formed, under the same conditions which governed those deposits of the ore at the present surface which are now so extensively mined east and south of Mt. Holly Springs, in front of Boiling Springs, and along the foot of the mountain further west towards Franklin county. Little red spots upon the map indicate 47 places north of the Yellow Breeches creek, and 35 places south of it (outside the mountain) where more or less ore has been mined, all of which represent ancient sink holes and caverns beneath a previous higher valley surface than the present one. The South mountain area in Cumberland county, nowhere exceeding 2000′ A. T., consists of quartzite, sandstone, and hard shale and slate strata of doubtful age, which can be called Potsdam or Cambrian,* and exhibits no useful minerals, although small pieces of red hematite iron ore have been found lying on the surface, which indicate small beds, or, perhaps, veins, which might here or there repay the expense of research. Traces of a trap dyke have been detected crossing the mountain between York county and Boiling Springs; but from the springs northward a well-defined and nearly straight dyke runs along the two township lines between S. Middleton and Monroe, and between Middlesex and Silver Spring, 11 miles to the Blue mountain, which it cuts through and passes on across Perry county. The ridge which it makes across the valley, about 50 feet high and mostly left in woods, can be seen for a great distance by travelers on the railroad or turnpike. A small area of Mesozoic rocks is inclosed by the bends of the creek at Lisburn, in the south-east corner of the county. The limestone quarries opposite Harrisburg are very extensive and expose a noble section of the strata.

22. Dauphin.—Area, 520 square miles; population in 1880, 76,148. The two prongs of the fish-tail at the western end of the southern Anthracite coal field penetrate the northern part of the county; that of the Wiconisco coal basin for 5 miles; that of the Dauphin county coal basin

* The pink coloration of this area on the little map, and the name "Huronian" applied to it, are among the mistakes of this hand atlas.

for 10 miles, and along its southern edge runs the northern line of Lebanon county. This basin is narrow and sharp, and the lowest coal beds are pinched into a groove along the top of the mountain. The Wiconisco basin is broader, deeper, and very productive. It differs from all other Anthracite coal fields in possessing the magnificent Lykens Valley coal bed, at its maximum thickness of 10 to 15 feet, and of exceptionally fine quality; for everywhere else this bed is a thin, poor streak in the lowest layers of the Conglomerate. Wiconisco creek issues from the coal basin through a gap in its southern mountain rim, near its western end, which projects into a broad red shale (XI) country, covering five townships, bordered on the north by the Mahontongo mountain (X); and on the south by Berry's mountain (X.) From Berry's mountain gap, 4 miles above Halifax, to Peter's mountain gap, 7 miles below Halifax, there is a grand double rock-arch, the highest crown of which crosses the river 1½ miles above Halifax, and brings up Chemung rocks (VIII). Both mountains cross the county, converging as the arch sinks eastward, and meet just inside of Schuylkill county. From Berry's mountain (X) to Second mountain (X) is 3½ miles, and between them lies a red shale (XI) valley which, in Perry county, heads up as the Cove; and in the other direction, is split by the Third mountain into Clark's Creek valley* on the north, and Stony Creek valley on the south. The formations from Halifax to the mouth of Clark's creek all dip south about 45°. From Clark's creek down through Second mountain and Blue mountain gaps, they ought to dip north, but in reality they are thrown over on their faces 20° beyond the vertical, so that they dip southward 70°; affording a superb section of formations XI, X, IX (6000′), VIII (5000′) except its lowest beds, V, and IV, down to the slates of the Cumberland valley, III. But the Oriskany (VII), Lower Helderberg (VI), and Onondaga (upper of V), are also missing, in all about 1000 feet, in a section of nearly 20,000′. In all this thickness of strata there is absolutely no mineral deposit of any value. The overturn continues eastward along the mountain into Lebanon county. The southern half of Dauphin county is (1) a belt of valley slate (III) six miles wide; (2) a belt of limestone (II) three miles wide; (3) a belt of Mesozoic red shale and sandstone and trap, seven miles wide, to the Lancaster county line. The limestone belt, solid from the Lebanon line to the Swatara, splits into two; one arm running up to Harrisburg, the other keeping on straight to the river, a synclinal of slate lying between them, and both arms being extensively quarried for lime and furnace flux at the river bluffs. Brown hematite iron ore has been extensively mined at Hummelstown, near the edge of the Mesozoic. A good deal of graphite is disseminated throughout some of the limestone layers. A few poor limestone beds, very earthy, appear in the heart of the slate belt.

23. Delaware.—Area, 190 square miles; population in 1880, 56,101. The oldest or fundamental hornblende gneiss is laid bare in three isolated areas; the northern spreading through Radnor and Newtown into

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* A mistake in the map puts this creek on the south.

Chester county; the middle spreading from southern Newtown, Edgmont, Thornbury, northern Middletown, and northern Concord; the southern spreading across Aston, Bethel, and U. Chichester into the State of Delaware. These areas are separated and surrounded by the Chestnut hill micaceous and garnetiferous schist country holding the serpentine beds. An irregular line through Haverford and U. Darby to Chester creek (2½ miles up from its mouth) divides this country from the triangular area of Manayunk and Philadelphia mica-schists, which no doubt extends southward beneath New Jersey. The county has a rolling surface averaging 450′ A. T., but drops to a terrace of 200′ A. T., and then to the mud flats of the Delaware. Patches of old Bryn Mawr gravel remain in various townships on the divides at 400′ A. T. Patches and streaks of brick-clay remain on the terrace, and are extensively wrought. Brick clay (holding bowlders) passes also under the river mud. Cobb's creek (along the eastern line,) Darby creek, Crum creek, Ridley creek, and Chester creek cross the county from north-west to south-east, flowing in rock-cut channels, or tortuous glens, presenting a lovely variety of picturesque scenery, and affording a considerable amount of valuable mill power. The geological exposures are numerous; but the rocks are so metamorphosed, decayed, crumpled, cross-laminated, and probably faulted, that in the absence of fossils, and of well-defined mineral strata like limestone and iron ore, it is not easy to arrive at any definite opinions respecting the order of their super-position, or the classical system to which they belong. Under an appearance of vertical stratification, they really lie almost horizontal, as may be seen at Griswold's "granite" quarry in Darby, Ward's quarry in Ridley, Deshong's quarries in Nether Providence, and the Avondale quarries in Nether Providence and Ridley townships, lithograph views of which are published for the purpose of showing the true structure in Report C^5 on Delaware county. It is undoubtedly the real structure throughout the county. But as the general dip (as shown along the Schuylkill river) is north or north-westward, carrying the Philadelphia schists under the Manayunk schists, and these again under the Chestnut hill schists, it is hard to understand why all three should not be regarded as descending beneath the isolated areas of "older" hornblendic gneiss. A *serpentine* belt extending from Chester creek at Lenni (or Rockdale) past Media to Darby creek in Radnor township (9 miles) has been quarried for building stone. It consists of separate and parallel outcrops; and at least 27 other local exposures of serpentine in various townships are marked upon the map, *all of them in the Chestnut hill schist area*, and apparently belonging to the upper part of that series. Castle rock, in Edgmont township, is a huge exposure of *enstatite* (anhydrous serpentine) of picturesque aspect, and doubtful geological structure. (See plates in Report C^5.) Extensive mines of *kaolin* are worked at the west end of the county, and an outcrop of pure *feldspar rock* in Concord township is exploited for the use of dentists. (See numerous heliotype views of the Kaoline mines in Report C^5.) Mineralogical cabinets, public and private, have been amply enriched with fine specimens of *corundum*, *tremolite*, *actinolite*, *asbestus*, *beryl*, *chrysolite*, *garnet*, the micas, feldspars, and quartzes, *tourmaline*, *andalusite*, *fibrolite*, *cyanite*, *staurolite*, *stilbite*, *sepiolite*, *marmolite*, *chrysotile*, *deweylite*, *damourite*, *jefferisite*, *margarite*, *apatite*, *autunite*, *mirabilite*, *magnesite*, *bismuthite*, *menaconite*, *magnetite*, *chromite*, *rutile*, *molybdite*, &c. from numerous exposures in different parts of the county. A small percentage of gold has been obtained by analysis from the brick clays; a few small deposits of iron ore have been tried and abandoned; no other ore seems to exist in the county. A few small local exhibitions of trap have been noticed.

24. ELK.—Area, 770 square miles; population in 1880, 12,800. This region, lying 2000 feet above the sea, and still largely a wilderness, is traversed by four extremely gentle, but broad and irregular, anticlinal rock-waves and by four coal basins: (1) That of Caledonia and Benezette, along Bennett's branch of the Susquehanna; (2) that of Shawmut, Brockport, Early (Daguscahonda,) Centreville, and St. Mary's, along the Little Toby and Elk creek; (3) that of Lake City, Ridgway, Mount Moren, Wilmarth, Bridgetown, Wilcox, Pistner hill, and Upland, crossing the Clarion river, and extending up Bear creek, Big Mill creek, Little Mill creek, and Clarion creek; and (4) that of Spring creek, Summit, and Highland, along the divide from which the head waters of the Tionesta flow westward into Forest county. The highest lands along the middle line of the second of these basins in Horton, Fox, and Benzinger townships are capped by the Mahoning sandstone and a little of the Barren measures. The body of the hills consists of flat productive coal measures (250′ thick) containing among the limestones the Ferriferous limestone, but without its "buhrstone" iron ore covering. The valleys are cut down through an additional 300 feet of the Conglomerate measures (XII,) so that the underlying Mauch Chunk red shale (XI) has an enormous length of outcrop all over the county, as the red line on the map will show. Of course, the lower slopes of the bluff walls of the valleys are made by horizontal outcrops of Pocono greenish, false-bedded, and fine-grained sandstone (X,) the bottom of which is nowhere reached, except at one point on the north fork of West creek, 4 miles north of Hemlock station, on the P. & E. R. R., and in the beds of the valleys of Benezette township as they approach the Cameron county line, and cut down into the upper strata of the Catskill formation No. IX. The remarkable flatness of the stratification keeps the Conglomerate belts very narrow, and gives an uncommon width to the areas of the lower coal beds, which must occupy fully one half of the whole surface of the county. The highest (Freeport) coal bed, on the other hand, and for the same reason, has been preserved only in spots on the highest lands. The average outspread of coal, taking the whole 250 feet of productive measures into account, must be equal to about 200 square miles. Beds of carbonate of iron and beds of fire-clay are the only other minerals of value in the region, the former being always unreliable. This was the last retreat of the elk. In 1841, a herd of thirteen individuals still existed in the forest, but they were soon after that exterminated. The Ridgway well (1790′ A. T.) went through 85′ of Olean conglomerate and sandstone (XII); slate 15′; *coal*; *Mauch Chunk red shale* (XI) 45′;

Pocono sands and shales (X) 625′; then almost a continuous series of *Catskill red shales* and sands (IX) 334′; and 96′ into Chemung shales (VIII).—The St. Mary's well (1605′) commences with Drift 32′, and *Olean sand* (XII) 18′, and goes through (XI and X) "blue slate" 45′, sand 25′, slate 140′, sand 16′, slate 124′, sand 20′, slate 205′ (total 575′,;) then through continuous red Catskill (IX) 335′; then blue slate 12′, sand 49′, slate 369, *red rock* 25′, slate 35′, *reddish rock* and the rest blue slate 220′, sand 44′, black slate and shells of sandstone with a few red streaks 286′, and ended in sand 10′ (total of VIII 1050′); total depth of well 2010′, to 405 feet below ocean level.

25. Erie.—Area, 770 square miles; population in 1880, 74,688. Its straight Lake Erie shore line, 23 miles long, is only broken by the hook-shaped peninsula in front of the city of Erie. The present level of the lake is 573′ A. T. A bluff of sand and clay faces the shore, lower at the Ohio line, but increasing in height eastward, often abruptly rising 80′, 100′. and even 120′ above the lake. From the brow of the bluff back (southward) the surface slopes up gently to the foot of an escarpment, 400′ to 450′ above the lake, (1000′ A. T.) The escarpment itself then rises boldly to a summit line of 1300′, towards the west, and 1500′, towards the east, back of which lies the upland of the middle and southern townships, at an elevation ranging from 1400′ at the west to 1700′ at the corner of New York. The eastern half of the upland drains, by the head branches of French creek, southward; the western half sheds its waters through the two deep ravines of Elk and Conneaut creeks into Lake Erie. The face of the escarpment and the 1000′ terrace beneath it cast their rainfall directly into the lake by smaller streams like Raccoon, Crooked, Trout, Walnut, 4-Mile, 6-Mile, Elliott's, Scott's, 12-Mile, and 16-Mile runs. The level of Lake Erie stood once much higher than now; for in Harbor Creek and North East townships four terraces may be counted at 1150′, 1070′, 875′ to 795′, and 765′ to 740′, the top of the sand bluff overhanging the lake (573′ A. T.) The lowest terrace, a plain a mile wide, is covered with a lake deposit of *brick-clay;* the second terrace, a broad, sloping plain, exhibits a steep escarpment of lake *beach sand*, 40′ high, extending for a long distance parallel to the present shore; and at 1070′ are remnants of a terrace covered with *beach sand and shingle;* but the 1150′ plain, 3 miles back from the lake, is destitute of such deposits.* Glacial drifts cover the whole county, and deeply fills all its water channel beds. The upland formations consist of (1) *Pocono sandstone* and shale (X) along the Crawford county line, on isolated divides in Wayne and Amity townships, and a long irregular ridge from Mill village to Franklin corners; and (2) the *Oil Sand group*, which spreads around and north of the Pocono areas to the brow of the great escarpment looking down upon the lake. This is made by the outcrop of the lowest or 3d Oil Sand, quarried in many places for building stone, and generally more or less dripping petroleum, but affording no assurance of containing pay-

* This, of course, implies a continental submergence; for the highest Erie R. R. grade (at Batavia) is only 895′ A. T.

ing quantities of the oil in any part of the county. The dip is everywhere extremely gentle, a careful calculation making it 22 feet to the mile, S. 45° W. (See Report Q[4], p. 54.) The (Lower ?) *Chemung* rocks (325′) cropping out along the upper steeps of the escarpment and over the broad, flat valleys of French and LeBœuf creeks, and covering the southwest corner of the county, are very fossiliferous. The next underlying *Girard shales* (225′), destitute of fossils except markings supposed to be sea weeds, are exposed in the ravines descending towards the lake, and especially in that of Elk creek, the sides of which resemble vast banks of gray coal-ashes; the bottom of this formation touches the lake level at Raccoon creek near the Ohio State line, and gradually rises to 475′ above the lake at the New York State line. The next underlying *Portage* formation of alternate layers of gray shale and thin hard sandstone, non-fossiliferous (except fucoids), occupies the lake shore. Petroleum trickles from some of the sand layers, which are never more than one or two feet thick, and represent the Warren Oil Sand group. Collections of condensed gas exist, which produce little explosions at the building-stone quarries. The gas and oil wells which have lighted and heated the city of Erie vary in depth from 450′ to 1200′, the average being about 600′, which should not be far from the Bradford Oil horizon. Building stone of excellent and various character is the only mineral wealth of Erie county, and quarries are numerous in the Shenango (Sub-Olean) sandstone belt of the southern townships; in the three coarse Oil Sands; and also in the finer sandstone layers of the Portage series, east of Erie, along the lake. (See Report Q[4].)

26. FAYETTE.—Area, 830 square miles; population in 1880, 58,842. The Second, Third, and Fourth Bituminous coal basins cross the county from N. N. E. to S. S. W. into West Virginia. The *Second* or *Ligonier Valley Basin* lies between the two broad anticlinal mountains of Laurel hill (along the Somerset county line) and Chestnut ridge, rising 1300 feet above the water in the two gaps made through them by the Youghiogheny river, which crosses the valley diagonally, keeping most of the way in the red shale (XI,) but making the beautiful *Ohiopile Falls* where it passes over a narrow synclinal strip of the Conglomerate (XII.) The basin is lined with the Lower Productive coal measures, supporting numerous isolated hills of Barren measures, none of which are lofty enough to preserve the Pittsburgh (Connellsville) coal bed. In the two gaps may be seen the arched outcrops of Pocono sandstone, forming vertical cliffs, with steep taluses, covering strata which may be called Catskill (IX,) but contain Chemung fossils (VIII.) On the broad summits of the two mountains remain plates of the Conglomerate, 50′ to 70′ high, composed of a friable whitish sandstone, cleft in vast cubical masses, and weather worn into shallow caves. The "Elk rock" may be easily visited from Connellsville, and the "Cow rock" on the edge of the precipice looking down into the gap is covered with Indian sculptures. The Lower Productive coal measures cover all the west half of the county, and so do the Lower Barren measures, except along Red Stone creek at Upper Middleton. The Pittsburgh bed extends along

the middle of the *Third* or *Connellsville Basin* for 33 miles, with a width of 4 miles. This noble bed, sometimes more than 12 feet thick, is very extensively mined, and its coal coked for Pittsburgh and the western and south-western cities. It carries the Upper Productive coal measures, consisting of four principal coal beds and many massive limestone strata. At two or three points of this basin small hill tops have preserved some of the Upper Barren measures. The *Fourth* or *Monongahela Valley Basin* occupies all the western townships, with a multitude of collieries on the Pittsburgh bed facing the river pools. The Upper Barren measures make a considerable show on the map in Jefferson, Redstone, Luzerne, and German townships in the middle of this basin; but the Greene county series has not been preserved; and the Washington county series is not well exposed to observation, the uplands being well cultivated and the vales shallow; but the Upper and Middle limestones, the Jollytown coal, the Washington coal (5′), its iron ore, and the Waynesburg "A" coal, have all been identified. Below these spread 437′ of *Upper Productive coal measures*, containing the Waynesburg coal (6′,) Little Waynesburg coal (2′,) Waynesburg limestone (20′,) Uniontown coal (3′,) Uniontown limestone (12′,) Great limestone (80′,) Sewickley coal (3′,) Fishpot limestone (25′,) Redstone coal (4′,) Redstone limestone, (10′,) and at the base the Pittsburgh coal (12′,) *i. e.*, 40′ of coal and 147′ of limestone, with three marked sandstones 30′, 30′, and 40′ respectively. The *Lower Barren measures* measure only 492′. The *Lower Productive coal measures* are under ground; but where they come up with dips of 10° to 30° on the flank of Chestnut ridge they show at least five coal beds, the top and bottom ones varying greatly in thickness between 1′ or 2′ and 9′ or 10′. In the immediate presence of the outcrop of the Pittsburgh bed these lower coal beds stand no chance of being worked, and are there for scarcely better understood in 1885 than they were when examined by Dr. Jackson in 1840. Important beds of iron ore lie at five different horizons in Fayette county, and have been a good deal mined for the use of local blast furnaces at Dunbar, &c: (1) Five beds of lump and flag clay-iron-stone, within 25′ feet under the Pittsburgh coal; (2) two overlying the Mahoning sandstone near Lemont furnace; (3) the local Norris, Jacobs' creek, or Pridevale beds under the Mahoning sandstone; (4) the Stratford ore on top of the Conglomerate; and, (5,) most important of all, the Honey-comb, Kidney, and red ores of No. XI, in the ravines of Chestnut ridge. (See Report K^3, chapter 10.)

27. Forest.—Area, 430 square miles; population in 1880, 4,385. This little rectangular wilderness, 2000′ A. T., stretching from the Allegheny river eastward across the high divide, 30 miles, to the Clarion waters of Elk county, is deeply trenched lengthwise by the valley and side vales of Tionesta creek, along the steep sides of which runs the outcrop of XI, over flat Pocono measures X, and beneath cliffs of conglomerate XII, containing the thin *Alton* and *Marshburg coal beds*. None of the Productive coal measures remain upon the flat upland divides. The Venango oil sand formation underlies the bed of the Tionesta at Foxburg . . feet, and has produced a good deal of petroleum. (See Report R^2 and Report

I^3, p. 133, section 55.) The group here consists of six sands—20′, 10′, 15′, 20′, 30′, and 20 thick—separated by intervals of 82′, 43′, 10′, 45′, and 30′. Three red shales make the group remarkable in this district, the upper one 40′ thick in the middle of the first interval; the middle one 13′ thick in the middle of the second interval; and the lower one 10′ thick on top of the Fifth oil sand. The whole group is 325′ thick, and the plane of its base at Foxburg is only 20 feet above ocean level. From Foxburg to Parker. The formations in this county are nearly horizontal, the average dip being less than common railway gradients; and the surface being almost a continuous forest, presents few exposures even of a broken and uncertain character; while the oil wells show that the beds and groups of beds vary in thickness in every direction. Coal-openings are more numerous near Marienville in Jenks township than elsewhere, but even trial pits have been gradually discontinued owing to the abundance of wood and the general use of bore-hole gas for light and fuel. Most of the trial pits are isolated and cannot be used for constructing a classified system of the beds, none of which seem to be of noteable size, or suitable for future mining operations. The summits and divides are commonly patches of massive sandstone or conglomerate, all referred in former years to one called the *Tionesta* sandstone; now, to the three members of No. XII, described in McKean county, *Johnson run conglomerate, Kinzua creek sandstone, and Olean conglomerate;* between which lie the *Alton and Marshburg* small *coal beds;* and above the upper one the *Clarion coal* (2′ 3″) at Pine Ridge in Jenks township (1742′ A. T.); over which lie 50′ of shales. The *Ferriferous limestone* seems wanting (by erosion) from the whole country. Col. Hunt's summit at Marienville cross roads (1805′ A. T.) is *Johnson's run* rock 65′; Alton coal 3′ ?; shales 10′ to 15′; *Kinzua creek upper* rock 50′; soft measures and coal ? (?); *lower* rock 40′; *Marshburg upper coal* 2′ ? *Olean conglomerate.* Bog iron ores occur in various places, produced by springs issuing from ferruginous shales between the great sandrocks. The summits west of the Allegheny river are lower, the highest measured was 1680′ A. T. The *Brookston anticlinal axis* crosses the South Branch of Tionesta at Brookston on the Warren county line and runs past Marien (2 m. N. W.) to the south-west corner of Farmington township. The *Fifth anticlinal* crosses the Clarion 2 miles above Millstown. The axis of the intermediate *Kane synclinal basin* cuts across the great bend of spring creek. The oil well at Marien gives the following section: Mouth 1615′ A. T., Drift 8′, SS. 30′, slate 21′, coal 3′, pebbly SS. 98′, slate 25′, SS. 70′, slate (red ?) 70′, white SS. 45′, black slate 85′, SS. 100′, slate 20′, close pebble SS. 13′, blue slate 204′, (total X, 500′); *red shale* 25′, black slate 18′, *red shale* 76′, black slate 12′, slate and shells of sandstone 30′, gray SS. 15′, *red shale* 10′, black slate 25′, gray SS. 20′, black slate 25′, shells 15′, *red shale* 15′, (total IX, 286′); black slate 114′, shells of sandstone 15′, red slate 20′, slate and shells of sandstone 83′, (total Chemung bored through 232′.)

28. FRANKLIN.—Area, 760 square miles; population in 1880, 49,855. This important triangular area with its base line upon the State of Maryland covers an enlargement of the Great (Cumberland) valley between

the South mountains (Blue ridge) on the east, and the North (Blue) mountain on the west. Shirley's and Furnace branches of Meade's run, a branch of Connedogwinet creek, separate it from Cumberland county; but almost the entire rainfall of the county drains southward by the Conococheague creek into the Potomac. The western part of the county includes Path valley lying behind the North mountain, and also a cove in the south-west corner of Montgomery township debouching into Maryland. *The main limestone belt* of No. II, at the western foot of the South mountains, is 6½ miles wide at Shippensburg, 8½ at Chambersburg, 13 at Greencastle, and has a line of important brown hematite deposits along the foot of the mountains: the furnace banks on the Cumberland line, the Pond bank group opposite Chambersburg, the Mt. Alto banks a little further south, and others. Smaller isolated deposits of ore have been found scattered over the surface of the belt. *The great Slate belt* of III, lying on the limestone, is 6½ miles wide at Shippensburg, 5 at Chambersburg, and 3½ at the Maryland line. Back of the great Slate belt, No. II comes up again in a *Second limestone belt* 3 miles wide at the Maryland line, running north 28 miles and tapering to a point before reaching Roxbury P. O.; but the sharp anticlinal fold which brings up the limestone runs on in the slate and makes the great hook in the North mountain in Cumberland county. Back of this is a *Second slate belt* trough one or two miles wide, in which lies Casey's mountain (IV) at the Maryland line, and the long isolated mountain ridge of Parnell's knob opposite Chambersburg. Back of this lies the anticlinal *Third limestone belt*, of Mercersburg, 1 mile wide and 11 miles long, pointed at each end. Back of this runs the synclinal *Third slate belt*, holding at its south end Two-top mountain (IV) and at its north end Jordan mountain (IV,) which is a long loop of the North mountain, inclosing a long narrow elevated trough of red shale (V) drained northward by the main head stream of Connedogwinit creek. Back of this slate belt is the anticlinal *Fourth limestone belt*, 1½ miles wide and 11 miles long from its north point at London, to its south point where it passes under the slate in the "Corner," a little cove between Two-top and Cove mountains. In Path valley a *Sixth limestone belt*, 1½ miles wide and 11 miles long, is faulted along its western edge at the foot of Tuscarora mountain (IV); and here are the extensive Richmond brown hematite ore banks. The northern head of Path valley is closed by slate coves and sandstone spurs on the Perry county line. Cove gap, west of Mercersburg, leads into a red shale valley of V, which widens southward as the Cove, and contains an elliptical outcrop of the Lower Helderberg limestone (VI), the Oriskany sandstone (VII), and a small trough of Marcellus and Hamilton rocks (VIII), the only place in the county where the Devonian rocks are preserved. The fossil iron ore bed in V has been opened here. The parallel anticlinal and synclinal belts of limestone and slate in Franklin county are of the highest importance in proving the identity of formations II and III with the Lower (Cambro-) Silurian series in New York State and elsewhere, and with the limestone and slate belts of the Juniata river country. Trenton fossils abound along the west edge of the main limestone belt at Chambersburg and elsewhere; but the limestone formation (II), which is nearly 7000 feet thick in Blair county, seems to be only 3000 feet think in Franklin county; and the Slate formation (III), which is 6000 feet thick in Lehigh and Northampton counties, may not be more than 1500 or 2000 feet thick in Franklin county. Little lumps of a coal-like substance occur in the slate along Cove mountain, and have some connection with the multitudes of graptolites which then inhabited the sea. A great fault seems to run along the foot of the South mountains; for the limestone strata commonly dip east against and as if under the mountain rocks. Although basins and rolls traverse the limestone belt in front of the mountain, and prongs of slate project diagonally into the limestone belts, showing troughs, while prongs of limestone penetrate the slate belts, showing arches, the whole floor of the valley is closely crimpled into innumerable folds, many of which must be overturned and compressed, as shown by the general prevalence of east dips. The South mountain mass is divided in two by a curious transverse fault of great size, which runs east and west along the line of the Chambersburg and Gettysburg turnpike; the whole country north of the fault, both mountain and valley, being shifted about three miles westward. North of the fault the Franklin county mountain mass consists of several thousand feet of sandstones and slates, dipping 30° and 40° east, which may be called Potsdam (I) or Cambrian. South of the fault are red schists and massive and conglomeratic sandstones, folded, and at Mt. Alto standing nearly vertical. In the south-east corner of the county appear what may be Huronian strata. (See map in Atlas D^5.)

29. FULTON.—Area, 440 square miles; population in 1880, 10,149. The two principal features of the county are the McConnellsburg limestone cove lying along its eastern border, and the Broad Top coal field which occupies about 8 square miles of its north-west corner, at an elevation of 2000 feet above tide, and surrounded by a deep red shale valley (XI.) This again is surrounded by Sideling hill, which is prolonged southward to the Maryland State line, but sends out a long prong south-westward called Town hill. These mountains are outcrops of Pocono sandstone, No. X, and contain a number of worthless little coal beds. The workable coal beds are on the Broad Top. Through the middle of the county passes a broad belt of Catskill (IX) and Chemung and Hamilton (VIII) rocks, containing no minerals of value. At the northern line is a loop of Oriskany sandstone (VII) and Lower Helderberg limestone (VI) inclosing a Clinton red shale valley with some fossil iron ore circling round the south end of Black-Log mountain. At the Maryland line there is an exactly similar loop, twice as long (8½ miles) in which flows Pigeon creek. Between the two loops lies a curious trough of higher rocks (IX, X, XI) making a mountain 13 miles long and 2 wide, with a double crest and little inclosed valley, over the northern point of which runs the Bedford turnpike. The McConnellsburg cove is floored with the limestone II, and walled in by a mountain of slate (III) with a crest of Medina sandstone (IV,) all round except on the western side. Here runs the most remarkable fault in the State, the west-dipping limestones of the cove

being cut off and dropped about 8000 feet, so that at the present surface No. II and No. VIII are in contact. The limestone floor of the cove is 2 miles wide and 13 miles long, pointed at the north and south ends. A little iron ore has been found in it. Fossil ore outcrops come up out of the fault and run northward into Huntingdon county and southward along Licking creek into Maryland. The whole surface of the county is most picturesquely broken; and charming mountain and valley scenery can be enjoyed from many points of view, especially along the turnpike from Saluvia past McIlvaine's tavern over into Bedford county. Thin veins of *sulphate of baryta*, cutting the shales of No. VI, have been mined near Fort Littleton for paint stuff. (See Report T^2.)

30. Greene.—Area, 620 square miles; population in 1880, 28,273. This county, lying at the south-west corner of Pennsylvania, is remarkable for preserving the highest known strata of the Coal age, higher even than those in the hill tops near Wilkes-Barre and Minersville in Luzerne and Schuylkill counties. It is, in fact, a great flat dome-shaped country between the Monongahela and Ohio rivers, underlaid by the almost perfectly flat uppermost coal measures on top of the Pittsburgh bed, the edge of which appears in the Monongahela valley only in front of Clarksville, and for 2 miles below Greensboro', and 8 miles above Greensboro', rising slowly into W. Virginia. The coal beds above it outcrop along both sides of Ten-mile run (south fork) up to Waynesburg, up Muddy creek 2½ miles, White creek 1½ miles, Whitely creek 4 miles, and Dunkard's creek 5 miles. At the three high divides, where Aleppo, Jackson, Gilmore, and Springhill townships join each other, the land is so elevated that it would be necessary to sink 1200′ to reach the *Waynesburg coal bed* and 1700′ to reach the *Pittsburgh coal bed*. The section of these highest Palæozoic rocks in Pennsylvania, as exhibited along Fish creek, begins with 80′ of concealed rocks on the *14th limestone* (4′;) shale, 25′, on bituminous shale (2′) representing the latest of the coal beds; shale, 30′; *Gilmore sandstone* (forming cliffs) 30′; shale, 20′, on the *13th limestone*, (1′;) sandstone and shale, 255′, on the *Nineveh coal bed*, (2½′;) sandstone and shale, 30′, on the *10th limestone*, (6′;) the *Fish creek sandstone*, on a *coal bed* (?′;) shale and sandstone, 45′, on a *limestone* (1′;) sandstone, 20′, and then ferriferous shale, 10′, on the *Dunkard coal bed* (1′;) shale, including 10′ of sandstone, 63′, on a *coal bed* (1′;) shale and sandstone, 45′, on a *coal bed* (1′) lying upon the *Upper Washington* or *6th limestone*. The 7th, 8th, 9th, 11th, and 12th limestones, all of them thin, are exposed along Ten-mile run in Centre township. On Dunkard creek there are two limestones (25′ apart) between the 8th and 10th. There is an evident increase in thickness of all the intervals going south across the county into W. Virginia. The next lower group *underlying* the *Upper Washington (6th) limestone* (3′) consists of shaly sandstone, 20′, on the *5th limestone* (5′;) shale and sandstone, 30′ to 45′, on the *Jollytown coal bed* (1′;) shale and sandstone, 180′, on the *3d limestone* (3′;) sandstone, 18′, on black shale (3′,) on the *2d* or *Lower Washington limestone* (3½′;) shale, 6′, on the *Washington coal bed* (2½′;) clay and thin sandstone, 18′, on the *Little Washington coal bed* (with shale, 7′;) sandstone, 20′, on the *Waynesburg*

"*B*" *coal bed* (1';) sandstone and shale, 18' on the *1st limestone* (with shale, 13') on the *Waynesburg* "*A*" *coal bed* (1½;) variegated shale, 10', on the Waynesburg sandstone which tops the Upper Productive Coal measures. The *6th limestone* in Washington county becomes a group of alternate lime and shale beds, 30' thick. Its middle layers are full of minute *Crustaceans*, as also in all the other limestones. Under it is a plant bed. (See Report K, p. 47.) The 4th limestone is rich in minute forms of *Bellerophon* and *Euomphalus* and *Bryozoa*; fish teeth and spines are found. Under the 2d limestone is a crustacean and fish bed. The Washington or Brownsville coal bed extends into Ohio and north as far as Eldersville in Allegheny county; its thickness varies from *six inches to eleven feet* in the Washington county mines. The Upper Productive Coal measures embrace the *Washington sandstone* 70'; shale 0' to 12', on the *Waynesburg main coal bed* (6',) with its under clay (3';) sandstone 20', on limestone (5';) sandstone and shale 60', on the *Uniontown coal bed* (1' to 3';) the *Upper Great limestone* 18'; sandstone and shale, 60'; *Lower Great limestone* 55'; sandy shale 40', on the *Sewickley coal bed* (1' to 6';) sandstone 10'; the *Fishpot limestone* 18'; sandstone and shale, 25', on the *Redstone coal bed* (1' to 4';) limestone 10'; Pittsburgh upper sandstone 40'; shale 0' to 10', on the *Pittsburgh coal bed* (5' to 12'.) The shale cover to the Waynesburg coal bed has preserved the finest *leaf impressions* yet obtained from these upper series. The coal bed covers at least 15,000 square miles in the two States, and has a parting which fluctuates in thickness from 0' to 6' in a few yards of distance. The coal is sometimes 8' thick, and the great overlying sandstone often descends into it, even to its floor. In roof shales the number of both species and individuals is great; but in the higher plant-horizons only the number of individuals is great, and a few species spread over large areas. In Report PP will be found plates and descriptions of various species of the following genera by Profs. W. M. Fontaine and I. C. White: *Equisetites, calamites, sphenophyllum, annularia, sphenopteris, neuropteris, odontopteris, callipteris, callipteridium, pecopteris, goniopteris, cymoglossa, alethopteris, tæniopteris, rhacophyllum, caulopteris, sigillaria, cordaites, rhabdocarpus, carpolithes, guillielmites, saportæa*, and *baiera*, with a cockroach *Gerablattina balteata*. Plant beds are rare in the series from the Waynesburg coal down to the Pittsburgh coal. The upper beds of the great limestone contain univalve fossils; the lowest beds, lamellibranchs. No collieries on the Pittsburgh bed exist on the Greene county side of the river, and only two (Cat's run and Jacob's slope) on the Fayette side. Petroleum was obtained from wells along two miles of Dunkard's creek; the Bobtail well flowed 5,000 barrels in three weeks and ceased; the Wiley No. 1 produced 5,000, and continued to yield a little; the Allegheny well began with 125 barrels a day, and slowly went dry; the Lone Star would still yield to the pump in 1875 two or three barrels per week; the Butler well gave to the pump 1,500 barrels; the Bailey wells began with 30 to 40 and ran down to 1 or 2 per day; the Ross No. 1 gave 200 the first day and suddenly stopped; many other wells yielded more or less oil. The heavy oil came from a sand lying 175' beneath the Pittsburgh coal bed;

the sweet smelling light oil, from the Mahoning sandstone, 400′, 440′, 460′ beneath the Pittsburgh coal bed. (See Report K, p. 101.)

31. HUNTINGDON.—Area, 900 square miles; population in 1880, 33,954. Through the middle of this large county runs, north north-eastward, the deepest synclinal trough in the State, and in its deepest portion (on the Bedford-Fulton line) has been preserved the Broad-Top semi-bituminous coal field, on a mountain surrounded by the red shale valley of Trough creek. This again is surrounded by a mountain of No. X (Pocono) called Terrace mountain on the western side, and Sideling hill on the eastern; the two uniting in a knob (2000′ A. T.) overlooking the Juniata valley at Huntingdon. The trough rises slowly northward bringing up successive curves of VIII, VII, VI, V, and finally IV in the Seven mountains on the Clinton line. The east side of the trough being nearly vertical, the outcrops are straight and narrow, No. IV forming Standing Stone mountain; the west side of the trough being a very gentle slope, the outcrops are broad, and minor rolls in it produce the spurs of sandstone (VII) and limestone (VI) of Warrior's Ridge, crowned by pulpit rocks, through which the Juniata cuts its picturesque gorge, 4 miles long, between Huntingdon and Petersburgh, in which the nearly horizontal sandstone is seen overlying the limestone. Corresponding to the spurs of the ridge are spurs in Tussey mountain; and between the two sets of spurs, in the broad valley of Shaver's creek and the heads of Mill creek, sweeps the zigzagged outcrop of the fossil iron ore beds of No. V, mined at Greenwood furnace in Jackson township. Tussey mountain is gapped by the Little Juniata at Spruce creek, and by the main Juniata at Water Street, and then, after one anticlinal spur, runs straight on southward to Bedford county, carrying on its lower slope the block ore and fossil ore beds mined at Barree forge, at Marklesburg, and at points further south. No fossil ore is mined along the Standing-stone outcrop south of Greenwood, nor in Hare's valley. The south end of Kishicoquillis valley, with its slate (III) and limestone (II), just enters the county. The Jack's mountain anticlinal arch is cut through between Mapleton and Mt. Union, and here the vertical Oriskany outcrop (VII) has been extensively quarried for glass-sand. Jack's mountain runs on south to Three Springs, where a fine fault has been pictured and described in Report F. The No. VIII valley of Aughwick creek separates Jack's from Black-Log mountain, along the west foot of which the Marcellus brown hematite ore (VIII) and the Clinton fossil ore (V) are mined at many points, especially at Orbisonia, where Black-Log creek makes a gap, through which runs a downthrow fault of 90′, mapped and described in Report F. The Black-Log anticlinal brings up III and II in a straight valley (2 miles wide) between Black-Log and Shade mountains, which crosses the county. East of Shade mountain runs the straight Tuscarora valley of V, VI, VII, and VIII, with traces of fossil ore, and bounded on the east county line by Tuscarora mountain. Black-Log mountain south of Orbisonia is shivered by numerous very small cross faults, discovered in mining the fossil ore. On the summit of the mountain is a very remarkable deposit of brown hematite ore, connected with one of these faults. The north-west corner

of the county covers the north end of Canoe valley and the wide limestone (II) valley of Spruce creek and Warrior Mark with numerous deposits of brown hematite ore. Tussey mountain is faulted in the Spruce creek gap, the fault being cut in the P. R. R. tunnel. The Juniata cuts a remarkable gorge lengthwise in the middle red member of IV, separating the ridge of White Medina from the higher ridge of Oneida, a very rare occurrence, and wildly picturesque. The anticlinal of Canoe valley, between Tussey and Canoe mountains, is excessively steep and compressed, with a double fold along its crest line, and the Cambro-Silurian limestone strata (No. II) are thicker here than anywhere else in the State; for the extensive topographical survey of this region by Mr. Sanders (see the contoured sheets in Atlas to Report T) resulted in a measurement of (1) an *Upper limestone series*, 5400′; (2) *Middle white limestone beds*, 40′; and (3) *Lower limestone series* (including perhaps some beds properly belonging to the Potsdam formation No. I) 1160′, a total of 6600 feet. As Canoe mountain ends in a synclinal knob at the Little Juniata river, the steep west dips of Canoe valley give place to the gentle east dips of Sinking creek valley up to Tyrone forges, where there is a fault, and the rocks immediately descend vertically westward in Bald Eagle mountain. Three miles north of the gap this mountain is faulted (1500′) crosswise, twice, so as each time to shift the terrace of Oneida sandstone into line with the crest of White Medina sandstone, making a beautiful piece of topography, mapped by Mr. Harden. (See Report T^3.) The upper Medina is about 1170′, the lower red beds 520′, and the Oneida 1320′ thick. The gorge of Little Trough creek, splitting Rocky ridge at the north end of the East Broad-Top coal basin, is one of the most picturesque bits of scenery in the State, and is of considerable geological importance. The limestone strata in No. XI red shale around Broad-Top is also most interesting as the beginning in Pennsylvania of the great sub-Carboniferous limestone formation of the Southern and Western States. The exposure of a group of small coal beds in the E. B. T. R. R. tunnel through Sideling hill (described in Report F) has thrown a clear light upon the nature and value of the numerous so-called discoveries of workable coal crops in the Pocono sandstone No. X, in various parts of Pennsylvania, none of which have ever answered the expectations of explorers. The group represents, however, the valuable *sub-Conglomerate coal system* of Virginia, Tennessee, and Alabama. (See Report T^1.)

32. INDIANA.—Area, 830 square miles; population in 1880, 40,527. With the exception of five spots in as many gaps, and four other spots on the anticlinal axes, the whole surface of the county is occupied by the coal measures. The south-east county corner is in the bed of the Conemaugh river in the center of the Johnstown gap through Laurel hill, where XII, XI, X, and perhaps a little Catskill IX arch over each other. The north-east corner is on the crest of the continuation of the Chestnut hill arch, in the midst of a wilderness elevated 2000 feet above tide. The east line of the county therefor crosses diagonally the Ligonier valley coal basin, which, however, is divided into two sub-basins by a low anticlinal arch running through Nolo P. O. and Kimball P. O., bringing up

the conglomerate (XII) on Yellow creek at Strongstown. Both sub-basins are so deep that they are filled with the Barren measures, but the Productive coal beds crop out along the valleys which follow or cross the anticlinals, and an irregular belt of them, 2 or 3 miles wide, follows the great Chestnut ridge axis from Blairsville to the Jefferson-Clearfield county corner. This belt widens to 5 miles on the Conemaugh, and in the district of the south branch of Little Mahoning creek, around Robertsville, Smethport corners, and the heads of Bear run where coal-outcrops are abundant. At the first great bend below Blairsville the "Indiana anticlinal" arch crosses the Kishkimenitas river and runs in a wonderfully straight line past Indiana (1 mile E. of the town) and Kintersburg (Gilpin P. O.) to the Little Mahoning one mile above Richmond, and so on to the Jefferson line at the N. E. corner of Canoe township. The basin between this axis and that of Chestnut ridge, drained by Two Lick and Black Lick runs, is only deep enough to hold the Productive coals, with some areas of Barren measures in its hill tops; but, going south, the Barren measures take possession of the whole surface west of the Two Lick, and then invade the whole basin from Homer (Phillips' mills) southward. In the east end of Black Lick township the basin gets deep enough to take the Pittsburgh coal bed into its hill tops, and in Burrell township the hills north and east of Blairsville hold this bed (under a cover of 150 feet of upper measures) running about 6 feet thick and not very good, and lying about 200 feet above the river. At the second bend above Saltzburg the "Saltzburg anticlinal" arch crosses the river and runs on straight to the south-west corner of East Mahoning township where it flattens out and is lost; but here, on a line 4 miles further west, the "Perryville anticlinal" arch starts and runs on into Jefferson county at the N. E. corner of West Mahoning township. The Saltzburg axis crosses McKee's run near the mill, and exposes the Freeport Upper coal bed (E,) but all the others are underground, and the surface of the whole country is occupied by the Barren measures. Bed E is also brought to the surface in the bed of the Little Mahoning by the Perryville axis. The basin west of the Indiana axis, and between it and the Saltzburg and Perryville axes, is nowhere deep enough to allow the Pittsburgh bed to be preserved in any of its hill tops. But west of the Saltzburg axis all the higher lands of Young and Conemaugh townships between the streams which enter Black-Log creek from Armstrong county contain the Pittsburgh bed, 10 feet thick, with its regular upper bench and main clay parting as in the Monongahela river country. (See a description of Ashbaugh's, Alms', Ewing's, Evans', George's, and Holston's mines in H', pp. 274–278.) The highest geological ground in the county is in Elder's ridge, 4 miles N. E. of Coalport, where 200 feet of measures, capped by the Great limestone, and containing the Sewickley coal and limestone, the Redstone coal and the Pittsburgh Upper sandstone overlie the Pittsburgh coal bed. On Harper's run 217′ of Barren measures may be seen beneath the Pittsburgh coal bed, containing thin fossiliferous limestone beds, olive and red shales, and the Morgantown sandstone (50′ thick) the massive upper 15′ member of which makes the picturesque cliff scenery of this quarter of the county. The Barren measures in Indiana county may be called 600′ thick. Nowhere in the Ligonier basin has more than the lower 400′ been preserved. Seven or eight coal beds exist in the Barren measures, but no reliance can be placed on any of them, although one or another may be found in a good condition (3 or 4 feet thick) in some restricted locality, like Painter's coal at Nineveh and the Philson coal at Armagh. The beds seem to be pretty persistent throughout the region, but running only one or two feet thick. The Green Crinoidal limestone and the Black Fossiliferous limestone of the Barren measures are of not much economic importance, but have great geological value as bases of measurement down to the Productive coal beds. Limestone is very abundant in the county and the beds very numerous. Besides the two above mentioned there are three others in the Barren measures and six in the Productive coal series, of which the Freeport Upper limestone is 10′ thick in several parts of the county; the Freeport Lower 6′ on Two Lick; the Johnstown Cement bed (under coal D) varies from 2′ to 16′, and is 15′ in Black Lick gap; but the *Ferriferous limestone*, which is the great key rock of all the more western and northern counties, fades away to nothing at the Indiana anticlinal, and is nowhere to be found to the eastward of that line. The coal beds of the county will in future years be mined mostly by shafts. The uppermost one of the series (Freeport Upper coal E) is 150′ beneath the Conemaugh river at New Florence and 600′ at Blairsville; 400′ underground beneath the turnpike between Armagh and Lings, and so on elsewhere; where it comes to the surface it is a fine bed from 3½′ to 6′ thick, at Griffith's and other mines on Yellew creek 7′, at Agey's and St. Clair's on Two Lick 7′ 3″, on McKee's run 7′ 4″. The Freeport Lower coal (D′) is unreliable, varying from 1½ to 4½′. The Kittanning Upper coal (D) gets up to 4½′ on Little Yellow creek, and 5½′ in the German settlement. The middle coal is 3′ (C′;) the lower coal (C) small, but is 4′ at McFarland's at Greenville. The Clarion coal (B) is a noble bed ranging widely as 4′ to 8′ thick over a valuable fire-clay; but the famous fire-clay bed of Bolivar is under the Brookville coal A. There seems to be very little workable iron ore in the county. No evidence of the existence of productive oil sands has been obtained; most of the wells bored have been too short to reach the Venango oil rocks, much less the Warren and Bradford horizons. Of the natural gas springs, that of "Burning spring" in Deep Hollow, two miles below Blairsville, is best known, but it comes from the Mahoning sandstone, which yields oil and gas on Dunkard creek in Greene county.

33. JEFFERSON.—Area, 640 square miles; population in 1880, 27,935. The Clarion river is its northern boundary. The Red Bank creek, with its two forks of Sandy Lick creek and its smaller affluents, Mill creek, Laurel run, Red Lick, Trimble, Willow, Five-mile, and Beaver runs, drains most of the county westward. Little Sandy waters drains the south-western quarter, and the Mahoning flows (westward also) along the Indiana county border. The county resembles Indiana county as to its eastern and southern parts, and Clarion county as to its north-western half; the basins all rising gradually north-eastward, and the rolls be-

tween them running in straight parallel lines into Elk and Forest counties; so that while the Barren measures cover most of Bell and Henderson townships, and broad areas in Gaskill, Young, McCalmont, Winslow, Snyder, Perry, Porter, and Ringgold, and the hill tops in Knox, one half of the county exhibits the outcrops of the Lower Productive coal measures, which grow thinner and thinner northward, and at last leave most of the surface in Barnet and Heath, and much of that in Eldridge and Polk, destitute of coal beds, a region of Conglomerate No. XII. The "Indiana anticlinal" crosses Sandy Lick near the Clearfield county line, and exposes No. XII along Wolf run. The "Perryville anticlinal" passes Frostville, and dies away at Rockdale mills in Washington township. The "Waynesburg or Roaring run anticlinal," entering the county one mile east of its S. W. corner, runs straight across it to the Elk county line 6 miles east of the Clarion river. The "Bagdad anticlinal" crosses the whole county, passing 1½ miles west of Brookville. The "Anthony's bend anticlinal" runs parallel with the last at a regular distance of 4 miles from it. The "Kellersburg anticlinal" cuts across the north-west corner. Jefferson county therefore has six remarkably regular coal basins. The Brookville anticlinal brings up the Mauch Chunk red shale No. XI, and some of the Pocono rocks No. X, along Sandy Lick near the Armstrong county line. The same formations are cut down into by the Clarion river all along the northern county line. The Freeport upper coal (E) is not reliable in this county. In the eastern townships it is thick enough, but of poor quality; at Reynoldsville 4′, at Brockawayville thinner but better. Its limestone is 15 feet thick at Worthville, and keeps its unusual thickness along a narrow belt from here to Perryville, but thins rapidly westward and eastward, and cannot be found in Knox and McCalmont townships; but it reappears around Brockwayville. The Freeport lower coal bed is the main deposit of the county, and gives its great value to the Reynoldsville basin. It is in all parts of the county of workable thickness, sometimes thickening to 10 feet, but it varies much both in size and quality. It is already extensively mined, lying 43 feet beneath Coal E (4′ just under the Mahoning sandstone, the cliffs and blocks of which make a huge show.) The Freeport lower limestone (2′) lies 10 feet under it, on top of the Freeport sandstone (30′) which is here massive enough to make cliffs, but elsewhere in the county is shaly and inconspicuous. The Kittanning group of three coal beds is of small importance in this county; the upper nowhere exceeds 3′, and its underlying Johnstown cement bed is merely an impure ferriferous limestone. The middle coal is thicker in Knox and McCalmont, but impure, and in Union township shows its best aspect. The lower coal is persistent, but small and poor everywhere. The Buhrstone iron ore enters the county as far as Brookville, but fades away into insignificance. No trace of it is seen on the Mahoning where it belongs at Perryville, but it can be detected in the north at Brockwayville. The Ferriferous limestone, which carries this ore, is not nearly so thick a stratum as in Clarion and Armstrong counties. Its outcrop however runs along the sides of all the valleys of the Red bank and Sandy waters, and surrounds the hill-tops in the northern townships, furnishing an indispensable guide to the classical positions of all the other strata above and below it, especially for the sinking of trial oil wells. The Clarion coal bed (B) is a mere streak. The Brookville coal bed (A) is nearly everywhere of workable size, but impure. Its best show is made in Beaver township, where are many small mines in it. Between the three sub-divisions of the underlying conglomerate No. XII (300′ thick) lie shales containing very thin coal beds, of no value, the equivalents of the Mercer and Sharon coals of the Ohio State line. No oil fields are known in the county. (See Report H^6.)

41.* JUNIATA.—Area, 400 square miles; population in 1880, 18,227. This county, 10 miles wide by about 50 miles long, stretches in a gentle curve between the Tuscarora and Shade mountains from the Susquehanna river to the bend of the Juniata below Newton Hamilton on the Huntingdon county line. It is a single trough or basin, on the two sides of which crop out Clinton and Onondaga shales (V,) Lower Helderberg limestone (VI,) Oriskany sandstone (VII,) and the central part of which still preserves the Marcellus, Hamilton, and Chemung divisions of VIII, but nothing higher in the series, and, therefore, of course, no coal, although a few thin streaks of carbonaceous slate (VIII) have led to that belief. The sides of the basin are steep, and its belly is crimpled into several close folds, which produce the zigzags which appear on the geological colored map, so that the northern outcrop of VI and VII if stretched out would measure at least 70 miles, and the southern outcrop 40 miles. For measurements and descriptions of the formations see Mifflin and Perry counties. The fossil ore beds have been mined along the Juniata river (which cuts through Clinton rocks for about 15 miles) and in the low ridges in front of East and West Shade mountains, back from the river. East Shade mountain is a sharp anticlinal fold of Medina (IV) split lengthwise, so that the Loraine shales (III) appear on the crown of the arch in a secluded vale between the two crests of the mountain. Blue ridge is a similar rock wave of No. IV dying east at the river. Between the two mountains are the "Long Narrows," a basin of No. V, in which the river Juniata flows. West Shade mountain is a similar rock arch of No. IV, but so much higher than the other two that, when it splits into two crests going south, not only the slates of No. III, but the limestones of No. II, appear at the surface, and this becomes Black Log valley in Huntingdon county. At the eastern point of the county the basin has a sharp wave in its bottom, which brings up to the surface on both sides of the Susquehanna river at the mouth of Mohontongo creek both the Oriskany sandstone (VII) and the underlying limestone (VI.)

34. LACKAWANNA.—Area, 440 square miles; population in 1880, 89,269. This county, recently cut off from Luzerne, is in its south-eastern half a wilderness plateau of horizontal Pocono sandstone strata (X)

* The counties of Juniata and Mifflin are mapped together, and the map is numbered 41.

2000′ A. T., traversed by deep ravines of Catskill red rocks (IX) drained by Spring brook, Roaring run, and other smaller streams, through gaps in the Wyoming or Bald mountain into the valley of the Lackawanna river. This valley is the Scranton-Carbondale anthracite coal basin, the upper end of the great Northern Anthracite coal field entering the county at its north-east corner and running south-west into Luzerne county, with a length of 25 miles, and a width (of coal measures) of 2 miles at its upper, and 3 miles at its lower end, but nearly four miles wide at Scranton. Its north-western wall is the Shickshinny or Lackawanna mountain of steeply dipping Pocono rocks (X,) with a terrace of the Conglomate (XII) running along its face, beautifully sculptured into a series of triangles by the drainage from the crest. Opposite Providence, Blakely, and Carbondale the mountain is gapped by small streams. The country behind it, constituting Benton, Abington, Greenfield, Scott, Newton, and Ransom townships, is a wide and elevated anticlinal valley of Catskill formation No. IX, mostly drained north-westward by the Tunkhannock waters into the Susquehanna river in Wyoming county. This river forms the western boundary for about seven miles, and affords good sections of nearly horizontal Catskill and Pocono rocks, growing steeper down stream, and standing in bold cliffs (Campbell's ledge) in the gap at Pittston. Here the lowest pebbly beds of the Conglomerate (57′) have under them a remarkable black shale (5′) full of fossil plants (for list see Report G^7, pages 39–40) and *six species of fossil insects* belonging to the genera *Miamia*, *Haplophlebium*, *Euphemerites*, *Gereblattina*, and *Archymilacris*.† Mr. Lacoe of Pittston, whose magnificent collections furnished a large contribution to Mr. Lesquereux's Coal Flora (Report P,) found *Spirorbis carbonarius* shells attached to many of the plants, and obtained also a few poorly preserved shells from the lower layers of the shale. Beneath the shale lies a 3′ sandstone, and then 150′ of Mauch Chunk flagstone layers and greenish sandy shales, without a trace of the usual red shales of XI. The Pocono No. X here measures 353′, with massive gray sandstone at the top (100′); at the bottom, a beautifully ripple-marked massive gray sandstone (30′) having very large quartz pebbles at its base, lying on 100′ of soft green shale; and 55′ above it the white *Griswold Gap conglomerate* (45′,) the upper layers of which have been extensively quarried in Ransom township for public buildings. Alternations of X and IX (300′) underlie it; beneath these 1231′ of typical Catskill (IX) have been measured along the river down to the crown of the arch, near the west corner of Ransom township. The Lackawanna Coal basin holds only 307′ of coal measures, with a total of 20′ of coal, at its north-east end; 282′ of measures, with 13′ of coal, at Carbondale; 633′ of measures, with 67′ of coal, at Scranton; and 816′ of measures, with 85′ of coal, further west.* The floor of the great trough rolls so as to sub-divide it into several sub-basins. The rolls issue from the south-east

† Described by Mr. Scudder in his "Palæozoic Cockroaches," Boston Soc. Nat. History, Vol. VIII.

* See Report AA, p. 222 to 226.

side, and run diagonally westward, dying out against the north-west side. Twenty-one collieries are at work in the Carbondale mine inspector's district, producing in 1873, 1,738,853 tons. Forty collieries in the Scranton district produced in 1883, 4,725,315 tons. The north part of the Pittston district lies in this county. For details of these collieries, see Summary Tables on Sheet Plate VI of Second Report of Progress (AA.) The whole of this county is covered with glacial drift, and the surface rocks are scratched by ice, which must have been at least 2000' thick to pass over the valley and cover the great highlands to the south of it; but the drift in the valley itself is made up mostly of native fragments, very few pieces from New York or New England being observed.

35. LANCASTER.—Area, 970 square miles; population in 1880, 139,447. Its extreme length from the Berks-Lebanon corner south to the Maryland line is 43 miles. Its breadth from the Chester-Berks corner west to Falmouth on the Susquehanna river is 47 miles. The river bounds it for 41 miles (in an air line) and exposes sections of its three geographical belts: the northern New Red (Trias) sandstone belt, the central Lower Silurian (No. II) limestone plain, and the southern Azoic (gneiss, mica-schist, roofing-slate, and serpentine) country. The New Red formation, having been deposited on the ancient uneven limestone surface, has been itself reduced by erosion to a rolling hill country, (no where much more than 500' A. T.), very rough along the Lebanon line, and traversed by several trap-dykes, one of which extends from the river below Bainbridge eastward 25 miles, and is largely developed approaching the Cornwall iron mines in Lebanon county; another runs from the river at Falmouth 10 miles into Dauphin county; but the trap is not confined to the New Red, since it crosses the East Donegal arm of the limestone plain; and a third remarkable dyke starts from the river at Peach Bottom ferry and runs (N. N. E. 26 miles) through the Azoic rocks, across the Chester county valley limestone strip at May P. O. across the Salisbury arm of the limestone plain (past Springville), and into the Potsdam rocks (No. I) of Mt. Airy. Other smaller exposures of trap occur, notably one at the Wharton nickel mine, near the Gap west of Christiana station P. R. R. One third of the county is a limestone plain of unsurpassed fertility, under the highest cultivation, drained centrally by the two forks of Conestoga creek; its southern edge by the Pequea; and its north-western arm by the Chiquesalunga. An extensive bay of limestone land around Rome, Ephrata and Lincoln penetrates northward into the heart of the New Red belt, and shows how shallow the Mesozoic deposits must have been, although their universally north dip would seem to make them thick. In this bay are the old Warwick iron works. Back of Columbia are the famous Chestnut Hill brown hematite iron ore mines near the contact of the limestone and slate. Near Landisville, some lead and zinc ore has been obtained from the limestone, but no extensive deposits like those of the Saucon valley in Northampton county have been found, nor is their possible existence indicated by the structure, although the limestone strata are everywhere steeply upturned, and the whole limestone region seems to be traversed by sharp compressed anticlinal and synclinal folds,

some or which are probably overturned towards the north. Two of these little rolls bring the Potsdam sandstone to the surface at Manheim 4 m. N. of Lancaster. Another is seen in the cliffs of Chicques Rock facing the river above Columbia. Here the Potsdam is thrown up by a fault against the limestone lying north of it, and for a distance of 8 miles eastward. The edge of the limestone plain is made irregular by projecting spurs of Potsdam, (overlying gneiss) from Chester county; and Pequea valley and Conestoga valley are two projections of low limestone land into the Azoic country of the Welsh mountain region of that county. The edge of the limestone is masked in many places by Potsdam quartzite fragments, the mother rock of which does not appear. The contact of the limestone with the New Red is usually masked by fragments of mica-schist; especially is this true around the Ephrata limestone basin. It suggests that the New Red rests upon these schists, and that the limestone was high dry land, when the New Red estuary received its deposits. These "York schists" are the iron-bearing rocks of the county. The limestone formation does not consist wholly of pure limestone beds, but of alternations of these with argillaceous slates, and some quartzose beds, and it is impossible to assign a certain thickness to the mass. The southern part of the county may be said to be a country of chlorite-schists (exposed in the northern end of Turkey hill on the river between Fishing and Peter's creeks) apparently 5,500 feet thick, overlying an older series of mica-schists (southern end of Turkey hill to the mouth of the Conestoga) apparently 7,000 feet thick, and these overlying still older gneisses brought to the surface along the river at the mouth of Tocquan creek in a broad and gentle anticlinal, which must be considered as passing under Martic, Providence, Eden, Bart, and Sadsbury townships into Chester county. South of the Tocquan anticlinal the overlying series descend again. South of Fishing creek in Drumore township and to Peter's creek is a chlorite-schist belt containing the roofing slates of Peach Bottom so extensively quarried. (See pictures and descriptions in Report C^3.) South-east of this are two belts of serpentine, separated by a belt of schists; the southern running along the Maryland line, and holding the famous Wood *chrome-iron mines* (described in Report C^3, p. 195) which at one time produced all the chrome in the world, and in busy times as high as 500 tons per month. The serpentine is here unstratified, 1,000 yards wide, striking N. 78° E., with sandy chlorite slates north of it and hornblendic gneiss and syenite south of it. The *brucile* crystals from this mine, once exceptionally abundant and beautiful, are now rarely found.

4. * LAWRENCE.—Area, 370 square miles; population in 1880, 33,312. The Shenango river flowing south out of Mercer county, and receiving Neshannock creek from the north-east at Newcastle, meets (2 miles further south) the Mahoning river from the State of Ohio, and becomes the Beaver river. Along the eastern edge of the county Slippery Rock creek flows S. S. W. and joins the Conneconessing three miles from where the latter enters the Beaver at the county line. All these main valleys

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* This map is printed on the same sheet with that of Beaver.

are deeply trenched through the Lower Productive coal measures into the Conglomerate (XII), whose solid, massive sandstone upper and middle divisions (Homewood SS. and Conecomnessing SS.) shut the valleys in with vertical cliffs of singularly picturesque beauty. The exceedingly gentle rise of the rocks north-westward brings up the underlying "Sharon shales" in the valley of the Beaver one mile below the mouth of the Mahoning. From this point up the Mahoning and the Shenango, and for two miles up the Neshannock, these shales occupy the lower slopes of all the valleys and ravines, gradually pushing back the Conglomerate series (300′ thick) into the hills, leaving only the high lands and divides occupied by the lowest (Clarion) coal series, crowned in three places with Ferriferous limestone, viz: one patch (2 miles long) in Wilmington township; another (3½ by 1½ miles) in Neshannock township; and a third (3 by 1) in Union township. All the upland east of the Neshannock and east and west of the Beaver river is occupied by the Ferriferous limestone supporting the three Kittanning coal beds; and in Big Beaver and Perry townships the high divides hold also the two Freeport coal beds, and even some of the lowest Barren measures. The Mahoning sandstone is quite shaly in Lawrence county; but the coarse, massive "Buffalo sandstone" (30′) caps the highest ridges of Perry township with bluffs and gigantic blocks. Under it is the Brush creek coal 4′, with underclay 3′, and limestone sometimes 8′ thick. The Freeport upper coal (70′ lower) locally known as the "Five-foot" and "Four-foot" bed, is over 6′ thick in several mines near the north line of Little Beaver township, but thinner and poorer elsewhere; its underlying limestone seems wanting. The underlying sandstone which makes such noble cliffs on the Ohio river and Little Beaver creek is a laminated sandy shale along the Newcastle and Darlington railroad, but is quarried for flagstones near the west line of North Beaver township, and also south-west of Mt. Jackson. The Darlington (Kittanning) coal bed varies from 2′ to 4′, and is exceptionally pure at the Beaver valley mines, being greatly esteemed at iron mills and as coal gas; but in the Slippery Rock valley it gets sulphury. In the S. W. corner of Plain Grove township it is "block coal" (4′) and was used raw in the old furnace on Taylor's run. The most northern outlier of it is on a high knob on the Mercer county line in Washington township. Eight analyses show from 38 to 41 p. c. of volatile matter, 1.6 to 5.0 ash, 1.6 to 3.0 water, and .5 to 2.5 sulphur. (See Report Q^2, p. 34.) Two other coal beds of the Kittanning series spread through the county and are locally mined, one of which overlies the famous fire-clay deposit of Beaver county, 10′ thick where mined 1 milebelow Clinton, just outside the south Lawrence county line, and 10′ thick where mined by Mr. Henderson north of Croton. Many more mines might be opened on this fire-clay. The underlying 30′ Kittanning sandstone is very massive near Harlansburg, and over the ore diggings near the north Wayne line. The "Buhrstone iron ore" seems confined to Wayne, Shenango, Slippery Rock, Scott, and Plain Grove townships east of the Beaver river. At Houk's mine the section is soft "keel" ore 1′, hard massive mottled ore 7′, bunch and lump ore mixed with buhrstone flint nuggets 6′, lying on the Ferriferous limestone 3′. At some mines there is only from 1′ to 4′ of ore; at others it swells to 20′, and even (Big bank) to 22′, entirely replacing the limestone in such a way as to show that the deposit was made in an ancient cavern, for a wall of limestone can be seen against which the ore stops. (For eight analyses of this limonite ore see Q^2, p. 42.) The outcrops of the limestone range up and down all the valley sides of the eastern and south-western parts of the county, its usual thickness being 15′, frequently swelling to 25′, or fading away to nothing, and divided into an *upper gray* and a *lower blue* limestone (often with an intervening shale) both very fossiliferous: *Spirifer cameratus, lineatus, opimus; Productus nebracensis, longispinus, semireticulatus, prattenanus; Hemipronites crassus; Chonetes mesoloba; Euomphalus rugosus; Pleurotomaria grayvilliensis, carbonaria, turbinella; Bellerophon carbonarius, montfortianus, percarinatus, stevensanus; Nucula ventricosa; Nuculana bellistriata; Macrocheilus primigenius, ventricosus; Astartella concentrica; Polyphemopsis peracuta; Aviculopecten carbonarius, whiteii; Athyris subtilita; Solenomya radiata; Macrodon obsoletus; Aviculopinna americana; Nautilus occidentalis; Platyceras tortum; Synocladia biserialis; Lophophyllum proliferum; Orthoceras cribrosum; Archæocidaris wortheni; Pentremites pyriformis; Zeacrinus mucrospinus,* and many others; stems of *crinoids* sometimes make up one half of the rock; *cone-in-cone* structure of the rock is common; quarries are numerous, especially near Newcastle. Four analyses (Q^2, p. 48) show 93.3 to 95.7 p. c. carbonate of lime, 1.1 to 1.7 carb. magnesia, .6 to 1.5 oxide of iron and alumina, .08 to .16 sulphur, .017 to .047 phosphorus, 2 to 3 insoluble. Close under the limestone lies the "Scrub grass" or Clarion *upper* coal of slight importance; 10′ to 15′ under it the small *middle* coal (20″ thick and quite pure at Crawford's mine, Neshannock township;) and the *lower* (Brookville) coal, 2′ where mined above East Brook. Between the upper and middle divisions of the conglomerate come the Mercer upper and lower coals, *with a limestone over each* except where the two beds come together as on Slippery Rock creek. The upper is a "block coal" bed 5′ thick a few miles west of Edenburg. Iron ore accompanies the upper limestone. (For the fossils of these limestones see Q^2, p. 61.) Between the middle and lower divisions of the Conglomerate lies a "block coal" bed, which is 2′ thick at the falls of Quakertown run. Under the lower division of the conglomerate lies the "Sharon block coal bed," nowhere yet found workable in this county; 40′ of shales under this coal are visible at the north and west county lines. Glacial drift covers the whole county north and west of the line of the Terminal moraine (described in Report Z) which crosses the Butler county line and Slippery Rock creek a little below Roseport, the Beaver river at Chewtown, and the Little Beaver where it enters Beaver county. Petroleum (heavy oil) has been got from the Slippery Rock wells in Perry township, about 550′ beneath the bottom of the Conglomerate XII; the Lawrence well giving 40,000 barrels up to 1877.

22. LEBANON.—Area, 350 square miles; population in 1880, 38,476. This county shaped like the spanker sail of a ship is cut out of Dauphin by a line running along the Sharp mountain 10 miles, and another line 20 miles long drawn south across the Stony creek red shale valley of XI, Second mountain X, the Pinegrove valley IX, VIII, and V, the Blue mountain IV, the Great valley with its belts of slate III, and limestone II, and the Mesozoic New Red belt, to the Conewago creek and trap dyke along the Lancaster county line. Its geology is therefore an unchanged continuation of that of Dauphin county eastward (which see already described) except that the Sharp mountain begins to split and open into a coal basin, between two crests, half a mile apart at the Schuylkill county corner. Another difference consists in the reappearance of traces of the Helderberg limestone VI and Oriskany sandstone VII, two formations quite wanting in Dauphin county. The overturned condition of the formations at the Susquehanna, gradually changing to vertical, becomes a regular but very steep north dip in Lebanon county; and in front of the Blue mountains runs a sharp anticlinal, in the trough south of which has been preserved a strip of No. IV, making Hole mountain, and well illustrating the plicated structure of the Great Valley. Three longitudinal trap dykes run along in the slate belt south of Jonestown; and other exhibitions of trap are made at the edge and in the body of the New Red district, especially along the county line south and west of Cornwall. A triangular area of slates is noticeable just east from Shafferstown, and the dips in the limestone on its north-west and north-east sides prove that it is a trough, or dimple in which the lower strata of Formation No. III have been preserved, covered along the south side of the triangle by New Red. In the south-east corner of the county Potsdam No. I surrounds the west end of Mulbaugh hill. The breccia of Mt. Ararat, a ridge running 3 miles north of Lebanon, is a remarkable exhibition of limestone strata crushed to fragments by pressure and re-cemented in place. The pride of Lebanon county is its wonderful mine of magnetic iron ore, containing sulphurets of iron and copper, and encased in decomposed trap, against a south wall of white marble, overlaid by New Red shale, at Cornwall. The ore has been stoped in three adjoining low hills for many years to supply a number of large blast furnaces near the mine and at Lebanon, and for sale to most of the other blast furnaces of Eastern Pennsylvania.

36. LEHIGH.—Area, 360 square miles; population in 1880, 65,969. This county carries the geology of Berks county (already described) eastward, along the Great Valley and South Mountains to the Lehigh river, which issues from the Blue (Kittatinny) mountain through a water-gap of surpassing beauty. The slate belt however, which is 17 miles wide at the Berks county line, contracts itself to 9 miles at the river; and the limestone belt, which is only 4½ miles wide at the Berks county line, widens to 9 miles. This change is effected by a set of four anticlinals which cross the limestone belt diagonally (E. and W.) and enter the slate belt making coves of lowland, walled round by a slate escarpment about 200 feet high; the coves being separated by projecting spur ridges of slate,

one of which, just south of the Jordan, is five miles long from root to point. In these coves are large brown hematite iron deposits, mined by open quarries, one of which in especial, the old Balliot mine at Ironton, is of vast size and very famous. (See a map of it in Report D^2). The excavation is 2,000 feet long, 600 wide and 100 deep to the water level, with walls of white, black and red clay, a deposit of oxide of manganese, and much ore under foot. It lies in a limestone cove half a mile wide cut off from the slate belt by a projecting strip of slate on the south. Other deposits are mined in the vicinity. Two hundred and two mines are marked upon the topographical map of the district published in Report D^2. Those at Trexlertown are also of large size, and all have contributed to make the blast furnaces at Allentown, Catasauqua, Hokendauqua, &c., on the river, among the largest and most productive iron works of the world. The floor of the limestone belt (No. II) is broken at two points by small projecting hills of gneiss and Potsdam quartzite No. I; one on the Berks county line; the other where the Little Lehigh passes out of Lower Macungie into South Whitehall township. The South Mountain mass of gneiss separates into two ridges, in Upper Saucon county, which enclose the head or west end of the Saucon limestone valley, in which lie the world-famous deep mines of carbonate and silicate of zinc, in layers of limestone. The Friedensville mine of zincblende and pyrites disseminated throughout a series of minutely fissured limestone beds (10′ to 40′ thick) is 1,000 feet long on the strike and 250′ deep on a south-by-east dip of 30° to 35°. The southern slope of the mountain (none of whose summits exceed 1,200′ A. T.) is banked against by the northern edge of the great New Red formation of Montgomery and Bucks counties, the loss of which by erosion is plainly shown by the fact that its edge rises to 930′ A. T. overlooking a gneiss summit to the north of it which is only 830′ A. T. The outcrops of Potsdam quartzite No. I, which are very numerous at the foot, on the slope, and even at the summit of the gneiss hills (not well exhibited on the small map, but all laid down in yellow on the Index map in D^3 Atlas) are seen at Centre Valley in the east corner of Upper Saucon township passing down under the New Red; as is also the limestone at other places. The slate quarries at Slatington and up Traut run (west of it) are described in D^3, Vol. I, with a section (on page 147) showing the two folds into which the six sets of beds (in a total mass of 500′ of the formation) have been pressed. The Franklin beds (15′) overlie the Hess beds (50′) 63′; these overlie the Washington beds (60′) 12′; these overlie the Blue vein (15′) 15′; these overlie the Pennlynn beds (25′) 222′; these overlie the Blue mountain quarry beds (12′) 16′. (For pictures of quarries; details of cleavage; notices of slate quarries elsewhere in the county, &c., see Report D^3 Vol. 1.)

Luzerne.—Area, 910 square miles; population in 1880, 133,065. This county is wealthier in mineral values than any other, except Schuylkill. The great Northern Anthracite coal field crosses it; and the Eastern Middle Anthracite coal field forms its southern border. Between them runs the great Montour's Ridge rock-arch bringing to the surface an anticlinal belt of Marcellus, Hamilton, and Chemung rocks No. VIII (for the description of which see COLUMBIA COUNTY) 5½ miles wide at the line, extending to the Susquehanna river 5½ miles, and about 8 miles further east up the center of the Wapwallopen valley; with a south-dipping belt of Catskill rocks (No. IX) on its south side, and a north-dipping belt of the same rocks on its north side, the two uniting around its end, and then flooring the whole valley, 6 miles wide, for about 11 miles further east, into Bear Creek township. Here a high plateau (1800′ A. T.) of Pocono rocks (No. X) covers the Catskill rocks as far east as the county line and as far south as the Lehigh river. Bear creek flows in a shallow bed through this high wilderness, and then cuts a deep channel down to the Lehigh. Mill creek and several other small streams cut precipitous glens northward down into the coal basin. The Nescopec mountain (No. X) separates the southern Catskill belt from the Mauch Chunk red shale valley of Conyngham, which surrounds the Middle coal field, and in the gap which Nescopec creek makes through the mountain its steeply-tilted rocks can be studied; No. XI being here about 2,000′ thick; No. X, 600′; transition beds, 375′; No. IX, 4,400′; transition beds, 245; No. VIII, 2,500′; total, from the bottom of the Conglomerate No. XII down to the lowest rocks seen in this county at the mouth of the Wapwallopen, say 9,000 feet of strata. A fine section of these formations, descending steeply (northward) under the west end of the Northern coal field, is made by the river between Hartville and Wapwallopen a distance of 4½ miles; but the red shale (No. XI) is here diminished in thickness to 1,335′; when it rises from beneath the coal basin, a mile further on, in Shickshinny gap, it is only 1,200′; and so it thins away in 22 miles to 150′ in the gap at Pittston; and is certainly not thicker than that on the top of the Great North mountain at the north-west corner of the county. The front brow of this Great North mountain consists of Pocono rocks (No. X), here only 300′ thick; and its slope of transition beds (X–IX) 430′; and of Catskill beds (No. IX) here only 1,800′ thick, composed of the usual red and gray sandstones and red and gray shales, with some conglomerates, and calcareous breccias containing innumerable *fish-plate fragments*. Between the North mountain and the Wilkesbarre (Wyoming or Northern) coal field spreads a high valley or rolling plain of lower Catskill rocks, gently lifted in a broad low arch (the flattened east end of the Buffalo mountain anticlinal) along the axis of which Harvey's creek, Pike's creek, and several branches of Shickshinny creek make small local exposures of the top layers of the underlying Chemung formation (No. VIII), which, rising westward gradually take possession of the whole surface around Bloomingdale, Harveyville, Cambria, Townhill and New Columbia; the axis of the rock-arch crossing the Susquehanna river at the north-east county corner. The Wyoming coal basin (see Report and Atlas on the Northern Anthracite field) enclosed between the Shickshinny mountain (X) on the north and the Wyoming mountain (X) on the south, with their terraces of Conglomerate (XII), is (as to its coal area) 4 miles wide at Pittston, 5½ at Wilkesbarre, 2½ at Nescopec, and comes to a point at Hartville, a length in the county of about 25 miles.

Its floor being crumpled into many diagonal rolls, it is sub-divided into as many small basins, which run out eastward against the side of the Wyoming mountain. The deepest of these basins near Wilkesbarre holds about 900 feet of coal measures, and 16 coal beds, mined at 59 collieries (in the Wyoming Mine Inspector's district) producing in 1883, 7,400,096 tons. The Pittston Mine Inspector's district (three fourths of which is in this county) supports 39 collieries, producing in 1883, 2,173,144 tons. At the top of the series, on a hill near Wilkesbarre, fossil shells of a Permian type can be found; as in Greene county in a similar situation plants of a Permian type are found. The Eastern Middle coal field in the southern townships is subdivided into fourteen coal basins, lying side by side on an elevated plateau of the Conglomerate No. XII, some of them only deep enough to hold the lowest workable coal bed; others the Buck mountain, Mammoth, and several higher beds. Of these the Black creek basin has an east and west length of 23 miles (in this county) by a width of 1 to 1¼ miles; the Hazleton basin a length of 12 miles, and a width of 1 mile. In the Green Mountain Mine district are 5 collieries, producing in 1883, 429,555 tons; in the Black Creek district, 24 collieries, producing 2,455,091 tons; in the Hazleton district, 15 collieries, producing 1,443,448 tons; and in the Beaver Meadow district (partly in Schuylkill county) 12 collieries, producing 1,236,006 tons; total, 56 collieries and 5,564,100 tons. While in the Wilkesbarre basin there remains about 900 feet of coal measures, with a total thickness of 90 feet of coal, more or less, there remain in the Black Creek basin only 558′ of measures, with 38 feet of coal; and at Hazleton 528′ of measures with 81 feet of coal. (For all such details see Report AA, pp. 226, 232, 234.) Although Wilkesbarre and Hazleton are distant from each other 20 miles, the same coal beds can be recognized at the two places, showing that they once spanned the wide rock-arch of the Wapwallopen valley; that all the coal fields were once united; and that the slow erosion of ages has spared to the people of Pennsylvania but a small fraction of the mineral which once covered the entire area of the State. The Carbondale main coal is 7′ thick; the Baltimore bed at Wilkesbarre 15′, and the Red Ash bed 17′; the Buck Mountain bed at Nanticoke 10′. In the Black creek basin the Buck Mountain bed is 13′, and the Mammoth bed 27′. At Hazleton the Twin bed is 12′ (with a 3′ parting); another 158′ below it is 9′; a third 42′ lower is 4½′; a fourth 6′ feet lower is 6½′; the Mammoth 124′ lower is 33′; the Wharton bed 44′ lower is 9′; and the Buck Mountain bed 88′ lower is 8′ thick. The action of the northern ice in the Glacial age is well-illustrated in this county. All the exposed hard rocks, even the very summit of Penobscot Knob which overlooks the Wyoming valley at a height of 2,200′ A. T. are scratched; and the whole country north of the line of the Terminal Moraine is covered with a sheet of Drift. A rather mysteriously-excavated ancient valley of the Susquehanna river lies beneath the present Kingston flats, so deeply buried that a bore hole near Forty Fort went down through fine mud and quicksand 212′ (185′ below present river level) before striking solid rock. (See Report G^7 p. 25.) The line of the Terminal Moraine is traced (in Report Z, pp. 99 to

111) from the south-east corner of the county, up Sand Run valley, over Hell Kitchen mountain, across Conyngham valley, over Nescopec mountain, and down to the river at Berwick in Columbia county. It is finely exhibited where it surmounts the crest of Nescopec mountain opposite Hughesville. (See local map in Z, page plate 14.)

38. LYCOMING.—Area, 1,205 square miles; population in 1880, 57,486. The rock formations of this large area range from the coal measures (No. XIII) on the Allegheny plateau (2,000' A. T.) in the northern tier of townships, down through the Devonian and Silurian strata, to the limestones of No. II in Nippenose and Oval valleys in Limestone and Armstrong townships, two elliptical holes of erosion sunk through the great Nittany valley anticlinal arch of Medina sandstone (No. IV), between the Seven mountains of Union and Clinton counties, and the Bald Eagle mountain which bounds the valley of the West Branch Susquehanna on the south. At the foot of this mountain flows the river along the outcrop of Helderberg limestone (No. VI), the Oriskany (No. VII) being absent, and the hills of Hamilton, Chemung, and Catskill forming the foothills at the foot of the bold escarpment of the Allegheny mountain, which sweeps in a gentle curve from west to east the whole length of the county, 47 miles. The Nittany valley anticlinal slowly sinking eastward, the river bends around it at Muncy; and all the formations (Clinton, Onondaga, Lower Helderberg, and Marcellus) curve back through Clinton, Brady, and Washington townships; form concentric loops in the White Deer Hole; and then pass east again through Union county, to cross the river into Northumberland. The limestone beds of the river valley are extensively quarried. "Black marble" beds of great beauty occur in the Trenton limestone of Nippenose valley, where fossils are abundant. A sharp steep anticlinal arch runs along the foot of the Allegheny mountain and brings up the Mansfield iron ore of Tioga and Bradford counties, compact, reddish brown, in red slate, very fossiliferous, full of fish teeth, dipping very steeply to the north, and 2' to 4' thick. The same bed has been a good deal mined at Cogan's station on Lycoming creek for the Danville furnaces; at Quigglesville, 1 mile N. W. of Perrysville, with phosphate pebbles (fish dung?) dipping only 6° to 8° N.; on Stewart's run N. E. of Jersey Shore; and on Furnace run near the south line of Watson township. Four analyses given in Report G^2, p. 153, show oxide of iron 41 to 50 (metallic iron 28.5 to 35); oxide manganese 1 to 3; lime 1 to 6; insoluble residue 29 to 46; and phosphoric acid .863 to 1.759 (phosphorus .377 to .768.) The Marcellus iron ore has not been recognized in this county. One Clinton fossil ore bed has been mined for two miles along the face of Bald Eagle mountain opposite Jersey Shore, in three layers of block ore 3 inches, 4 inches and 8 inches thick (average) yielding as usual about 30 per cent. of iron. Very little attention has been paid to this ore along its outcrop of 45 miles, but what prospecting has been done has been discouraging. The Ralston iron ore of No. XI, underlying the Conglomerate No. XII, along the brow of the precipitous one thousand foot slopes of the grand gorges of Pine creek and its forks, Lycoming creek and its side branches, and Loyalsock creek

with its two branches and side ravines, has been traced throughout northern and western Pennsylvania, but nowhere mined with any success except in Fayette county. At McIntyre No. XII is only 70′ thick, and No. XI under it only 75′, divided into: (1.) 20′ of red and gray slates with large lumps of ore, and some ore beds *one inch* thick; (2.) 5′ of shale with *two feet of ore;* (3.) 50′ of red shale with small nodules and layers of ore. No. X shows 105′ of sandstone, 10′ black slate with ore nodules, 40′ of sandstone, 420′ of shale and sandstone, 1′ *coal bed*, 80′ massive sand stone=total 655′. At the Red Run mines are 3′ to 4′ "white ore." At the old Carterville Furnace mine the ore yields 31 per cent. of iron and has only .07 per cent. phosphorus. The old Astonville furnace was started in 1837, the new one in 1853. Every attempt to establish an iron industry on this attractive deposit has ended in disaster.* A small patch of coal measures remains on the mountain top of Plunkett's Creek township between Big and Little Bear runs, with one small coal bed on 120′ of coarse Conglomerate XII; another remains on the mountain top in the south-east corner of Cogan House township; and several at the west county line, ends of the Queen's run and Tangascootac basin of Clinton county. A wide gentle anticlinal arch runs through Cascade, Lewis, Cogan House, Cummings and McHenry townships, and all the coal measures (XIII), conglomerate (XII), red shale (XI), and much of the Pocono sandstone (X) have been swept away from the county, so that wide elevated rolling valleys of Catskill red shale and sandstone (IX) lie sunk in the general upland. North of this arch is an equally well-marked synclinal trough in which a large body of coal measures have been preserved in all the mountain tops of McIntyre, Jackson, Pine and northern McHenry townships. Little Pine creek (Blockhouse run) cuts the coal field in half, a western portion 15 miles long by 3 wide, and an eastern 17 miles long by 4 wide. The highest summits are covered with remaining blocks of a conglomerate (80′ thick at Red run), under which lies coal E from 2′ to 5′ thick; then massive sandrock 80′; coal D 7′ (with a 3 foot parting); sandstone 21′; coal C′ 1′; sandstone 13′; coal C 1′ to 3′; shales 20′; coal B (the "big bed") 4½′ to 6′; slates 20′; coal A less than 1′; Conglomerate XII 130′; XI 120′; X 300′; IX 40′=795′ to Little Pine creek level. The Banner, Old and New Bache, English and other mines get coal which yields to analysis from 20 to 22 per cent. gas, and from 7 to 14 ash. Old and new mines at Ralston, Astonville, Cartersville, Red run and McIntyre work the same beds, which, at McIntyre appear thus: Top rock 50′; coal E 5′ 7″; interval 80′; coal 9 inches; interval 5′; coal D 2′ 3″; interval 48′; coal C 7′ 4″; interval 21; coal B 7′ 1″; interval 13′; coal A 9′ 10″; sandstone and conglomerate (XII) 66′,=total 332′. (For the exact details of this section see Report G², p. 124.) The Terminal moraine enters the county at its eastern point, crosses Muncy creek just below Tivoli, ascends the escarpment to the top of the Allegheny mountain, swings round north to Bodinesville, crosses the Lycoming creek and again as-

* For the carefully made section at Ralston, see Report G², p. 106.

cends to the highland, runs westward north of Gray's run, and crosses Pine creek (first fork) just below Seachrist's mill, the next branch below Texas, and the main creek at Lloyd, where the Babb fork comes in, then traverses the high plateau to Elk Run P. O. and descends into Pine creek valley a second time just as it enters Potter county. The whole surface of Lycoming county north of this line is scratched and covered with Drift. (See Report Z.)

39. McKEAN.—Area, 1,000 square miles; population in 1880, 42,565. This is a square district 38 miles long upon the New York State line, by 27 wide on the west county line of Potter. The branching heads of the Allegheny river gather the rain-fall of its eastern half to flow northward into New York at Olean; the small water-tree of the Tuniangwant (Potato creek) does the same for Bradford and Lafayette townships, while the western townships shed their streams into Warren county, especially by the Kinzua and Tionesta valleys. Innumerable ravines descend in all directions from the flat and narrow divides into which the now deeply-sculptured table land is broken up, lying at a general level of more than 2,000′ A. T., and the steep slopes of these ravines are cliffed and terraced by the lower coal measures, the three divisions of the Conglomerate No. XII, the thin underlying shales, the massive sand-rocks of No. X, and the softer shales and sandstones of No. IX. The foot slopes and valley beds of all the main water-courses are composed of the upper beds of the Chemung formation, far down in which lie the sands of the Bradford oil field. The highlands are covered with what remains of the Lower Productive coal measures, nowhere more than 140′, holding a coal bed 1′ thick; 40′ under that the Dagus coal bed 3′, opened only at two places; 10′ to 30′ below that the Ferriferous limestone 4′ to 8′ thick at Clermont, and 30′ below that the Clermont coal bed 3′ thick. The Alton coal beds (upper, 2′ to 3½′; middle, 4′ to 8′; lower 4′) mined at Alton, Clermont, and elsewhere, lie between the Upper (Johnson's Run sandstone) and Middle (Kinzua Creek sandstone) divisions of the Conglomerate No. XII. The Marshburg coal bed between the middle and bottom divisions of XII, and lying 170′ beneath the Ferriferous limestone, has been opened at several places, but never much worked, being thin and poor. The bottom division of XII (Olean round-pebble conglomerate) caps the high ridges along the New York line, and makes picturesque "Rock cities" (pictures of which are published in Report R, plates 1 to 6.) It varies from 25′ to 50′, and under it lie red and blue shales varying from 40′ to 70′ Sometimes a bed of black slate or poor coal bed underlies the Conglomerate. Beneath the shales lie Sub-Olean (flat-pebble) conglomerate, very uniformly 40′ thick, making fine ranges of cliffs along the Kinzua valley, for example at Ludlow station on the Phila. and Erie railroad (1,604′ A. T.) Beneath it are other Pocono sandstones and shales, near the bottom of which lies the Marvin Creek limestone, exposed along Shephard run in southern Bradford (2′ thick), and on the west slope of Chappel hill in northern Sergeant (5′ thick), and elsewhere, or traceable by its fragments pitted with the indistinct casts of fossil shells, or by lime-water springs and deposits of tufa, as on the Warren road 6 miles west

of Smethport. The dip of the formations is scarcely perceptible southwards, and the Pocono formation (X) thickens in that direction, thus: at Smethport 250′, at Norwich 300′, at Keating station 400′, at Shippen 450, at Emporium 550′, at Driftwood 700′, at Sinnemahoning in Cameron county 750′. This fact is important to those who bore through to reach the Bradford oil, for their trial wells must be proportionately deeper the further south they locate them. The Catskill formation (IX) varying little from 250′ in thickness in the western and central townships, thickens to 334′ at Ridgway (Elk county), to 347′ in the Cameron well (Cameron county), and to 370′ at Coudersport (Potter county.) The *Chemung* (VIII) *upper* shales and soft sandstones are 1,282′ thick at Bradford, 1,305′ at Smethport, 1,300′ at Wilcox (divisible into 350′ upper gray shales, 300′ middle red shales,* and 650′ lower gray shales.) The *Chemung middle* gray sandstone and shale beds. 650′ thick, make the famous *Bradford Oil-Sand Group* of the drillers shown in the Dennis well thus: gray s. and sl. 36; *1st sand* 25′; gray s. and sl. 44′; gray sl. 175′; brown s. 17′; sl. 28′; *2d sand* 36′; gray sl. and some s. 283′; *3d sand* (the only productive Bradford oil sand, although the other two have produced some "slush oil" at one place) about as coarse as ordinary Jersey shore sand, loosely cemented, averaging 45′ in thickness, and so much alike under an area 18 miles long (N. 30° E.) and 12 miles wide, that 98 out of every 100 wells have been productive. The first well drilled by the Deans in 1865 at Custer City, only 900′, was abandoned, because the "3d sand" (then unknown) lies 1,130′ beneath railroad grade. The first Tarport well (605′) was also stopped 400′ too soon. The first Barnsdall well (begun in 1862) at Bradford village was deepened in 1866 to 875′, 150′ short of the sand. The "3d sand" was discovered November, 1871, by the first Foster Oil Co. well, 2 miles N. E. of Bradford, at a depth of 1,110′ ("slush oil" at 751′), producing 10 barrels. Three years later the Butts well No. 1, 2½ m. N. E. of Bradford, started off December 1874 with 70 barrels, and inaugurated the wonderful later history of the region. By April, 1880, 4,000 producing wells were yielding 50,000 barrels per day, i. e. *five sixths* of the total oil production of Pennsylvania that month. The total production of the years 1877–1882 (inclusive) was 85,866,000 barrels. (See Carll's chart in Report III Atlas), in 1883, 13,235,000; and in 1884, 11, 682,000; in all 110,783,000 barrels. The geyser well near the Mountain House hotel at Kane, and the Wilcox spouting well, are described in Report R, pp. 246, 248.

40. MERCER.—Area, 660 square miles; population in 1880, 56,161. The Shenango river flows south down the western side of the county making a great bend to the east through Delaware township, and another to the west in Hickory township, where, at Sharon, it approaches the Ohio State line within one mile, and two miles below Sharon within a quarter of a mile. Otter creek flows south through the middle of the county to join the Neshannock at Mercer. Wolf creek flows south through Worth, Wolf Creek, Pine and Liberty to the south-east corner. Sandy creek

* Mansfield fossil ore beds of Tioga and Bradford counties?

drains the north-eastern quarter eastward into Venango county. 21 patches of the Clarion coal bed have been preserved on the high divides in the eastern and southern townships, two of which, in Pine and Liberty, are of considerable size, and support smaller overlying, isolated areas of the Ferriferous limestone. 4 hill-tops south-east of Jackson Centre contain the limestone; another at Henderson post-office; and two others on the Lawrence line in Springfield township. The hills on the Butler county line on each side of Wolf creek are high enough to take in the Kittanning coal (2′) and the Darlington coal (3′). The Ferriferous limestone is 12 to 15 feet thick along Wolf creek, south of Pardue in Finley township it does not seem to exist, and the bore holes south of Stoneboro in Lake township did not find a trace of it. It seems to be absent also in the high, narrow ridge south of Greenfield in Lackawannock township. At the quarries in Jackson township it is from 9′ to 12′ thick, the top layers having been planed off in the ice age, and scratched and covered with drift, which may conceal it also in Boreland's Knob in New Vernon township, and in a very high knob in French Creek township, near the Crawford line. The northern drift covers the entire county, even on the very summit of Keel ridge in Hickory township 1250′ A. T. Bowlders of large size are often found in the drift; granite, gneiss, greenstone from New York or Canada, mixed with limestone, sandstone, shale, pieces of coal, and an abundance of bluish-white clay. Oakland shaft No. 1 struck a large granite bowlder in blue clay 60 feet below the present surface. A bore-hole at Stoneboro went through clay, sand, gravel and bowlders 60′, blue clay 30′, total 90′. The whole surface of the county is dotted with loose bowlders, some of them 10′ in diameter, which were once no doubt enveloped in clay and sand now washed away from them. Some of the valleys are filled with drift to a considerable extent, and swamps like that on the low divide between the head of Little Shenango river and the head of Sandy creek, represent ancient ponds produced by dams of drift left by the ancient glaciers on their retreat. The ancient valley bed of the Pymatuning at its junction with the Shenango has been filled up 100′ to the present surface of the tamarack swamp. A deserted buried valley, once occupied by the Shenango, extends along the line of the Erie and Pittsburgh R. R., from Clarksville station to Shenango station, between hillsides 200′ high. A bore-hole 63′ deep through silt did not strike bed rock. The Neshannock valley ancient bed near Leesburgh station (New Castle and Franklin R. R.) has been filled with drift more than 80′. The Scrub-grass coal bed, less than 1′ thick, is found underlying every exposure of the Ferriferous limestone. The Clarion coal bed (20′ below the limestone in Beaver county) has not been seen in Lawrence. The Brookville (Pardoe) coal bed, ranging from 40′ to 70′ below the limestone is mined at many places in Findley, Jackson, and Lake townships, 3′ to 5′ thick, by companies shipping from 100,000 to 150,000 tons per annum. The bed lies on the Homewood sandstone (XII d) 50′, under which lie the two Mercer coals, the two Mercer limestones, and the three Mercer iron-ore beds, all small, in 70′ of shales. Then the Connoquenessing upper sandstone (XII c) 40′, under which lie the Quakertown coal and iron ore, both small, in 50′ of shales. Then the Connoquenessing lower sandstone (XII b) 30′, under which lies the Sharon block coal in 30′ of shales, over the Sharon conglomerate (XII a) 20′. The Mercer iron ore plates of carbonate of iron where they reach a thickness of 1½ or 2′ have been mined along their outcrops, for the Oregon, Iron City, Clay, Sharpsville, and Mineral Ridge charcoal furnaces. The Mercer coals sometimes reach 3′ in thickness. The Quakertown coal reaches 3′ in N. E. Worth, and has been mistaken formerly for the Sharon coal, which itself varies from 2′ to 5′, and most of its mines are confined to Hickory township. Its roof shales are rich in fossil plants. The coal is one third gas, very free from ash, and requires no coking for blast furnace use. The Sharon conglomerate changes to a beautiful flagstone at Greenville quarries. It is finely striated by ice where exposed, contains fragments of wood; and fish spines, teeth, and scales are often abundant. Under it lie the Shenango shales and flagstones 45′; the Shenango sandstone (Sub-olean flat pebble conglomerate of McKean county) with nodular iron ore and fish remains, 15′; and the Crawford shales, 90′ of which are visible in the north-western corner of the county.

41. MIFFLIN.—Area, 380 square miles; population in 1880, 19,577. The western half of this long narrow county is a secluded Lower Silurian limestone anticlinal valley, drained by Kishicoquillis creek through Logan's gap in Jack's mountain, between which and Stone mountain (on the west) the valley tapers to a point southward, and is split at its northern end into three long, narrow, straight anticlinal vales, separated by two picturesque synclinal spurs of the Buffalo mountains coming from Snyder county. The limestone floor of the valley contains deposits of brown hematite iron ore once extensively mined in open quarries. Its sides consist of Loraine and Utica slate No. III, rising to a very remarkable terrace of Oneida conglomerate (IV a,) broken at short regular intervals by little ravines heading in the upper slope of red Medina slates (IV b,) crowned by the mountain crest of white Medina sandstone (IV c). The scenery is not only romantic in an artistic but in a geological sense, and an end view of the northern spurs affords the finest illustration of synclinal and anticlinal wave structure to be found in Pennsylvania. The eastern county line (40 miles long) follows the crest of East Shade mountain (IV,) crosses the synclinal vale of the Juniata "Long Narrows" to Blue Ridge (IV) the crest of which it follows to the great bend of the Juniata river. Between this eastern mountain line and Jack's mountain runs the Lewistown valley, 38 miles long and 6 miles (with great regularity) wide; a trough (deeper at its two ends and shallower midway) of Upper Silurian and Lower Devonian measures, crumpled into numerous sharp parallel folds, producing at the present surface many zigzag outcrops of the Lewistown limestone (Lower Helderberg No. VI) and Oriskany sandstone No. VII, with the overlying Marcellus pyritous ferriferous black clay, turned near the surface into a valuable brown hematite iron ore, extensively mined west of Lewistown in the numerous low ridges bordering the north bank of the Juniata river. The fossil ore beds of the Clinton No. V are opened at many points along the slope of

Jack's mountain, and outcrop also along the slopes of Shade mountain and Blue ridge. See in Report F descriptions of the mines on both ore ranges, and on the Marcellus ore bed, and also of the large broken down deposits of glass-sand mined near McVeytown on the Oriskany outcrop. The instrumental measurements of the formations at Lewistown, McVeytown, Mount Union and other points, reduced to graphic cross sections and published in Report F, are the most perfect made by the Survey in Middle Pennsylvania, and furnish a useful handbook for field geologists. The Lewistown section, for example, sums up its details as follows: Marcellus black slate 290′+; iron ore bed; Marcellus* limestone, 40; Scoharie? dark shale, 53′; Cauda-galli? clay, 40′; Oriskany sandstone, 110′; Oriskany shale, 205′; Lewistown shale, 140′; Lewistown (L. Held.) limestone, 185′; Water-lime shale, 470′; Salina variegated shale, 358′; Niagara? limestone, 4′; Niagara? shale, 70′; Clinton upper red shale, 305′; lower red shale, 260′; lower lime shale and upper olive shale, 250′; fossil ore beds and ore-sandstone, 120′; middle olive shale, 128′; iron-sandstone, 7′; lower olive shale, 571′; Medina white sandstone, 820′; red sandstone and shale, 1280′; Oneida red conglomerate, 309′; gray sandstone, 313′ (total of IV, 2722′); Hudson river gray sandstone, 425′, gray shale, 190′, hard fine sandstone, 140′, dark ferruginous shale, 182′, Utica upper gray slate, 210′, middle black shale, 302′, lower gray slate, 855′ (total of III, 1367′); Trenton limestone in Kishicoquillis valley (exposed) 320′.

42. MONROE.—Area, 600 square miles; population in 1880, 20,175. The north-western third of this county is a wilderness of Catskill upper rocks (IX) with low knobs and ridges of Pocono sandstone (X) everywhere 2,000′ to 2,200′ A. T. drained westward by the Tobyhanna waters into the Lehigh river. Two steep escarpments 1,000′ high, front east and south, and the angle where they meet is called the Pocono Knob, looking down and across to the Kittanning mountain, which is the southern boundary. The five north-eastern townships cover a rolling-hill country of the Catskill middle and lower strata, a belt of which forms also the foot hills of the Pocono in northern Jackson, Chestnut Hill, and Polk townships to the Carbon county line. Chemung, Genessee, Hamilton, and Marcellus outcrops cross the county from east to west, a length of 30 miles, the first three as hills, the last one as a valley of erosion, bordered on the south by a continuous but zig-zagged ridge of the Oriskany sandstone No. VII, backed by Upper Helderburg strata (VIII) on its north slope, and letting out from its south slope the edges of the Lower Helderberg limestone, lime shales, and cement beds No. VI. A deep valley of Clinton red shale No. V separates it from the Kittanning mountain with its sharp crest of Medina sandstone No. IV, everywhere about 1,500′ A. T. In this red-shale valley the Delaware river flows until it turns into its Water Gap (where Cherry run flows to meet it); and also

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* Doubtfully called "Corniferous" in the Report. It has been since then made pretty certain that the Corniferous formation is wanting in Middle Pennsylvania. See Reports G[6], G[7], F[2], T[4].

the Aquanchicola creek from the Wind gap westward into Carbon county.

Across all these outcrops flow southward from the foot of the escarpment the two principal streams of the county, the Bushkill along its eastern border, and Brodhead creek (with its main branches, Goose pond, Stony, and Holler runs, Pocono and St. Michael's creeks, which last two meet it at Stroudsburg, and the combined waters cut a romantic little gorge through the Oriskany ridge into the bend of the Delaware. Marshall's creek makes a longer cut, where the Oriskany is broadened out by several rolls, and here are the picturesque Buttermilk Falls. The high falls of the Bushkill are over Hamilton sandstone strata. Several anticlinal rock waves issue from the Kittatinny mountain and traverse the county (zig-zagging the outcrops) from east to west. The first one crosses the Delaware just below Walpack bend, broadens the Oriskany east of Stroudsburg, doubles the Marcellus there, and keeps on to the north-west corner of Polk. The second one crosses the Delaware in the Water Gap, makes the Red Hill, and the limestone hook at Kellersburg, and keeps on in Hamilton rocks past Brodheadsville, Kriegesville, to become the great arch on the Lehigh at Weissport. The third, is a short one running under Mechanicsville. The fourth comes through the mountain at the Offset and dies away in front of the Wind Gap, swelling the Oriskany ridge so that it is called locally Dodendorf's mountain. (For details of the geology see Report G^6, with which are published a contour line map of the Water Gap and a measured section of its strata.) The *Mt. Pleasant conglomerate* caps knobs along the northern line of the county, one of which near the railroad in Coolbaugh township (2050′ A. T.) shows it in cliffs of 50′. The Pocono plateau is made of *Mt. Pleasant red shales* perhaps 200′ thick; and the underlying *Elk mountain green sandstones and shales*, say 200′ thick. The next underlying *Cherry Ridge conglomerate*, *upper* 30′, shale 20′, *lower* 25′, form the cliffs which run along the top of the great escarpment; the upper one with quartz pebbles as large as eggs, and fish remains; the lower one with rather smaller pebbles, and more fish remains, and more lime in its cement. Under it appear red sandy shales, say 250′, increasing westward to perhaps 500 at the Carbon county line. Under these lie the two massive *Honesdale sandstones*, with large pebbles in a calcareous cement, separated by red shale, and measuring 200′ in the Pocono Knob, 500′ on the Carbon line, and 1000′ on the Lehigh river. Under this the *Montrose red shale*, at least 600′ thick at Henryville on Brodhead's creek, and swelling to 1200′ on its way through Pocono, Jackson, Chestnut Hill, and Polk townships makes a broad red soil belt. Under it the *Delaware flagstone quarry-beds*, 1430′ thick in eastern Pike, are 1200 in Monroe on Brodhead's creek between Henryville and the first bridge; they range east and west across the county, affording unlimited scope for this special industry; near the top of the group comes the *Lackawaxen conglomerate*. Underneath lies the *New Milford red shale*, 100′ at Spragueville, 500′ at Broadheadville; and a patch of it is left in the Wire Hill synclinal on the Eldred-Ross township line. Underneath lies the *Starrucca sandstone* (with red beds) 600′ thick at Spragueville and a mile above Bartonville. (All the above Catskill groups sum up 5000′.) The *Chemung* beds measuring 1750′ of gray and blue, hard, fossiliferous sandstone along Brodhead's creek, make the ridge just below Spragneville. The *Genessee* dark sandy shales (200′) make a little narrow valley. The *Hamilton* sandstone (1200′) has the *Tully* limestone coral rock at its top (best seen 30′ thick at the head of the falls on Middle Bushkill creek, 1½ miles above its junction with the Bushkill; and also a mile north of Kresgeville); forms the cliffs of the Delaware at the Munroe-Pike line; and the whole series of beautiful cascades in the ravines of both counties; fossils numerous, but no useful minerals. The *Marcellus* soft dark shales 500′, and gray shales 300′, form the valley of Pond creek in Smithfield, and Prince's creek in Eldred and Lower Towamensing; people have often tried to find coal in the black slate, in this and many other counties of the State (see Perry and Juniata,) as at Bonser's on Frantz's creek near the western line of Ross township, and at Kunkletown in Eldred. The so-called "iron ore" with this black slate (manufactured into paint) is the same as that mined in Mifflin county. School slates have also been quarried on the west Polk township line. Fossils (poor) are plentiful at the base of the slate at Stroudsburg. The *Corniferous limestone* 200′, *Cauda-galli grit* 250′, *Oriskany sandstone* 50′, *Stormville* lime shales 150′, massive cherty limestone 10′, conglomerate 15′, lower limestone 75′, *Waterlime* (Peth stone) 5′, *Dicker's Ferry* limestone 20′, pebbly sandstone 15′, greenish shales 15′, *Bossardville limestone* (the main quarry beds of the county are in this) 90′, and the *Poxono Island* shale 200′, run across the county as Godfrey's Ridge. (See descriptions of fossils and quarries in G^6.) The *Clinton* red shale is say 900′; the *Medina* 700′, the *Oneida* 800′. Thus the Brodhead's creek section shows 13,495′ of rocks in Monroe county. The *Terminal Moraine* crosses the Blue (Kittatinny) mountain crest just west of Fox gap, slopes down to Poponoming lake, bends round Wire ridge to Brodheadsville, runs past Lake Minneola up the west bank of McMichael's creek, bends east and ascends to Pocono Knob, runs north over the plateau (2000′ A. T.) to S. E corner of Tobyhanna township, and then with a sharp turn runs straight west (as the Long Ridge) across the outlet of Long Lake, and between Big and Moses ponds to Sailorsville and the Lehigh river. The whole surface of Monroe, east and north of this well-defined ridge of sand, clay, gravel, and bowlders (50′ to 150′ high, and ¼ to ¾ mile wide) has been once covered with ice, one or two thousand feet thick, moving south south-westward on the highlands, and south-westward over the lowlands and Blue mountain into Northampton county; and the ice on its retreat not only left the ridge of trash which it formed along its extreme front edge, but left the whole country clad in a sheet of clay, sand, rough gravel, and scratched blocks of native and foreign rocks of all kinds, averaging 50′ in depth, and much deeper in the valleys. All the lakes and ponds of the county have been made by irregular dams and pot-holes of Drift. (See full details in Report Z.)

43. MONTGOMERY.—Area, 480 square miles; population in 1880, 96,494. The geology of this county is the same as that of Bucks county between which and the Schuylkill it lies, with a length of 38 miles (along its

north-east line) and an average breadth of 16 miles (along its north-west line). Two of its townships, Upper and Lower Merion, lie on the west side of the river. Philadelphia city (once county) is cut out of its southern corner. Four fifths of the county has a surface of Mesozoic (New Red, Trias) soft red shale and sandstone, dipping gently northward. A ridge of greenstone trap in Marlborough township is gapped at Sumnertown by a branch of the Perkiomen, the main creek flowing (south) past the west end of the dyke at Green Lane. Another small hill of trap rises one mile north of Pottstown. The North Penn railroad tunnel at Gwynned cuts trap in the hill. The villages of Morganville, Sorrel Horse, Dreshertown, Fort Washington, Hickorytown, and Plymouth mark the line of the south edge of the New Red, where the Potsdam quartzite No. I (North Valley Hill rock of Chester county) comes out from under it, in a series of diagonal (anticlinal) ridges, with basins of Chester county limestone No. II between them. The Chester county valley heads up eastward through Upper Merion and Whitemarsh townships, and along the Upper Dublin and Abington line, before reaching Penn Park creek, where the older gneiss comes to the surface. The southern edge of the limestone No. II crosses the Schuylkill at Conshohocken, and runs past the marble quarries, Marble Hall, and the north corner of Cheltenham township to a point 2 miles east of Pinetown. The narrow southern outcrop of No. I runs along side of the limestone from Conshohocken eastward to within a mile of Sorrel Horse. A narrow belt of the South Valley Hill slate runs from Conshohocken westward as a continuation of the belt of No. I. South of this slate and south of the outcrop of No. I, all across the county, runs a belt of the older gneiss, bordered on the south by the Chestnut Hill and Edge Hill line of garnetiferous and serpentine-bearing schists. Three lines of serpentine outcrop cross Merion, one of them at Merion Square, the other two a mile and two miles north of it. From Jenkintown eastward Edge Hill carries the famous *eurite* or *itacolumite* outcrop which has been assigned to the Potsdam formation No. I. (For details of the geology of the formations south of the New Red, with the brown hematite iron ore deposits in the valley, see Report C^6.)

44. MONTOUR.—Area, 140 square miles; population in 1880, 15,468. For the geology of this county see COLUMBIA county. Its principal feature is the remarkable anticlinal rock-wave of Montour's Ridge, on the two slopes of which rise with opposite N. and S. dips the fossil iron ore beds of the Clinton formation No. V, once the dependence of the great iron works at Danville and Bloomsburg. No other useful mineral except limestone (extensively quarried west of Washingtonville and along the north and south foot hills of Montour ridge) exists in the county, which, being a piece cut out of Northumberland can better be described under that head. (See Report G^7.)

44. NORTHUMBERLAND.—Area, 460 square miles; population in 1880, 53,123. This county borders on the Susquehanna river for 22 miles above, and for 21 miles below Northumberland, where the North Branch comes in from the East. The anticlinal arch of Montour's Ridge makes a belt of Clinton shale 4 miles wide at the river, between two outcrops of No.

VI limestone. North of it the Wilkesbarre trough crosses into Union county, as a belt of No. VIII (three miles wide) to another outcrop line of the limestone (2 miles below Milton) which runs into Montour county and zig-zags back again to the river 9 miles higher up. The space inclosed by this semi-circle is occupied by No. V coming over from Union county on the backs of four of the Buffalo mountain anticlinals. No. VIII swings round (outside the semi-circular outcrop of No. VI limestone and No. VII sandstone) into Lycoming county, making the Muncy Hill range on the county line, 800′ to 900′ A. T. The great anticlinal of Shade mountain in Juniata and Snyder counties crosses the river at Selinsgrove and runs on east as a belt of Hamilton and Chemung rocks (No. VIII) 4 miles wide on the Columbia line, and 9 miles wide at the river, where it is split by a point of No. VI limestone, between two outcrops of Oriskany No. VII, uniting 2 miles from the river. The center line of the Juniata valley trough (between the Montour ridge and Shade mountain anticlinals) crosses the river at its fork and runs on east (south of the North Branch) holding Catskill lower strata. The great trough in which lies the Shamokin and Mahanoy anthracite coal basins, surrounded by a mountain of conglomerate XII, a red shale valley XI, and an outside mountain of X, like a frame of two beads around a picture, shallows up westward so as to bring the two outside Catskill (IX) outcrops together at the river at Port Trevorton. At Georgetown the great Tuscarora mountain anticlinal of Perry and Juniata counties crosses the river making two ridges of No. VI limestone and Oriskany sandstone (each four miles long) along the center line of the great cove of Hamilton and Chemung rocks, around the head of which sweeps the Mahantongo mountain, first east, and then back south-west through Schuylkill and Dauphin counties.

On all the outcrops of limestone VI numerous quarries are wrought, and this is the only mineral of value in the county outside of the coal field, for the lead and zinc found in this limestone amounts to nothing practical. Only the west end of the coal field (19 miles long from Mt. Carmel to the double point west of Trevorton) is in this county, comprising the three Shamokin basins; the three Mahanoy basins (all six being in the same grand trough) lie in Schuylkill county. In the Shamokin Mine Inspection district 21 collieries produced, in 1883, 1,439,567 tons, to which must be added the production of the collieries at and south and west of Mt. Carmel, which, although in this county, are included among the 56 collieries (5,196,530 tons) reported in the West Mahanoy district. The coal of Trevorton and Shamokin has a higher percentage of gas (12 to 14) than any other anthracite, but not enough to rank it with the semi-bituminous coals of Broad Top and Maryland. Fourteen workable coal beds (with intermediate small ones of no value) were carefully surveyed and described by Prof. H. D. Rogers in 1850, and afterwards published in his Geology of Pennsylvania, 1858, Vol. 2, pp. 297; the lowest four being in the body of the Pottsville Conglomerate No. XII, here 600′ thick, so beautifully exposed (dipping 40° south) in the two walls of the fine gap which the Shamokin makes in escaping from the coal field through Big Mountain into the red shale valley outside (precisely as the Susquehanna escapes from the Wilkesbarre basin at Nanticoke.) The lowest bed (1) overlying the lowest mass of Conglomerate is 2¼ thick; the next (2) above the second mass of conglomerate, 7′; (3) 8′; (4) 6′; (5) 75′ above the last, 2½′. Then (between XII and a small pebble conglomerate higher up) lie four notable beds (and four others not worthy of attention) (6) 11′; (7) ?; (8) 6′; (9) one bed at Trevorton, but here separated by a parting fifteen feet thick into two, the lower 9′ and the upper 4′. Above the small conglomerate lies a third series, five workable; and several not certainly workable beds: (10) a specially pure red-ash, 6′, increasing eastward to 14′; (11) fifty feet above the last, 6′, also very pure. In the Trevorton gap a similar section shows some variation in the details, the lower beds being thicker than in the Shamokin gap. (For many interesting facts concerning the different thicknesses of the formations in the northern and southern parts of the county; the coming in of the Selinsgrove series; the abundance and species of fossils; the curious gravel terraces of as yet unknown origin between Milton and Muncy; the erratic blocks on top of Montour ridge and elsewhere; and the difficulty of explaining the rock dams in the Susquehanna in connection with the now deeply-buried ancient water-channel of the North Branch; see Report G^7.)

36. NORTHAMPTON.—Area, 380 square miles; population in 1880, 70,-312. Its geology is that of Lehigh county, already described, extended eastward from the Lehigh to the Delaware, 28 miles along the Kittatinny (Blue) mountain, and 14 miles along the Lehigh from Allentown to Easton. The slate belt (III), nine miles wide, has a nearly straight edge, 23 miles long, and a pretty uniform height of 200′ above the flat limestone belt (II), which is 8 miles wide, and crossed by the Monocacy and Bushkill creeks, which drain the slate belt southward through the little gaps at Bath and Stockertown, where it is plain to see that the limestone goes under the slate; a short prong of slate at Nazareth, and two small outliers of slate at Howertown and Weaversville show the same fact; as does also the limestone area inside of the slate belt east of Kreidersville, and three other smaller ones between it and Bath. But the best show is made by the anticlinal limestone valley of Cobus creek, 3½ miles south of the Delaware water gap; in which interval the whole of No. III rises to the surface with a thickness of 5240′ (1540′ upper massive series; 3700′ lower thin beds. See Report D^3, Vol. I, p. 85.) At the Lehigh III is faulted and folded, but seems to measure about 6000′. The limestone formation No. II cannot be measured with any accuracy on account of its extremely crumpled condition, as shown in the large quarries worked for the blast furnaces between Newport and Allentown. (See pictures in Reports D^2 of quarries at Coplay and Catasauqua.) Several well-defined large anticlinals and synclinals traverse the belt lengthwise. (See dips marked by arrows, on the six-sheet topographical map in Atlas to D^3.) The general plain of limestone land (400′ A. T. rising in swells to 450′) is broken by uplifts of Potsdam sandstone No. I and old gneiss in two places (apparently on one anticlinal range) viz: Chest-

nut hill, 4 miles long, gapped by the Bushkill; and Quaker hill, 3 miles long, gapped by the Monocacy. The belt may therefore be considered as two grand basins, in one of which the lower Lehigh flows; the other is sub-divided into two sub-basins by a line of local anticlinals, which govern the underground drainage; for the surface is almost destitute of streams, and numerous sinkholes testify to concealed caverns ramifying beneath it; one of these of an extraordinarily instructive character, 4 miles north of Easton, and another one mile east of Catasauqua are described and reasoned from in Report D^3, Vol. I, pp. 16, 17. The farmers distinguish the beds as "rock limestone" and "slate limestone," the former, massive, making a stronger farm lime. Thin pure dolomite beds occur giving a sonorous sound when struck. Hydraulic limestone beds are quarried on the west bank of the Lehigh above Coplay for making Saylor's Portland Cement (see analyses and tests in D^2, pp. 59+); the purer limestone beds are carefully selected by the iron-works. (See analyses in D^2, pp. 17+.)

The comparative absence of ore banks in this county, north of the Lehigh river is remarkable; only 27 being described in D^2 (pages 197 +); but along the foot of the South mountain there are 51 (pp. 191+) and 5 more in the limestone valleys inclosed in the mountains, viz: the lower reach of Saucon valley, and the Raubsville, Uhlersville and Riegelsville (Durham) valleys which are merely the western ends of the long limestone valleys of New Jersey, inclosed between the ranges of the Highlands. The summit of the mountain south of Bethlehem is only 960′ A. T.; the three summits east of the Saucon valley 1000′, 820′, and 940′; the Hexenkopf south of Smith's Island 1030′; Morgan hill south of Easton 820′; the Raubsville ridge 770′; and Brougher hill at the river 650′, rising westward in a series of knobs along the Bucks county line to 940′ A. T. The knob at the east end of Chestnut hill is only 690′ A. T., the Delaware river beneath it being 170′, making a picturesque gap. The hill is interesting as being the westward disappearance underground of the old gneiss rocks of the northernmost range of the New Jersey highlands; for the development of serpentine beds among the lower limestone strata upon its flank; and for being a fine collecting ground for rare species of mineral crystals. The principal mineral wealth of the county lies in its range of roofing-slate quarries in front of the Blue mountain, from Bangor and Penargyl through Jacobsburg, Milgrove, Douglassville, Cherry hill, Chapman's, Danielsville, and Berlinsville, to Walnut Port and Slatington in Lehigh county. More than one hundred quarries and exposures are located on the colored geological county map, and described or noted in Report D^3 Vol. I, with pictures and sections, showing the contortions of the beds, and the relation of the slaty cleavage to the planes of stratification; with tables of the quantity of slates made; sizes and mode of working. The South mountain gneiss is supposed to be of Laurentian age; it is very similar throughout; mostly a granulite; feldspathic; with little or no mica; but much magnetite, generally disseminated, and also in lenticular beds, mined near Vera Cruz, and on Mine hill just east of Durham P. O. Some corundum is found just north of Shimersville. The

Potsdam sandstone or quartzite beds, only 25′ thick at Allentown, lies unconformably on the gneiss. Great rounded (weathered?) bowlders of gneiss cover the southern slope of Lehigh mountain, and are common elsewhere; some of these are 20′ high, evidently fragments from cliffs now no longer existing. (See one in Plate 3 page 240 of D^3.) The *Terminal Moraine* crosses the Delaware at Belvidere, and curves by Mt. Pleasant, Factoryville, and Bangor to Fox gap, a slight notch in the crest of the Blue mountain. All east of this is covered with ice drift. A fine *kame*, or under ice, gravel, and sand ridge runs from Portland up Jacobus creek valley. (See description and sketches of it in Report Z.)

45. PERRY.—Area, 480 square miles; population in 1880, 27,522. The construction of the underground world of this flag-shaped county is so beautifully simple as a whole, and so curiously complicated in details, that it will ever stand the typical district of the Appalachian mountain belt of the Atlantic seaboard:—two grand basins, cut across by the Susquehanna and Juniata rivers; sinking eastward to receive the two lobes of the fish-tail of the Southern anthracite coal field in Schuylkill county; and rising westward, so as to bring to the surface in concentric ellipses the successively lower formations from No. XI down to No. IV, the mountain outcrops of which form the southern, western, and northern borders of the county. Between the two basins rises the great anticlinal which makes, by the corrugations of its arch, the two loops in the Cumberland county line, and the long projecting spurs of Bower's mountain, Amberson's mountain, and the Great and Little Round Tops; with a much larger number of close crimples in the middle of its course, producing a system of zig-zags on the colored map like the grain of wood cut bias for ornamental furniture work; and with at least three notable downthrow faults, one of which running along the north foot of Dick's hill, brings into contact the middle beds of the Chemung and the Lower Helderberg limestone beds, with a maximum throw of 4075 feet. (See Report F^2 page 88.) The *Clinton fossil iron* ore is mined in front of Tuscarora mountain near Millertown; the *Marcellus iron ore* in little basins of Oriskany sandstone south of Newport; on Iron Ridge, at the Old Perry furnace; on Mahony ridge at and west of New Bloomfield; in Bell's hill north and west of Little Germany; and in Pisgah hill at Oak grove furnace. The *Hamilton fossil ore* near Manorsville, at old Juniata furnace, south of Newport, at Girty's Notch on the Susquehanna, and at various points along the south side of Mahanoy, Crawley's, Dick's, and Pisgah hills, and back of the Susquehanna river at Marysville. Small coal beds have been opened near Duncannon, and near Mt. Patrick, in the Pocono sandstone rocks (X) of Berry's and Buffalo mountains, but they are of course worthless. The enormous length of the zig-zag outcrop of the Lower Helderburg limestone, No. VI, amounting in all to 150 miles and more, has filled the county with quarries; and a large trade in lime to other counties is carried on in Liverpool township. Four remarkable trap dykes cross the Cove in Rye and Penn townships; the largest, Ironstone ridge, is the north end in Perry county of the remarkable dyke which crosses Cumberland county. It makes a water-shed

across the valley of Fishing creek 9 miles west of Marysville. It must be 200 feet wide for its blocks cover a width of 500. Another much smaller one runs 500 yards east of it, also N. 10° E. Two others cross the Cove in a direction N. 20° E., one of which passing Duncannon runs across Wheatfield and Watts townships. The fossils of the Upper Silurian and Devonian formations V, VI, VII, VIII, and IX, have been systematically studied in the field only in this county, (see the provisional lists of characteristic species published in the preface to Report F^2, in advance of the regular descriptions and figures in a future volume.) Here have been found the first specimens of *Onchus clintoni* (in Clinton No. V*a*) and of *Palæaspis bitruncata*, *Palæaspis americanus*, and *Onchus pennsylvanicus* (in Onondaga red shale No. V*b*) the oldest fish as yet known.

46. PHILADELPHIA.—Area, 130 square miles; population in 1880, 847,170. A special map of the Philadelphia belt of the older and younger gneiss formations, first appearing at the surface at Morrisville, opposite to Trenton, N. J., and widening westward so as to cover most of Delaware county, will be found in this Hand Atlas, in the place of a map of Philadelphia alone. (See the description of Delaware and Montgomery counties already given.) The special feature of the geology of the city is its brick-clay and gravel beds, deposited at various levels; *the oldest* (Bryn Mawr gravel) at 400′ A. T. a patch of which remains about Chestnut Hill; the *less ancient* sands and brick-clay of Nicetown and the terrace west of the Schuylkill on which the railroad to Media and West Chester is built, at 200′ A. T.; the *more recent* gravel, sand, and brick-clay encountered in laying the foundations of the city houses, from 80′ to 100′ A. T. to below the river mud of the Neck. The abundance and excellence of the Delaware valley clay has conduced to the celebrity of the Philadelphia house-brick, and its almost universal use in the construction of its houses, a comparatively small number of public and private edifices being built of marble, New Red brownstone, or Delaware county serpentine. The red color of the brick, due to a constant particular percentage of iron in the clay, contrasts strongly with the yellow bricks manufactured from the Drift clay in other parts of America. As a curiosity it may deserve mention that the Assayers of the U. S. Mint found by calculation that there was enough *disseminated gold* in the bricks of the houses of the city to pay off the National debt; and they calculated that it would cost $10 to extract one dollar's worth of the metal from the clay at the brick-yard.

47. PIKE.—Area, 630 square miles; population in 1880, 9,963. The Delaware river after flowing along the north-east border, in a sort of canon, 500′ deep, full of sharp bends, 27 miles in a straight line, turns a right angle at Port Jarvis and flows 28 miles S. W. along the outcrop of the Marcellus shale at the foot of the Shawangunk mountain of New Jersey. The road on the north side of the river, excavated in Hamilton soft sandstone shale, is the best and most picturesque long public drive in the State. Through the hills of Hamilton, capped with Genessee and Chemung behind, break the Sawkill (at Milford), the Raameskill (3 miles

below Milford), Adam's creek (7), Dingman's creek (8), Decker's creek (11), Tom's creek (18), the Little Bushkill (22), and the Middle Bushkill (with the Bushkill) at the county line (24 miles below Milford) and a number of other small streams, through deep, narrow, dark, wooded gorges, walled with vertical cliffs, and over rapids and cascades, in the first two instances 100′ and 140′ high. The upper edge of the Chemung formation crosses the whole county in a nearly straight line 2 or 3 miles back from the river. The whole county except this narrow belt, has a rolling hill surface of Catskill red and gray sandstone and slate, covered with a sheet of Glacial Drift, in the billowy surface of which lie innumerable little lakes and ponds in process of being turned into swamps in due course of time. But in the south-west corner of Palmyra and south-west half of Greene townships the land rises 1950′ A. T., the eastern edge of the great Pocono plateau, down through which the head branches of the Wallenpaupack cut wild gorges, the walls of which are 300′ or 400′ high. All the rocks are horizontal strata of conglomerate or massive sandstone; and the lower country is covered with vast quantities of their fragments, isolated or in piles, many of great size. North and South knobs in Blooming Grove township are solitary sentinels of the plateau left standing 3 miles in front of its eastern edge, their tops of *Cherry ridge conglomerate* (with cliffs of 60′ to 75′) rising to 2010′ A. T. and commanding magnificent views. The whole Catskill formation measures 3430′ in northern and eastern Pike, as exposed in the cliffs and slopes of the long canal-like gorges of the Paupack and the Delaware; *Mt. Pleasant* red shale 150′; *Elk mountain* sandstones 150′; *Honesdale* sandstone 100′; *Montrose* red shale 225′; *Delaware river* flags 1430′; *New Milford* shale 75′; *Starucca* shales and sandstones 600′. The "blue stone" quarries between Narrowsburg and Pond Eddy at Stairway, Pond Eddy, and Shohola (where Vanderbilt's great pavement flag 15′×25′×8′) was got, and at Millville, Kibler and Rowland's along the Lackawaxen, are celebrated. Some red shale beds occur in the upper 430′ of the series (one of them 50′) but their absence in the lower 1000′ is remarkable. The massive pebbly *Lackawaxen conglomerate* (50′ to 60′) occurs near the top. The flag-stone belt is very broad and crosses the county into Monroe and Carbon counties. Plant remains are rare in the Catskill, but fish bone fragments occasionally appear in calcareous breccias in the upper half. The amount of disseminated sesquioxide of iron in the red shale varies from 7.5 to 8 per cent. No iron ore, coal, or other mineral beds exist in the county. Even the limestone and cement rocks of Monroe county run along on the south side of the river in the State of New Jersey. (For curious details respecting the buried river valley at Port Jarvis and the possible ancient course of the Delaware eastward into the Hudson; for drift scratches; and for fossils, see Report G^6.)

48. POTTER.—Area, 1,070 square miles; population in 1880, 13,797. This large square, on the New York State line, with its south-west angle cut off to form part of Cameron, is the most geologically symmetrical in the State; an elevated wilderness crossed diagonally (N. E. and S. W.) by ten parallel belts of lower Catskill anticlinal valley land, and of

intermediate higher synclinals of Pocono table-land; the former showing the underlying Chemung in their deeper water-courses; the latter trenched lengthwise and crosswise by innumerable gorges, cut down from 200 to 500 feet by a radiating-drainage system: Kettle creek waters flowing south; Pine creek waters, east; Tioga river waters, north-east; Genesee waters north; Oswayo creek north-west; the heads of the Allegheny river, west; and the Sinnemahoning waters south-west. On a tract of land near Raymond corners, 2,500′ A. T. (the highest flat land in the State) the rain-fall parts and flows in three directions—to the Gulf of Mexico, to Chesapeake bay, and to the Gulf of St. Lawrence. And precisely over this highest flat land in Pennsylvania, passes the line of the great Terminal moraine, left by the northern ice in its retreat at the close of the Glacial age, a line, nearly straight, from Pike mills on Pine creek at the Potter county line, to Goldsmith village in the north-west corner of the county; the north-eastern third being covered with a sheet of Drift; the south-west two thirds quite bare. In front of the moraine, in the valley of Pine creek below West Pike P. O., are the remarkable secondary glacial terraces described in Report Z, p. 145 (pictured in plate 15, fig. 4, p. 106.) The northern prong of the Wellsborough Chemung valley of Tioga county penetrates Hector and Jackson townships to West Pike P. O.; extensive outcrops of Chemung follow all the streams of Harrison township; and a broad belt of Chemung crosses Oswayo and Sharon townships. Everywhere else the Bradford oil group is far underground. The rocks of the northern townships are nearly horizontal; but the dips increase in strength going south; but never enough to make the synclinals deep enough to preserve anything that could deserve the name of a coal basin. The high lands (all synclinal) retain on many of the highest summits patches of the Conglomerate XII; or of its lowest member, the Olean conglomerate; or of the Mauch Chunk red shale formation No. XI, which is however very thin. At Coudersport, Roulet, Hebron, &c., the formations are:—*Olean conglomerate* 50′; slates and sands, 70′; *Sub-Olean* flat-pebble conglomerate 60′; *Pocono* gray shale and sandstone, and red shale 20′; false-bedded sandstone and shale, 50′; gray shale with red beds 110′; gray shale and sandstone 90′; *Catskill* red shale, with gray shale and flagstone 110′; gray shale and sandstone (with fish-beds) 60′; red, gray, and green shales 200′; *Chemung* gray shale and sandstone (with fish-beds in the upper part) 140′ ?; olive shale 30′; red shale, &c., &c., downwards. In the southern townships the formations gradually thicken to their size in Lycoming county (which see, already described.) The coal bed opened fifty years ago west of Coudersport has been fully explored and found to be a worthless bed only 12 to 16 inches thick, in the Sharon shales over the Olean conglomerate; another small seam overlies it 50′; and a third underlies it as much. The Mill Creek coal basin of Tioga county runs into Pike county, and a 3′ coal has been mined north of the West branch of Pine creek, and at Whitmore run in Jackson township. In summit township the plain over which the old turnpike passes is underlaid by a 3′ coal bed at Herod's tavern, and another 1′ coal lies 20′ higher. In the next basin to the south, the center line crossing Kettle creek 1½ miles N. of Oleona, and at the top of one of the knobs into which the mountain is broken, remains a few acres of a 3′ coal bed, lying on the (Olean ?) conglomerate, 80 thick, overhanging a slope of 700′ down to the creek.

49. SCHUYLKILL.—Area, 840 square miles; population in 1880, 129,974. This is the richest county in Anthracite coal; the southern field, or Pottsville basin, having a run across it of 38½ miles, along the Sharp mountain and 41½ miles along Locust mountain, Mine Hill and Thick mountain, from the Carbon to the Dauphin county line. The Mine Hill basin is 14 miles long. The New Boston basin 4½, and the Mahanoy basin 18 along its southern edge, and 12 along its northern, passing west into Columbia county. Four of the basins of Luzerne county also have runs of from 1 to 4 miles in Schuylkill. In 5 mine-inspectors' districts, west of Tamaqua, 64 collieries produced in 1883 2,134,000 tons; and in the 2 inspectors' districts in the Mahanoy basin (one fourth of one of them being in Northumberland county) 74 collieries produced 6,630,000 tons. All the coal basins are in the northern half of the county, being separated from each other by anticlinal waves of Pottsville Conglomerate No. XII (1000′ thick); from beneath which rises the Mauch Chunk Red Shale No. XI (3000′ thick) forming the floor of Catawissa valley in the north of Locust valley in the east, and of Deep creek and Mahanoy valley in the west; also Wiconisco valleys, between the two western arms of the Pottsville basin; also the long, narrow, nearly straight valley running across the county next south of the Sharp mountain. This, the last outcrop of Red Shale No. XI in the State towards the south-east, crosses the Schuylkill river at Mount Carbon, 1 mile below Pottsville. The various coal basins are traversed lengthwise by secondary, sharp, parallel rolls, two of which sub-divide the Mahanoy field into three sub-basins; one sub-divides the western end of Mine Hill basin into two sub-basins; six issue from the Sharp mountain spurs opposite Patterson, and run through the Pottsville coal field across Mill creek, and across the West Branch, past Minersville, into the spurs of Thick mountain, making 4 principal sub-basins at Forestry, Llewellyn, Taylorville and Woodville; while the two rolls in Fishing Creek mountain add three more sub-basins at Tremont. The deepest part of the Pottsville field (3000′) is under a hill south of Minersville. The lower coal beds outcropping along the north slope of the Sharp mountain, past Pottsville, descend vertically to a depth of between 2000′ and 3000′; and then they gradually rise northward (rolling several times) to appear at the surface, on a dip of about 30°, along the south slope of Mine hill, where a range of old and extensive collieries work the Mammoth bed, here showing sometimes a thickness of 60′. It has many partings of slate, two of which increase so much in size going west as to convert the Mammoth into three distinct coal beds, which at length get to be 100′ more or less apart! This however is constantly happening with all the larger beds in all parts of the region, and is the principal cause of the confusion of names given to the bed, of the difficulty of certainly identifying some of them in different collieries, even on neighboring tracts, but especially in different main

basins, and of the dissimilarity of the vertical sections drawn to one scale, and published on sheets in the Atlases of the Survey. The difficulty has been further increased by the value of a name as a trade-mark, the old "Diamond," or the old "Primrose," for example, names of the purest coal beds in the region, applied by other operators to their own coal coming from other beds. The chief practical distinction is that between the *lower white-ash* and the *red-ash* beds above the Mammoth. A general idea of the relationships of the coal beds to the strata which separate them may be got from the old Carey shaft at St. Clair: Rock and slate, 119′; *Primrose* bed, 3′; rock and slate, 68′; *Holmes* bed, 4½′; rock, 65′; coal, 1′; slate, 51′; coal, 2′; rock, 72′; *Sevenfoot* coal, 8½′; slate, 14′; *Mammoth* bed, 22′; total, 439 feet.* On Mill creek east of Pottsville the First Survey measured 2700′ of measures, embracing 36 coal beds, divisible into six groups.

(1,) *Upper red ash*: consisting of the South Salem at the top, Salem, Weasel, North Salem, Faust, Nest, Rabbit Hole, and Little Tunnel, in 700′ of rocks; (2,) *Middle red ash*: Peach mountain, Lower Peach mountain, Little Tracy, Tracy, Yard (or Clinton), in 300′; (3,) *Lower red ash*: Thin coal, Peacock, Little Peacock, two unnamed coals, Little Diamond, South Diamond, Diamond, in 435′; (4,) *Gray ash*: Hancock, Orchard, Primrose, Flowery field, in 430′; (5,) *Upper white ash*, six coals (including Pinkerton's Mammoth 22′), in 310′; (6,) *Lower white ash*: five coals (including the Big Johns' Co. bed 25′) in 500′. (See Rogers' Geol. Pa., 1858, Vol. II, p. 229.) On the West branch west of Pottsville the same six groups show different details; measure 2800′ total thickness at Westwood; and have different names and very different thicknesses for the coal beds. Thus, Group (1) of 200′ has 5 beds, none over 4′; Group (2) of 250′, 4 beds, Skidmore (bottom), Mammoth, Black heath, and Black valley (top); Group (3) of 350′, 3 beds; Group (4) of 775′, 7 beds; Group (5) of 400′, 4 beds; Group (6) 700′ or 800′, 5 to 7 beds. The Mammoth in the Mahanoy field reaches 70′ in thickness; but its average in the region may be called 30′.

The Sharp mountain is cut through to its base by the Little Schuylkill at the eastern end of the county; by the Swatara at the western end; and in the center by the main Schuylkill and by its West branch, these two gaps being 3 miles apart. In the Tamaqua gap the Conglomerate dips north about 50°; but in the other three gaps it stands vertical, with the lower coal beds on one side of it, and the Red Shale on the other. The Schuylkill river makes here one of the finest geological sections in the State, through 15,000′ of vertical strata, in the three miles from Pottsville down to the great Orwigsburg anticlinal at Schuylkill Haven; measured by the First Survey thus: Pottsville Conglomerate (XII) in Sharp mountain 1030′; Mauch Chunk red shale (XI) 2950′; Pocono sandstone (X) in the north half of Second mountain 1800′; Catskill (IX) in the south half of Second mountain say 6000′; Chemung and Hamilton in Little mountain say 3000′. The Orwigsburg anticlinal is vertical to the

*The intervals however are too large owing to the dip.

north and only 20° to the south; dies out westward at Pinegrove; but makes the northernmost long spur of the Blue mountain beyond the Little Schuylkill. South of it lies a Chemung basin holding a strip of Catskill in the form of a long ridge the southern slope of which called Summer Hill, looks down upon a valley of Marcellus and Clinton shales (the limestone VI and the Oriskany sandstone VII being nearly or quite wanting here, as are also the fossil ore beds) rising upon the back of the Blue mountain, through which the Schuylkill and Little Schuylkill (joining at Port Clinton) make a fine gap, in which the Medina and Oneida sand rocks (IV) are seen standing vertical, and against their under-side abut the edges of nearly horizontal slates (III). A map of this gap, with the fault, is published in Report D^3, Vol. I. Ten anticlinal rolls come through the mountain and die out west of the Little Schuylkill in the seven miles above the gap.

54. SNYDER.—Area, 320 square miles; population in 1880, 17,797. Its border on the west bank of the Susquehanna from Northumberland down is (in a straight line) 18 miles. Through its center runs the Shade mountain anticlinal of Medina sandstone No. IV gradually burying itself under Onondaga and Clinton rocks No. V, which pass across the river at Selinsgrove; and splitting into two crests on the Juniata county line, between which lies a high and narrow little vale of Hudson River slate No. III. Outcrops of No. VI limestone and No. VII sandstone follow the south foot of the mountain past Fremont, Freeburg and Kantz post-office. Another outcrop of VI and VII 28 miles long follows the north foot of the mountain past McClure City, Adamsburg, Beaverton, Paxtonville, Middleburg, and Kreamer P. O. (where it forms the hilly north bank of Middle creek) to the Susquehanna just above Selinsgrove and the mouth of Penn's creek. The northern county line follows the top of Jack's mountain to its end at Centreville; and along the foot of Jack's mountain (composed of Clinton and Onondaga No. V) runs a third outcrop of VI and VII 18 miles long from Bannerville on the Mifflin county line past Troxelville to Centreville and New Berlin on Penn's creek. The three townships south of the first VI–VII outcrop, and the space between the two other outcrops (*i. e.* the middle of the great valley between Stone mountain and Jack's mountain) are occupied by rocks of the Hamilton, Portage, and Chemung No. VIII, and the lower beds of Catskill No. IX. The well-known Fossil iron-ore beds of the Clinton group No. V have been opened at a great number of points along the foot of Jack's mountain, along the north foot of Shade mountain, especially at Paxtonville, Adamsburg and Middleburg, and along the south foot of Shade mountain, at Freeport and Freemont. The *Sand-vein* ore bed, the highest in the series, and resting on the *Ore sandstone*, is a fossiliferous limestone; often nearly destitute of iron, but in places rich enough to yield 20 and even 40 per cent; usually soft along the outcrop, and always hard below drainage level; less than 2′ thick along Jack's mountain, and dipping 25° at Centreville, 38° at Ulsh's gap, 40° at Bennerville, *south;* along Shade mountain at Smithgrove 1′ thick, dip 30° *north;* from Middleburg to Paxtonville, too small to work, dip 45° N.;

at and west of Beavertown *soft fossil ore* 20″ to 26″. The *Danville ore beds* underlying the Ore sandstone, are three fossil limestone beds impregnated with iron close together, one or other of them very rarely becoming 3′ thick, and all softened for a variable number of yards from the surface down the dip and in proportion to its gentleness. The *Block ore bed* or *Iron sandstone* (1′ to 12′ thick) underlies the Danville ore bed by 150′. In the 500′ of olive shales beneath it the highly-esteemed *Bird's Eye fossil ore*, 100′ to 150′ above the top of the Medina No. IV, has been worked at Paxtonville, 6 to 14 inches thick, on a gentle north dip, and soft where the covering of shale is thin.

50. SOMERSET.—Area, 1100 square miles; population in 1880, 33,110. This county is sub-divided into three regions. The first and smallest consists of Southampton township in the south-eastern corner of the county; a semi-bituminous coal basin (the northern end of the Cumberland basin in Maryland) 10 miles long and 2½ wide, of the lower coal beds surrounded by a mountain of Conglomerate XII, Red Shale XI and Pocono Sandstone X (Little Savage mountain) cut through at the north end of the basin by Brush creek, which shows the general synclinal structure of the trough very finely. The second region lies between the Little Savage mountain and the Great Savage or Allegheny mountain, the crest of which is Conglomerate No. XII faced with a terrace of Pocono. The space between the two mountains is occupied by a belt of wild and broken country, 6 miles wide, of Catskill rocks No. IX, elevated by a gentle anticlinal sinking southward, and rising northward so as to bring up Chemung strata along its central line, as explained in the description of Bedford county. The third region of Somerset county embraces all the townships lying between the Allegheny mountain and the Fayette and Westmoreland line; a region of bituminous coal measures, divided into two great basins by the anticlinal of Negro mountain, through which Castleman's river makes a fine gorge of five miles between Garrett and Mineral Point, showing the arch of the conglomerate, the red shale underneath it, and the first coal bed over it. The Lower Productive coal measures occupy more than one half of the surface of the region, and coal beds from 3′ to 5′ thick are mined for local use at a multitude of points. The middle belt of each of the two great basins is occupied by hills of the Barren Measures 600′ thick, where they are all preserved, on Castleman's river in the first basin. In these Barren Measures are several coal beds too small to work, except where they become locally of exceptional thickness, especially around Berlin in Brothers' Valley township where one of the beds was for many years mistaken for the Pittsburgh bed.

South of Castleman's river, and rising from its west bank at Salisbury, the center of the first basin is occupied by a long ridge in which has been preserved a little coal field of the Upper Productive coal measures, 5 miles long by 1½ miles wide, much broken into by side ravines, but offering 3600 acres of the Pittsburgh coal bed, averaging 8′ thick, and of excellent quality: Carbon (in four analyses) 68.7 to 70.2; vol. matter 19.6 to 22.3; ash 6 to 8.3; water 1 to 1.7; sulphur 0.7 to 1.2 per cent. The section from the hill top down may be generalized thus: Sandstone 40′;

Uniontown coal; limestone 10′; shale 45′; *Sewickley coal;* limestone 10′; shale and sandstone 44′; *Redstone coal;* limestone 10′; shaly sandstone 30′; *Pittsburgh coal* 10′;* slate &c. 54′; limestone 5′; *Saylor coal* and three other lower equally small coals, with shale intervals, 144′; *Elk Lick coal* 4′; limestone 8′; shale 70′; *Berlin coal* 3′ to 6′ (slaty and sulphurous); shale 10′; limestone 8′; shale 5; *Platt coal*, good, 7′; interval 60′; *Coleman coal*, 2′ (locally 6′); limestone 3′; interval 40′; *Philson coal* 1′; limestone, 3′; interval 100′; Mahoning sandstone (upper and lower, parted by 15′ of shale) say 77′; total, Barren measures beneath the Pittsburgh coal, 600. The section of Barren measures in the Second Basin, from the hill tops at Ursina down to the water level of the Youghiogheny, at the Turkey Foot where Castleman's river and Laurel Hill creek join it, shows 504′ of shale and sandstone; holding one coal 6′, another 5′, and four others under 2′ thick; two thin limestones near the bottom and the double Elk Lick limestone (5′ and 10′ with a shale and coal streak-parting of 3½′) within 7′ of the hill top, which should be 200′ higher to take in the Pittsburgh coal. The erosion of this basin is illustrated finely by the isolated hill called "the Fort," 500 high, with its slightly scolloped flat top, and its four sides beautifully terraced like a Mexican teocallis, or the "pyramid of steps" in Egypt, each branch representing a horizontal coal bed of the Lower Productive series, thus: *Rose* coal 1′; interval (Mahoning) 100′; *Coal E (Freeport)* 2′; shale 1′; limestone 3′; interval 115′; *Coal D;* interval 40′; *(coal?)* bench; interval 70′; *(coal?)* fire-clay, bench; interval 55′; *coal*, thin; interval 15′; *Coal A?* 4′; interval (massive sandstone blocks) 100′; coal (Mt. Savage?) 1′ to river level; 517′. (This series, so important in the county, is better shown by the Johnstown section in Cambria, already described. See also Report H^2.)

51. SULLIVAN.—Area, 430 square miles; population in 1880, 8,073. This county is an eastward continuation of the Allegheny mountain plateau wilderness of Lycoming county about 2,000′ A. T. composed of a plate of nearly horizontal Pocono sandstone No. X, through which Muncy creek and the north branch of Lycoming creek, with Elk creek coming into the latter from the north, cut deep valleys and gorges, in the walls of which appear about 500′ of Catskill strata No. IX. Between Muncy creek and the north branch of Loyalsock runs an exceedingly shallow east and west trough, along the center line of which flows the Loyalsock south branch from the Wyoming county line 19 miles westward to Forksville, gradually cutting down into the Catskill rocks, but most of its course being in Pocono No. X. The mountain south of Forksville is capped by a small patch of Red Shale XI and Conglomerate XII. Another such is preserved north of the south branch at the northern corner of Laporte township; but where Birch creek joins the south branch the basin deepens eastward, and coal measures overlie the conglomerate for about 7 miles, and are mined at Bernice, where the grade at the terminus of the State Line and Sullivan railroad is 1,858′ A. T.; at Dushore in the Catskill belt 1,593; at Miller's station in the Chemung valley 1,330′;

* With a reportod rider of coal (4′ thick) 4′ above it. See Report H^3, p. 89.

and at Monroeton junction on Towanda creek in Bradford county (24 miles) 762′; the turnpike south from Dushore being at Loyalsock creek bridge 1,650′; at the Lee road 2,284′; and at the Long pond in the south-east corner of the county 2,318′; a hill east of the pond rising to 2,383′. The Bernice coal basin is about 600 yards wide, and holds two minable beds: On the Jackson tract *Coal B* 11′ thick; fire clay 8′; massive hard sandstone 22′; massive conglomerate 30′; *Coal A*, black slate roof 5′, coal 2′, slate 3 inches, fire-clay floor;—At mine No. 5, sandstone cover 80′; *Coal B*, coal 3′, slate 3′, coal 1′ 3″, slate and coal 1′ 6′, coal 4′ (total 12′ 9″); interval 10′, thin sandstones 20′, interval 20′, black slate 5′; *Coal A* coal, 1′ 11″, slate 3″; fire clay 8′; hard sandstone 22′; conglomerate sandstone 30′ (total section 215′.) (For details at other mines, see F. Platt's Report G^2, pp. 179; and C. A. Ashburner's report (not yet published AA.) The partings of *Coal B* increase eastward between mines Nos. 1 and 6 so as to separate the upper and lower benches of coal by an interval of 67′; and they separate still further from each other eastward; so that at the school-house bore hole the section is: *upper coal* 3′, parting of slate and fire-clay 45′, *middle coal* 1′ 3″, parting 11′, *lower coal* 5′. The Saw-mill bore hole to the north showed partings of 26½′ and 32½′. The remarkable feature of this basin is that the coal of *Bed B*, instead of being semi-bituminous, as in the Towanda mountain and Blossburg mountain basins, is a genuine *anthracite*, in the proportion of about 9 per cent. of volatile matter to 91 of solid carbon. One analysis of *Bed A*, however gave 67 carbon, 15 vol. mat., ash 12.7, water 4, and sulphur 0.5. The Pottsville Conglomerate under Bed A seems to be nearly 200′ thick, with perhaps 25′ of red shale under it, and then 450′ of Pocono sandstones exposed above water level at Shimersville.

52. SUSQUEHANNA.—Area, 830 square miles; population in 1880, 40,-351. This square county is 34 miles long on the New York State line and 26 wide on the Bradford and Wayne lines. Nearly its whole surface consists of rolling hills of Catskill red and gray shales, sandstones and conglomerates, with calcareous breccias containing quantities of broken fish scales and bones. In Rush township, along the three branches of Wyalusing creek, the erosion has exposed Chemung rocks. These also appear in the high cliffs which border the Great Bend of the Susquehanna river; Wiley creek valley for two miles; Salt Lick creek for 4 miles to Summers; Drinker's creek for 3½ miles; Çanauacta creek nearly to Comfort's pond; and Starucca creek for 5 miles in Harmony township; also Snake creek in Liberty for 7 miles to Franklin; Choconut creek for 9 miles to St. Mary's; and Apolacon creek nearly to Friendsville. Only the high hills of Apolacon and Choconut retain the lowest Catskill beds. In the south-east corner of the county at Forest City, with its little anthracite coal mine, the Lackawanna anthracite basin shallows to a point; and the Conglomerate No. XII, with thin Red shale No. XI under it, rests on a mountain ridge of Pocono sandstone No. X, through which the Lackawanna makes a deep gap at the outlet of Stillwater pond. The North and South Elk Mountain Knobs, in the south-east corner of Herrick township, are outlying relics of formation No. X, witnessing to its

former extension over the whole county. The drainage of the county is about equally divided between the waters of the Tunkhannock flowing south, the waters of the Wyalusing flowing west, and the numerous small streams which flow north into the Susquehanna. Montrose is centrally situated on the high drainage divide (R. R. Station 1,656′ A. T.) Glacial drift covers the entire county, and consequently ponds and swamps are numerous, with glacial dams, some of them very large; and there are many ancient buried valleys some of which afford the finest illustrations of the curious phenomenon of reversed drainage consequent upon the loose deposits of the glacial age. The general level of the country around the Elk Mountain Knobs is about 2,000′ A. T. The North Knob rises to 2,700′ and the South Knob to 2,575′; the former capped with sandstone 20′; interval concealed 175′; sandstone 10′; red shales, &c., 100′; cliffs of *Mt. Pleasant Conglomerate* (the base of the Pocono Formation No. X) 20; *Mt. Pleasant red shales* (top of the Catskill formation No. IX) 150′; interval 150′: *Cherry ridge conglomerate* sandstone and concealed 60′; *Cherry ridge limestone* 10; sandstone and shale 700′, (total say 1,400) down to East Tunkhannock creek water level at 1,300′. Since no glacial scratches are seen above 2200′ A. T. the two knobs seem to have projected like round rocky islets 400′ and 500′ through and above the sea of ice when it was at its maximum thickness. The Jefferson Branch railroad crosses its summit in Ararat township in a glacial drift cut 30′ deep, at 2020′ A. T. Mount Ararat is only 2125′ A T. capped by *Cherry ridge* sandstone. The view from the wide ledge of rocks projecting from the South Knob (Prospect Rock) at 2400′ A. T. commands an unsurpassed landscape. Fifty-one little lakes and ponds are catalogued in Report G^5, p. 21, of which the highest (measured) Dunn lake in Ararat is 2100′ more or less A. T.; Low lake in Herrick 1905′; Wrighter's pond in Thompson 1950′; Lewis and Crystal 1700′ and 1750′; Silver and Butler 1650′ and 1665′; Meadow, Mud, Hart, Jones, Brown, Stillwater, 1575′. 1550′, 1540′, 1580′, 1560′, 1525′; Quaker, Tripp, Page, Upper, Brown's, 1450′, 1430′, 1400′, 1400′, 1415′; Brushville, Elk, Middle, Lower, Tyler, 1305′, 1350′, 1365′, 1350′, 1325′; and Tucker pond 1200′. Some are surrounded by extensive swamps showing that they have formerly been larger. Bowlders of calcareous breccia of immense size are common in the Drift, and lying on the surface. The soil is very fertile, because chiefly derived from Catskill rocks, especially red shale, a specimen of which when analyzed yields 4.855 per cent of alkalies. (See Report G^5, p. 29.) There are no pure limestone strata in the Catskill formation, but "Nigger-heads" or rounded bowlders from the calcareous breccia outcrops are numerous enough to supply the population with all the farm-lime they require. In the northern townships the most important group of strata is that of (1) the *New Milford upper sandstone* making bold cliffs near the hill tops 20′; (2) *middle* greenish gray, current-bedded sandstones and alternate shales (some of them red) 300′; (3) *lower sandstone* (making a great show opposite the New Milford depot, 70′ over the railroad, and and unbroken line of cliffs to the "Fort 76 Cliff" at Great Bend, where it overhangs the river more than 400′ vertically, and so onwards) 20′. On the Bradford county line this rock lies 200′ above Wyalusing creek water level; and in the south-west corner of the county, it is quarried for flagstones at Skinner's Eddy, 240′ above river level, where it contains many plant remains. Below it lie the *New Milford red shales*, with calcareous breccia layers, 100′ to 120′. Below these the *Starucca olive shales*, 105′. Under the last appear the top layers of Formation No. VIII, olive shales with Chemung fossils, 20′; olive sandstone 3′; *conglomerate with flat pebbles*, 1′; olive sandstone 4′; olive shale 8′; olive sandstone 4′; then the *Mansfield red beds* of Tioga county: olive shale with *iron ore* near the middle 40′; brick red shale 10′; green sandstone 5′; greenish upper and purple lower shales 20′; olive shale with *Spirifer shells* and *fish fragments*. Then the *Cascade sandstone* (*Fall Creek conglomerate* of Bradford county) 25′; olive shale and sandstone, very fossiliferous, 30′; brown sandstone 25′; shale 25′; brown sandstone, very fossiliferous, 15′; shales and flags, fossiliferous, 25′, (total 275′ of Chemung upper strata exposed at the fine falls on Cascade creek, 2 m. N. E. of mouth of Starucca creek.) The Cascade conglomerate is identified by Prof. White with the *3d Oil Sand* of Venango county, but no signs of petroleum present themselves in this part of Pennsylvania.

53. TIOGA.—Area, 1120 square miles; population in 1880, 45,814. Nearly square; 36 miles along the New York State line; 32 miles along the Potter county line and 29 along the Bradford county line, with its extreme south-east corner cut off for 5 miles along Lycoming creek; a country of Lower Catskill and Upper Chemung hills, in four ranges, separated by three ranges of Upper Catskill and Pocono sandstone mountains, gapped by the Tioga river and its Cowanesque, Crooked, and Mill creek branches, flowing north; and by Pine creek and its Babb's and Stony forks flowing south. The range of broken heights running along the north side of Cowanesque creek into New York is too low to preserve any higher rocks. The second range through which Crooked creek and the Tioga river make long canons, retains a patch or two of Conglomerate No. XII in the N. W. corner of Delmar, and the small Gaines Coal Basin at the Potter county line, cut into two fields by Long run.* The summits are 2200′ to 2260′ A. T. and contain what remains of the three so-called "Three-Foot," "Four-Foot," and "Five-Foot" coal beds, lying nearly flat at an elevation of about 1000′ above Pine creek and Long run water-level, to which numerous brooks descend by short rocky ravines. The coal shows 28 per cent of volatile matter and 7½ of ash. This mountain range crosses the county and ends at the Bradford line. The third mountain range, in which the Tioga river heads, and which is split lengthwise, westward, by Babb's Fork of Pine creek, carries the old and famous Blossburg coal basin, and its western continuation the more recently developed Arnot and Antrim coal field, which has been shifted a little out of line, northwards, west of the Tioga river, by an anticlinal roll to the south of it. The coal area may be called 16 miles long by 4 miles wide; but the basin continues into Lycoming county, and

* Description in G, p. 233; and contoured map in G^2.

from Wilson's creek onward in that direction the high summits along Babb's fork are capped with Conglomerate, carrying patches of coal. Morris Run, Antrim, and Arnot are 1678′, 1682′, and 1672′ A. T. in a straight line along the center of the trough. Fall Brook, off the line, is 1842′ A. T. Several companies mine the coal for the northern market; the railroad distance from Arnot to Elmira being 49 miles. The Blossburg coal field was studied in 1832 by one of the best geologists in the world, Richard C. Taylor, so famous for his skill and accuracy that his report has been republished in Report G. pp. 146+ with others, more recently made, on subsequent pages; showing 300′ to 400′ of vertical coal-bearing strata, carrying at least 9 coal beds, running usually from 2′ to 5′ in thickness, and analysing 20 to 22 per cent of volatile matter, and 6 to 8 per cent of ash, with benches of cannel-like structure having 12 to 16 per cent of ash. The beds in the western part of the field are named (from above downwards) the Rock vein, Seymour (or Cushing) vein, Morgan (or Dirt) vein, Cannel vein, Bloss vein, Bear Creek vein, and Kidney vein. The Bloss vein, most esteemed and furnishing most of the coal shipped from Arnot and Antrim, has four persistent benches "top," "middle," "bottom," and "mining coal" (not worked) separated by parting slates one or two inches thick. The iron ore deposits of the coal measures and underlying formations exposed in the Blossburg gap and elsewhere in the county are of very little value, being almost entirely kidney or ball ore, neither rich enough, nor persistent enough to work. But in the Chemung formation No. VIII, in Charleston and Richmond townships and running into Bradford county, are three outcrops of a peculiar fossil iron ore the uppermost of which supplied for some years a small blast furnace at Mansfield; at the chief mine 3 miles west of Mansfield the bed varied from 2′ to 3′, pitching gently north, under gray shale, and contained only shells (*Productus* and *Spirifer*); in other places it was mined 1½′ or 2′ thick, under and over red shales; in other places it is little more than a limestone bed. A second *oolitic* ore bed, a foot thick, or more, and 200′ to 400′ beneath the Mansfield bed, contains many broken bones, scales &c. of *fish*. A third bed, 100′ to 200′ under the second, contains small flattened pebbles of quartz. The furnace flux was obtained from a 6′ bed of limestone largely composed of ground up sea shells, belonging to the series. Another remarkable member of the series is a white sandstone and conglomerate, 20′ thick, on Fall creek in South Ridgebury, where people have foolishly dug for silver. Prof. White's Tioga river section (G^5, p. 72) is as follows: Bottom member of Pottsville Conglomerate No. XII 60′; interval with red shales and gray sands (XI) 245′; massive sandstone 20′; interval of a mile (dip 6° to 8°) say 500′; gray sandstone 25′; *Calcareous breccia* 3′; gray sandstone 25′; red shale &c. (top of IX ?) 35′; greenish-gray current-bedded sandstones and shales (15′, 5′, 40′, 250′) 310′; finally laminated sandstone 30′; interval 50′; sandstone 20′; interval 350′; red shale and sandstone 35′; *fish conglomerate* 2′; red shale and sandstone 200′; concealed to top of Chemung (VIII) say 100′. Total from base of XII to top of VIII in Tioga county 1940′; in Wayne county 2740′ rate of thickening eastward 10′ per mile. His Falls creek section (G^5, p. 76) is: *New Milford lower* cliff sandstone 10′; concealed 120′; shales and thin sands full of Chemung fossils 80′; blackish quartz-pebble *conglomerate* 2′; shales and flags, very fossiliferous, with one or two *Spirifer beds* 120′; *Falls creek conglomerate* (*Cascade sandstone* of Susquehanna county, and probably *3d oil sand* of Venango county) 20′. It is wonderful to see the thin 2′ conglomerate of Tioga county represented by a 2′ conglomerate in the same position in the north-east corner of Susquehanna county, and occupying the place of the *2d oil sand* of Venango.

54. UNION.—Area. 310 square miles; population in 1880, 16,905. This county extends 20 miles along the west bank of the West Branch Susquehanna river, and tapers to 4 miles on the Mifflin county line. Its south line runs from Sunbury 9 miles to Penn's creek, 5½ miles up that creek to Centreville at the east end of Jack's mountain, and then 16½ miles along the summit of the mountain. The Centre county line (20 miles) crosses obliquely the 5 great anticlinal ranges of the Buffalo mountains to the head of White Deer creek, north of which the White Deer mountain carries the line east 9 miles. Gregg township occupies a piece of the White Deer Hole synclinal. The western side of the county, therefore, is occupied by seven anticlinal mountain spurs of Medina sandstone No. IV, dying eastward beneath a low country of Clinton and Onondaga No. V, across which the river flows, exhibiting the rock arches in succession. A triple synclinal runs up west between Jack's mountain and the Buffalo mountains, and along the deepest central line has been preserved a low ridge of Lower Helderberg limestone No. VI, for 5 miles west and 3 miles east of Mifflinburg. A loop of No. VI supporting Oriskany sandstone No. VII runs west from Lewisburg, south of Buffalo creek, 5 miles and returns to the river north of the creek. A small area of Marcellus shale (VIII) lies between the loop and the river. A third outcrop of VI and VII, 4 miles long, crosses Gregg township; and a small area of Marcellus lies north of it. The zig-zag red line on the map represents the *Bloomsburg red shale* division of the Onondaga (V); and between this red line and the edge of the Medina runs a similarly zig-zagged outcrop of the Clinton fossil iron ore beds as described already in Snyder county. The mines have been wrought for Union furnace on the banks of the river 4 miles below Lewisburg, in 1853. Here at the end of Longstown ridge, at water level, was first mined the lowest of the Danville beds 20″ to 3′ thick, with a breast of 80 yards on a dip of 35° southward, the soft ore changing to hard ore at water level; analysis of *hard ore:* iron 34; carbonate of lime 39; carb. mag. 2.5; phos. 0.358; sulphur 0.004. In the slope a mile west (dip 45°; bed 4″ to 10″) the soft ore goes deeper at the notch, but in the hill on each side turns to hard ore. Half a mile further west, ore lean, bed 4″ to 6″. In Chapel Hollow, 4 miles west of the river, bed rapidly varies 4″ to 18″, dip 45°, breast 80 yards, gangway 800 yards, upper beds thin. Two miles further west; ravine; lower levels hard ore, upper levels soft; three beds close enough to be worked together; in all 10″ to 12″ ore. West of the ravine the two upper beds each 6″ to 10″ are worked together; the other is 4″. The Price mine is six miles from the

river, worked by tunnel: two lower beds 8″ to 12″ have yielded 40,000 tons of superior ore. At the Maize bank they yield 10″; at the Moyer bank 6″ to 12″. The Kleckner mine is less than a mile from New Berlin; north of which the Colton mine is on a 3″ to 6″ bed; and a mile west of it Seabold's mine has 4″ to 6″ of soft ore, but further towards Centreville are no mines. This account of the fossil ore on its southernmost outcrop in this county will serve for a description of it on other outcrops.

55. VENANGO.—Area, 660 square miles; population in 1880, 8,480. Allegheny river enters from Forest county, meandering westward to Franklin, and then south-eastward to the corner of Butler and Clarion counties. At Franklin it receives French creek from the north-west, then the Sandy from the west, and the Scrubgrass from the south-west. At Oil City it receives Oil creek from the north and further east Pithole creek from the north-east. Sugar creek from the north enters French creek 3 miles above Franklin; and East Sandy creek comes in from the east 5 miles below Franklin. The whole county, therefore, is an excessively rough and broken table land, trenched to a depth of 500′ in every direction by narrow valleys and innumerable side ravines bounded by steep slopes, along which range nearly horizontal craggy outcrops of the sand rocks and intervening shales of No. XII and No. X; the intervening red shale formation No. XI being doubtfully present. An exceedingly gentle slope of the formations southward carry them one after another under water level down the river; and preserving at least 26 patches of the Lower Productive coal measures in the southern townships. One of these occupies a hill just north of Centerville in Pine Grove; four others west of it in Cranberry; six between East Sandy creek and the river; five in Irwin, four in Clinton, two in Scrubgrass; and the rest along the Butler county line. All the southern patches form knobs high enough to take in the *Ferriferous limestone*, with one or both of the overlying Kittanning coal beds. The limestone is even preserved in two knobs north-west of Centerville. The amount of workable coal in the county is small, but it has sufficed to run engines at the oil wells. Petroleum in quantities was discovered on Oil creek, at the north line of the county, in 1859; but for centuries previous to that date the Indians had collected it in shallow pits, for sacred and medicinal uses. August 28, 1859, Col. Drake's first well reached the *1st Sand rock* at a depth of 71′; the tools dropped into a crevice, and a flow of 25 bbls. per day commenced the production of the American Oil Regions. Of the many wells soon afterwards bored, some went 200′ deeper and got a greater yield from a *2d Sand rock*. In February 1861 Funk's well on the McElhenny farm, on Oil creek, at a depth of 400′ struck the still richer *3d Oil Sand*, and became the first "flowing well." Then the Phillips well on the Tarr farm and the Empire well, each flowed 3000 bbls. a day. Oil was then sold for 10 cents a barrel, or allowed to run waste, and the small wells were abandoned. In 1864 the whole production had dwindled to 4000 per day; but a market had been created; and oil sold for $14 per barrel. This excited the new developments along Pithole creek; and in 1866 wells began to be drilled from the

highland, without regard to the valleys, on Bennehoff, Pioneer, and Stevenson hills in 1866; on the Tidioute and Triumph hills in 1867; on the Pleasantville and Shamburg hills in 1868. C. D. Angell's theoretical line N. 16° E. was adopted by the drillers in 1871.* The Lower Oil Region south of Franklin was brought first into notice in 1868, by some good wells at Lawrenceburg, on the hill above Parker's landing. The enterprise at first expended in Venango county was transferred to Butler and Clarion and afterwards to Warren, McKean, and Forest counties, and the silent oil cities on the original hills are among the most impressive things of human history. The geological character of the Oil Sand Group as a well-defined formation separate from those above it and below it was worked out by Mr. J. F. Carll, of Pleasantville, in the years preceding his appointment in (1874) as Assistant Geologist on the Second Survey of the State, and is to be found described and illustrated in his first Report I, 1875. A great number of well records are published and annotated in I^2 (1877). A fuller report on the Oil regions, with an Atlas of maps and charts, I^3 appeared in 1880. Ennis hill at Pleasantville, the highest point in the county (1713′ A. T.) has not preserved the bottom layers of the Pottsville (Olean) conglomerate No. XII, but only its fragments. The section proceeds downwards thus: *Cuyahoga shale* (XI?) with some little poor coal, poor iron ore, black slates &c. 70′; *First mountain sand* (X) with Lower Carboniferous plants, 45′; shales, with ferns &c. crustacea, and fish remains, 55′; *Second mountain sand* (Lower Berea grit) with plants, sea weed, and shells (*Productus*, *Orthis*,) 45′; *Bedford and Cleveland shales*, with the same fossils. 231′; *Third mountain sand*, 56′; shales 168′; *First Oil Sand* 40′; shales 99′; *Second Oil Sand* 30′; shales 76′; "*Stray Third*" 16; parting shales 27′; *Third Oil Sand* 20′; thence downward nothing but soft Chemung shales to the greatest depths bored. Any given section, however, differs in its details from this and every other section, each Sand being found in various places split into two; and the Stray and Third in some places united and 100′ thick. But nevertheless the peculiar triple character of the group is always noticeable, and its normal thickness of 300′ to 350′ is wonderfully preserved. Where the sands are fine and light no oil is obtained; where they were found to be pebbly, and especially where the interstitial sand and clay had been washed away from between the pebbles by fresh or salt water in the course of ages, leaving a layer of pebbles loosely touching each other, there the wells flowed or spouted floods of oil and water, driven from below upward by the force of the more volatile hydro-carbon compounds, under the superincumbent weight of from 400 to 1000 feet of strata. (For detailed descriptions of the underground transfers of oil, water and gas, see Report I^3.)

56. WARREN.—Area, 910 square miles; population in 1880, 27,981. This county is square, 36½ miles long on the New York State line and 26½ miles wide on the Crawford and McKean county lines. The Alle-

*The Butler-Clarion belt was afterwards found to lie about N. 22° E., with a bend at Parker's.

gheny river reënters the State at its north-east corner; runs south and west to Warren, where the Conewango river comes in from the north; keeps on 7 miles further west to Irvineton, where the Brokenstraw comes in from the north-west; then 14 miles south-west to Tidioute and Triumph; then 4 miles to the Forest county line. The Oil creek waters drain out at its south-west corner. The most remarkable feature in the drainage of this county is the heading of Tionesta creek on the highest land overlooking the Allegheny river in Watson township;* whence it flows in a direction opposite to the course of the river, north-east, to Cranberry swamp (6 miles south-east of Warren). Here it turns and flows south 6 miles to Sheffield, where it receives a large branch from the east; then 2 miles south, where it receives its south branch coming from the *south*, and then the combined streams flow south and south-west through Forest county to the Allegheny river. There is no way of accounting for this remarkable topography in Meade, Cherry Grove, Sheffield, and parts of Kinzua and Pleasant townships, but by accepting Mr. Carll's conclusion that in the ages before the invasion of the northern ice the drainage of the Tionesta was *northward* to Warren, and that the reversal of the drainage to its present southward direction was caused by a dam of glacial drift being thrown across the ancient valley between the Cranberry swamp and Warren. In fact the oil wells at Clarendon have gone through 250′ of drift before reaching the bed rock of the ancient valley. Similar facts observed throughout the upper Allegheny river region in Pennsylvania and New York form a body of evidence that the whole rainfall north of Tidioute previous to the ice age passed northward into the eastern end of Lake Erie.

All the highest highlands of the southern half of the county consist of massive coarse *Olean conglomerate*, sloping gently south-westward at a rate of 16 feet per mile;† consequently the only coal beds in the county are the Sharon and perhaps Scrubgrass coals, and nowhere of much importance. At Quaker Hill, in the south-west corner of Elk township, north-east of Warren, the Sharon bed (2′) has furnished a good deal of coal for the neighborhood. The Oleon conglomerate caps the high ridges north of the Allegheny and Brokenstraw, making a great show in cliffs and gigantic fallen blocks, especially at Garland station on the Philadelphia and Erie railroad. The outcrops of the *Sub-olean conglomerate* form cliffs and steep bluffs along all the valleys and ravines; the lower slopes consist of Crawford shales, in the upper part, and the Venango oil sand group (300′ thick) in the lower part. The underlying Chemung flags are above water in the Allegheny river valley, from the State line up to Kinzua in the Conewango river valley, from the State line up to within 5 miles of Warren, in the Stillwater creek valley from the State line up to

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*Cobham P. O. is 1140′ A. T. Road forks to Warren 1790′. Head of west branch of Hickory creek at bridge 1555′. Sheffield depot 1344′.

† Base of Olean conglomerate in Glade township 1996′; on the Forest county line west of the river 1550′ A. T. (See Report I[4], p. 186.)

Sugar Grove, in the Little Brokenstraw valley, from the State line down to Lottsville.

The *Shenango shales* under the Olean conglomerate mark the end of a geological age by the fact that they vary in thickness from 60′ to 30′, and the Olean above them seems in some places not only to cut them out entirely but even to descend so as to take the place of the Sub-Olean conglomerate which underlies them; to say nothing of the fact that in Eastern Pennsylvania they are represented by 3000′ of Mauch Chunk red shale (XI) or perhaps by the uppermost strata of the Pocono formation No. X. North-west of the Allegheny river they are almost uniformly 50′ thick; but south-east of the river they thicken to 100′ at Sheffield and 120 or more at Brookston; and on the Clarion to 150′. The *Sub-Olean* conglomerate (X) marked by its *flat pebbles* ought to be a key rock to the oil drillers; but they have paid as yet no attention to it. The three *Oil Sands* of Venango county (already described on page — above) are in full force along the river up as high as Tidioute. Here the highest summits are capped by Olean conglomerate and Sharon shales, and (in Deerfield) by Kinzua sandstone (middle XII.); the general highland by *Shenango shales* and *Sub-Olean conglomerate;* and along the river bluffs run the three *Mountain Sands* of Oil creek. The lowest or *Third Mountain sand* (*Pithole* grit) loses its individuality (turning into a shaley flaggy series, no one sandy member of which can be followed with any certainty) as it slowly rises along the river from Tidioute towards Warren. The *First Oil sand* also outcrops along the hill-side, but becomes less well defined going towards Brokenstraw township. The *Second Oil sand* at Triumph is divided into two (the lower one at Tidioute just below water level) but loses its character and passes into shales under the high land west of the river. The *Third Oil sand*, 120′ thick at Triumph dwindles to 30′ at Tidioute, and in the next three miles north-eastward is indistinguishable as a separate stratum from the super and subjacent shales. The sandstone layers in the hill-sides at Warren therefore cannot be identified with the three *Oil sands* as has been often asserted; and furthermore no special thickness can be assigned to the interval between the *Venango Oil Sand group* and that *Warren Oil Sand group* which has yielded oil beneath Conewango creek. Nor do these Warren sands extend southward beneath the Venango sands; for the borings from Warren down to Triumph show nothing of the kind beneath the Venango *Third sand;* neither do the Bradford oil sands, as the Clapp well No. 1 (bored in 1882) and the Fagundus well No. 37 (deepened from the Third sand downwards in 1882) prove. The Clapp well, 3 miles west of the river and 3 miles north of the Forest line (2464′ deep) went to 2550′ beneath the *Olean conglomerate;* and the Fagundus well (2700′ deep) to 2700′ beneath it, without striking a single well-defined sand referable to either the Warren or Bradford rocks in the 1600 feet of shales underlying the Venango Third Sand. The Warren oil sand rocks are as specially and peculiarly a feature of Warren county as the Bradford oil rocks are a unique feature of the geology of McKean county. Gardner's rock is a picturesque outlier of horizontal Olean conglomerate (at "the Pass" S. E. corner of Elk township) from the bottom layer of which blocks (30′ high, 40′ wide and 70′ long) have detached themselves and slidden down the slopes of Hatch's run; top of rock at summit 2080′ A. T.; top of Gardner's rock 2030′ A. T.; Allegheny river at mouth of Conewango creek 1177′ A. T. The Wolf Den is another fine object. The Beatty well No. 1 at East Warren (or Glade City), the first paying well in measures lower than the three Venango Oil Sands, was bored in March 1875; well mouth 1217′ A. T.; valley drift 90′; oil and gas got from 620′ down to 629′; production 5 bbls.* Developments naturally spread from this as a center; North Warren was opened on one side and Stoneham on the other. The most astonishing oil development ever witnessed in Pennsylvania commenced with the Jamestown Oil Co.'s well, called the "Mystery" from the precautions successfully taken to conceal its first yield from the public until May 18, 1882, when the plug was removed and 1100 bbls. a day flowed; it was drilled a little deeper and yielded June 13, 2000 bbls. By the end of August this new Cherry Grove or Garfield district was pouring upon the oil market 40,000 bbls. per day from 69 wells completed to August 1, and many more bored that month. Of 405 wells commenced in seven months (May—November, 1882) 383 were productive and only 22 dry. But each flowing well fell off rapidly in its daily yield; for example, the Sardine Co.'s well flowed on its first six days 2000, 1128, 594, 444, 350, 274 bbls. The "Mystery" well, above mentioned (its mouth 1805′ A. T., struck oil at 1630′) or 175′ above tide level; passing the *Clarendon oil sand* at 1345′ or 460′ above tide level, with no show of oil. The order of Warren oil rocks is thus given by Mr. Carll: North Warren oil shales say 1200′ beneath the Olean conglomerate; Warren "third sand" 1325′; Stoneham wells 1400′ (gas horizon in N. Warren); and a little oil in North Warren from strata 1650′ beneath the O. C. (For innumerable details and discussions see Report I[4], 1883.)

57. WASHINGTON.—Area, 890 square miles; population in 1880, 55,418. The geology of this county is a continuation northward of the geology of Greene county already described, with the difference that the mass of the Upper Barren measures is thinner, *i. e.* confined chiefly to the lower or *Washington county group*, which is more and more washed away, until only the lowest beds are left on the hill tops south of the Pittsburgh, Cincinnati and St. Louis railroad, and south of Chartiers creek in North Strabane and Peters townships. The *Upper Productive coal measures* come out from under it in the northern and eastern townships; and the *Pittsburgh coal bed* not only carries its outcrop along the river below Millsborough and from Brownsville down stream; but along Chartiers creek 7 miles; along Cross creek from Patterson to the State line; along Harman's creek and Raccoon creek; and around the summits in Hanover township, all the lower grounds being occupied by *Lower Barren measures.* The best geological section is afforded by the wells recently bored for gas on Chartiers creek north of Washington. The *McGuigan well*, for example, in Mount Pleasant township, 6¾ S. S. E. of Burgettstown and 2½ miles S. W. of Hickory P. O. on a branch of

*For a map of the Warren wells see preface to Report I[4], pp. xvi–xix.

Cross creek, at 1,175′ A. T. was stopped by a tremendous flow of gas at a depth of 2,237′ *(1,062′ below sea-level)*, which was long allowed to waste itself in the air; but the Niagara Oil Company, who purchased it in 1882, have laid a 6-inch pipe, 22 miles long, to Pittsburgh, where the gas is used in Taylor's salt works at Temperanceville, in Painter & Louis' iron works, South Side, and in about fifty private houses along the route. In 1884 an additional 8-inch pipe line was laid from the Pittsburgh end for six miles, to be completed in 1885. This has already nearly doubled the delivery at the Pittsburgh end, although fed from the single 6-inch pipe at the well, where the pressure was (December 28, 1884) 193 ℔s. to the square inch, even while a large dark rich smoky flame was issuing from an escape pipe into the air, and a good deal of gas was escaping also from the safety-valve, with a rather fetid odor and a faint smell of petroleum. The old record marks *Coal* (5′) at 180′ down; *Coal* (15′!) at 285′; 1st sandstone (40′ thick) encountered at 762′; 2d (35′) 865′; 3d with a little gas (40′) 988′; 4th (55′) 1,100; 5th (234′ with 15′ of slate included in it) 1,266′ to 1,500′; 6th (10′) at 1,578′; 7th (5′) 1850′; 8th (10′) 2,035′; 9th *Gas sand* (8′ and more) from 2237′ to 2245′ bottom of well. The second coal encountered was probably the *Pittsburgh bed*. The 3d sand from which came a little gas is part of the Mahoning sandstone which furnished the oil for the Dunkard creek wells in Greene county; and the 5th sand the Pottsville conglomerate No. XII; below which the great Gas sand lies 700′, and therefore on the horizon of either the 1st or 2d Butler county Oil sand. The Gas sand of this well lies 1960′ beneath the supposed Pittsburgh coal bed cut in the upper part of the well. [The Boyd's Hill well in Pittsburgh poured its flood (3000 to 4000 bbls. per day) of brine from a white sand rock (112′ thick) the bottom of which lies 1950′ beneath the Pittsburgh bed. (See Report L, p. 229.)]

The *Hess* well is remarkable for showing in its record-bottles at least four *limestones*, at depths of 330′, 513′, 962′, and 1385′. The Pittsburgh coal being cut at 242, the lowest limestone is probably the *25′ limestone* at (889′–914′) in the Boyd Hill well at Pittsburgh, the ("Mountain lime stone") which appears in gaps of Chestnut Ridge and Laurel Hill on the Conemaugh and Youghiogheny rivers. The *Gantz Mill well*, bored just outside the Washington borough limits, late in 1884, at 1030′ A. T., had a carefully kept record of the strata underlying the uplands of the county: Loam 10′, *limestone* 20′, *coal* and slate 4′, *limestone* 20′, slate &c. 200′, hard gray sandstone 20′, black slate 30′, hard sandstone 25′, slate 4′, soft white sandstone 5′, blackslate 1′, (*Pittsburgh*) *coal bed* 5′, soft sand 10′, slate 12′, hard shell 2′, slate 10′, hard gray sand 11′, slate 30′, soft white sand 10′, slate 51′, very hard sand 80′, slate 10′, *limestone* 5′, slate 15′, *red rock* "inclined to cave" 60′, slate &c. 40′, *red rock* "caving badly" 25′, slate 32′, *red rock* 25′, white sand 20′, slate &c. 100′, hard gray (*Mahoning*) sandstone 100′. [*This makes the* LOWER BARREN MEASURES *648 feet thick.*] Then, (*Freeport Upper*) coal and slate 12′, slate &c. 60′, sandstone 20′, slate &c. 100′, hard white sand *with salt water* 57′, black slate (no grit) 15′, soft white sand 10′, slate &c. 15′, hard bluish gray sand 12′, slate &c. 27′, sandstone (*yielding gas but soon exhausted*) 10′, black slate (no grit) 10′, hard, flinty sand 3 . black slate (no grit) 77′, *limestone* 30′, [to 1450′, below which lay a continuous series of sandstone layers] hard white 90′, softer 6 , hard 8′, alternately hard and soft 40′, fine, blue gray 20′, alternately hard and soft 140′, very hard 16′, [to 1770′, in all 320′.] Then, black slate (no grit) 25′, *pebbly sandstone* 40′, slate and hard shells 100′ [to 1935′,] slate &c. 40′, white hard *pebbly sandstone* 8′, good drilling slate 25′, blackish rotten sandstone 10′, brownish red sandstone 8′, slate 15′, dark *pebbly sandstone* 6′, fine coffee colored sandstone 12′ [to 2199′] when on going 2′ more into sandstone the drill stopped with a good show of oil, at 2101′ [*1071 feet below sea level; and 1757′ beneath the Pittsburgh coal bed*,] which goes to disprove the popular idea that liquid petroleum cannot exist much below sea level; and indicates that the Clarion-Butler Oil Belt may extend through south-western Pennsylvania at a depth of 2500′ or 3000′, perhaps into West Virginia.

58. WAYNE.—Area, 740 square miles; population in 1880, 33,513. This is the only county in the State the surface of which is wholly occupied by one formation (Catskill No. IX), except a strip, two miles wide and 12 long, ending in two points on the western (Susquehanna county) line, occupied by the Moosic mountain outcrop of Pocono X, with a thin outcrop of red shale XI, and the Conglomerate XII, the extreme end of the Northern Anthracite coal field. It is bounded for 7 miles by the New York State line, and separated from that State for 50 miles by the meandering course of the Delaware river, from Hale's Eddy (974′ A. T.) down to the Pike county corner at Narrowsburg (714′ A. T.) flowing between two walls of horizontally outcropping gray and red sandstone and shale strata, 500′ high, broken by a hundred side valleys and ravines; but nearly all the county is drained through the water-tree of the Wallenpaupack south-eastward through Pike county, the two main branches of which unite at Honesdale (985 A. T. canal level.) The general surface is so high that the villages of Cold Spring, Rileyville, Pleasant Mount, and Belmont are 1600′, 1715′, 2025′, and 2040′ A. T. Drift covers the whole surface, causing innumerable little lakes and swamps. A bore hole in search of oil, made by the Wayne County Oil Company, on Dyeberry creek, 6 miles N. of Honesdale, of which a careful record was kept (published in the Pike and Monroe Counties Report, G^6, pp. 92–93) reveals the underground geology of the county to a depth of 1505 feet: Drift at the surface 36′; red shales and gray sandstones 29′; reds 10′; red sh. 5′; pebbly s. 5′; reddish s. 15′; red sh. 10′; sandstone, some layers pebbly, 55′; shale 8′; sandstone 10′; shale 7′; s. 4′; sh. 6′; dark red slate 15′; bluish green-slate 40′; gray s. 175′; brown shaly s. 30′; fine gray s. 20′; shale 50′; small-pebble sandstone 30′; dark gray s. 5′; dark red s. 35′; red sh. 10′; dark sh. 20′; gray s. 10′; red sh. 45′; gray s. 30′; sh. 5′; sandstones 50′; red shale (where *water* was cased off at 778′) 30′; gray s. 25′; dark red sh. 10′; shale 30′; sandstone 10′; red shale 5′; gray micaceous s. 50′; shale 95′; sandstone 50′; small-pebble s. 45′; sandstone (with weak vein of *salt water* at 1140′) 20′; shale 10′; sandstone 15′; shale 25′; sandstone, gray 5′, hard 10′, coarse 5′, small-pebble 10′; red shale 15′; sandstone, coarse 15′ (here a strong vein of *salt water*, at 1240′ filled the hole to

within –′ of the top), fine 5′; red shale 10′; sandstone, coarse 17′; brown 13′; dark red shale, 30′; sandstone, small-pebble, 5′, fine 10′, greenish, 5′, brownish 10′; shale 5′; sandstone micaceous 35′; shale, reddish 5′, red 36′, sandstone red, 5′; shale dark red 10′; sandstone micaceous, 14′; shales, red 20′, dark red 20′, to bottom at 1505′.

The stratification is not perfectly horizontal, for while there is a general slope of the whole south-westward a perceptible basin crosses the river at Damascus, and another below Scott, between Shrawder's and Shohokin creeks; and an intermediate slight anticlinal at Stockport. There is also a local rapid dip (N. W.) half a mile below Hawkin's station on the river; and other local slight but noticeable defections from the horizontal. On the western line the Moosic mountain rocks (X, 600′ thick) dip suddenly 10° to 12° into the coal basin. The Catskill rocks (IX) are about 2000′ thick. A remarkable gray-white sandstone, 20′ to 25′ thick, filled with *reddish quartz pebbles* caps Collins' high knob at Cherry Ridge P. O. and is traceable throughout the county; and at its base is one of the *calcareous breccias*, also holding pebbles. Under this are 20′ to 25′ of shales; underlaid by a 15′ sandstone and 5′ *limestone* making conspicuous rock-ledges in hundreds of localities all over the county; and in the southern townships charged with *reddish pebbles*. This *Cherry Ridge limestone* is a very remarkable member of the Catskill formation, wholly different from the local calcareous breccias; but it is usually very poor in lime: three analyses show 11, 18, and 20 per cent; a fourth however gave 64 per cent of carbonate of lime. (See Report G^5, p. 65.) The limestone rock is an agglomerate of chips of slate or shale, fragments of fish bones and fossilized wood, in a sand cemented by lime. Its place is marked by 100′ or more of *red shale* strata under it; under which again crops out the three *Honesdale sandstones: upper white* (25′) making Burns' cliffs a mile south of the town; *middle red* (40′) making the top of the Irvine cliff opposite the town and remarkable as the one solitary *red sandstone* in the whole Catskill formation in this county; and the *lower gray* (25′ rising occasionally to 50′) making the two miles of cliffs along Dyeberry creek above the town. The underlying *Montrose red shale* (100′) reddens all the roads around Honesdale; and at the top of this mass lies the so-called "Copper and nickel shale" of the old reports. The underlying *Paupack sandstone* of the quarries (25′ thick) is a beautiful bluish-green building stone, apparently confined to the southern townships. Under this lie 200′ of greenish-gray, current-bedded sandstones, and green, olive and occasionally red shales; under which in the extreme north come the *New Milford upper sandstone* (20′), middle shales (300′), and *lower sandstone* (20′), the latter forming cliffs about 100 feet above water level at Port Deposit, and falling southward fast enough to put itself beneath the river bed at the State line; of course it is underground throughout the whole county.

59. WESTMORELAND.—Area, 1,040 square miles; population in 1880, 78,036. The geology of this large and wealthy county is a continuation of that of Fayette county already described. But in the northern part of Ligonier valley on the Ligonier-Fairfield line the *Pittsburgh coal bed*

has been preserved in a long high ridge and some isolated hill tops. Another remarkable diversity of structure is presented along the west side of the valley in an extraordinary steepening of the commonly 20° to 30° east dip of the rocks to 80°, the Conglomerate, No. XII, forming a line of low sharp knobs on the slope of the mountain; and this explains why the basin east of it is locally deep enough to hold all the Barren measures and even some of the beds above the Pittsburgh coal. Chestnut Ridge, finely-gapped by the Loyalhanna, shows the usual arches of Conglomerate (XII) red shale and iron ore (XI) and Pocono sandstones (X). West of Chestnut ridge runs the remarkably straight and regular Blairsville basin, with the Derry and Latrobe mines to the north, and the Jacobs creek mines to the south, in the Pittsburgh coal bed, as at Connellsville, sustaining a vast number of coke ovens. Next west of this basin (5 miles wide at the south and 3 at the north, and 20 miles long) runs the Blairsville anticlinal, crossing the Loyalhanna near Bradey's old mill and the Pennsylvania railroad just east of Carr's tunnel; the arch on the Loyalhanna being high enough to expose all the Barren measures, and even the Freeport Upper coal bed, the stream cutting deep between cliffs of Mahoning sandstone. Approaching the Sewickley, with equal dips of 4° on both sides, it flattens away. West of it is the Greensburg basin of Pittsburgh coal bed and overlying measures, (4 miles wide by 12 long) and another smaller patch north of New Alexandria. West of this runs the Saltsburg anticlinal arch across the county exposing most of the Barren measures, under which appear the Freeport coals in the deep valley of the Loyalhanna; at the head of Little Sewickley creek; and along Sewickley creek and its branches around Sewickley mills; the anticlinal being very flat and only slightly represented on the Youghiogheny above the mouth of Jacob's creek. West of the Saltsburg belt lies the great (Lisbon) basin of the Pittsburgh coal bed (12′ thick), the northern point of which overlooks the Kiskiminitas river 3 miles below Saltsburg, and widens southward to 3 miles in Franklin township, 4 miles in Penn, 7 miles across Huntingdon into Hempfield, with its eastern edge running on south to the mouth of Jacobs creek, and spreading across the Yioughiogheny and Allegheny rivers westward into Allegheny and Washington counties. As it deepens southward the basin begins to preserve patches of the *Redstone coal* (4′ thick and 50′ above the Pittsburgh bed); then patches of the *Fish-pot limestone* (25′ thick); then the *Sewickley coal* (3′); then the *Great limestone* (80′); then the *Uniontown limestone* (12′) and its overlying *coal* (3′); then the *Waynesburg limestone* (20′) and its overlying coal (6′), roofed with the *Waynesburg sandstone* (70′), a total of Upper Productive coal measures overlying the Pittsburgh bed of 425′. Even some of the still higher Upper Barren Measures are preserved in a hill top in Huntingdon, and another at Fulton P. O. and a large patch between the Big and Little Sewickley creeks, a considerable area between the Sewickley and Youghiogheny, and another on the high divide between the two rivers in the south-west corner of the county. Although called "Barren measures" and holding six coal beds only 1′ thick, and a seventh only 2′ thick, in 236 feet of column to the top of the *Upper Washington limestone* (30′ thick), they have an eighth *(Washington coal)* lying 500′ above the Pittsburgh bed, of very poor quality, much parted with slate, and rapidly varying from 4′ to 9′. In the north-west the *Waynesburg anticlinal arch* crosses the Kiskiminitas near Roaring run; Pucketta creek west of Oakland P. O.; the Murraysville pike just east of Murrysville; and the Pa. R. R. exactly midway between Carpenter's and Stewart's stations. A continuation of this anticlinal roll runs down the county line across the Yough to the Monongahela river near Webster; it is so gentle as rarely to show a dip greater than 1°. West of it lies the *Waynesburg trough*, not deep enough in this county to hold the Pittsburgh bed, except in six hill tops west and north of McLaughlinstown. West of it runs the *Pinhook anticlinal* from 2 miles below Leechburg to the mouth of Patterson's run. (See Report K^2, 1877.) The character of the Pittsburgh bed along the Monongahela is amply illustrated in Report K^1 1885. In the Blairsville basin its *top bench (c)* varies from 0′ to 5′, its *main clay (b)* from 6 inches to 2½ feet; its *bottom bench (a)* from 6′ to 9′. In the Greensburg basin, *(c)* varies from 4 inches to 5′; *(b)* from ½ to 1½′; *(a)* from 6′ to 8′. In the Lisbon trough *(b)* varies from ⅛′ to 6′; *(c)* from ½′ to 1⅛′; *(a)* from 6′ to 9′. Six analyses from the Blairsville basin show 30 to 34 p. c. vol.; 59 to 64 carb.; 3.5 to 6 ash; 1 water; 1 sulphur; *coke* 65 to 69; and nearly the same in the other basins, (see K^2, p. 59.)

60. WYOMING.—Area, 400 square miles; population in 1880, 15,598. This small lozenge-shaped county has the same geology as Sullivan county on the west and Susquehanna county on the north, already described; but the magnificent meandering cañon-like valley of the North Branch Susquehanna, which crosses it from its north-west to its south-east corner, offers an unrivalled exhibition of the Chemung and Catskill measures; the highland of Pocono sandstone, to the west, supporting ridges of Conglomerate, containing at least one workable coal bed, mined at various points on the northern Mehoopany heights, west of Forkston. At the Company's bank in the wilderness summit of Dutch mountain, the bed is over 3′ thick, and 2125′ A. T. (See Report G^7, p. 42.); analyzing 73.5 free carbon, 10.2 volatile matter, 15 ash, 0.6 water, and 0.7 sulphur. In the shale under the coal are *Neuropteris*, *Cardiocarpus*, *Cordaites;* and in the sandstone roof *Sigillaria* stems nearly two feet in diameter (flattened.) The underlying Pocono sandstones No. X seem to be only 300′ thick, the bottom (*Griswold Gap*) conglomerate of which makes a great show. Under it lie 400′ of Pocono-Catskill (transition) greenish-gray sandstones, with several thin interpolated red shales, the lowest member of which more coarse and massive than the rest is the *Mt. Pleasant conglomerate* of the counties to the north and east. Under this lie the proper Catskill series of thick groups of red shale beds, separated by gray sandstone beds, and holding calcareous fish-bone breccias, the lowest of which is assumed as the base of the series, probably 1600′ or 1700′ thick in this county. A good section of the upper 1231 feet of the formation can be got along the river from Coxton up to the county corner, on a south dip. Here on the crown of the great Bald Eagle anti-

clinal they turn over to a north dip and the same section repeats itself ascending the river to the mouth of Bowman's creek (575′ A. T.) where *Miller mountain* in Eaton township, rises from the river bank in an isolated mass 1600 feet (to 2175′ A. T.) Its flat top massive gray sand rock strata show no glacial scratches, such as appear on the naked rock surfaces all over the county. It is one of the lower sandstones that makes the charming cascade (50′ high) in the forest-clad ravine of *Moneypenny's glen* near South Eaton. Four glacial terraces are visible at LaGrange: the *lowest* is the flood plain of the preseut river 30′ to 35′ above low water mark; the *second*, rising abruptly to 100′ is full of small rounded bowlders, many of them of rocks which must have come from northern New York or New England, or from the Drift on the Mohawk river heights; the *third* rises to 150′; and the *fourth*, at 200′ (775′ A. T.) is marked by fine, white siliceous clay, showing still-water when there was perhaps a temporary submergence of the United States to a depth of at least 1000 feet. Vast heaps of glacial drift line the sides of the river valley and its tributaries throughout Mehoopany township; and on its west line is a great *bowlder bed* at 950′ A. T. (235′ above the river at Scottsville) which seems to have been made by the descent of the drift materials from the slope above, and their arrest in standing water. In north-west township, where the Mehoopany breaks out from the Dutch mountain plateau (2200′ A. T.) is Lovelton (1020′ A. T.); 1½ miles N. W. of which (1350′ A. T.) a well was bored for oil, at the north foot of the Dutch mountain, which rises abruptly from it about 900 feet, capped by the *Griswold gap conglomerate;* sixty feet beneath which a brook descending the mountain side makes a cascade of 75 feet; seventy feet lower another of 90 feet; ten feet of red shale is followed by 130 feet of almost continuous cascade; 25′ red shale; 55′ flags; 35′ red shale; cascade of 25′; interval 65′; cascade of 20; red shale 10′; cascade of 15′; red shale 10′; cascade of 20′; red shale 30′; cascade of 30′; red shale 10; cascade of 20′; red shale 30′; cascade of 40′; red shale to 1350 A. T. well mouth level. The well went through alternate sands and shales 800′; then white sandstone 8′; red shale 200′; gray and red 175′; white sandstone 25′; interval 150′; gray sandstone with small quartz pebbles; interval 175′; "big red" 40′; interval 35′; "little red" 25′; hard blue micaceous sandstone 5′; gray green sandstone "*with a smell of gas*" 20′; interval 53′; hard gray sandstone beds 58′; red shale 12′; hard gray sands 20′; blue black shales 80′; purple shales 52′; greenish gray sandstone 10′; *white pebbly sandstone* "*with some oil*" 9′; sandstone 5′; shale 5′; sand 5′, blue shales 142′; shales 28′ to bottom of hole; depth 2089′; total section of rocks from top of mountain 2964′. Top of Chemung formation say 234′ above the bottom of the well. The Chemung rocks come up from under the Catskill at the eastern corner of Mehoopany township, and continue to rise gently along the river banks, as far as Skinner's Eddy where they turn over and descend again more steeply up stream into Bradford county. There are no valuable minerals to be found in this county in the Pocono, Catskill or Chemung strata; no iron ore; no oil; none of the precious metals; but valuable quarry beds have been exploited at Meshoppen and at Black Walnut in lower Catskill strata. The Black Walnut rock is a fine-grained slightly greenish blue sandstone 50′ thick, its layers furnishing either flags, sills, steps or heavy building stone; a *fish and plant bed* lies 10′ above the quarry rock. Overfield's quarry rock (30′ thick) is 100′ still higher in the series and furnishes large flags. Under it lie 40′ of red shale with macerated fragments of *Archæopteris hibernica.* The great Meshoppen quarry layers (6″ to 4′ thick) make up 45′, the best (bottom) bed being sawn and polished for ornamental work; a breccia overlies the mass; and fine specimens of plants (at least two species of *Archæopteris*) can be got from the shales between the courses.

61. YORK.—Area, 920 square miles; population in 1880, 87,841. This large and wealthy county, stretching for more than 50 miles along the west bank of the Susquehanna river, and 42 miles along the Maryland State line, has a remarkably varied geology, as yet very imperfectly understood. It is naturally divisible into three nearly equal areas: The *northern* townships of Mesozoic (New red) sandstone and shale (with an unusual quantity of trap ridges* and bowlders, and a good deal of magnetic iron ore), traversed centrally from S. W. to N. E. by Conewago creek (which drains most of Adams county) and by Little Conewago creek along the southern margin. A *middle belt* of townships along Codorus creek, and its west branch, flowing from the south-west (the south branch heads at the Maryland line) consists of (1) the southern appearance at the present surface of the Great Valley limestone (No. II) which undoubtedly floors the northern area beneath the Mesozoic rocks; (2) the underlying Potsdam sandstone of Chiques cliffs, and the Pigeon hills; (3) belts of hydro-mica schists connected in some as yet undetermined manner with Nos. I and II; and (4) a more southern belt of chlorite schists (of equally uncertain age) about 4 miles wide, running through Lower Windsor, Windsor, York, Springfield, Codorus, Manheim, and W. Manheim townships to the extreme S. W. corner of the county. The *southern* townships, with a general surface of gneisses and schists, evidently belonging to the Philadelphia Belt system, whatever that may be, are drained *transversely* by the extensive water-tree of Muddy creek (precisely as the same region in Delaware county is drained *transversely* by Darby, Cobb's, Ridley, and Chester creeks) which turns at a right angle where it meets the roofing slates of Peach Bottom township, and flows along their northern edge into the river, as if the drainage had been established by a fault, or by the basset edge of a synclinal; which last conjectured cause would have operated if the Peach Bottom slates with its fossil plants were of *Hudson river age* (No. III). The *Tocquan anticlinal* uplift of ancient (Laurentian?) gneiss mentioned in the account of Lancaster county (page lxiv above) undoubtedly runs on through York county, and must be the starting-point for any thorough investigation into the age and structure of this Azoic

* For a chemical discussion of the different kinds of trap see Report C, pp. 115 to 129, with two microscopic sections.

strata of the county. Carefully detailed sections along the Susquehanna river are published with Report C^3 on Lancaster county; maps and sections further west, with Reports C and C^2 on York and Adams. There are 126 iron mines described in C, with chemical analyses of the ores, and a map showing the locations of those which lie at and west of Dillsburg, Rossville, Wellsville, and Franklintown in front of the South Mountain range (the Blue Ridge of Virginia); which comes to its northern end in the north-west corner of York county; and against its slope the upper strata of the Mesozoic are deposited, as in Bucks county. Heavy deposits of clay lie at the foot of the mountain. An extensive manufactory of bricks (3,000 per day) is carried on at Barnetts, one mile from Hanover (on the H. and G. R. R.) from a mixture of clay (produced by decomposition of the mica slates) with red Mesozoic sand. The Great Valley limestone No. II at the north edge of the Mezozoic region is seen in the most interesting exposures along Yellow Breeches creek; and there is a certainty that this formation is identical with the *blue limestone* of the Cadorus valley; as it is with the blue limestone of the Chester valley in Lancaster, Chester, and Montgomery counties. But there is a belt of *white limestone* in York county, as there is a belt of *marble* in Chester county, which seems to be older than the blue limestone; the limestone beds (so extensively quarried along the river) set in 3300 feet north of the Wrightsville end of the long bridge at Columbia, and 350′ from the southern most *visible* outcrop of 50° south dipping slates (a formation in all apparently 5000′ thick,) with nothing to show the nature of this 350′ interval. The overlying (?) limestone beds dip also 50° southward, and are extensively quarried for 1600 feet along the river bank, the dip increasing to 60° and finally (at Kerr's & Cook's quarry) to 76° S. 4° E. (In Wrightsville 70°, S. 18° E.) Total thickness of limestone *exposed* 2800′. In Kerr's and Detweiler's quarries the stone is crystalline, and in Detweiler's the layers roll much; just south of it *white* (sometimes pink) *limestone pebbles* occur in a *blue limestone matrix;* and this is taken as a (doubtful) indication that the white limestone of York county is an older formation. From the bridge southward 2300 feet of probably overturned (83° to 86° south dipping) nearly vertical limestone beds are apparently a repetition of those north of bridge, coming up again on the south side of a deep compressed synclinal trough, the central axis of which is at the bridge; the total thickness of beds preserved in this trough at river is nearly 3000 feet. A fault seems to cut off the south side of the trough at Creitz's creek with an upthrow of the same sandy pyritous slates as those north of the trough, all dipping S. 10° E. at various very steep angles; but for half the horizontal distance of 2500′ along the river bank the slates dip 60°, 80°, 65°, 70°, 50°, 75°, and for the other (southern half) 90°, 85°, 87°, 85°, to within 300′ of Wilton's run; consequently it looks as if there was a closely compressed trough in which 1250′ of slates were preserved. Against the last vertical slate exposure has south of it the first exposure of the Wilton run belt of limestone beds dipping S. 5° E. 54°, then 60°, 1200 feet horizontal distance (1100′ of limestone) to Wilton's ore bank, at the north edge of the next belt of crystalline chlorite and hydromica schists (7000′ wide); apparently a huge anticlinal arch crimpled along its crest. North of Cline's run 1400 feet, the limestone beds begin again and continue down the river for 12,060 feet of exposed beds always dipping to the south, but at lower and higher angles alternately, suggesting several collapsed and overthrown anticlinals and synclinals. This third limestone belt is limited southward by a ravine and blank of 1400 in the exposures, and then recommence the precipitous river hills of compact crystalline mica-schists dipping back *diagonally toward the limestone* (N. 30° W.) at angles increasing from 49° to 52° and immediately to 68° and 77°. This dip was considered by Prof. Rogers to be cleavage; but there seems no good reason for not considering it stratification. The remarkable straightness of the southern edge of the Codorus valley limestone belt at its contact with the slate, from Littlestown N. 61° E. for 29 miles to a point nearly a mile S. E. of the Widow Fritz's ore bank (where it curves a little and runs on 8 miles about N. 75° E. to the lock below the Columbia dam) taken with a non-conformity of dip in the two formations everywhere along the line, proves the existence of at least one great fault crossing York county; but no outcrop is discernible along the line. A similar long straight southern edge to the Chester county limestone at its contact with the South Valley Hill slates suggests a similar fault in that region. For two instructive instances of unconformable contact see Report C, p. 135. A curious feature of some of the York limestone beds consists in the powdering of the surfaces of the laminæ of sedimentation with minute scales or flakes of mica-schist, making hand specimens look like pieces of genuine chlorite or hydromica slate, (see C, p. 133.) At many of the quarries beds of ore are interpolated conformably between the beds of limestone. On the other hand, at Figley & Brillhart's ore banks, layers of limestone are seen in the mass of ore. The slates are sometimes charged with disseminated crystals of magnetic iron ore, from microscopic size up to ⅛ inch, with scales of specular ore, and with pyrites; but usually the whole mass has moldered into brown hematite iron ore clays with a varying percentage of magnetic and specular ore. (Dr. Frazer discusses the possible origin of the limestone ores in C, pp. 136 +.)

SECOND GEOLOGICAL SURVEY OF PENNS

J. P. LESLEY, STATE GEOLOGIST

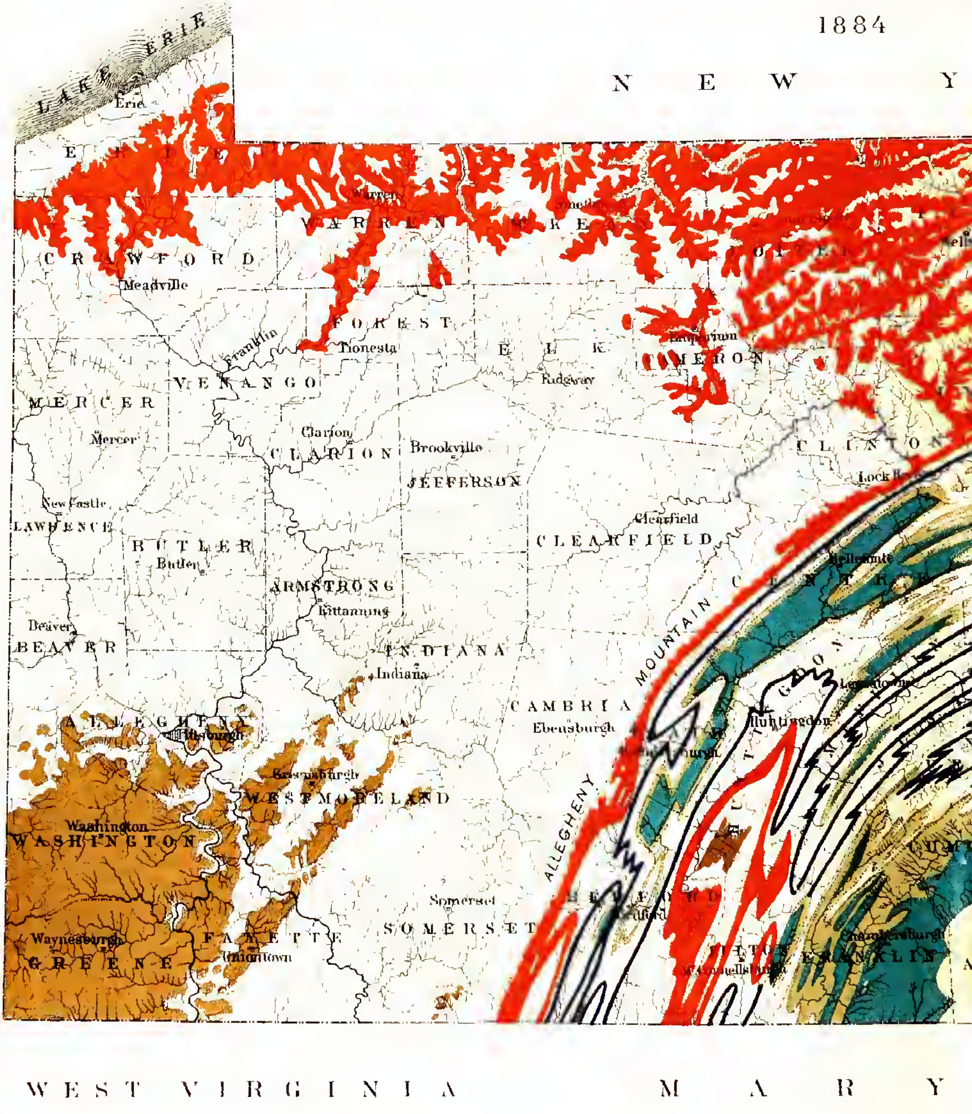
SKELETON

GEOLOGICAL MAP

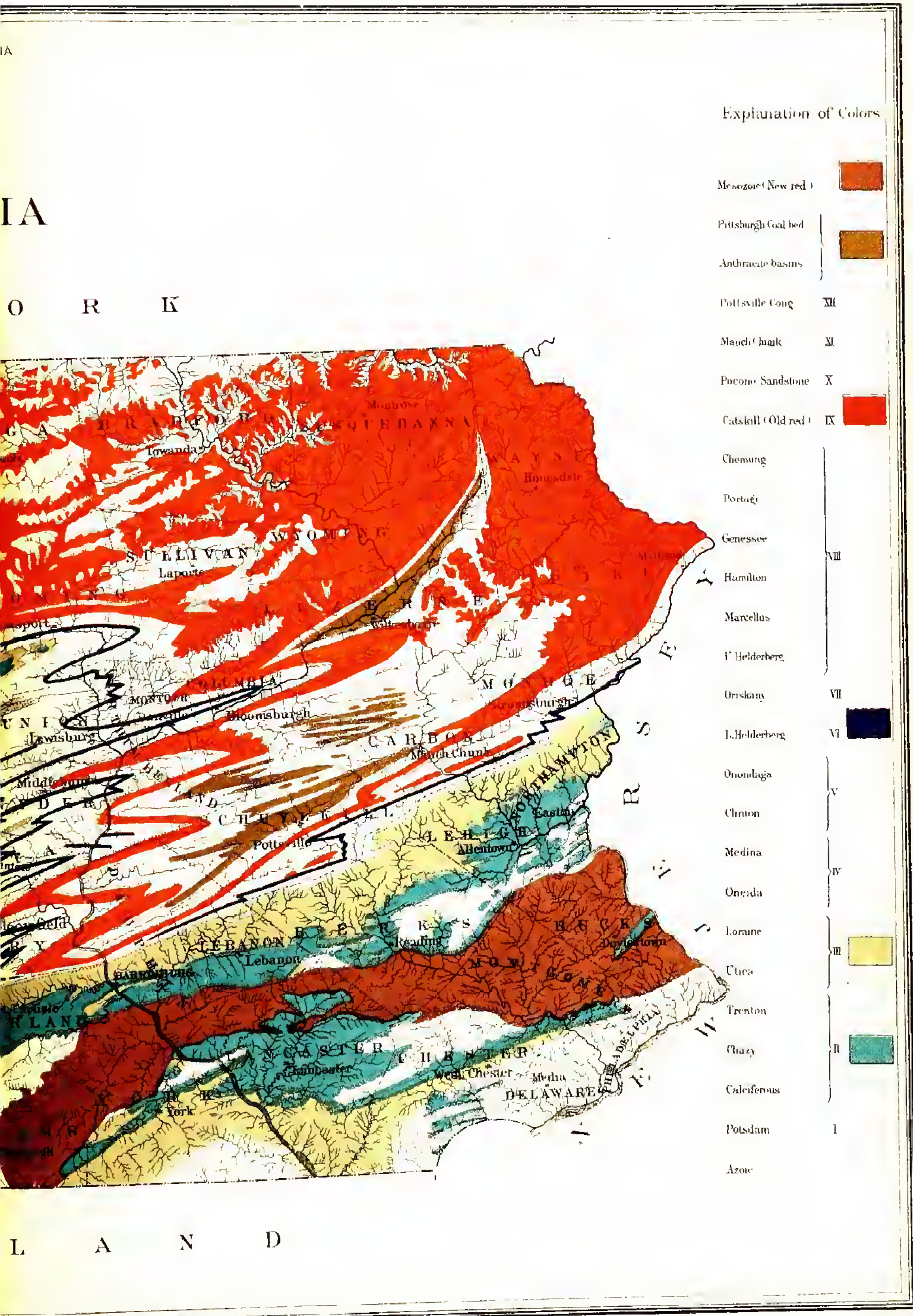
OF

PENNSYLVA

1884



J. P. Lesley del.


IA
O R K
L A N D
Towanda
Laporte
Lewisburg
Bloomsburgh
Mauch Chunk
Pottsville
Honesdale
Montrose
Stroudsburgh
Allentown
Easton
Reading
Lebanon
Harrisburg
Lancaster
West Chester
Media
York
Doylestown
DELAWARE
LEBANON
CARBON
MONROE
NORTHAMPTON
LEHIGH
BERKS
BUCKS
MONTGOMERY
CHESTER
LANCASTER
COLUMBIA
SULLIVAN
WYOMING
Explanation of Colors
Mesozoic (New red)
Pittsburgh Coal bed
Anthracite basins
Pottsville Cong. XII
Mauch Chunk XI
Pocono Sandstone X
Catskill (Old red) IX
Chemung
Portage
Genessee
Hamilton
Marcellus
U. Helderberg
VIII
Oriskany VII
L. Helderberg VI
Onondaga
Clinton
V
Medina
Oneida
IV
Loraine
Utica
III
Trenton
Chazy
Calciferous
II
Potsdam I
Azoic

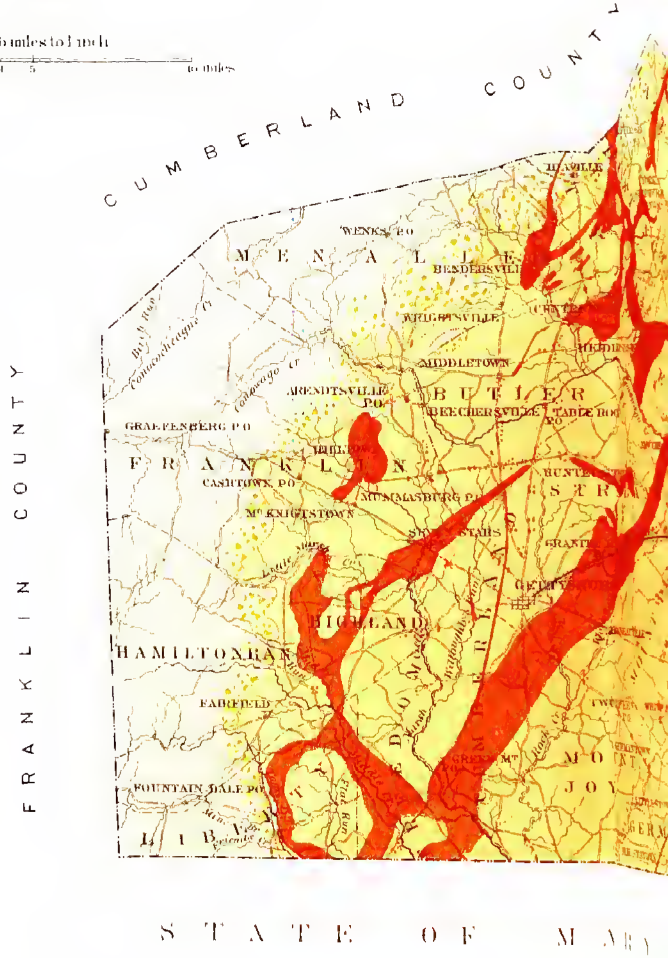
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

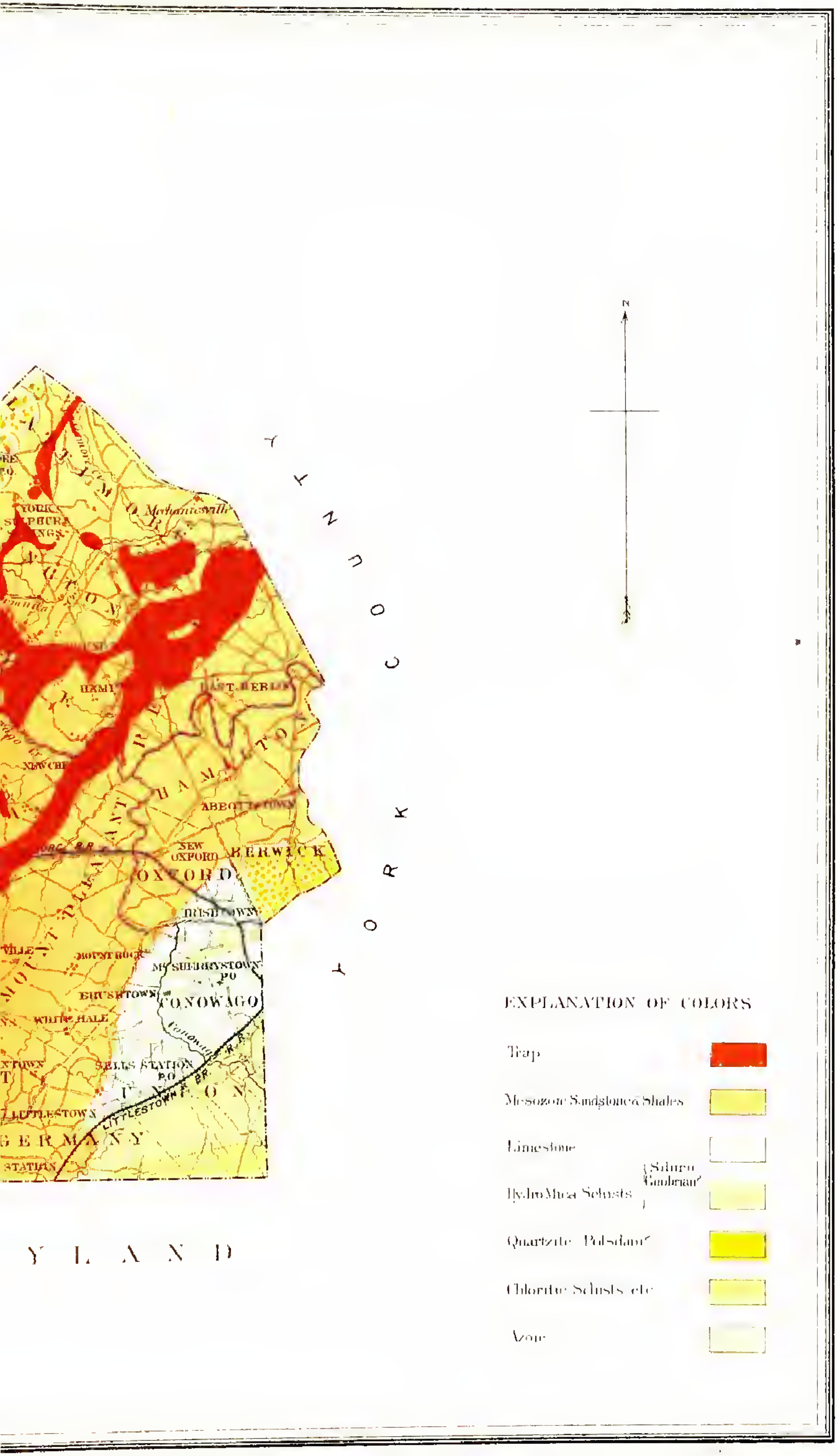
GEOLOGICAL MAP
OF
ADAMS COUNTY
1878.

Scale: 6 miles to 1 inch

0 1 2 3 4 5 10 miles



1



Y O R K   C O U N T Y
Y L A N D
O. Mechanicsville
EAST BERLIN
H A M P T O N
ABBOTTSTOWN
NEW OXFORD
B E R W I C K
O X F O R D
McSHERRYSTOWN P.O.
BRUSHTOWN
C O N O W A G O
WHITE HALL
MOUNT ROCK
U N I O N
LITTLESTOWN
G E R M A N Y
LITTLESTOWN R.R.
EXPLANATION OF COLORS
Trap
Mesozoic Sandstone & Shales
Limestone
Hydro Mica Schists
Siluro Cambrian?
Quartzite (Potsdam?)
Chlorite Schists etc.
Azoic

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

OF

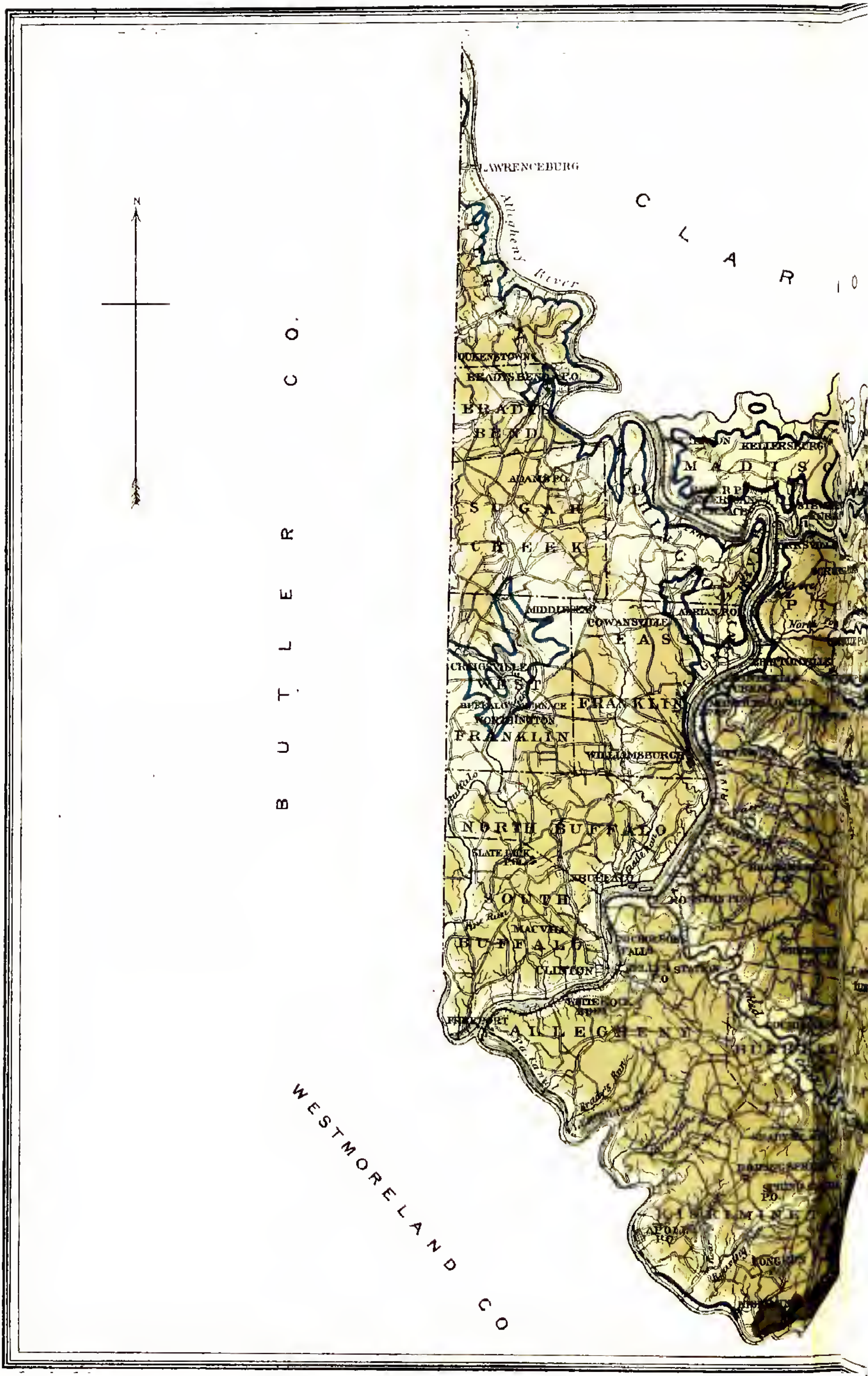
ALLEGHENY COUNTY

1878.

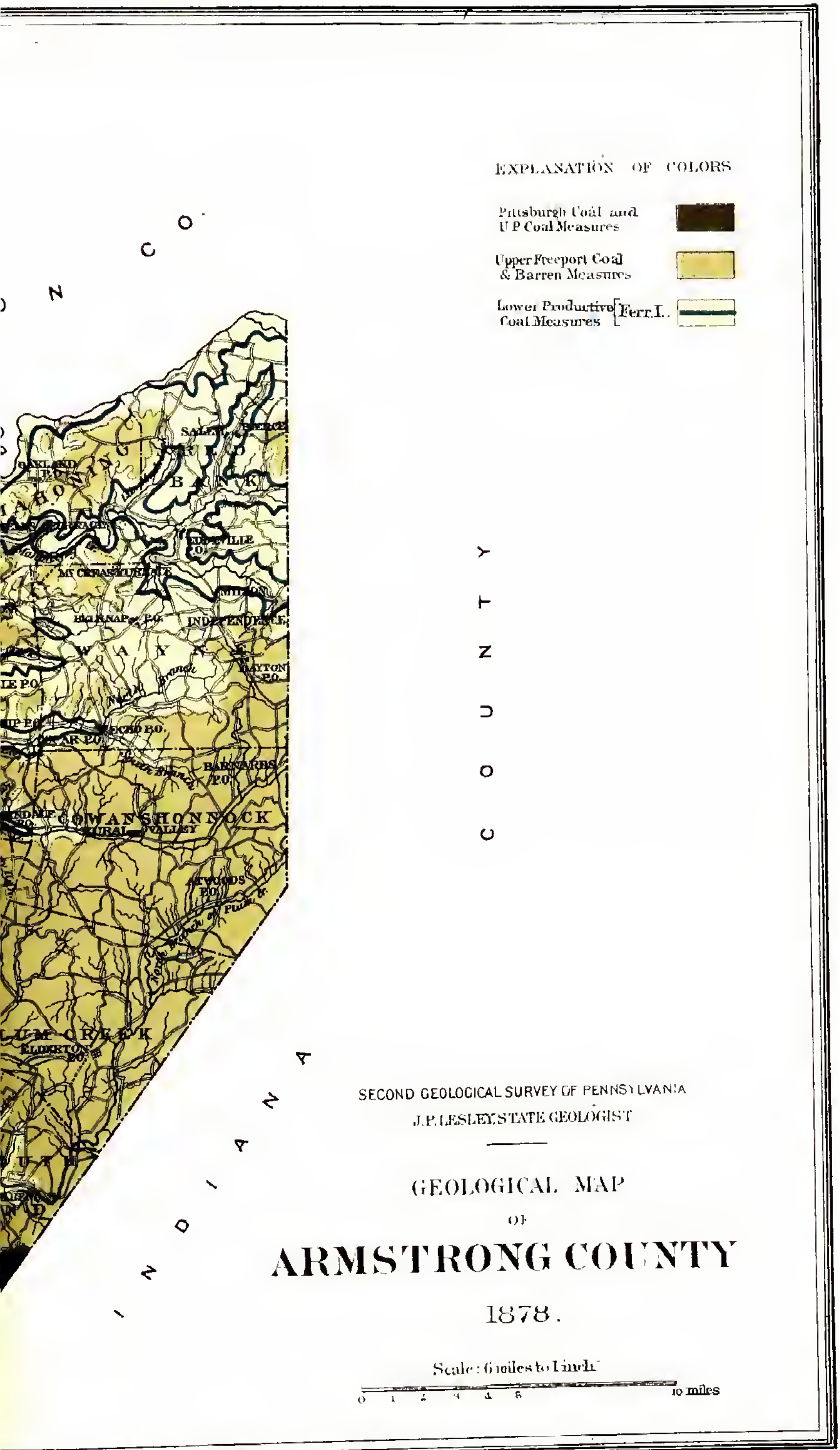
Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles

L E R C O U N T Y
W E S T M O R E L A N D C O U N T Y
RICHLAND
BAKERSTOWN
MILLERSTOWN
WEST DEER
HARRISON
EAST DEER
RURAL RIDGE P.O.
NATRONA P.O.
TARENTUM
TALLY CAVEY P.O.
HAMPTON
DORSEYVILLE P.O.
INDIANA
SPRINGFIELD P.O.
DEER CREEK
HARMARVILLE P.O.
HULTON P.O.
LOGANS FERRY P.O.
MEXICO
PLUM
PINE CREEK
SHARPSBURG
VERNONA
NEW TEXAS P.O.
PENN
NEW TEXAS
LAWRENCEVILLE
SANDY CREEK
LIBERTY
WILKINS P.O.
WILKINSBURG P.O.
MONROEVILLE P.O.
BIRMINGHAM
WILKINS
PATTON
TURTLE CREEK P.O.
PORT PERRY
NORTH VERSAILLES
BALDWIN
MIFFLIN
DRAVOSBURG P.O.
AMITY
LEBANON CHURCH P.O.
SOUTH VERSAILLES
VERSAILLES
SURGEONS HALL P.O.
OSCEOLA
GREENOAK
GILL HALL
JEFFERSON
BUENA VISTA
ELIZABETH
ELIZABETH P.O.
FORWARD
GAMBLES P.O.
SUNNYSIDE P.O.
SCRABBLETOWN
EXPLANATION OF COLORS.
Washington Group
Upper Barren Measures
Upper Productive Coal Measures
Pittsburgh Coal Bed
Lower Barren Measures
Lower Productive Coal Measures



N
BUTLER CO.
WESTMORELAND CO
LAWRENCEBURG
Allegheny River
BRADYS BEND
ADAMS P.O.
SUGAR CREEK
COWANSVILLE
EAST FRANKLIN
WEST FRANKLIN
WILLIAMSBURG
NORTH BUFFALO
SOUTH BUFFALO
CLINTON
FREEPORT
ALLEGHENY
MADISON
KELLERSBURG


EXPLANATION OF COLORS
Pittsburgh Coal and U.P. Coal Measures
Upper Freeport Coal & Barren Measures
Lower Productive Coal Measures
Ferr. L.
COUNTY
INDIANA
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J.P. LESLEY, STATE GEOLOGIST
GEOLOGICAL MAP
OF
ARMSTRONG COUNTY
1878.
Scale: 6 miles to 1 inch
0 1 2 3 4 5
10 miles
MAHONING
BOGGS
WAYNE
COWANSHANNOCK
PLUM CREEK
OAKLAND P.O.
INDEPENDENCE
DAYTON P.O.
ECHO P.O.
BARNARDS P.O.
RURAL VALLEY
ATWOODS P.O.
ELDERTON P.O.

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

OF

LAWRENCE COUNTY

1878.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles

EXPLANATION OF COLORS

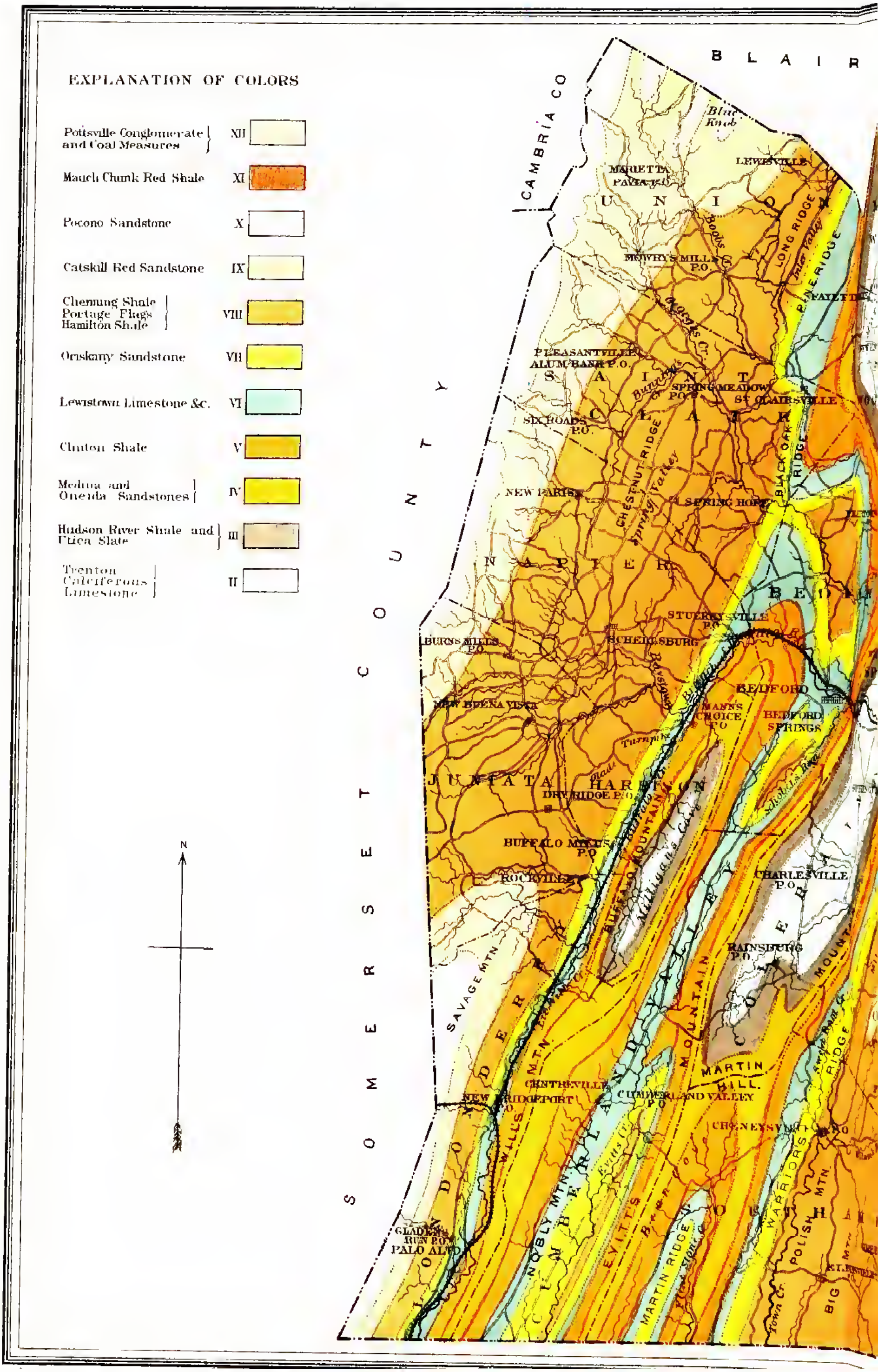
U. Freeport Coal

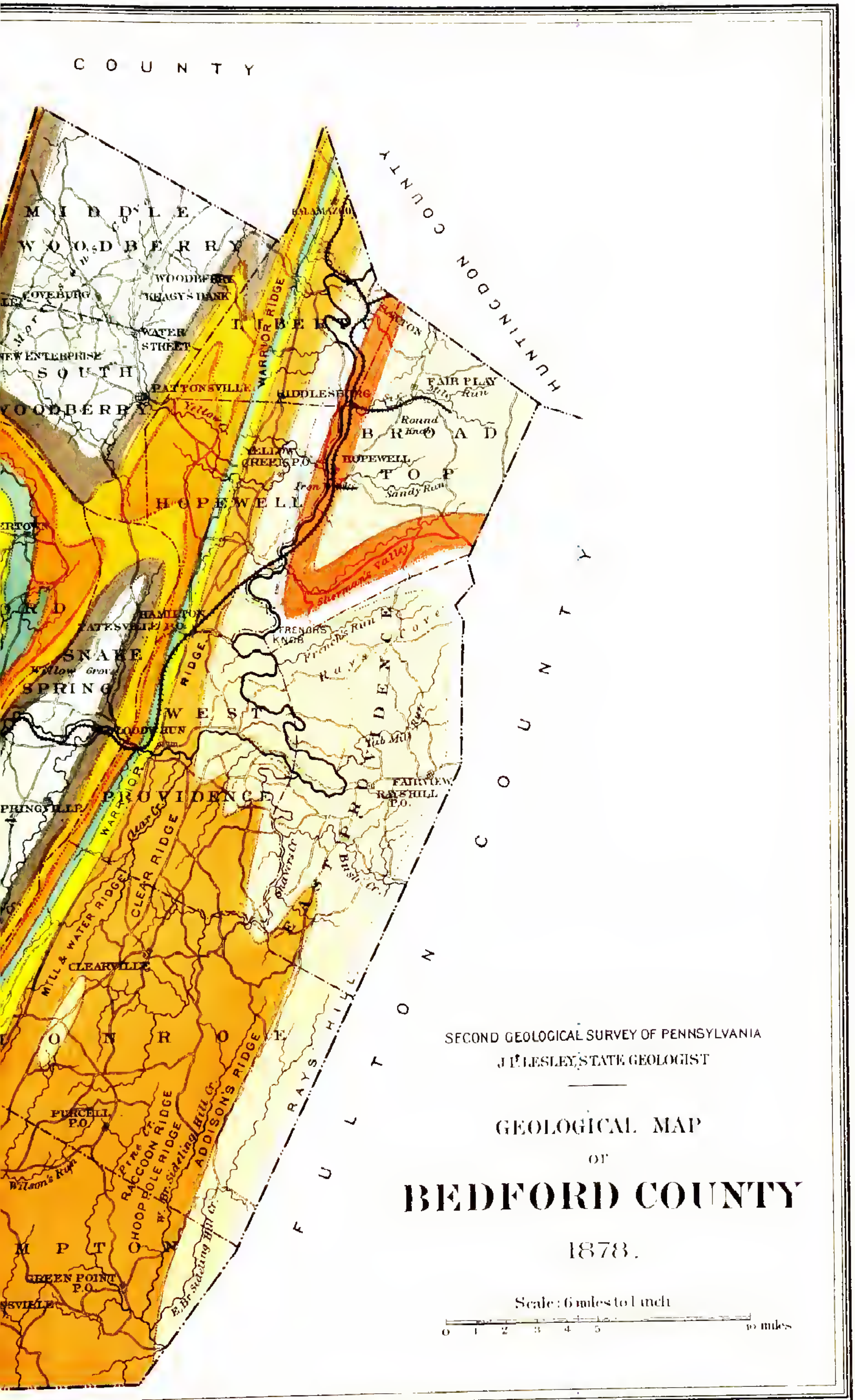
Ferriferous Limestone

Conglomerate

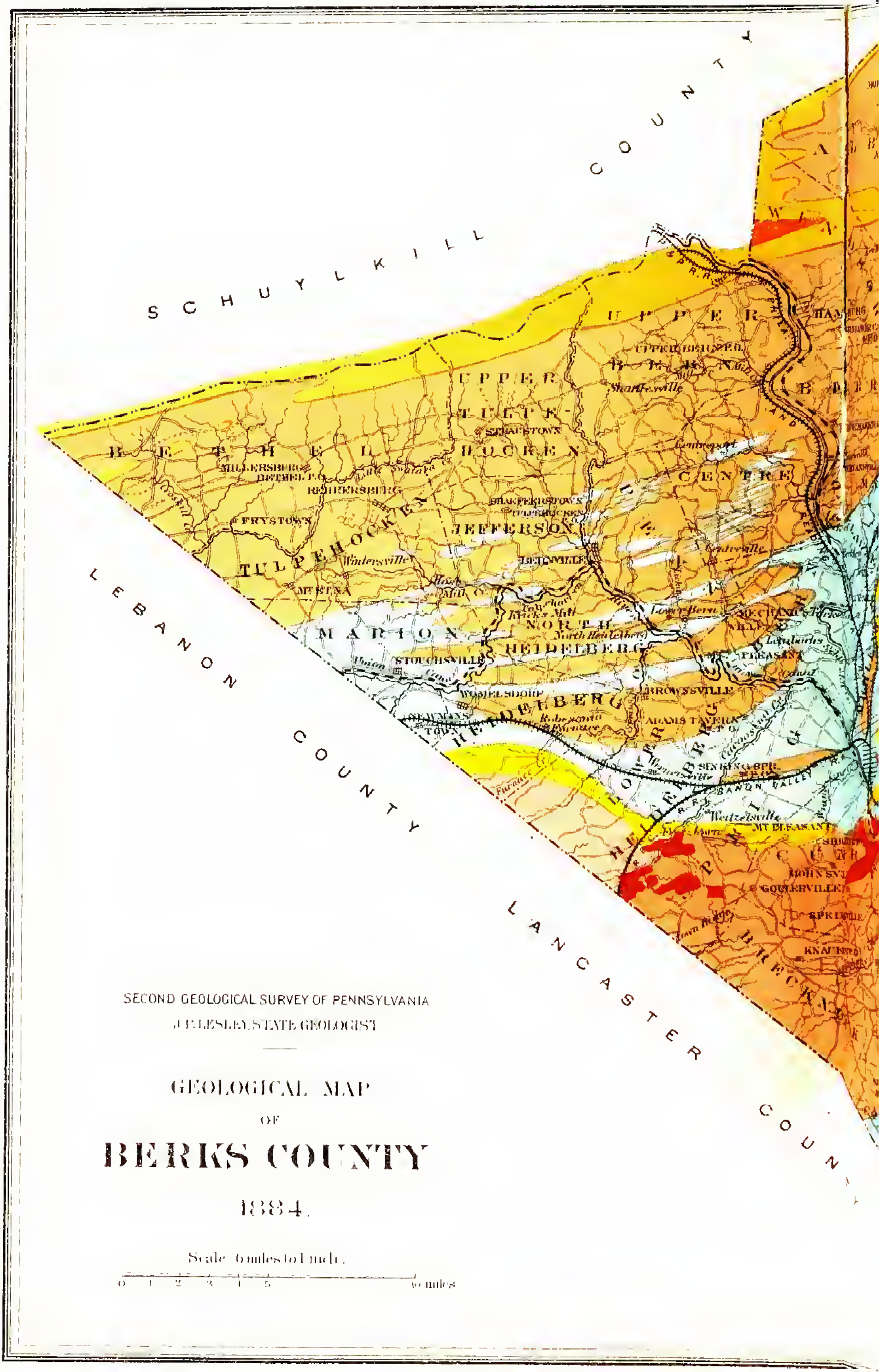
Sharon Shales


SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST.
GEOLOGICAL MAP
OF
BEAVER COUNTY
1878.
Scale: 6 miles to 1 inch
0 1 2 3 4 5 10 miles
N
LAWRENCE COUNTY
BUTLER COUNTY
ALLEGHENY COUNTY
WASHINGTON COUNTY
WEST VA. STATE OF OHIO
FRANKLIN
BIG BEAVER
NEW GALILEE
DARLINGTON
NORTH
SEWICKLEY
MARION
CHIPPEWA
SOUTH
BEAVER
PULASKI
UNIONVILLE
NEW
NEW BRIGHTON
BLACK HAWK
FALLSTON
SHARON
BRIDGEWATER
BRIGHTON
ROCHESTER
SEWICKLEY
OHIO
FAIRVIEW
BEAVER
FREEDOM
VANPORT
WATER CURE P.O.
OHIOVILLE
INDUSTRY
MOON
ECONOMY
BADEN
SMITHS FERRY
GEORGETOWN
SHIPPINGPORT P.O.
ROLT P.O.
M'C CLEARY P.O.
RACCOON
HOOKSTOWN
GREENE
GREEN GARDEN P.O.
HOPEWELL
NEW SCOTTSVILLE
NEW SHEFFIELD
HARMONY
SEVENTY SIX P.O.
MECHANICSBURG
SERVICE P.O.
HANOVER
INDEPENDENCE
KENDALL
POE P.O.
FRANKFORT SPRING
EXPLANATION OF COLORS.
Pittsburgh Coal
U. Freeport Coal
Kittanning Coal
Ferriferous Limestone
Conglomerate


EXPLANATION OF COLORS
Pottsville Conglomerate and Coal Measures XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
Chemung Shale, Portage Flags, Hamilton Shale VIII
Oriskany Sandstone VII
Lewistown Limestone &c. VI
Clinton Shale V
Medina and Oneida Sandstones IV
Hudson River Shale and Utica Slate III
Trenton Calciferous Limestone II
N
SOMERSET COUNTY
CAMBRIA CO
BLAIR
UNION
SAINT CLAIR
NAPIER
JUNIATA
HARRISON
BEDFORD
LONDONDERRY
CUMBERLAND VALLEY
COLERAIN
SOUTHAMPTON
Blue Knob
MARIETTA P.O.
LEWISVILLE
MURPHY'S MILLS P.O.
PLEASANTVILLE
ALUM BANK P.O.
SPRING MEADOW P.O.
ST. CLAIRSVILLE
SIX ROADS P.O.
NEW PARIS
SPRING HOPE
STUCKEYSVILLE P.O.
SCHELLSBURG
BURNS MILLS P.O.
NEW BUENA VISTA
BEDFORD
MANNS CHOICE P.O.
BEDFORD SPRINGS
DRY RIDGE P.O.
BUFFALO MILLS P.O.
ROCKVILLE
CHARLESVILLE P.O.
RAINSBURG P.O.
CENTREVILLE
NEW
RIDGEPORT
CUMBERLAND VALLEY P.O.
MARTIN HILL
CHENEYSVILLE
GLADDENS RUN P.O.
PALO ALTO
LONG RIDGE
PINE RIDGE
CHESTNUT RIDGE
BLACK OAK RIDGE
BUFFALO MOUNTAIN
SAVAGE MTN
WILLS MTN
NOBLY MTN
EVITT'S MTN
MARTIN RIDGE
WARRIOR'S RIDGE
POLISH MTN
Spring Valley
Milligan's Cove



COUNTY
HUNTINGDON COUNTY
FULTON COUNTY
MIDDLE WOODBERRY
WOODBERRY
KEAGY'S BANK
WATER STREET
NEW ENTERPRISE
SOUTH WOODBERRY
PATTONSVILLE
WARRIOR RIDGE
LIBERTY
RIDDLESBURG
FAIR PLAY
BROAD TOP
Round Knob
HOPEWELL
YELLOW CREEK P.O.
Sandy Run
Sherman's Valley
HAMILTON
FRENCHS KNOB
French's Run
Ray's Cove
SNAKE SPRING
Willow Grove
WEST PROVIDENCE
BLOODY RUN
Tub Mill Run
FAIRVIEW
RAYSHILL P.O.
EAST PROVIDENCE
CLEAR RIDGE
CLEARVILLE
MILL & WATER RIDGE
MONROE
RAYS HILL
ADDISON'S RIDGE
PURCELL P.O.
Wilson's Run
RACCOON RIDGE
HOOP POLE RIDGE
GREEN POINT P.O.
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST
GEOLOGICAL MAP OF BEDFORD COUNTY
1878.
Scale: 6 miles to 1 inch
0 1 2 3 4 5 10 miles



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

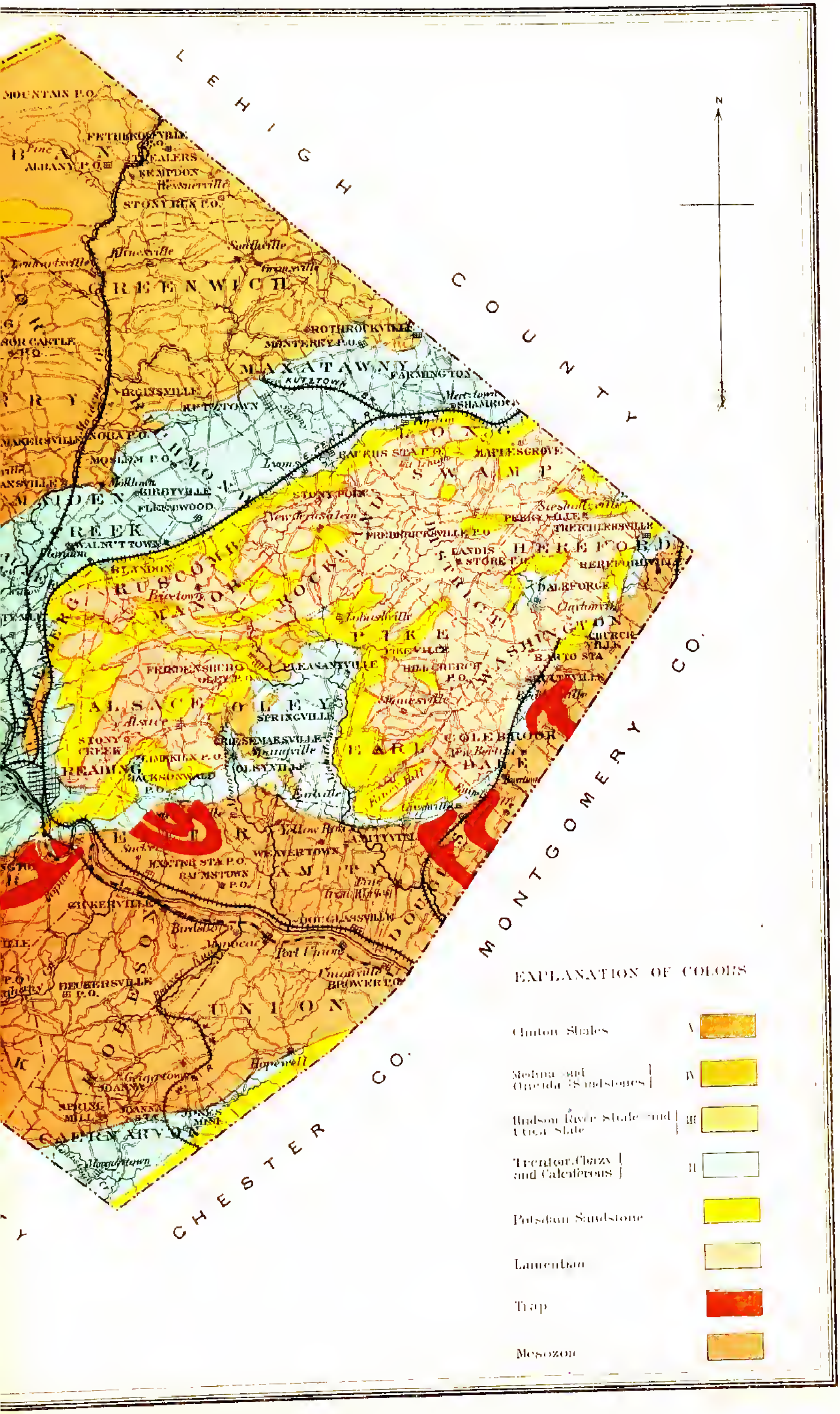
OF

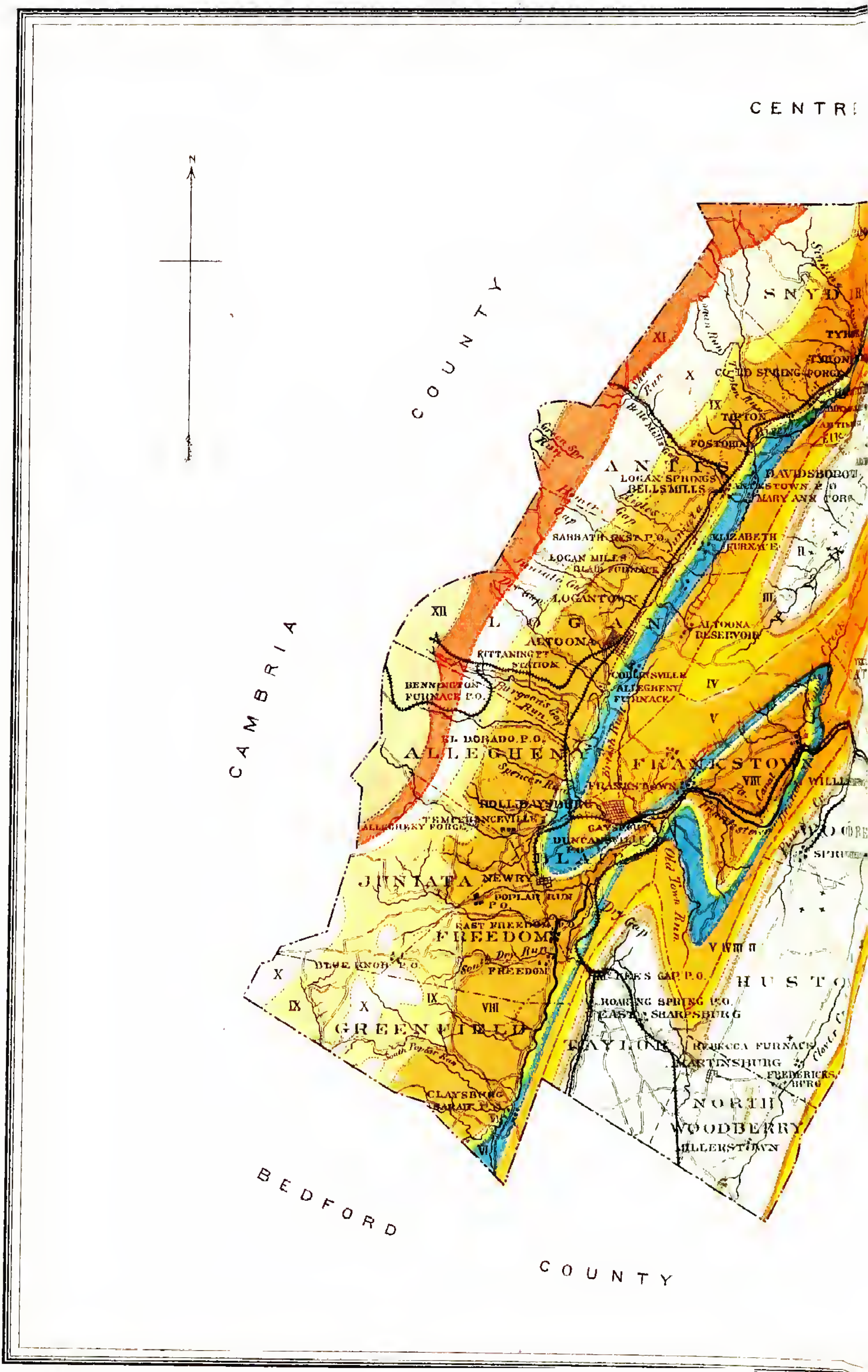
BERKS COUNTY

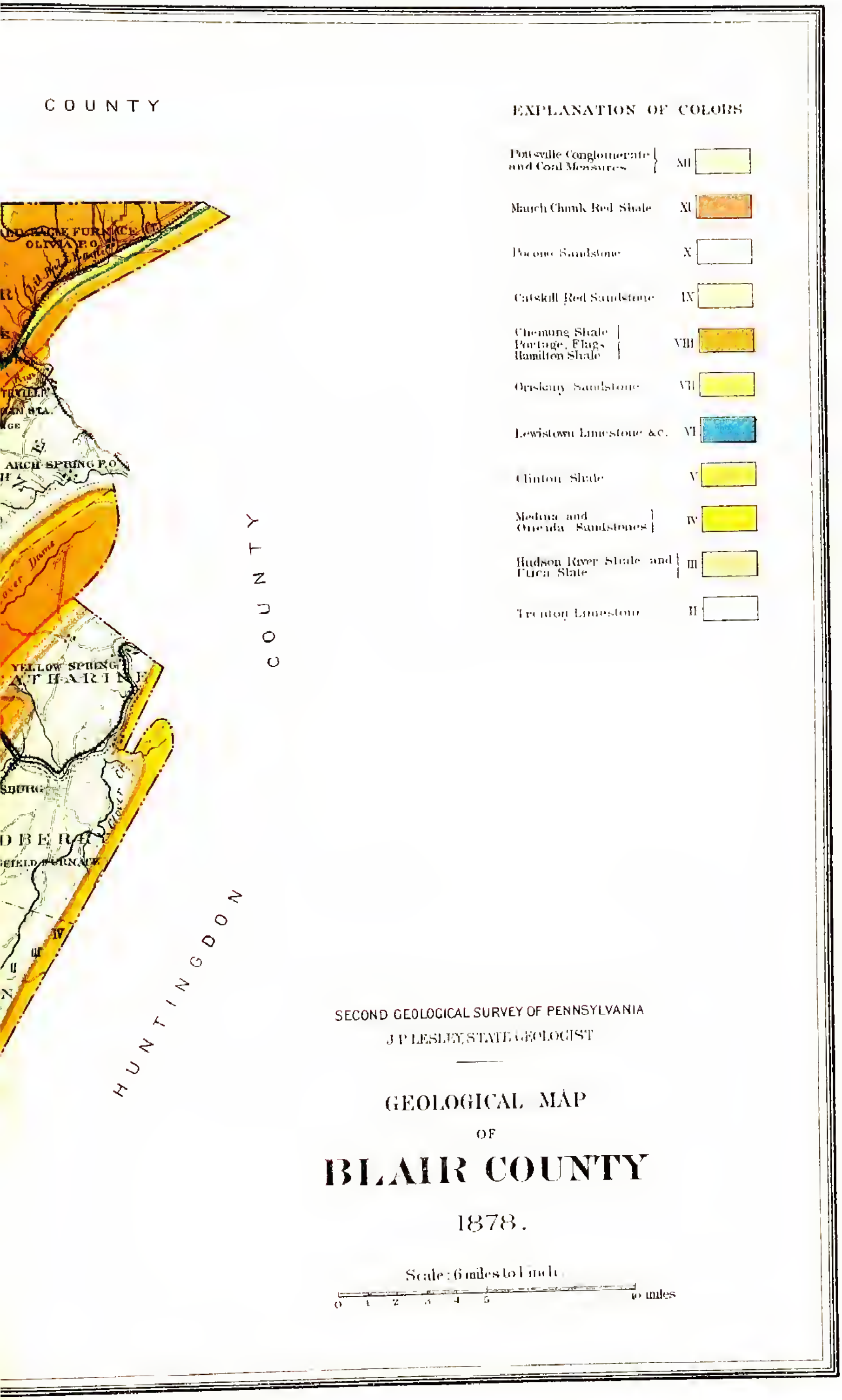
1884.

Scale 6 miles to 1 inch.

0 1 2 3 4 5 6 miles


LEHIGH COUNTY
MONTGOMERY CO.
CHESTER CO.
GREENWICH
MAXATAWNY
KUTZTOWN
LONGSWAMP
HEREFORD
ROCKLAND
RUSCOMBMANOR
PIKE
DISTRICT
WASHINGTON
ALSACE
OLEY
EARL
COLEBROOK DALE
AMITY
EXETER
DOUGLASS
UNION
READING
EXPLANATION OF COLORS
Clinton Shales
V
Medina and Oneida Sandstones
IV
Hudson River Shale and Utica Shale
III
Trenton, Chazy and Calciferous
II
Potsdam Sandstone
Laurentian
Trap
Mesozoic


CENTRE
CAMBRIA
COUNTY
BEDFORD
COUNTY
N
SNYDER
ANTIS
LOGAN
ALLEGHENY
FRANKSTOWN
BLAIR
JUNIATA
FREEDOM
GREENFIELD
TAYLOR
HUSTON
NORTH
WOODBERRY
COLD SPRING FORGE
TIPTON
FOSTORIA
LOGAN SPRINGS
BELLS MILLS
SABBATH REST P.O.
LOGAN MILLS
BLAIR FURNACE
LOGANTOWN
ALTOONA
KITTANING PT. STATION
BENNINGTON FURNACE P.O.
ALTOONA RESERVOIR
ELIZABETH FURNACE
MARY ANN FORGE
COLLINSVILLE
ALLEGHENY FURNACE
EL DORADO P.O.
HOLLIDAYSBURG
TEMPERANCEVILLE
ALLEGHENY FORGE
FRANKSTOWN
GAYSPORT
DUNCANSVILLE
NEWRY
POPLAR RUN P.O.
EAST FREEDOM P.O.
FREEDOM
BLUE KNOB P.O.
CLAYSBURG
McKEES GAP P.O.
ROARING SPRING P.O.
EAST SHARPSBURG
REBECCA FURNACE
MARTINSBURG
FREDERICKSBURG
MILLERSTOWN
Juniata
Canal
Old Town Run
Dry Gap
South Dry Run
Burgoons Gap
Spencer Run
South Poplar Run
Clover Cr.
XII
XI
X
IX
VIII
VII
VI
V
IV
III
II


COUNTY
EXPLANATION OF COLORS
Pottsville Conglomerate and Coal Measures XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
Chemung Shale Portage, Flags, Hamilton Shale VIII
Oriskany Sandstone VII
Lewistown Limestone &c. VI
Clinton Shale V
Medina and Oneida Sandstones IV
Hudson River Shale and Utica Slate III
Trenton Limestone II
OLIVIA P.O.
ARCH SPRING P.O.
YELLOW SPRING
COUNTY
HUNTINGDON
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J P LESLEY, STATE GEOLOGIST
GEOLOGICAL MAP
OF
BLAIR COUNTY
1878.
Scale: 6 miles to 1 inch
0 1 2 3 4 5 10 miles

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

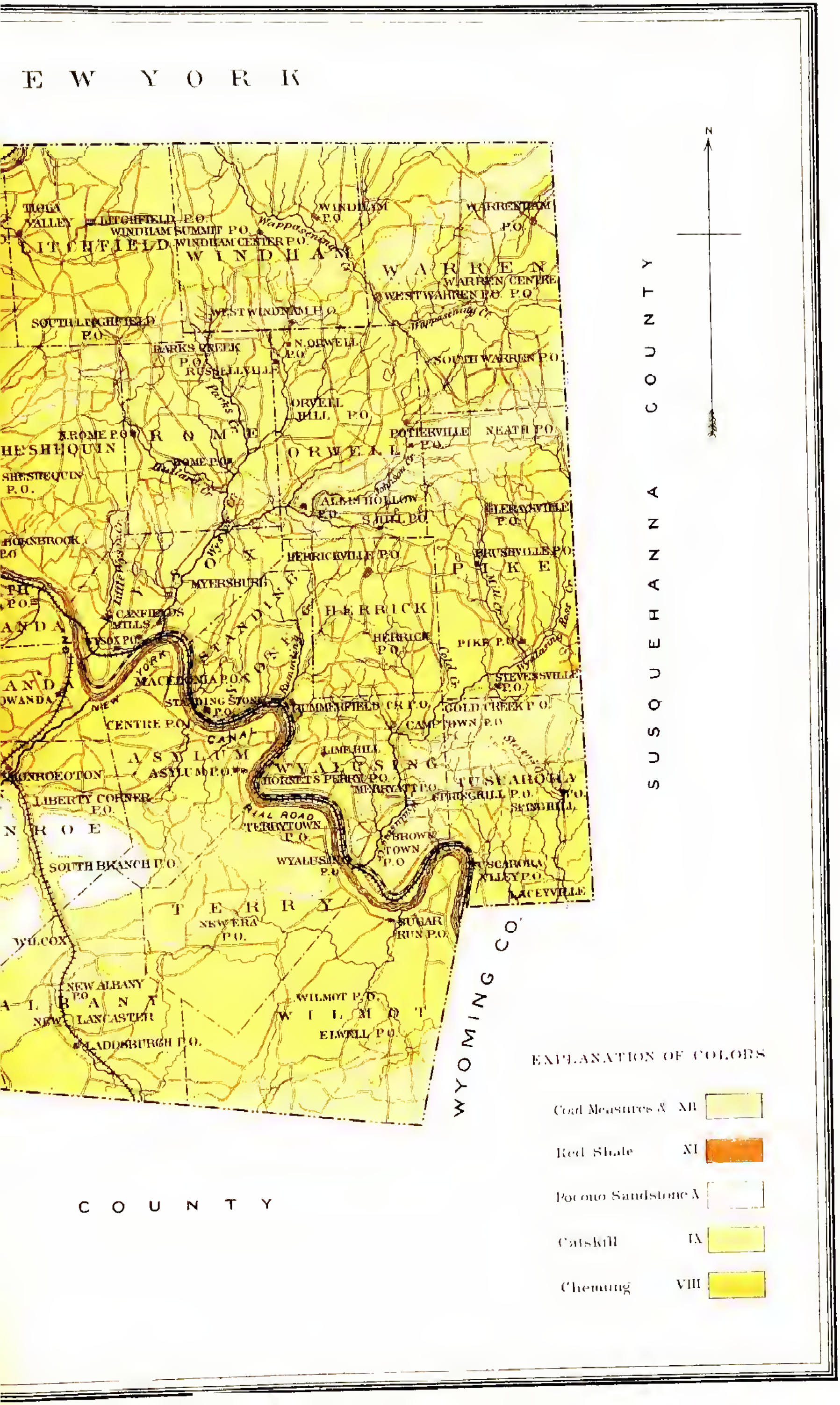
OF

BRADFORD COUNTY

1878.

Scale: 6 miles to 1 inch

0 1 2 3 4 5 6 miles



N E W Y O R K
S U S Q U E H A N N A C O U N T Y
WYOMING CO.
C O U N T Y
N
TIOGA VALLEY
LITCHFIELD P.O.
WINDHAM SUMMIT P.O.
WINDHAM CENTRE P.O.
L I T C H F I E L D
W I N D H A M
WINDHAM P.O.
WARRENHAM P.O.
W A R R E N
WARREN CENTRE P.O.
WEST WARREN P.O.
Wappasening Cr.
WEST WINDHAM P.O.
SOUTH LITCHFIELD P.O.
PARKS CREEK P.O.
RUSSELLVILLE
N. ORWELL P.O.
SOUTH WARREN P.O.
Parks Cr.
ORWELL HILL P.O.
POTTERVILLE P.O.
NEATH P.O.
E. ROME P.O.
R O M E
SHESHEQUIN
ROME P.O.
SHESHEQUIN P.O.
O R W E L L
Johnson Cr.
ALLIS HOLLOW P.O.
S. HILL P.O.
LERAYSVILLE P.O.
HORNBROOK P.O.
HERRICKVILLE P.O.
BRUSHVILLE P.O.
P I K E
MYERSBURG
H E R R I C K
CANFIELDS MILLS
HERRICK P.O.
PIKE P.O.
Wyalusing Cr.
STEVENSVILLE P.O.
MACEDONIA P.O.
STANDING STONE P.O.
SUMMERFIELD
GOLD CREEK P.O.
CAMPTOWN P.O.
NEW YORK
CENTRE P.O.
CANAL
A S Y L U M
ASYLUM P.O.
LIME HILL
W Y A L U S I N G
HORNETS FERRY P.O.
MERRYALL P.O.
SPRING HILL P.O.
T U S C A R O R A
MONROETON
LIBERTY CORNER P.O.
TERRYTOWN P.O.
BROWN TOWN P.O.
WYALUSING P.O.
TUSCARORA VALLEY P.O.
LACEYVILLE
SOUTH BRANCH P.O.
T E R R Y
NEW ERA P.O.
SUGAR RUN P.O.
WILCOX
NEW ALBANY P.O.
A L B A N Y
NEW LANCASTER
WILMOT P.O.
W I L M O T
ELWELL P.O.
LADDSBURGH P.O.
EXPLANATION OF COLORS
Coal Measures & XII
Red Shale XI
Pocono Sandstone X
Catskill IX
Chemung VIII

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

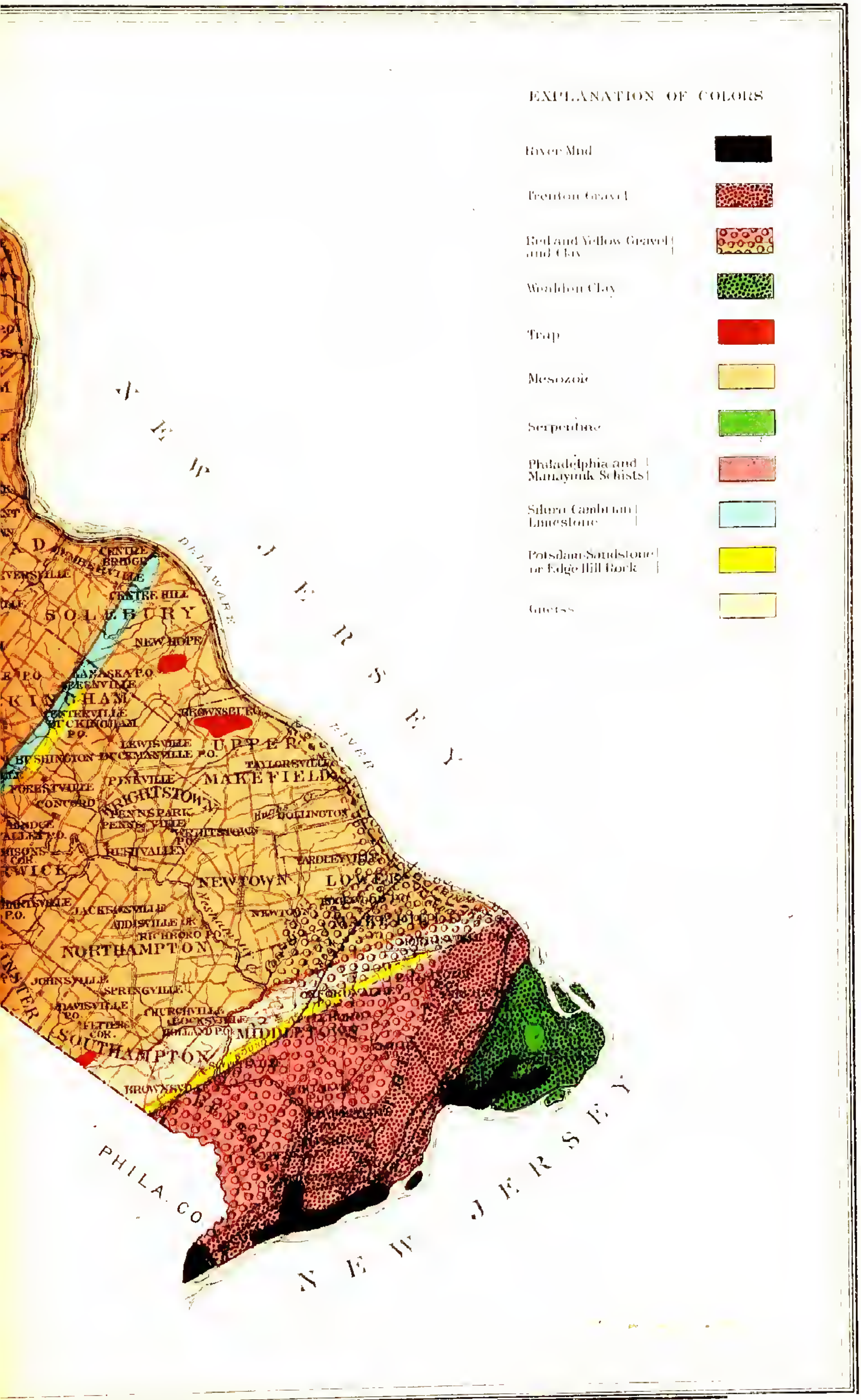
OF

BUCKS COUNTY

1884.

Scale 6 miles to 1 inch

0 1 2 3 4 5 10 miles


EXPLANATION OF COLORS
River Mud
Trenton Gravel
Red and Yellow Gravel and Clay
Wealden Clay
Trap
Mesozoic
Serpentine
Philadelphia and Manayunk Schists
Siluro Cambrian Limestone
Potsdam Sandstone or Edge Hill Rock
Gneiss
NEW JERSEY
DELAWARE RIVER
SOLEBURY
NEW HOPE
UPPER MAKEFIELD
NEWTOWN
LOWER
NORTHAMPTON
SOUTHAMPTON
MIDDLETOWN
PHILA. CO
NEW JERSEY

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

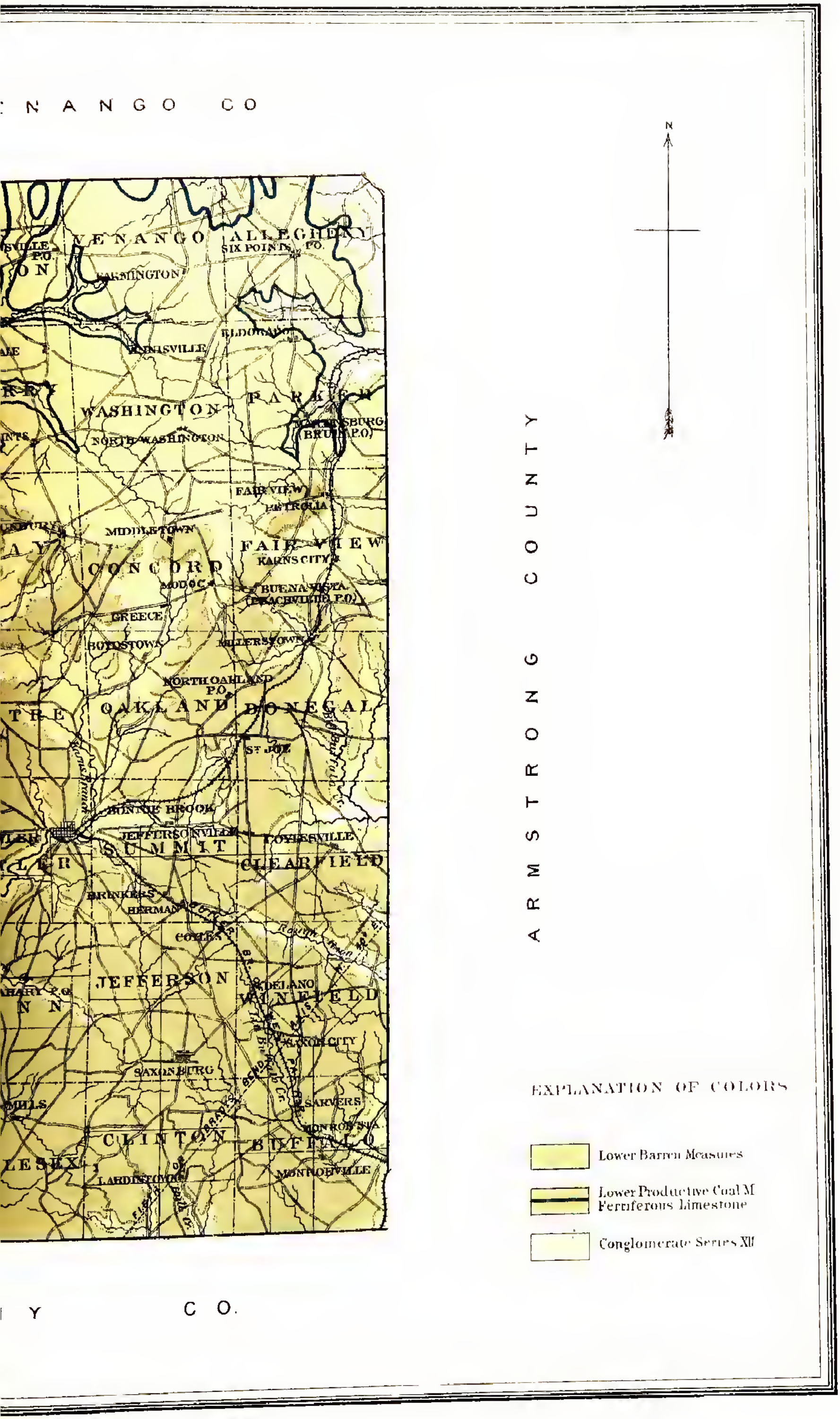
GEOLOGICAL MAP

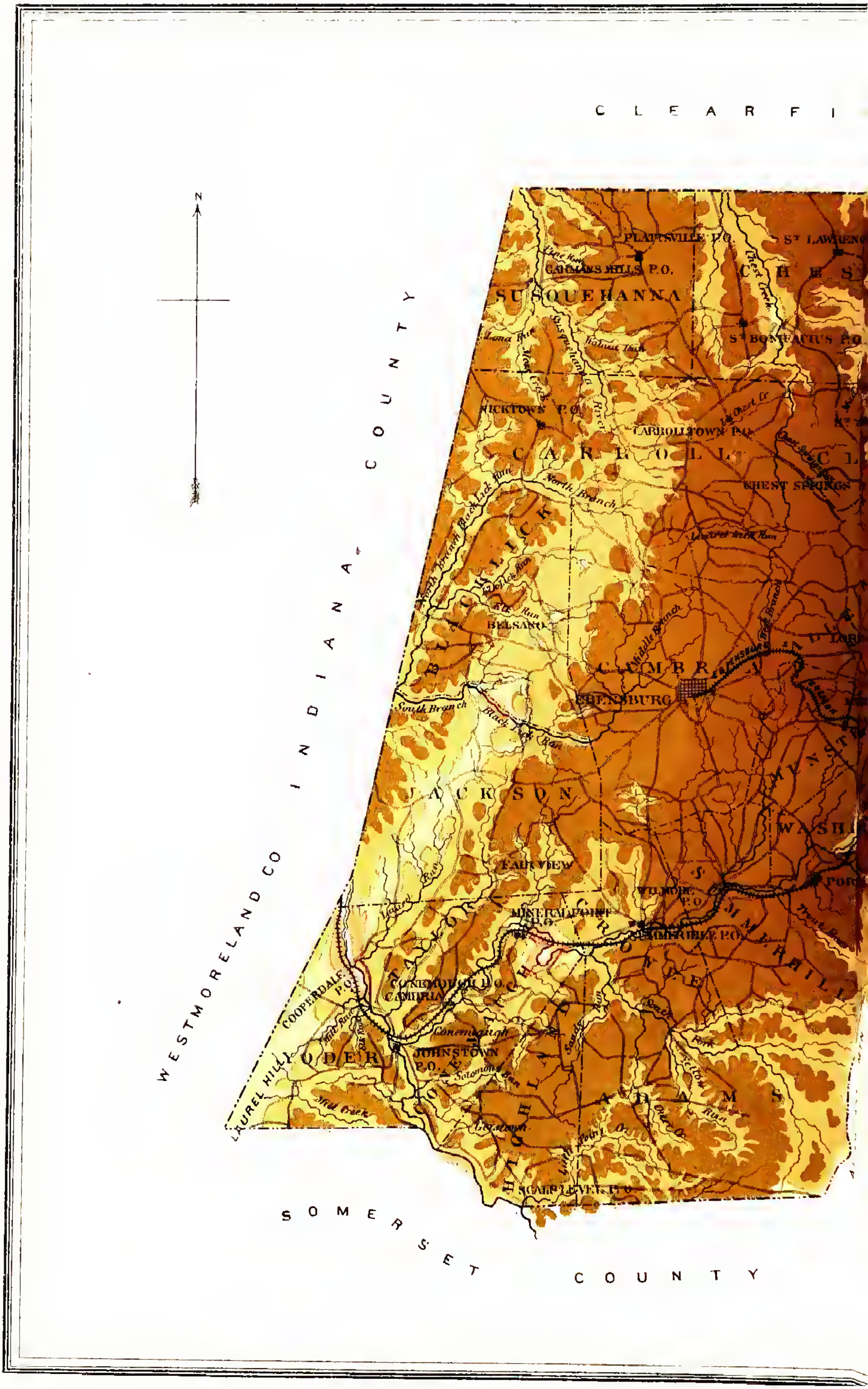
OF

BUTLER COUNTY

1878.

Scale: 6 miles to 1 inch


NANGO CO
N
VENANGO
ALLEGHENY
SIX POINTS P.O.
FARMINGTON
ELDORADO
WASHINGTON
NORTH WASHINGTON
PARKER
FAIRVIEW
PETROLIA
MIDDLETOWN
FAIR VIEW
KARNS CITY
CONCORD
MODOC
BUENA VISTA
GREECE
BOYDSTOWN
MILLERSTOWN
NORTH OAKLAND P.O.
OAKLAND
DONEGAL
ST JOE
BONNIE BROOK
JEFFERSONVILLE
SUMMIT
COYLESVILLE
CLEARFIELD
BRINKERS
HERMAN
JEFFERSON
DELANO
WINFIELD
SAXON CITY
SAXONBURG
SARVERS
CLINTON
BUFFALO
MONROE STA.
MONROEVILLE
LARDINTOWN
ARMSTRONG COUNTY
Y CO.
EXPLANATION OF COLORS
Lower Barren Measures
Lower Productive Coal M
Ferriferous Limestone
Conglomerate Series XII



C L E A R F I
I N D I A N A   C O U N T Y
W E S T M O R E L A N D   C O
S O M E R S E T   C O U N T Y
N
PLATTSVILLE P.O.
S U S Q U E H A N N A
St BONIFACIUS P.O.
NICKTOWN P.O.
CARROLLTOWN P.O.
C A R R O L L
CHEST SPRINGS
North Branch
BELSANO
EBENSBURG
South Branch
J A C K S O N
FAIRVIEW
WILMORE P.O.
MINERAL POINT P.O.
SUMMERHILL P.O.
COOPERSDALE P.O.
CAMBRIA
JOHNSTOWN P.O.
Conemaugh
LAUREL HILL
Y O D E R
A D A M S
SCALP LEVEL P.O.

EXPLANATION OF COLORS

Barren Measures	XIII	
Lower Productive Coal Measures		
Pottsville Conglomerate	XII	
Mauch Chunk Red Shale	XI	
Pocono Sandstone	X	

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J.P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

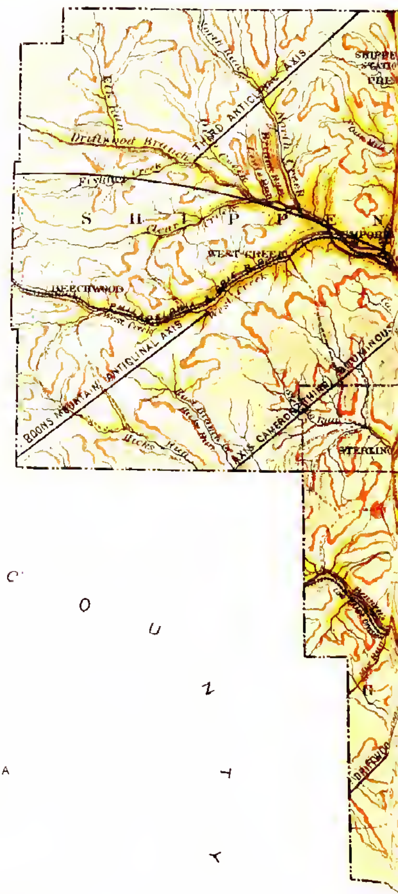
OF

CAMBRIA COUNTY

1884

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles.



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY STATE GEOLOGIST

GEOLOGICAL MAP

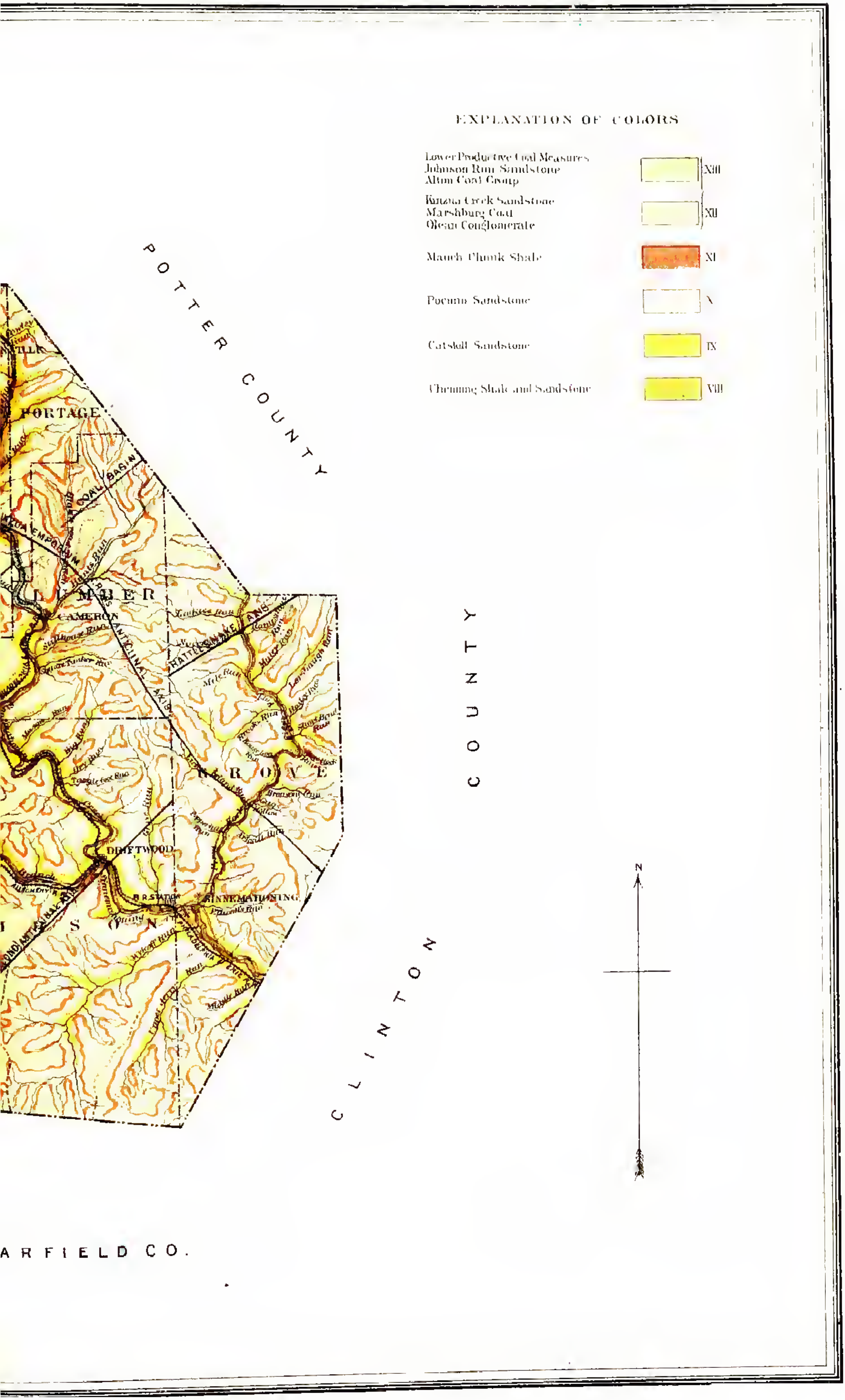
OF

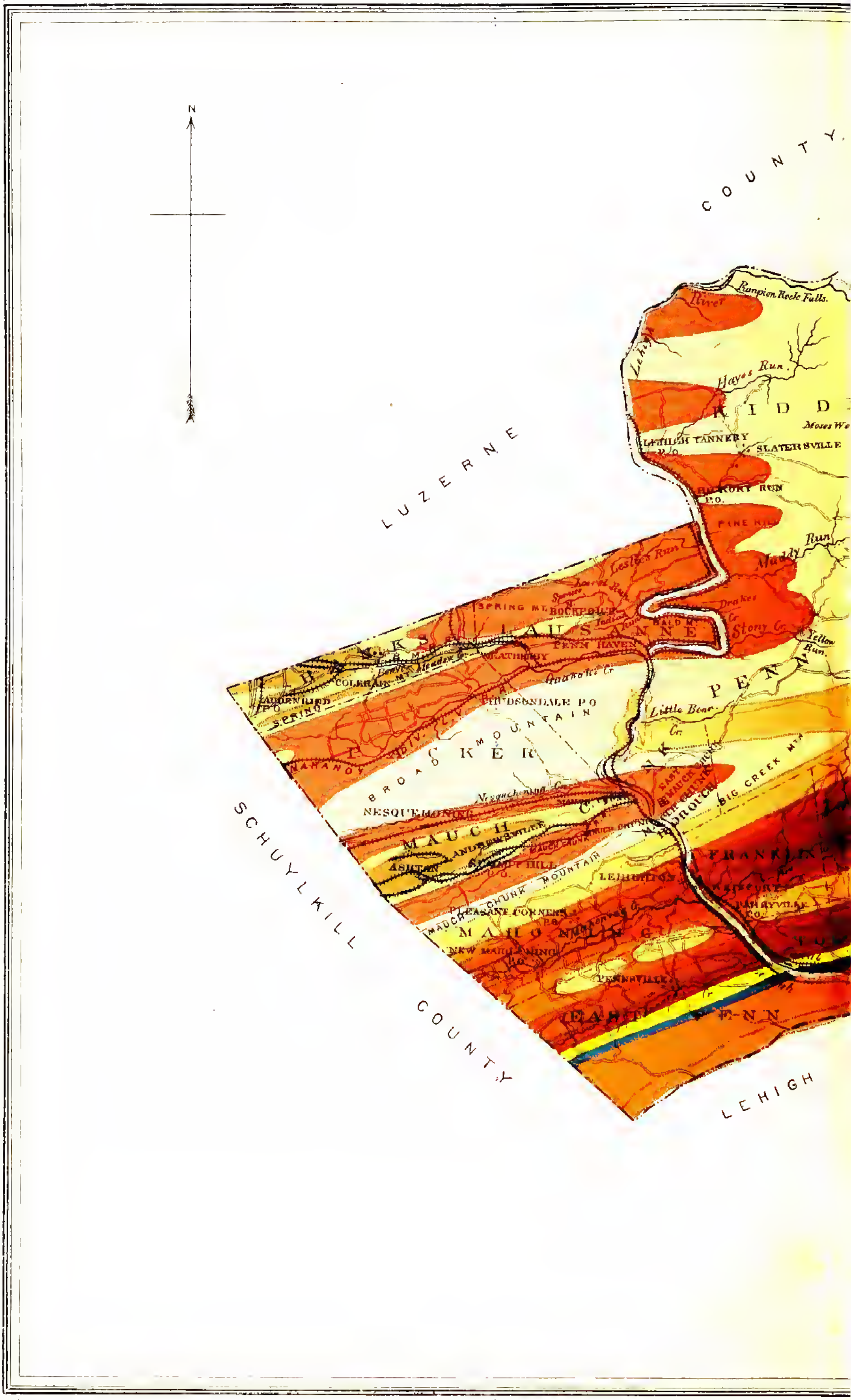
CAMERON COUNTY

1881

Scale 6 miles to 1 inch

0 1 2 3 4 5 10 miles


EXPLANATION OF COLORS
Lower Productive Coal Measures
Johnson Run Sandstone
Alton Coal Group
XIII
Kinzua Creek Sandstone
Marshburg Coal
Olean Conglomerate
XII
Mauch Chunk Shale
XI
Pocono Sandstone
X
Catskill Sandstone
IX
Chemung Shale and Sandstone
VIII
POTTER COUNTY
PORTAGE
CAMERON
GROVE
DRIFTWOOD
SINNEMAHONING
COUNTY
CLINTON
N
ARFIELD CO.



N
LUZERNE
COUNTY
SCHUYLKILL COUNTY
LEHIGH
Lehigh
River
Hayes Run
LEHIGH TANNERY P.O.
SLATERSVILLE
Muddy Run
Drakes Cr.
Stony Cr.
Yellow Run
SPRING MT.
LAUSANNE
PENN HAVEN
COLERAIN
PENN
Little Bear Cr.
BROAD MOUNTAIN
MAHANOY
NESQUEHONING
BIG CREEK MT.
MAUCH CHUNK
ASHTON
MAUCH CHUNK MOUNTAIN
LEHIGHTON
FRANKLIN
PLEASANT CORNERS
MAHONING
NEW MAHONING P.O.
PENNSVILLE
EAST PENN

EXPLANATION OF COLORS

Coal Measures	XII	
Pottsville Conglomerate	XII	
Mauch Chunk Red Shale	XI	
Pocono Sandstone	X	
Catskill Rocks	IX	
Chemung	VIII	
Genesee	VIII	
Hamilton	VIII	
Marcellus	VIII	
Oriskany Sandstone	VII	
Lower Helderberg Limestone	VI	
Clinton Red Shale	V	
Medina and Oneida Sandstones	IV	

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

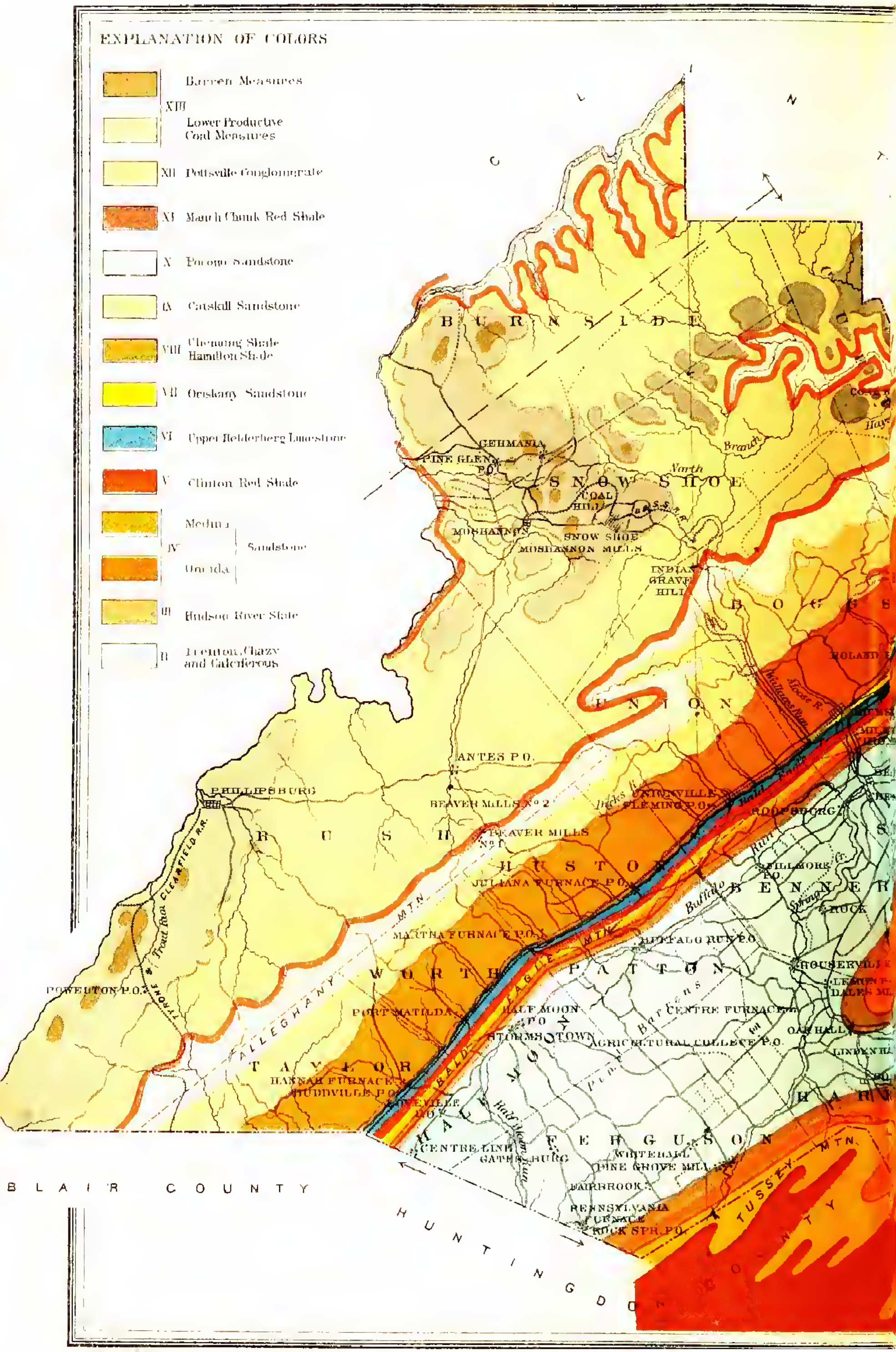
OF

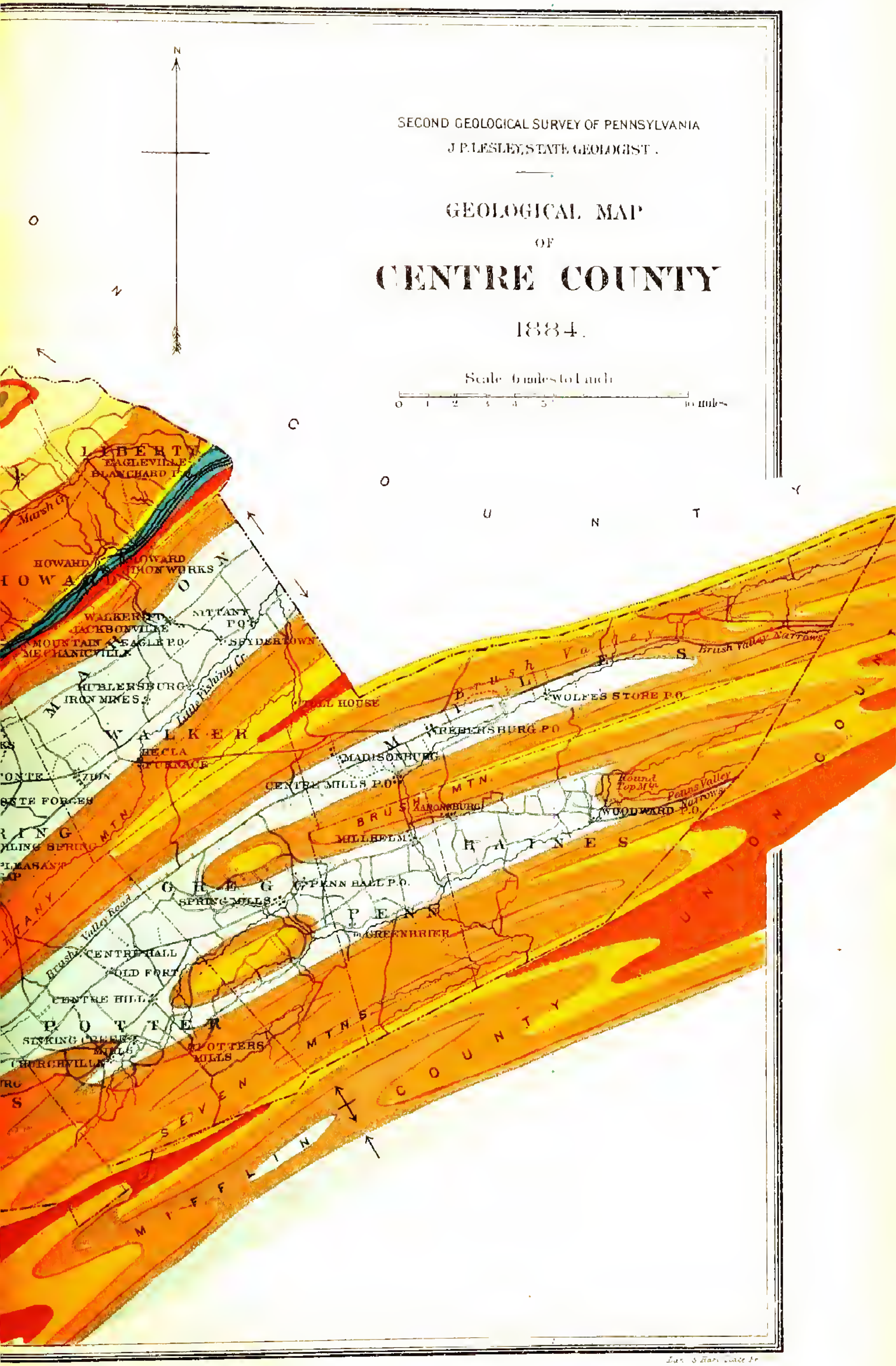
CARBON COUNTY

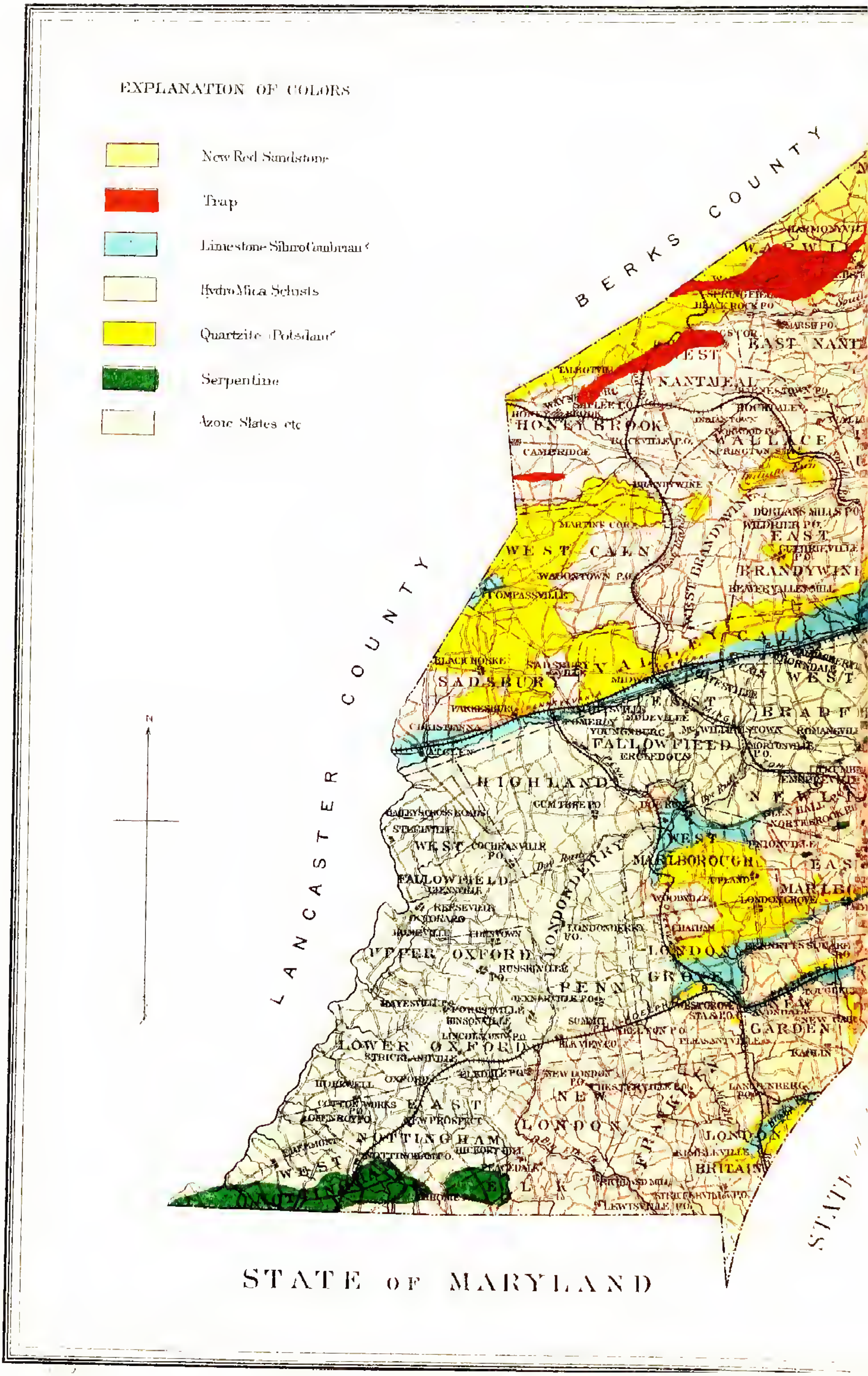
1884.

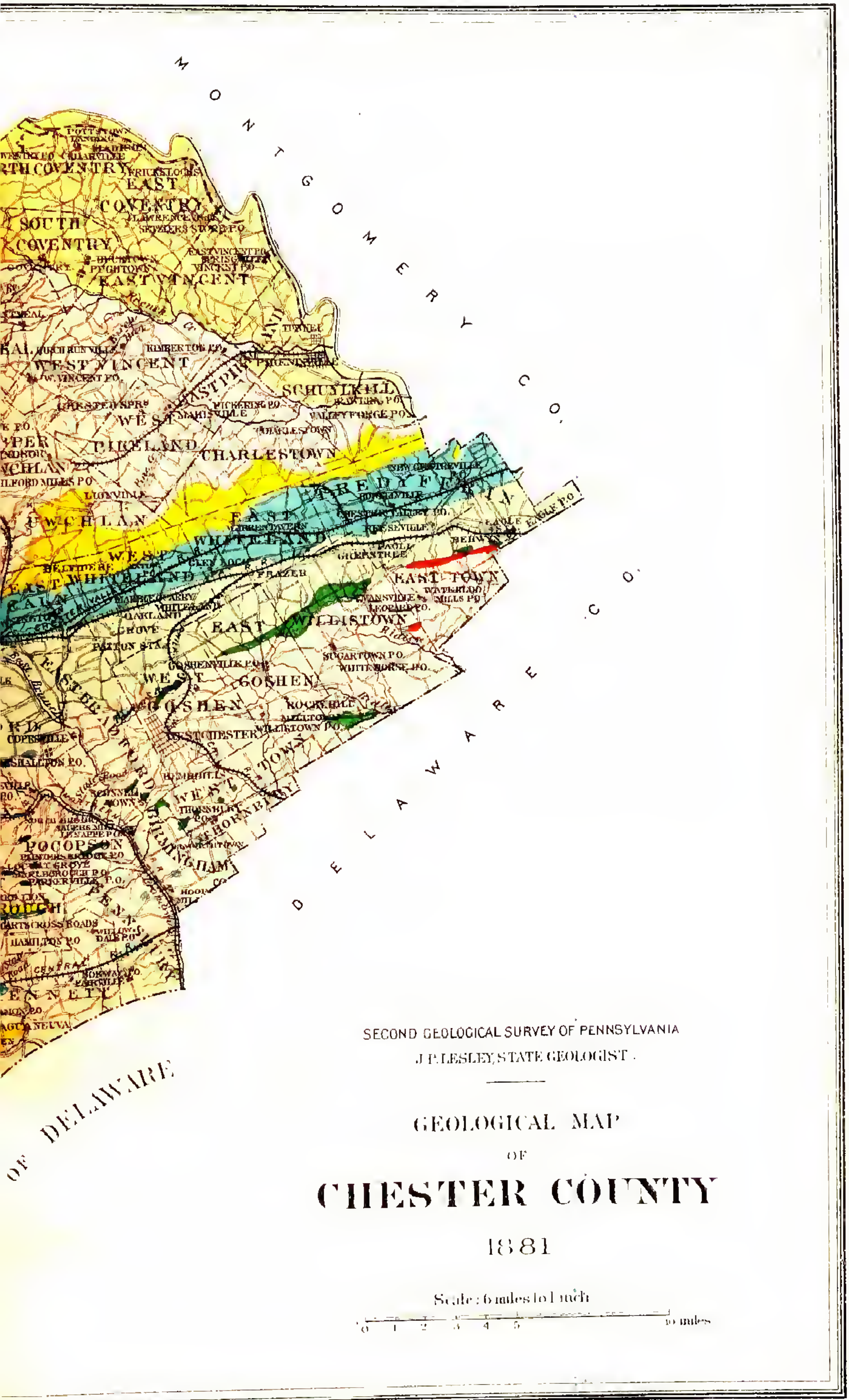
Scale 6 miles to 1 inch.

0 1 2 3 4 5 10 miles


EXPLANATION OF COLORS
XIII Barren Measures
Lower Productive Coal Measures
XII Pottsville Conglomerate
XI Mauch Chunk Red Shale
X Pocono Sandstone
IX Catskill Sandstone
VIII Chemung Shale Hamilton Shale
VII Oriskany Sandstone
VI Upper Helderberg Limestone
V Clinton Red Shale
IV Medina Oneida Sandstone
III Hudson River Slate
II Trenton, Chazy and Calciferous
BURNSIDE
GERMANIA
PINE GLEN P.O.
SNOW SHOE
COAL HILL
MOSHANNON
SNOW SHOE
MOSHANNON MILLS
INDIAN GRAVE HILL
BOGGS
ROLAND
UNION
ANTES P.O.
PHILLIPSBURG
BEAVER MILLS No 2
BEAVER MILLS No 1
RUSH
UNIONVILLE
FLEMING P.O.
ROOPSBURG
HUSTON
JULIANA FURNACE P.O.
MARTHA FURNACE P.O.
BUFFALO RUN P.O.
BENNER
WORTH
PATTON
POWELTON P.O.
PORT MATILDA
HALF MOON P.O.
STORMSTOWN
CENTRE FURNACE
AGRICULTURAL COLLEGE P.O.
OAK HALL
TAYLOR
HANNAH FURNACE
HALF MOON
FERGUSON
CENTRE LINE
GATESBURG
WHITEHALL
PINE GROVE MILLS
FAIRBROOK
PENNSYLVANIA FURNACE
ROCK SPR. P.O.
ALLEGHANY MTN
BALD EAGLE MTN
TUSSEY MTN
TYRONE & CLEARFIELD R.R.
BLAIR COUNTY
HUNTINGDON COUNTY


SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST.
GEOLOGICAL MAP
OF
CENTRE COUNTY
1884.
Scale 6 miles to 1 inch
0 1 2 3 4 5 10 miles
N
LIBERTY
EAGLEVILLE
BLANCHARD P.O.
Marsh Cr.
HOWARD
HOWARD IRON WORKS
WALKER P.O.
JACKSONVILLE
MOUNTAIN EAGLE P.O.
MECHANICVILLE
NITTANY P.O.
SNYDERTOWN
HUBLERSBURG
IRON MINES
Little Fishing Cr.
WALKER
HECLA FURNACE
ZION
TOLL HOUSE
Brush Valley
Brush Valley Narrows
WOLFE'S STORE P.O.
REBERSBURG P.O.
MADISONBURG
CENTRE MILLS P.O.
BRUSH MTN.
AARONSBURG
Round Top Mtn.
Penns Valley Narrows
WOODWARD P.O.
MILLHEIM
HAINES
GREGG
PENN HALL P.O.
SPRING MILLS
PENN
GREENBRIER
Brush Valley Road
CENTRE HALL
OLD FORT
CENTRE HILL
POTTER
SINKING CREEK MILLS
CHURCHVILLE
POTTERS MILLS
SEVEN MTNS
MIFFLIN COUNTY
UNION COUNTY
PLEASANT GAP


EXPLANATION OF COLORS
New Red Sandstone
Trap
Limestone Siluro-Cambrian?
Hydro Mica Schists
Quartzite (Potsdam?)
Serpentine
Azoic Slates etc
BERKS COUNTY
LANCASTER COUNTY
STATE OF MARYLAND
HONEY BROOK
WEST CALN
SADSBURY
HIGHLAND
FALLOWFIELD
WEST FALLOWFIELD
LONDONDERRY
UPPER OXFORD
LOWER OXFORD
PENN
EAST NOTTINGHAM
WEST NOTTINGHAM
NEW LONDON
LONDON GROVE
WEST MARLBOROUGH
WALLACE
EAST BRANDYWINE
WEST BRANDYWINE
LONDON BRITAIN
ELK
FRANKLIN



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

OF

CHESTER COUNTY

1881

Scale: 6 miles to 1 inch

0 1 2 3 4 5 10 miles

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

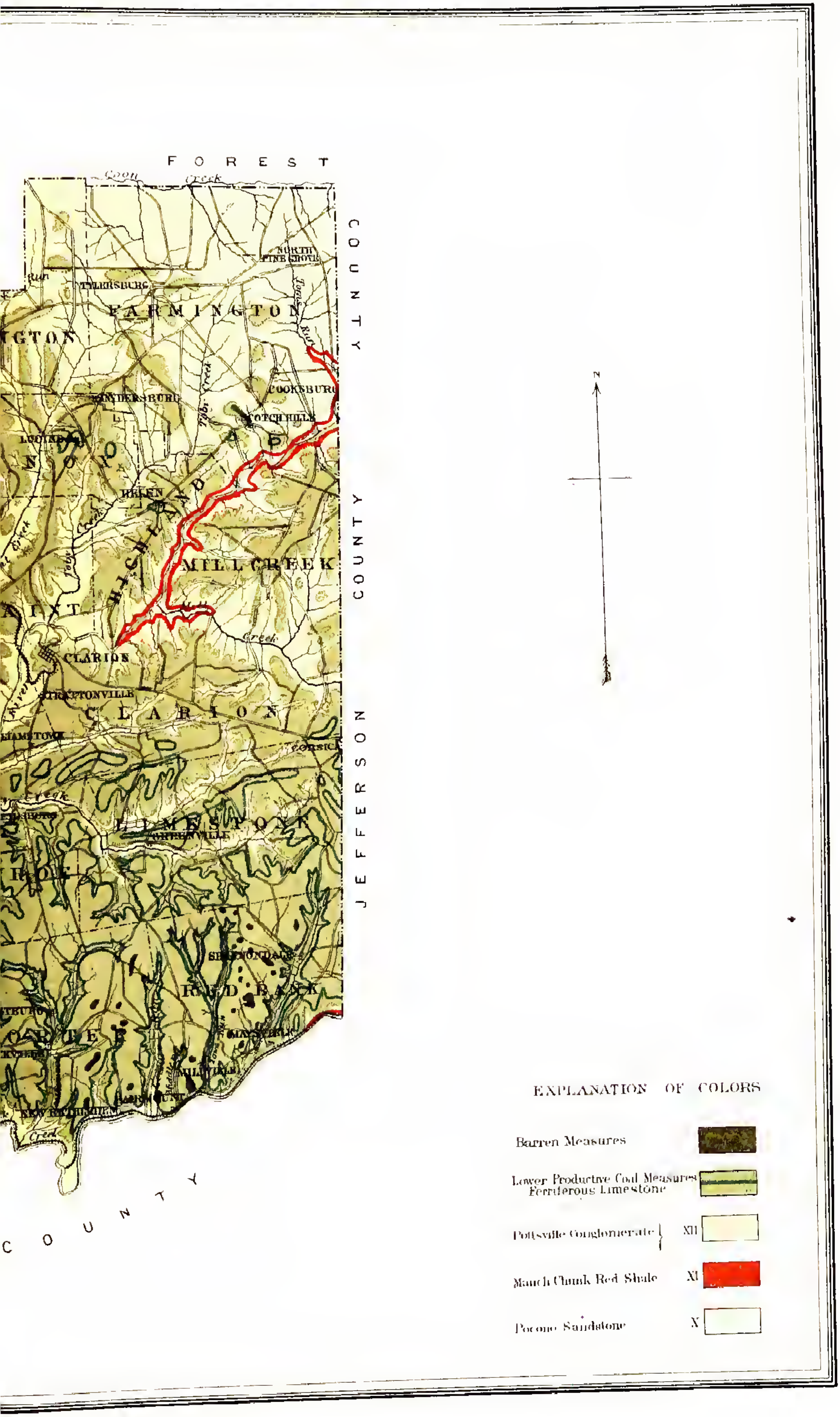
J.P. LESLEY, STATE GEOLOGIST.

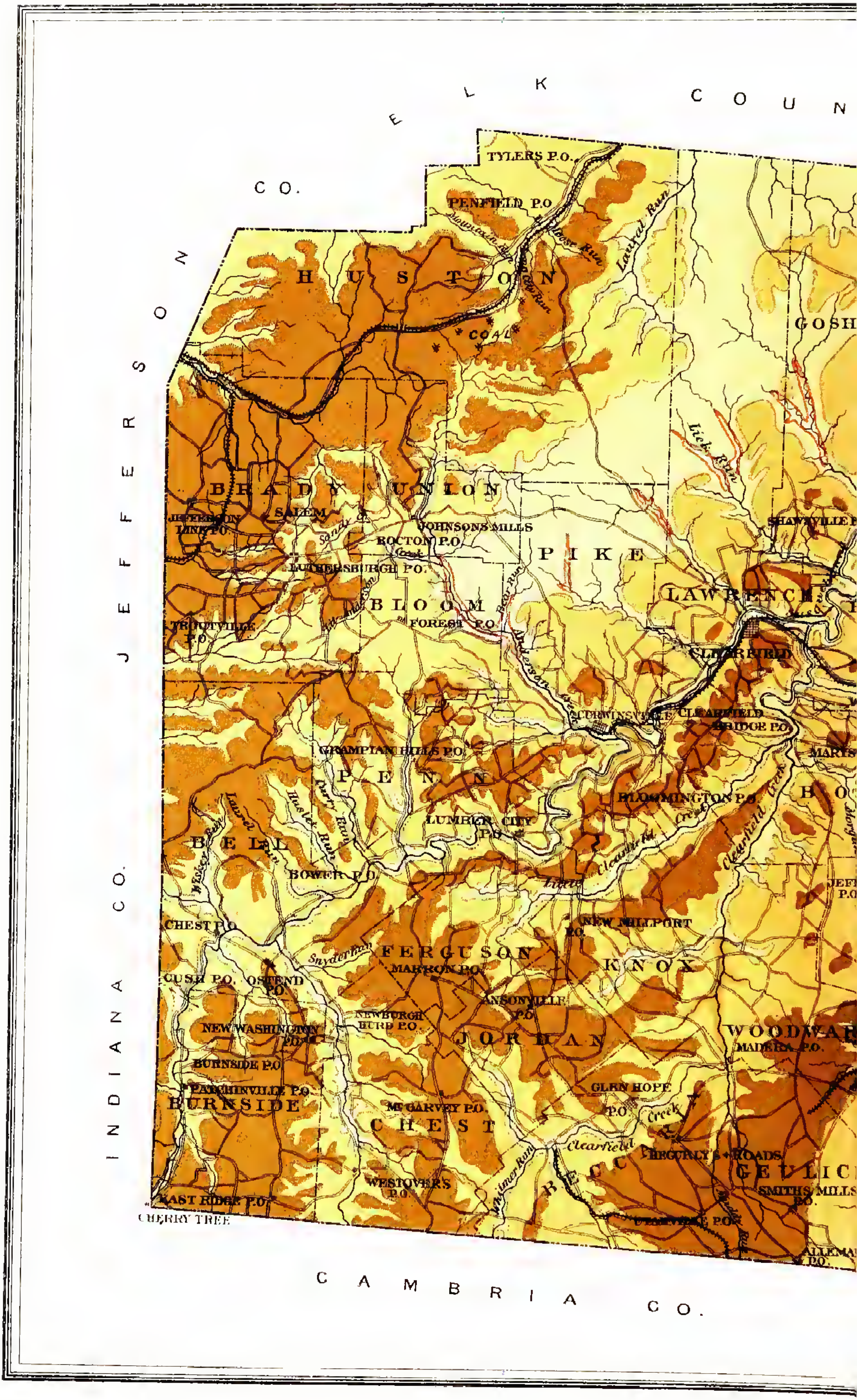
GEOLOGICAL MAP
OF
CLARION COUNTY

1878.

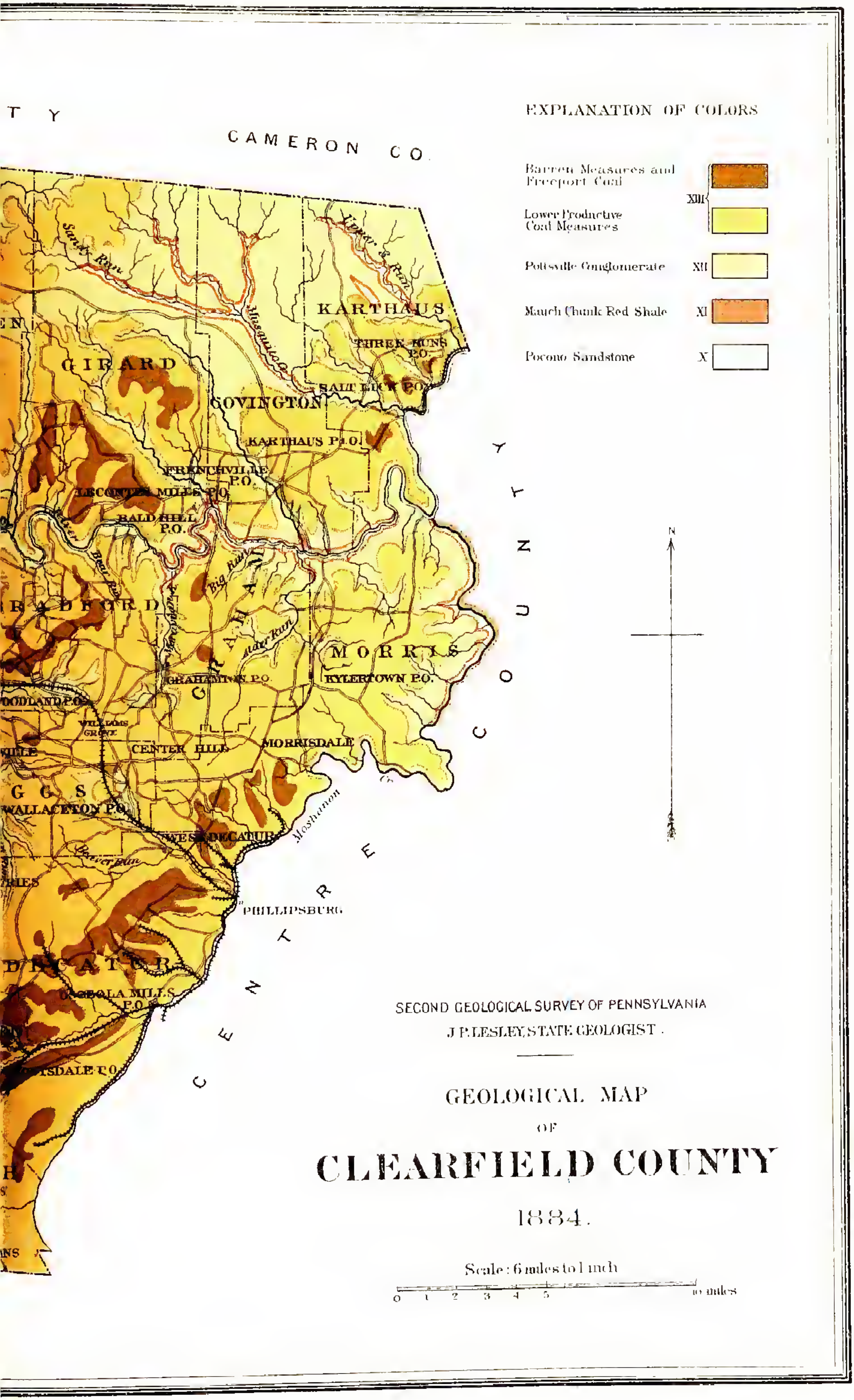
Scale: 6 miles to 1 inch

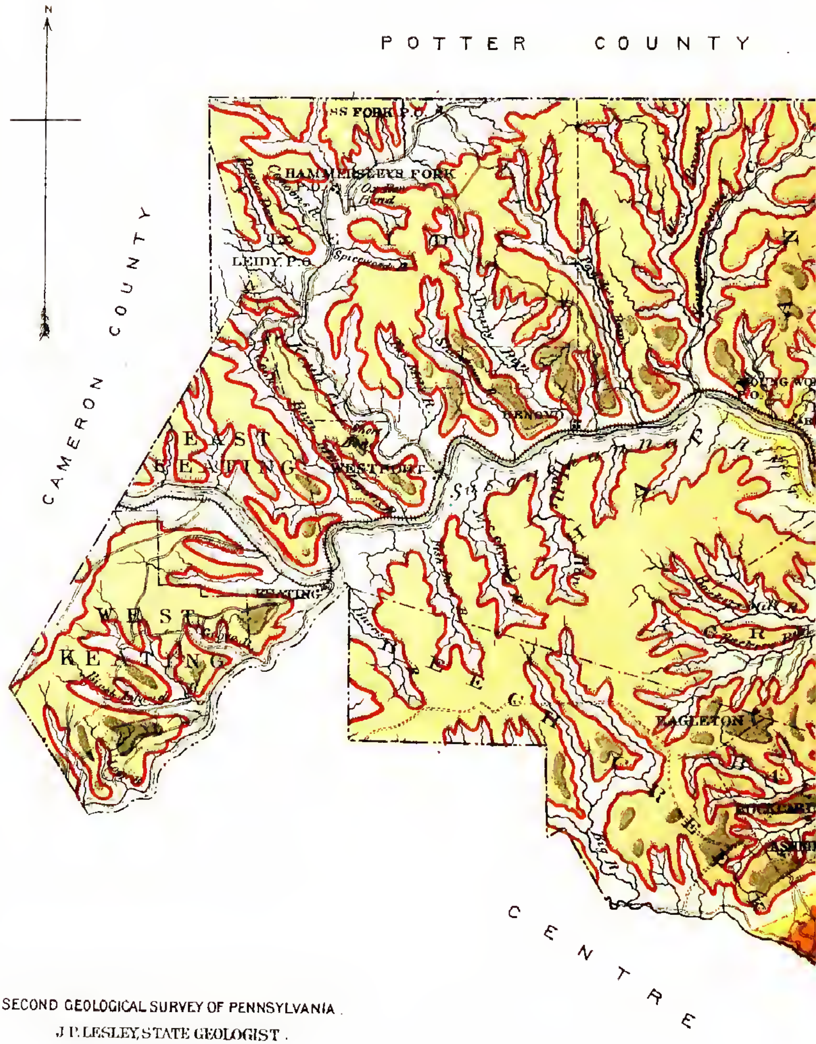
0 1 2 3 4 5 10 miles


FOREST
COUNTY
JEFFERSON COUNTY
COUNTY
FARMINGTON
TYLERSBURG
NORTH PINE GROVE
COOKSBURG
SNYDERSBURG
HELEN
HIGHLAND
MILLCREEK
CLARION
STRATTONVILLE
CLARION
CORSICA
LIMESTONE
GREENVILLE
RED BANK
MAYSVILLE
NEW BETHLEHEM
EXPLANATION OF COLORS
Barren Measures
Lower Productive Coal Measures
Ferriferous Limestone
Pottsville Conglomerate XII
Mauch Chunk Red Shale XI
Pocono Sandstone X



E L K C O U N
J E F F E R S O N C O.
I N D I A N A C O.
C A M B R I A C O.
TYLERS P.O.
PENFIELD P.O
H U S T O N
COAL
Laurel Run
Lick Run
GOSH
B R A D Y
U N I O N
SALEM
JEFFERSON LINE P.O.
JOHNSONS MILLS
ROCTON P.O.
LUTHERSBURGH P.O.
P I K E
LAWRENCE
SHAWVILLE
B L O O M
FOREST P.O.
TROUTVILLE P.O.
CLEARFIELD
CURWINSVILLE
CLEARFIELD BRIDGE P.O.
GRAMPIAN HILLS P.O.
P E N N
LUMBER CITY P.O.
BLOOMINGTON P.O.
B E L L
BOWER P.O.
Clearfield Creek
Little Clearfield
NEW MILLPORT P.O.
CHEST P.O.
F E R G U S O N
MARRON P.O.
K N O X
CUSH P.O.
OSTEND P.O.
ANSONVILLE P.O.
NEW WASHINGTON P.O.
NEWBURGH
J O R D A N
W O O D W A R
MADERA P.O.
BURNSIDE P.O.
PATCHINVILLE P.O.
B U R N S I D E
GLEN HOPE P.O.
McGARVEY P.O.
C H E S T
BECCARIA
BEGURLY'S ROADS
SMITHS MILLS P.O.
WESTOVERS P.O.
EAST RIDGE P.O.
CHERRY TREE


EXPLANATION OF COLORS
Barren Measures and Freeport Coal
XIII
Lower Productive Coal Measures
Pottsville Conglomerate XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
CAMERON CO.
CENTRE COUNTY
GIRARD
COVINGTON
KARTHAUS
THREE RUNS P.O.
SALT LICK P.O.
KARTHAUS P.O.
FRENCHVILLE P.O.
LECONTES MILLS P.O.
BALD HILL P.O.
GRAHAM
GRAHAMTON P.O.
MORRIS
KYLERTOWN P.O.
BRADFORD
WILLIAMS GROVE
CENTER HILL
MORRISDALE
WALLACETON P.O.
WEST DECATUR
PHILLIPSBURG
DECATUR
OSCEOLA MILLS P.O.
Sandy Run
Upper3 Run
Mosquito Cr.
Big Run
Alder Run
Moshannon
Beaver Run
N
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST.
GEOLOGICAL MAP
OF
CLEARFIELD COUNTY
1884.
Scale: 6 miles to 1 inch
0 1 2 3 4 5 10 miles



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

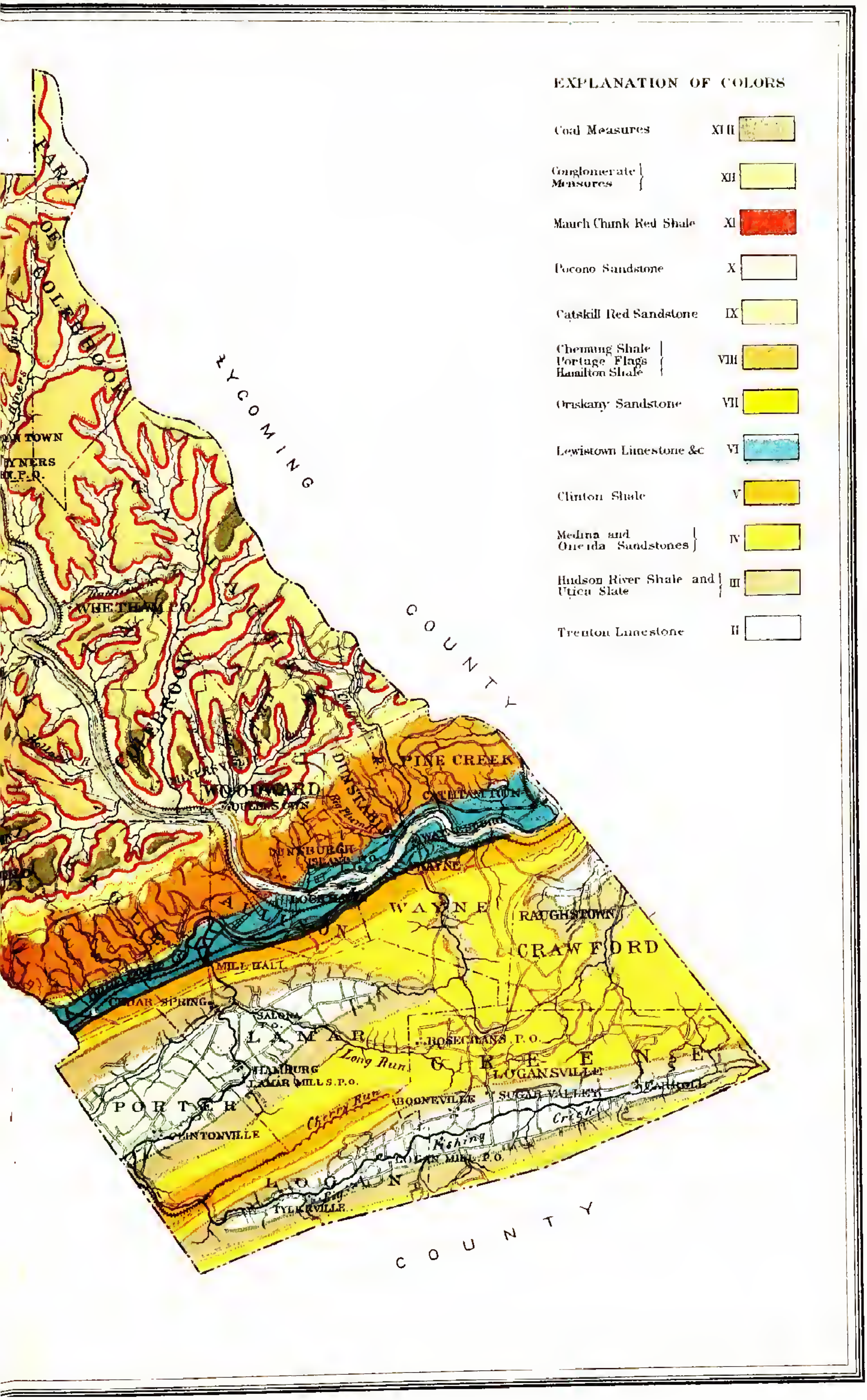
OF

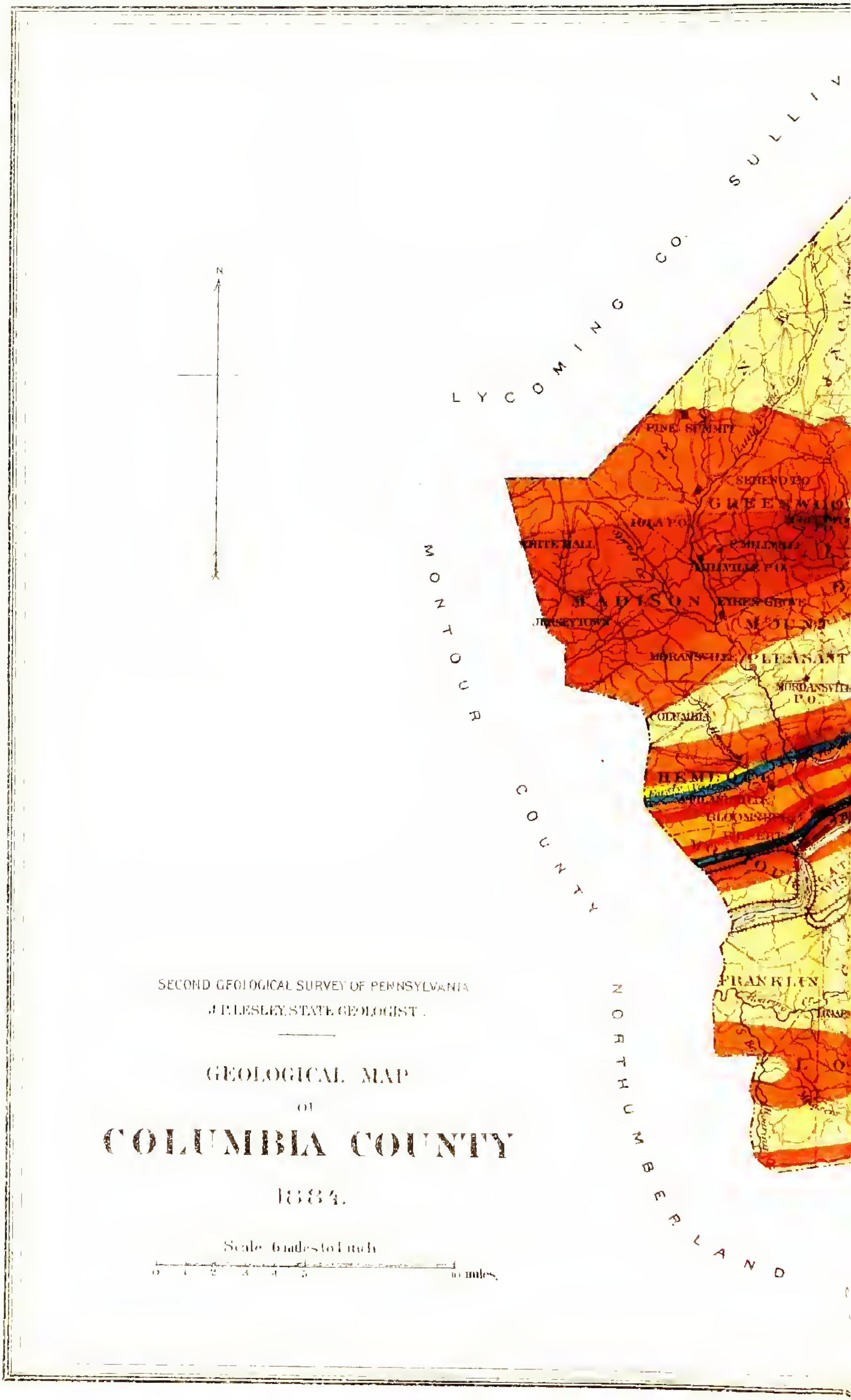
CLINTON COUNTY

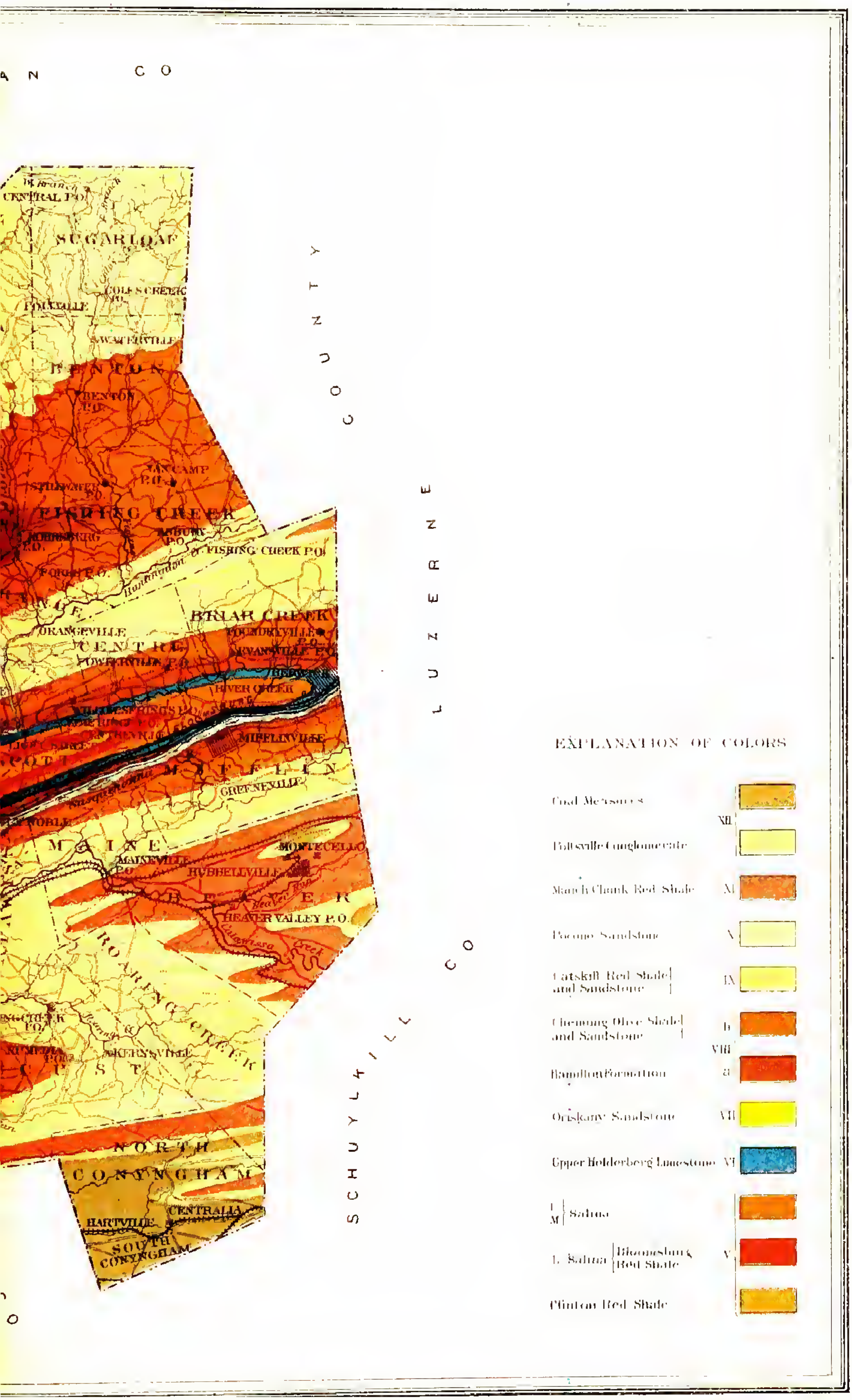
1878.

Scale: 6 miles to 1 inch.

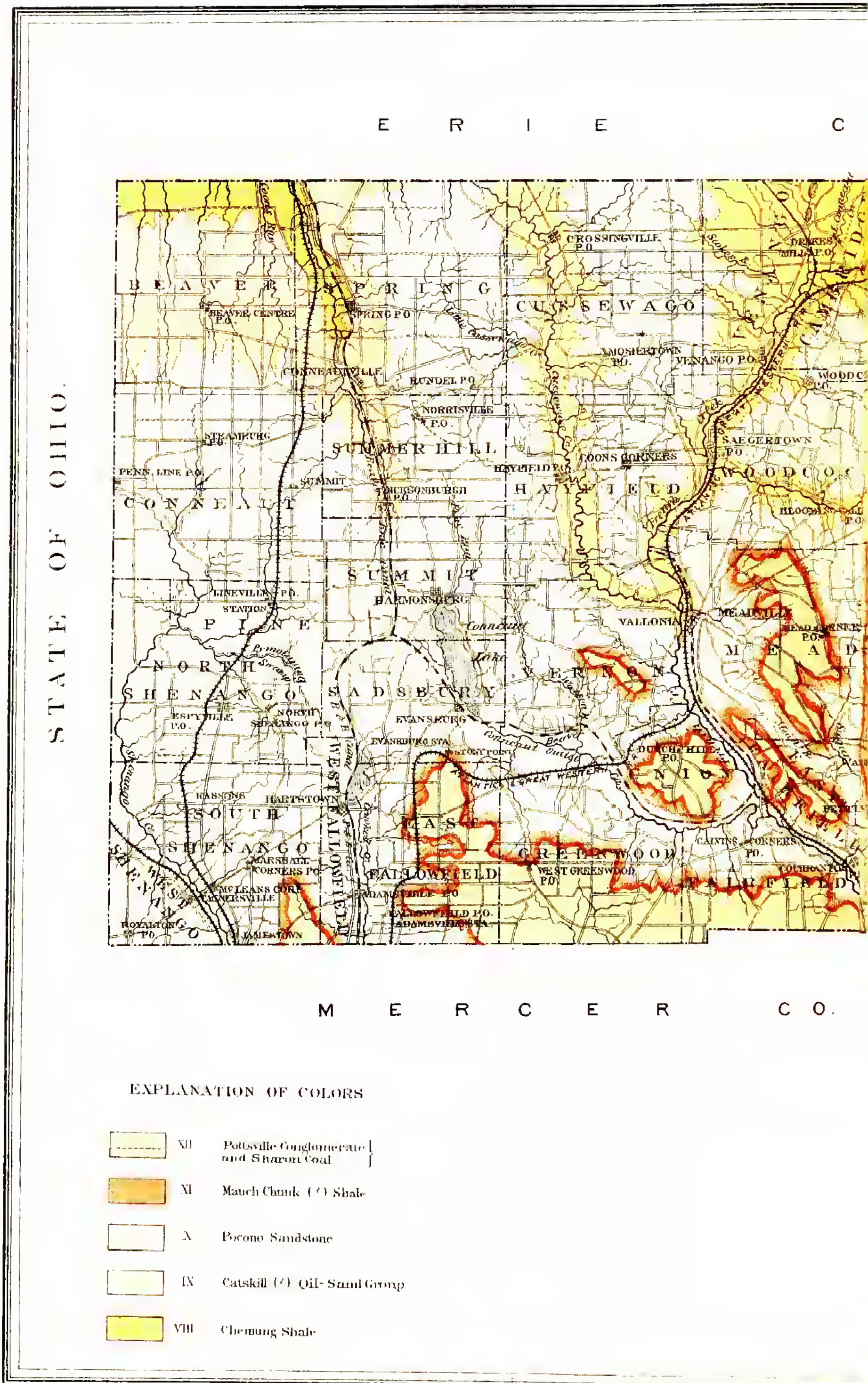
0 1 2 3 4 5 10 miles

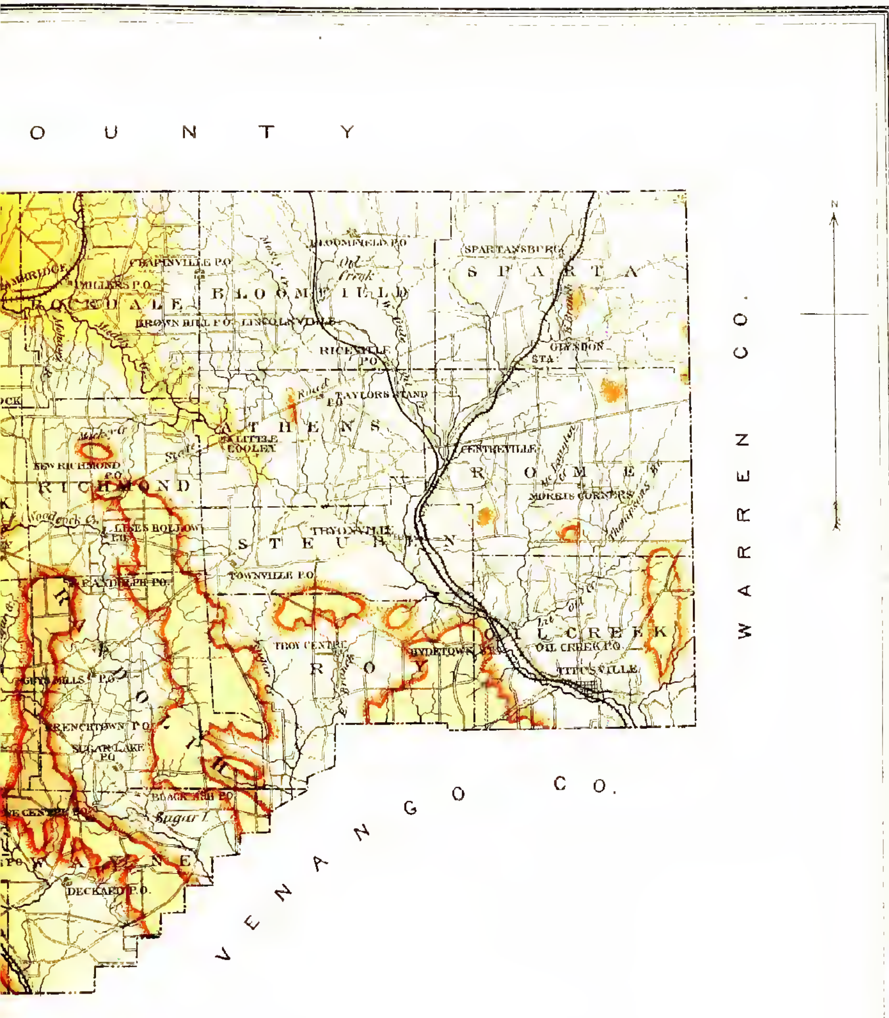

EXPLANATION OF COLORS
Coal Measures XIII
Conglomerate Measures XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
Chemung Shale Portage Flags Hamilton Shale VIII
Oriskany Sandstone VII
Lewistown Limestone &c VI
Clinton Shale V
Medina and Oneida Sandstones IV
Hudson River Shale and Utica Slate III
Trenton Limestone II
LYCOMING COUNTY
COUNTY
PART OF COLEBROOK
WOODWARD
DUNSTABLE
PINE CREEK
WAYNE
RAUGHSTOWN
CRAWFORD
LAMAR
GREENE
PORTER
LOGAN
MILL HALL
CEDAR SPRING
SALONA
HAMBURG
LAMAR MILLS P.O.
ROSECRANS P.O.
LOGANSVILLE
SUGAR VALLEY
BOONEVILLE
CLINTONVILLE
TYLERSVILLE
LOGAN MILL P.O.
Long Run
Cherry Run
Fishing Creek


SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST.
GEOLOGICAL MAP
OF
COLUMBIA COUNTY
1884.
Scale 6 miles to 1 inch
0 1 2 3 4 5 10 miles.
N
LYCOMING CO.
MONTOUR COUNTY
NORTHUMBERLAND
PINE SUMMIT
IOLA P.O.
MADISON
JERSEYTOWN
EYRES GROVE
MORDANSVILLE P.O.
FRANKLIN



C O
SUGARLOAF
COLES CREEK P.O.
FORKSVILLE
BENTON
BENTON P.O.
JAMISON CITY
STILLWATER P.O.
FISHING CREEK
ORANGEVILLE
CENTRE
BRIAR CREEK
FOUNDRYVILLE P.O.
EVANSVILLE P.O.
BERWICK
MIFFLINVILLE
MIFFLIN
GREENSVILLE
MAINE
MAINEVILLE P.O.
MONTECELLO
BEAVER
BEAVER VALLEY P.O.
ROARING CREEK
MIFFLIN
NORTH
CONYNGHAM
CENTRALIA
HARTVILLE
SOUTH CONYNGHAM
LUZERNE COUNTY
SCHUYLKILL CO
EXPLANATION OF COLORS
Coal Measures
XII
Pottsville Conglomerate
Mauch Chunk Red Shale
XI
Pocono Sandstone
X
Catskill Red Shale and Sandstone
IX
Chemung Olive Shale and Sandstone
b
VIII
Hamilton Formation
a
Oriskany Sandstone
VII
Upper Helderberg Limestone
VI
Salina
L. Salina
Bloomsburg Red Shale
V
Clinton Red Shale


E R I E C
STATE OF OHIO.
M E R C E R C O.
BEAVER
BEAVER CENTRE P.O.
SPRING
SPRING P.O.
CUSSEWAGO
CROSSINGVILLE P.O.
MOSIERTOWN P.O.
VENANGO P.O.
CONNEAUTVILLE
RUNDEL P.O.
NORRISVILLE P.O.
STEAMBURG P.O.
SUMMERHILL
PENN. LINE P.O.
SUMMIT
CONNEAUT
HAYFIELD P.O.
HAYFIELD
COONS CORNERS
SAEGERTOWN P.O.
SUMMIT
HARMONSBURG
LINEVILLE P.O.
STATION
PINE
NORTH SHENANGO
ESPYVILLE P.O.
NORTH SHENANGO P.O.
SADSBURY
EVANSBURG
EVANSBURG STA.
STONY POINT
VALLONIA
MEADVILLE
VERNON
DUTCH HILL P.O.
KASSONS
HARTSTOWN
SOUTH SHENANGO
MARSHALL CORNERS P.O.
McLEANS CORS.
EAST FALLOWFIELD
WEST FALLOWFIELD
GREENWOOD
WEST GREENWOOD P.O.
CALVINS CORNERS P.O.
FAIRFIELD
ADAMSVILLE P.O.
FALLOWFIELD P.O.
ROYALTON P.O.
JAMESTOWN
Conneaut Lake
Pymatuning Swamp
Shenango
ATLANTIC & GREAT WESTERN
EXPLANATION OF COLORS
XII Pottsville Conglomerate and Sharon Coal
XI Mauch Chunk (?) Shale
X Pocono Sandstone
IX Catskill (?) Oil-Sand Group
VIII Chemung Shale



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J.P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

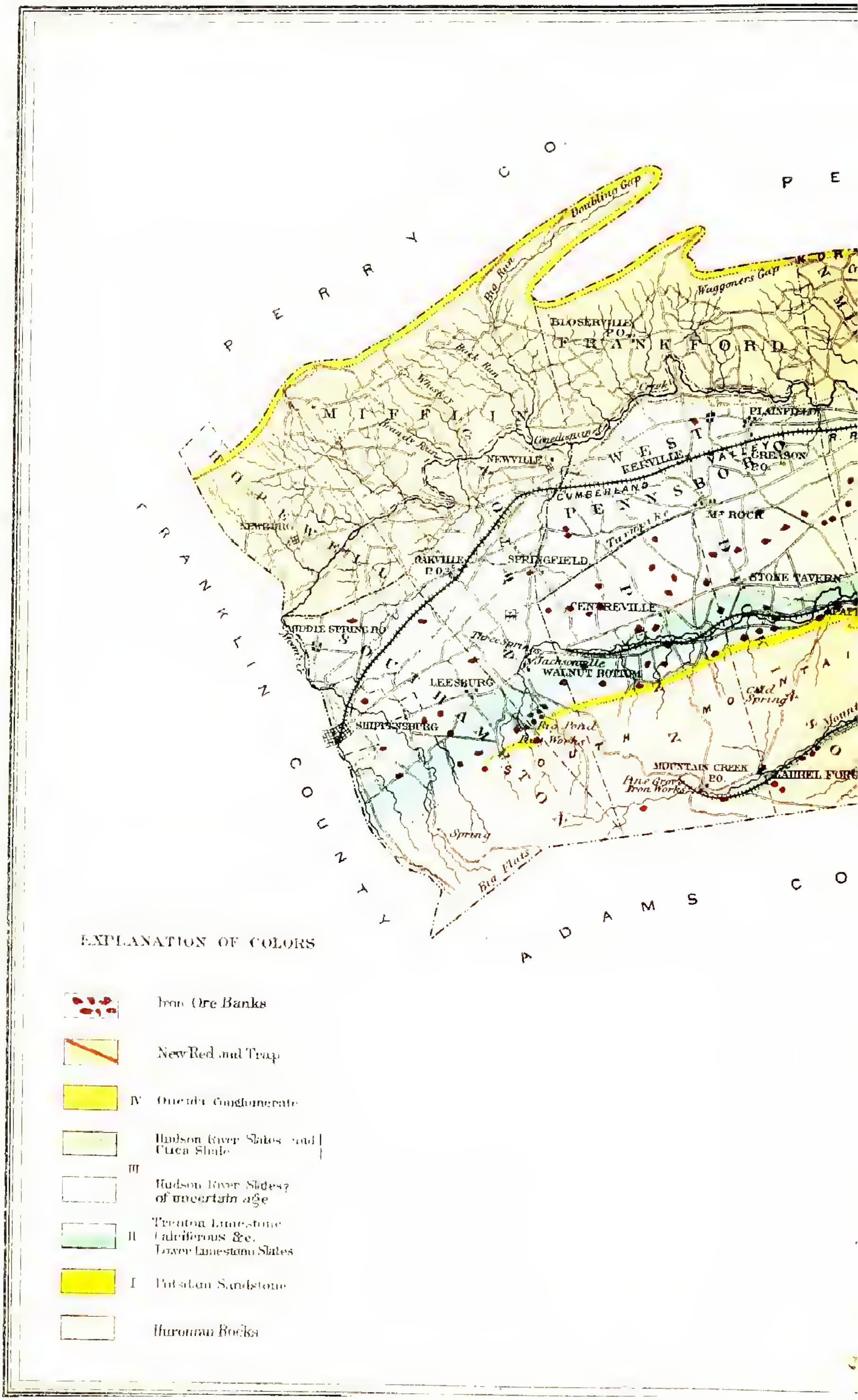
OF

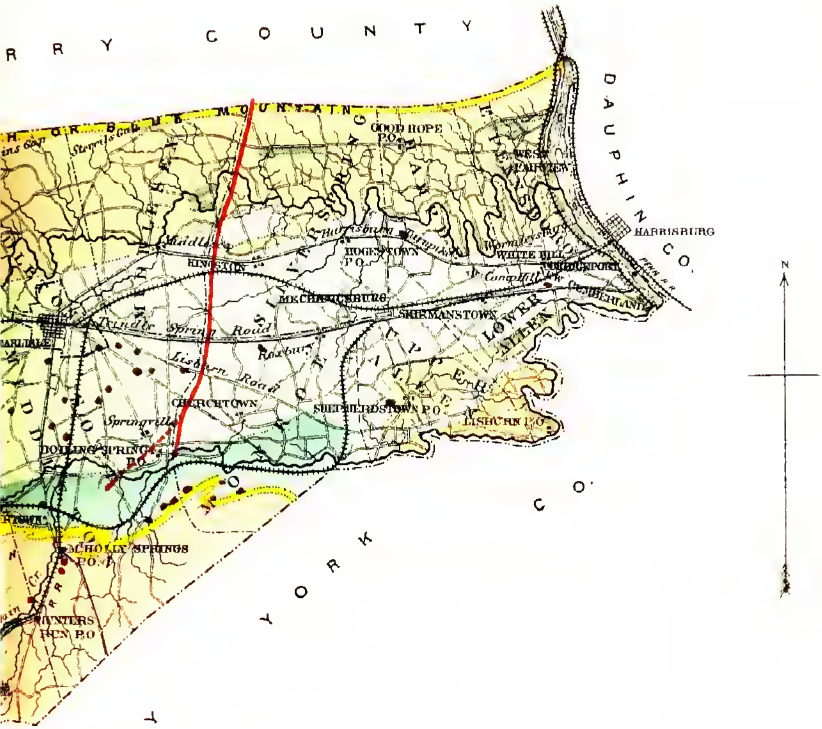
CRAWFORD COUNTY

1879.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles


PERRY CO.
FRANKLIN COUNTY
ADAMS CO
Doubling Gap
Waggoners Gap
Big Run
Back Run
Wheeler
Brandy Run
BLOSERVILLE P.O.
FRANKFORD
MIFFLIN
HOPEWELL
NEWBURG
NEWVILLE
Conedoguinet
Creek
WEST PENNSBORO
KERVILLE
CUMBERLAND VALLEY R.R.
PLAINFIELD
GREASON P.O.
MT ROCK
Turnpike
OAKVILLE P.O.
SPRINGFIELD
STONE TAVERN
CENTREVILLE
MIDDLE SPRING P.O.
Three Springs
Jacksonville
WALNUT BOTTOM
LEESBURG
SHIPPENSBURG
Big Pond Iron Works
Cold Spring
MOUNTAIN CREEK P.O.
Pine Grove Iron Works
LAUREL FORGE
SOUTHAMPTON
Spring
Big Flats
EXPLANATION OF COLORS
Iron Ore Banks
New Red and Trap
IV Oneida Conglomerate
Hudson River Slates and Utica Shale
III
Hudson River Slates? of uncertain age
II Trenton Limestone Calciferous &c. Lower Limestone Slates
I Potsdam Sandstone
Huronian Rocks



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

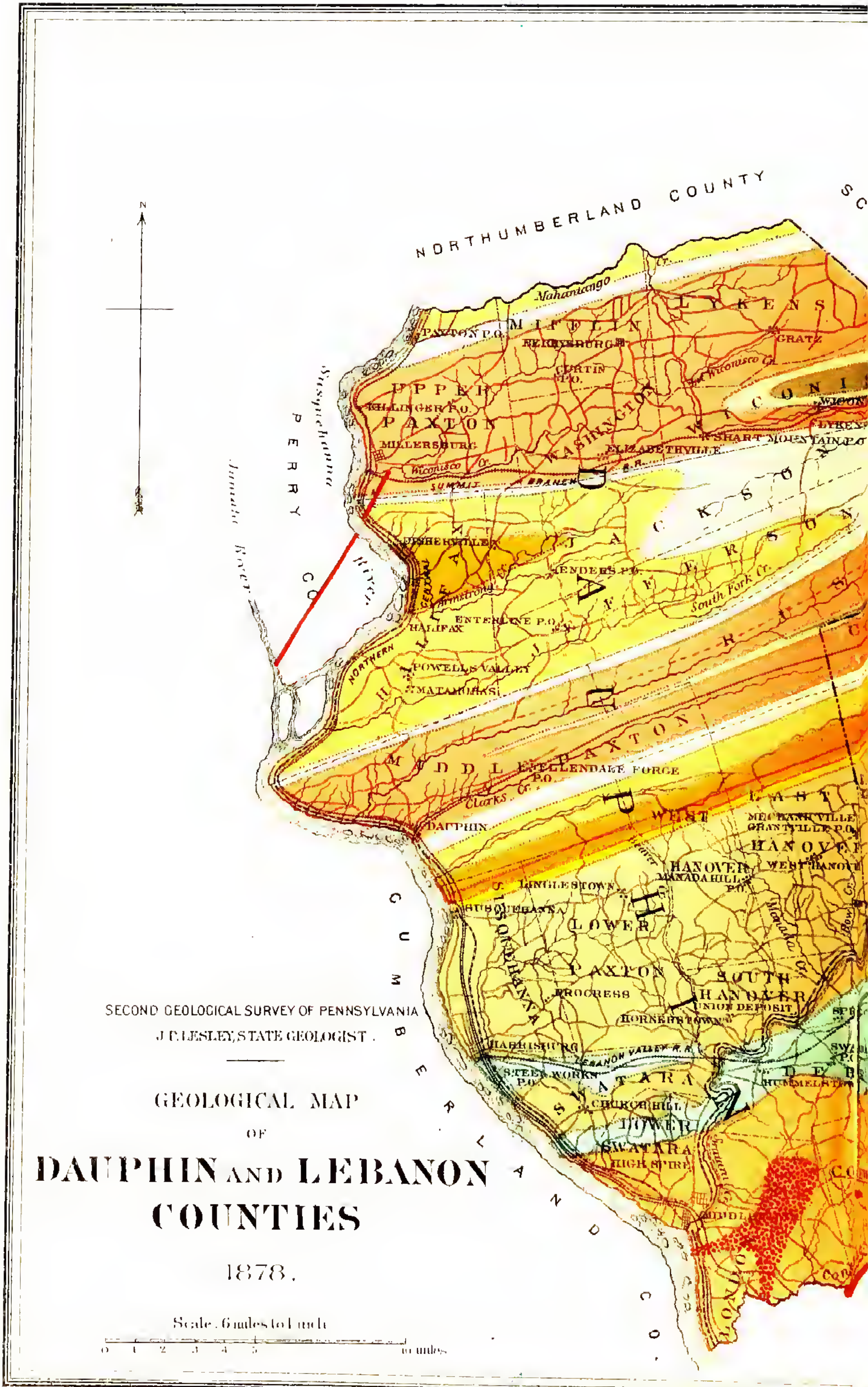
OF

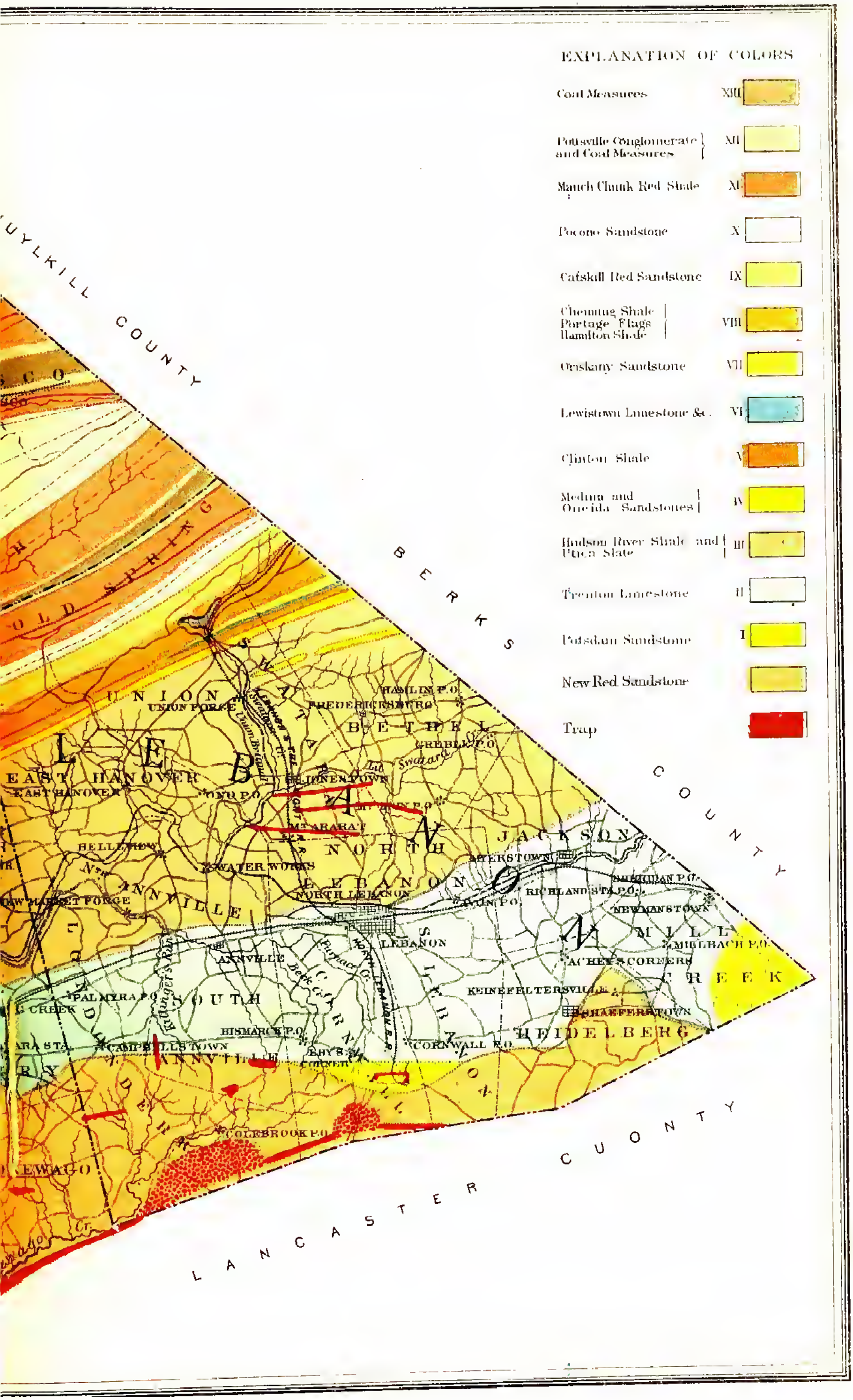
CUMBERLAND COUNTY

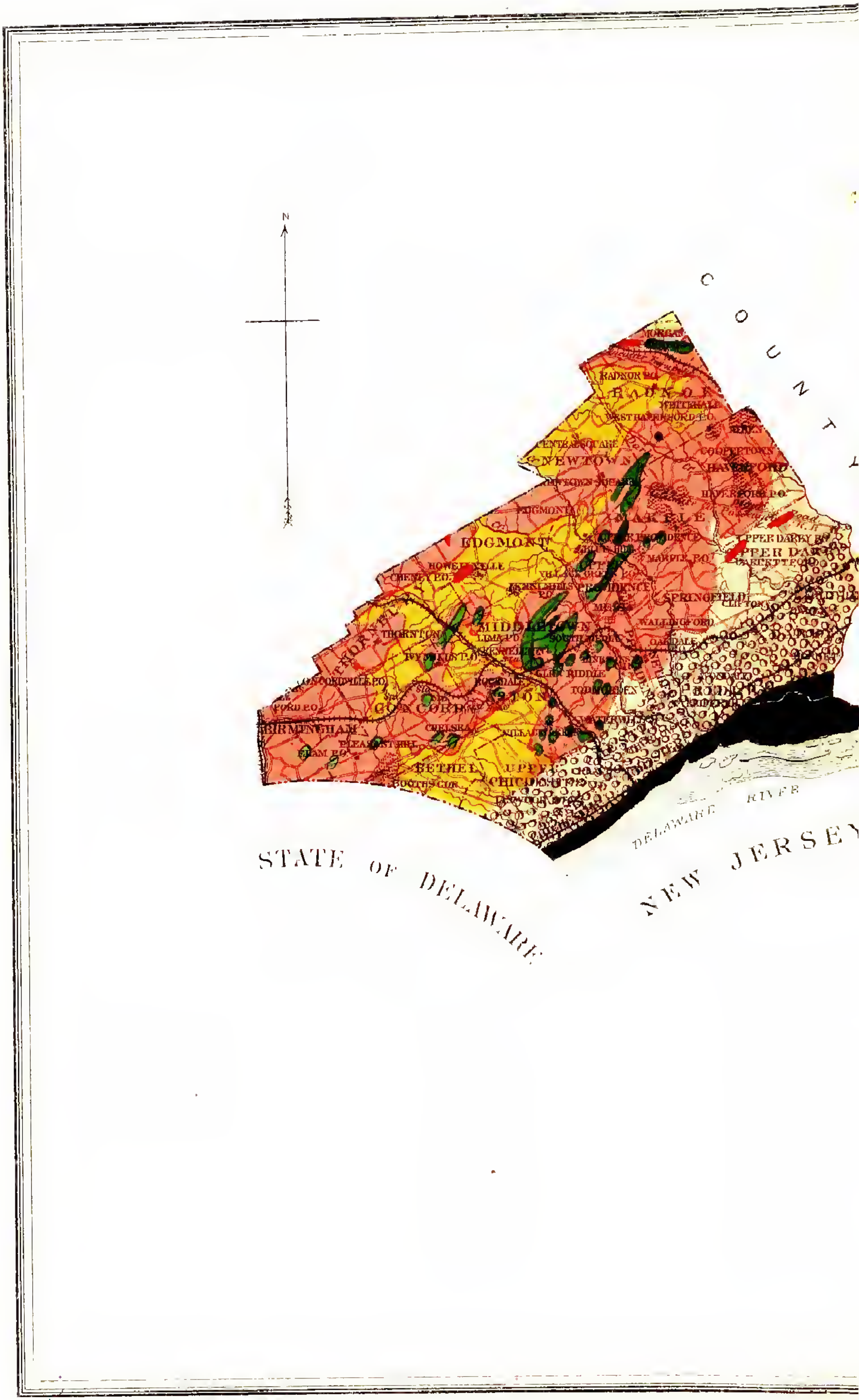
1881.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles


SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST.
GEOLOGICAL MAP
OF
DAUPHIN AND LEBANON
COUNTIES
1878.
Scale, 6 miles to 1 inch
NORTHUMBERLAND COUNTY
PERRY CO.
CUMBERLAND CO.
DAUPHIN
Mahanoy
MIFFLIN
LYKENS
UPPER PAXTON
WASHINGTON
WICONISCO
JACKSON
JEFFERSON
HALIFAX
MIDDLE PAXTON
EAST HANOVER
WEST HANOVER
LOWER PAXTON
SOUTH HANOVER
SWATARA
LOWER SWATARA
MILLERSBURG
ELIZABETHVILLE
GRATZ
HALIFAX
DAUPHIN
LINGLESTOWN
HARRISBURG
STEELTON
HIGHSPIRE
HUMMELSTOWN
Juniata River
Susquehanna River


EXPLANATION OF COLORS
Coal Measures XIII
Pottsville Conglomerate and Coal Measures XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
Chemung Shale Portage Flags Hamilton Shale VIII
Oriskany Sandstone VII
Lewistown Limestone &c. VI
Clinton Shale V
Medina and Oneida Sandstones IV
Hudson River Shale and Utica Slate III
Trenton Limestone II
Potsdam Sandstone I
New Red Sandstone
Trap
SCHUYLKILL COUNTY
BERKS COUNTY
LANCASTER COUNTY
COLD SPRING
UNION
UNION FORGE
EAST HANOVER
BETHEL
FREDERICKSBURG
JONESTOWN
NORTH LEBANON
NORTH LEBANON
WATER WORKS
BELLEVIEW
ANNVILLE
NEW MARKET FORGE
LEBANON
SOUTH LEBANON
JACKSON
MYERSTOWN
RICHLAND STA. P.O.
NEWMANSTOWN
MILLCREEK
MILLBACH P.O.
SCHAEFFERSTOWN
HEIDELBERG
CORNWALL P.O.
KEINEFELTERSVILLE
BISMARCK P.O.
SOUTH ANNVILLE
PALMYRA P.O.
CAMPBELLSTOWN
COLEBROOK P.O.
LONDONDERRY
CONEWAGO
Swatara
MT. ARARAT


N
STATE OF DELAWARE
NEW JERSEY
DELAWARE RIVER
RADNOR P.O.
WHITEHALL
NEWTOWN
EDGMONT
HAVERFORD
HAVERFORD P.O.
SPRINGFIELD
WALLINGFORD
THORNTON
BIRMINGHAM
CHELSEA
BETHEL
PLEASANT HILL
GLEN RIDDLE

EXPLANATION OF COLORS

- River Mud
- Gravel and Brick Clay
- Brynmawr Gravel
- Trap
- Serpentine
- Chestnut Hill and Garnetiferous Schists
- Manayunk and Philadelphia Mica Schists and Gneiss
- South Valley Hill Slate
- Syenite and Granite (Laurentian?)

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

OF

DELAWARE COUNTY

1884.

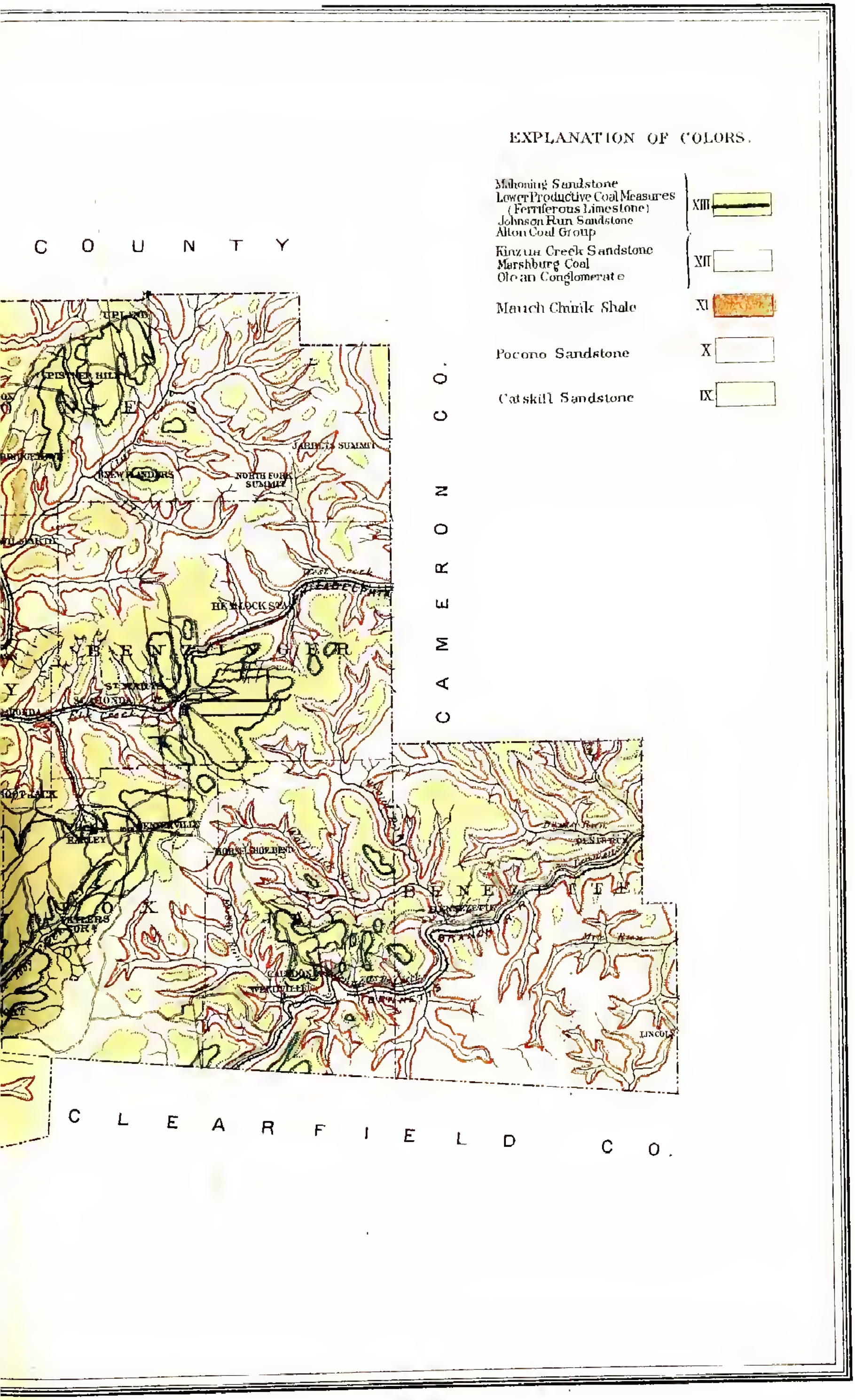
Scale, 6 miles to 1 inch

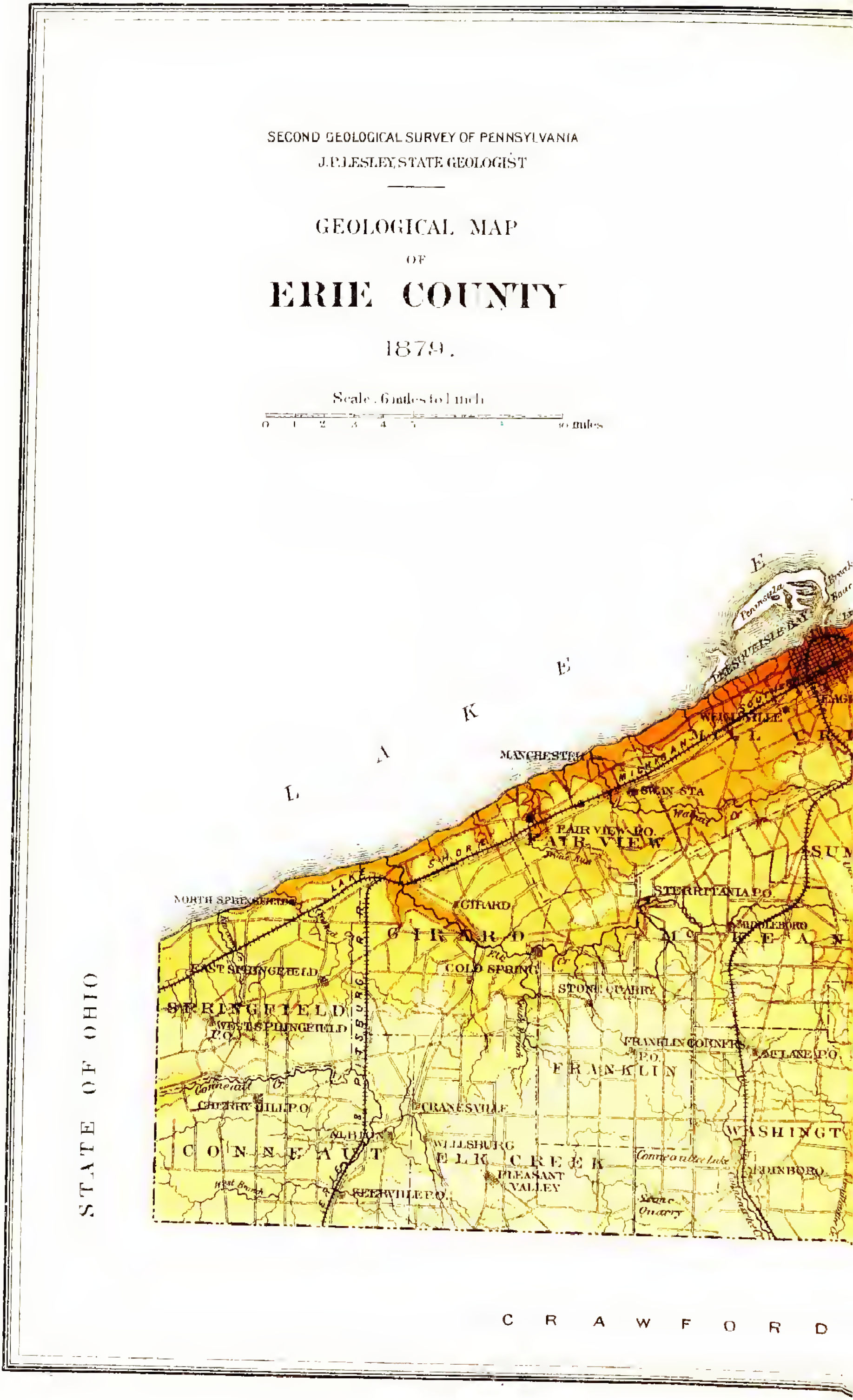
0 1 2 3 4 5 10 miles

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.
J. P. LESLEY, STATE GEOLOGIST.

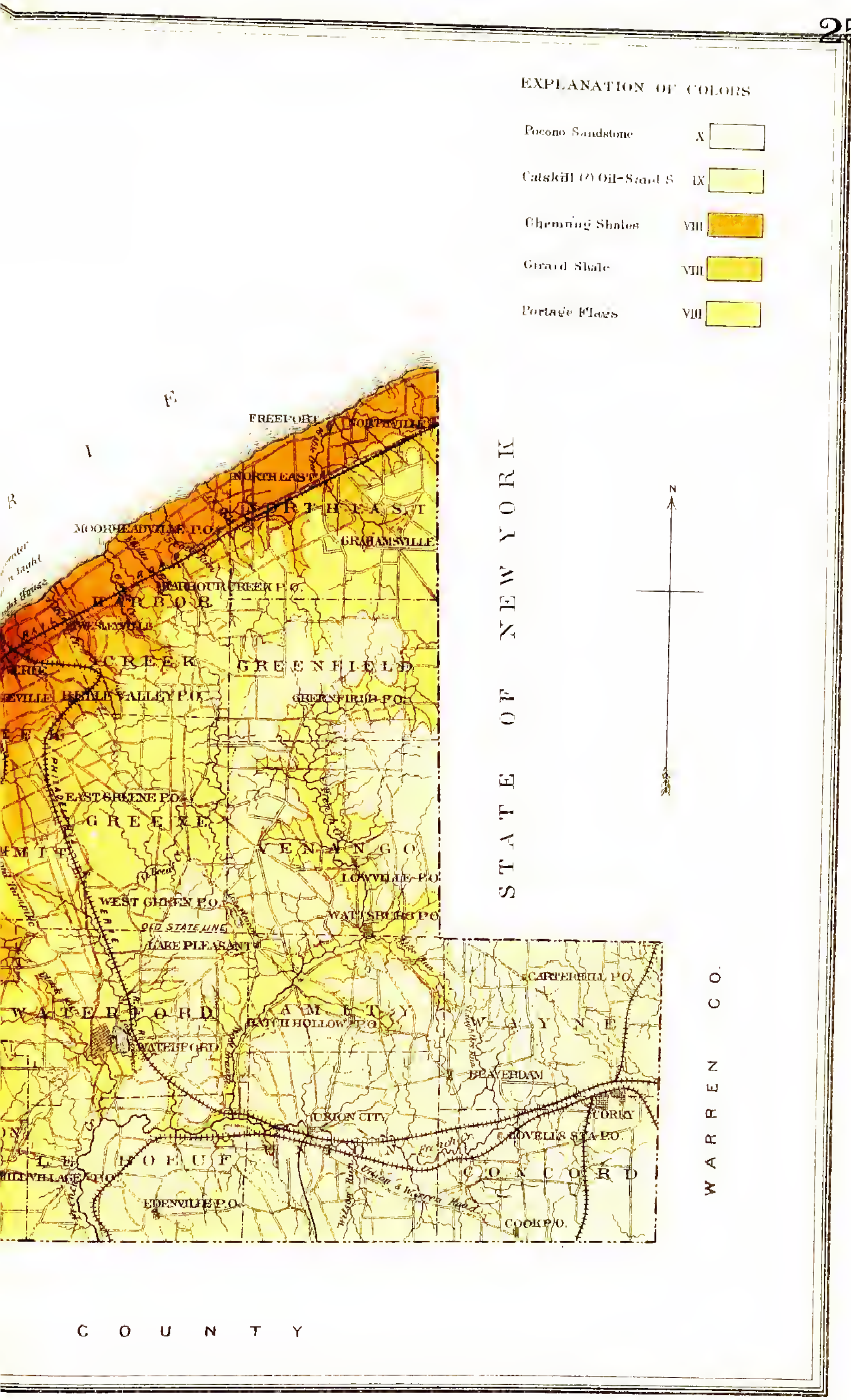
GEOLOGICAL MAP
OF
ELK COUNTY
1878.

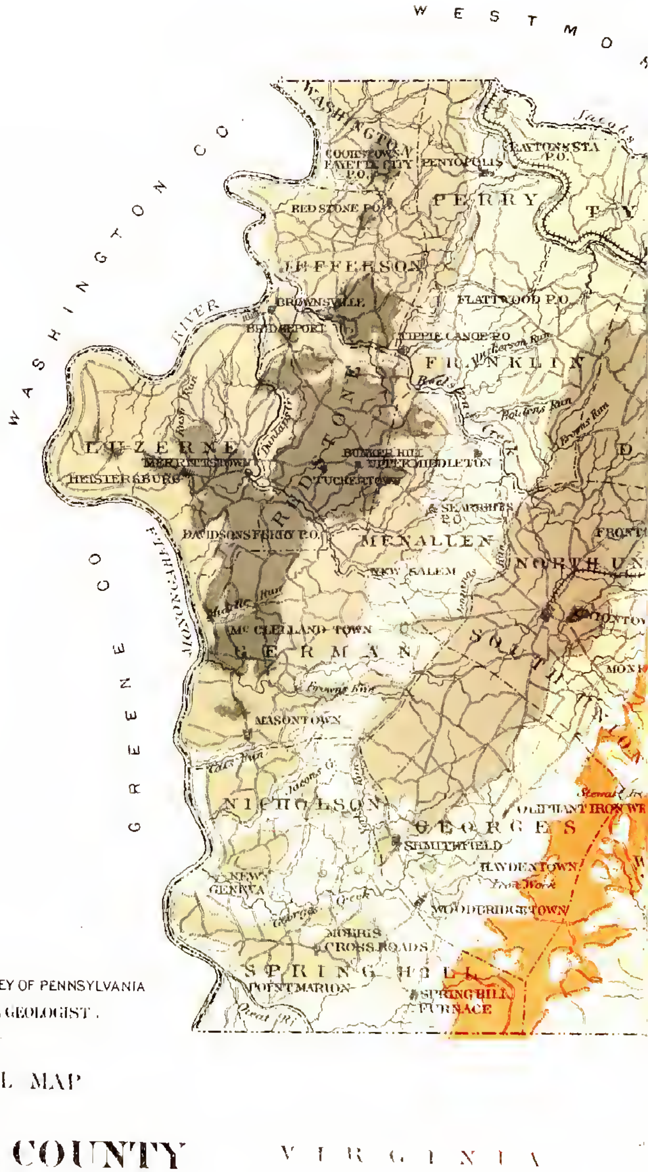
Scale 6 miles to 1 inch
0 1 2 3 4 5 10 miles


EXPLANATION OF COLORS.
Mahoning Sandstone
Lower Productive Coal Measures
(Ferriferous Limestone)
Johnson Run Sandstone
Alton Coal Group
XIII
Kinzua Creek Sandstone
Marshburg Coal
Olean Conglomerate
XII
Mauch Chunk Shale
XI
Pocono Sandstone
X
Catskill Sandstone
IX
COUNTY
CAMERON CO.
CLEARFIELD CO.
UPLAND
JARRETS SUMMIT
NEW FLANDERS
NORTH FORK SUMMIT
HEMLOCK SPA
ST. MARYS
BENZINGER
EARLEY
BENEZETTE
BENNETT
LINCOLN



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST
GEOLOGICAL MAP
OF
ERIE COUNTY
1879.
Scale. 6 miles to 1 inch
0 1 2 3 4 5 10 miles
L A K E E
Peninsula
PRESQUE ISLE BAY
MANCHESTER
SWAN STA
FAIR VIEW P.O.
FAIR VIEW
NORTH SPRINGFIELD
GIRARD
STERRETTANIA P.O.
MIDDLEBORO
COLD SPRING
STONE QUARRY
EAST SPRINGFIELD
SPRINGFIELD
WEST SPRINGFIELD P.O.
FRANKLIN CORNERS P.O.
FRANKLIN
CHERRY HILL P.O.
CRANESVILLE
ALBION
CONNEAUT
WELLSBURG
ELK CREEK
PLEASANT VALLEY
WASHINGTON
EDINBORO
Conneautee Lake
Stone Quarry
STATE OF OHIO
C R A W F O R D


EXPLANATION OF COLORS
Pocono Sandstone X
Catskill (?) Oil-Sand S. IX
Chemung Shales VIII
Girard Shale VIII
Portage Flags VIII
E
I
R
FREEPORT
NORTH EAST
NORTH EAST
MOORHEADVILLE P.O.
GRAHAMSVILLE
HARBOUR CREEK P.O.
HARBOR
WESLEYVILLE
CREEK
GREENFIELD
ERIE
BELLE VALLEY P.O.
GREENFIELD P.O.
EAST GREENE P.O.
GREENE
VENANGO
LOWVILLE P.O.
WEST GREEN P.O.
WATTSBURG P.O.
OLD STATE LINE
LAKE PLEASANT
CARTERHILL P.O.
WATERFORD
AMITY
WAYNE
HATCH HOLLOW P.O.
WATERFORD
BEAVERDAM
UNION CITY
CORRY
LOVELL'S STA. P.O.
MILL VILLAGE P.O.
LE BOEUF
CONCORD
EDENVILLE P.O.
COOK P.O.
Union & Warren Road
STATE OF NEW YORK
N
WARREN CO.
COUNTY



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J.P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

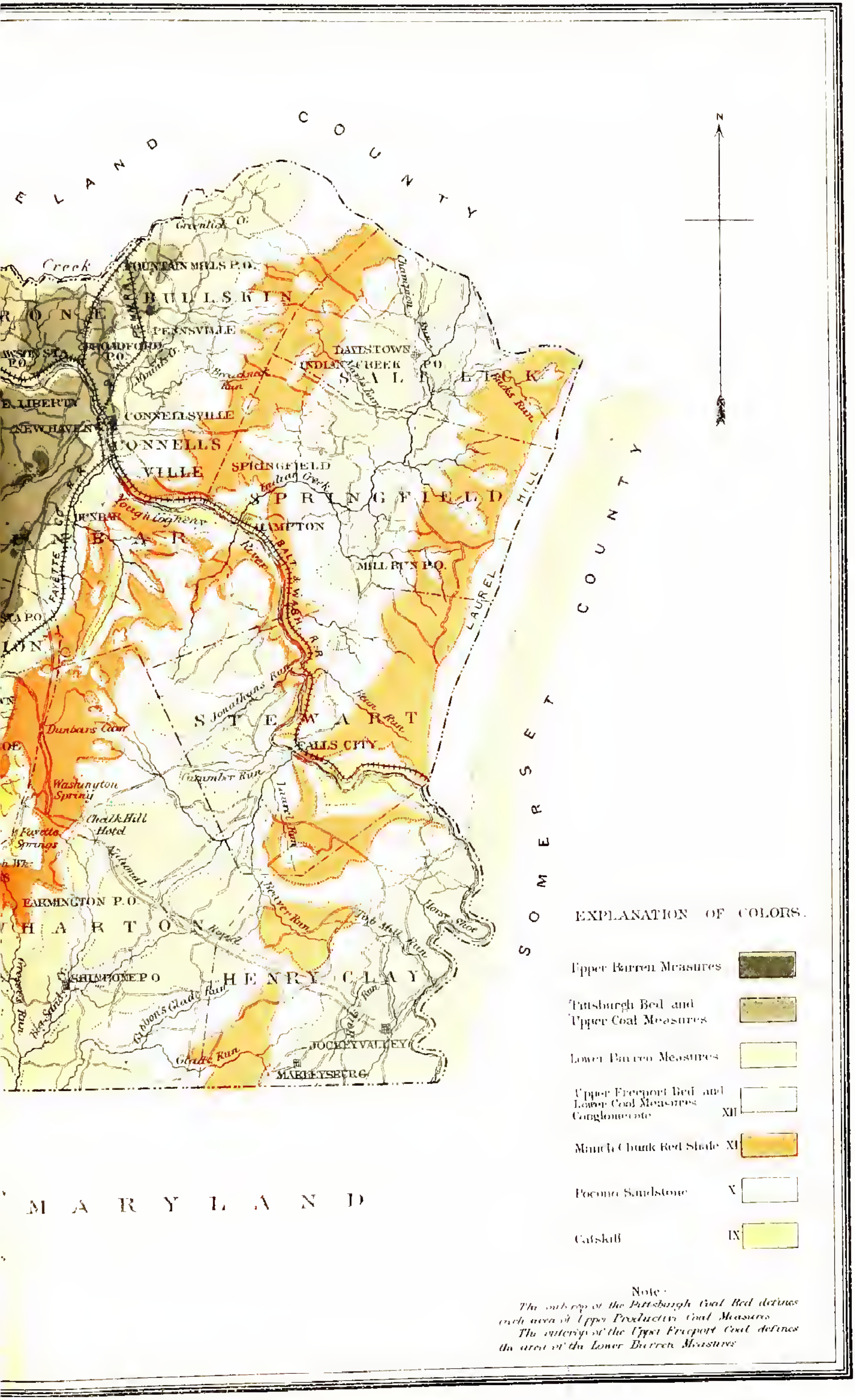
OF

FAYETTE COUNTY

1878.

Scale: 6 miles to 1 inch

0 1 2 3 4 5 10 miles

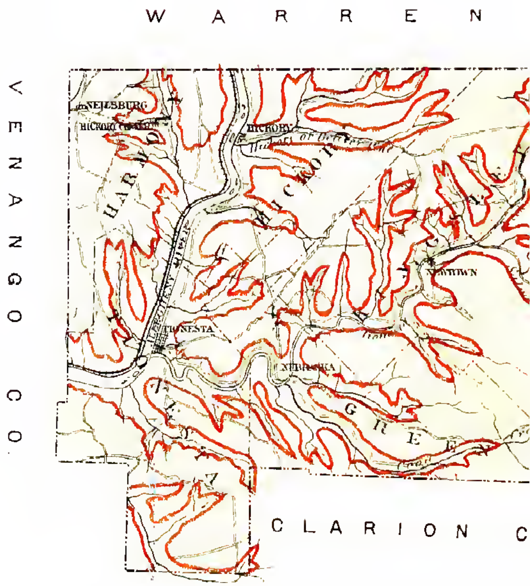

COUNTY
SOMERSET COUNTY
MARYLAND
N
FOUNTAIN MILLS P.O.
BULLSKIN
PENNSVILLE
BROADFORD P.O.
CONNELLSVILLE
NEW HAVEN
CONNELLS VILLE
SPRINGFIELD
SPRINGFIELD
DAVISTOWN
INDIAN CREEK P.O.
SALTLICK
Indian Creek
Youghiogheny River
DUNBAR
HAMPTON
BALT & WASH. R.R.
MILL RUN P.O.
LAUREL HILL
LAUREL HILL
STEWART
FALLS CITY
Jonathans Run
Bear Run
Cucumber Run
Laurel Run
Dunbars Creek
Washington Spring
Chalk Hill Hotel
Fayette Springs
FARMINGTON P.O.
WHARTON
National Road
Beaver Run
Horse Shoe
HENRY CLAY
SHIPPFORT P.O.
Gibbon's Glade Run
Glade Run
JOCKEY VALLEY
MARKLEYSBURG
EXPLANATION OF COLORS.
Upper Barren Measures
Pittsburgh Bed and Upper Coal Measures
Lower Barren Measures
Upper Freeport Bed and Lower Coal Measures Conglomerate XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill IX
Note:
The outcrop of the Pittsburgh Coal Bed defines each area of Upper Productive Coal Measures.
The outcrop of the Upper Freeport Coal defines the area of the Lower Barren Measures.

EXPLANATION OF COLORS.

XII { Johnson Run S.S. / Alton Coal Group / Kinzua Cr. S.S. / Marshburg Coal / Olean Conglomerate } Pottsville Conglomerate

XI Mauch Chunk Shale

X Pocono Sandstone



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

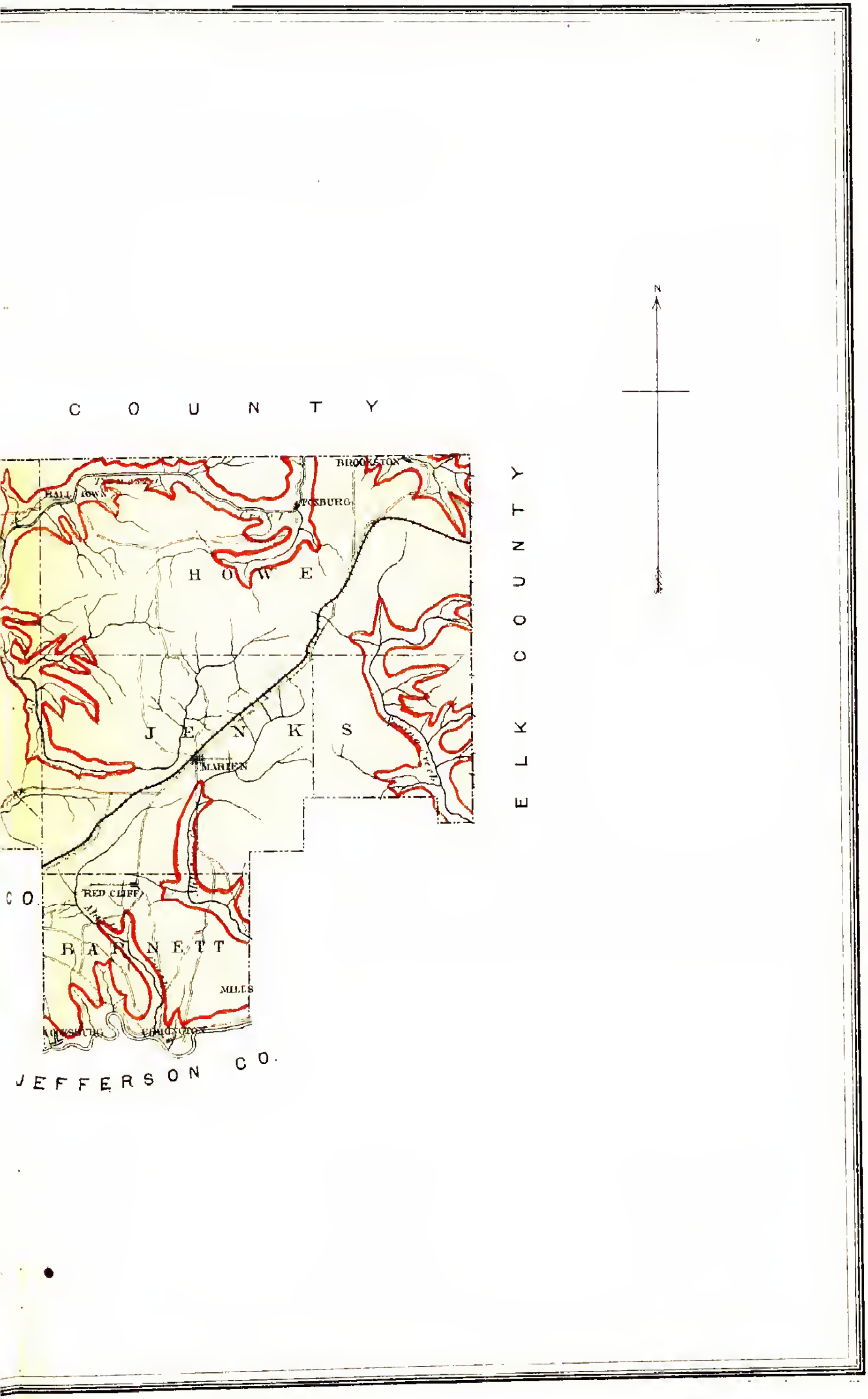
J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP OF FOREST COUNTY

1878.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles


COUNTY
HOWE
JENKS
MARIEN
ELK COUNTY
CO.
RED CLIFF
BARNETT
MILLS
JEFFERSON CO.
N

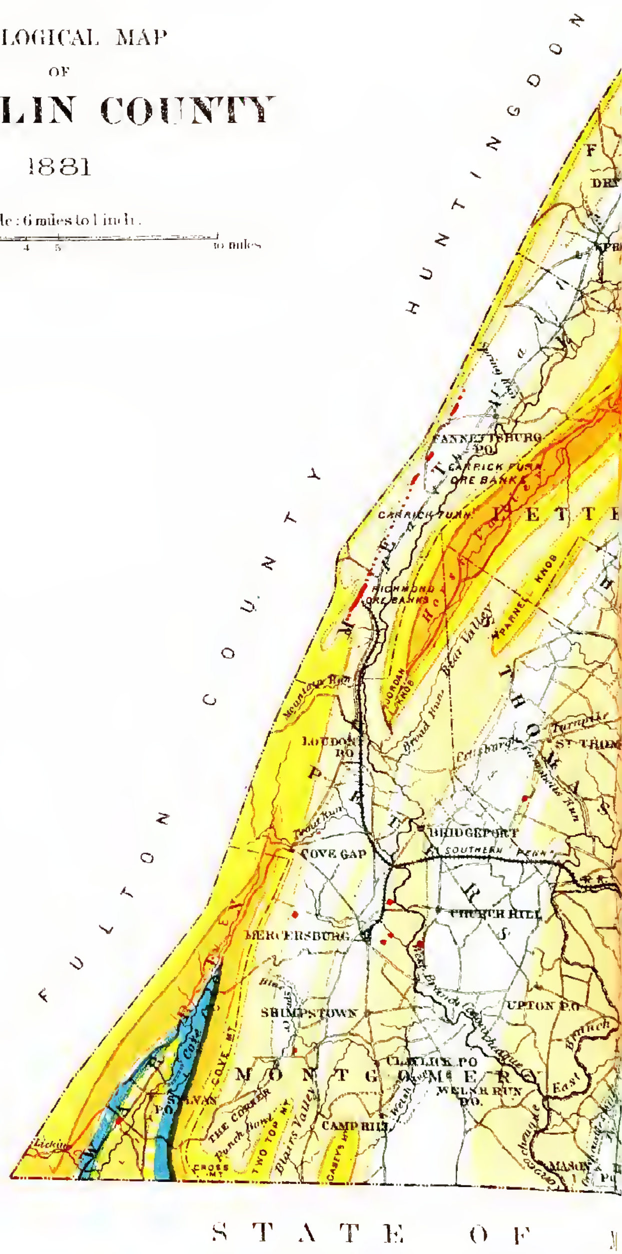
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

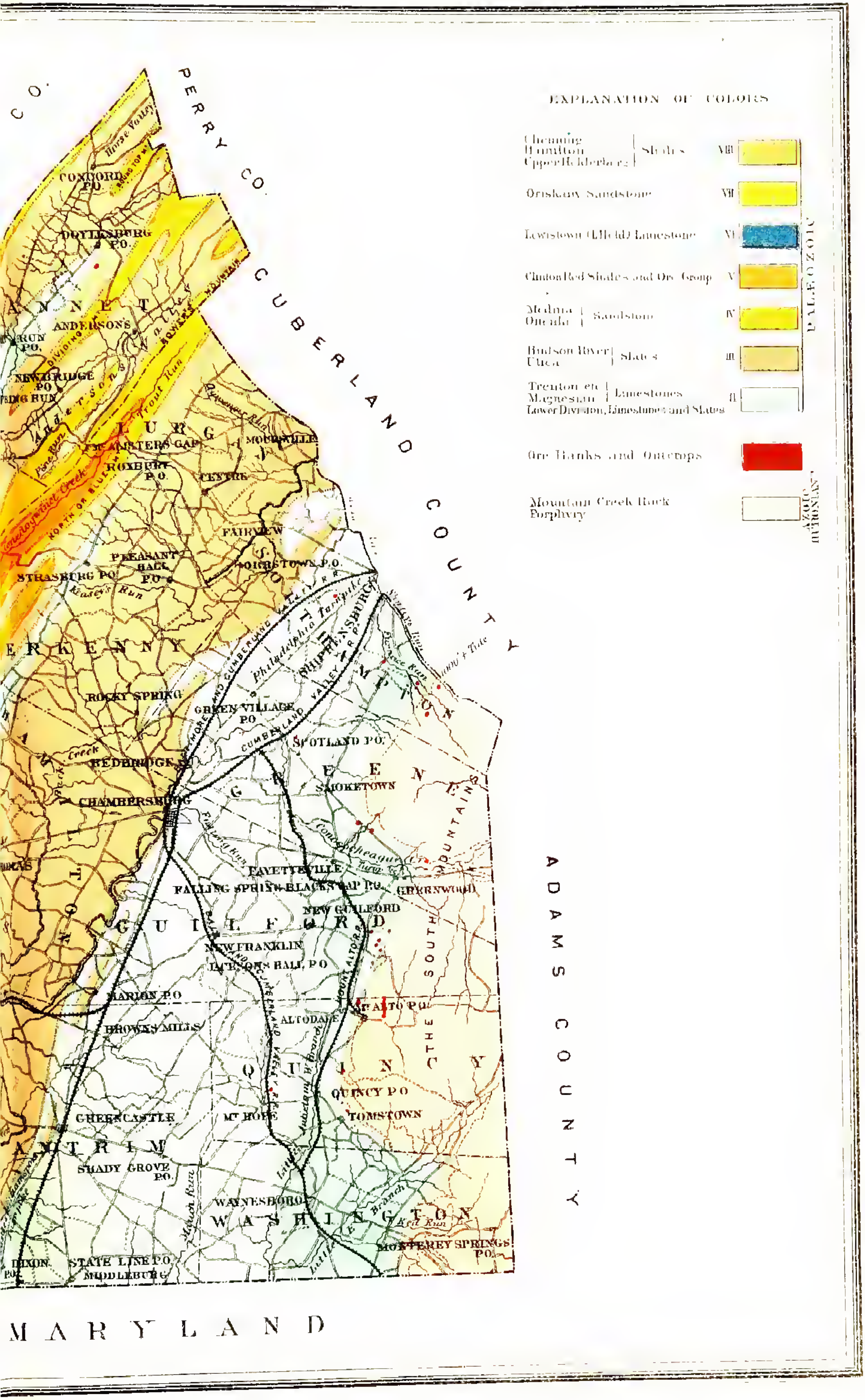
J. P. LESLEY, STATE GEOLOGIST.

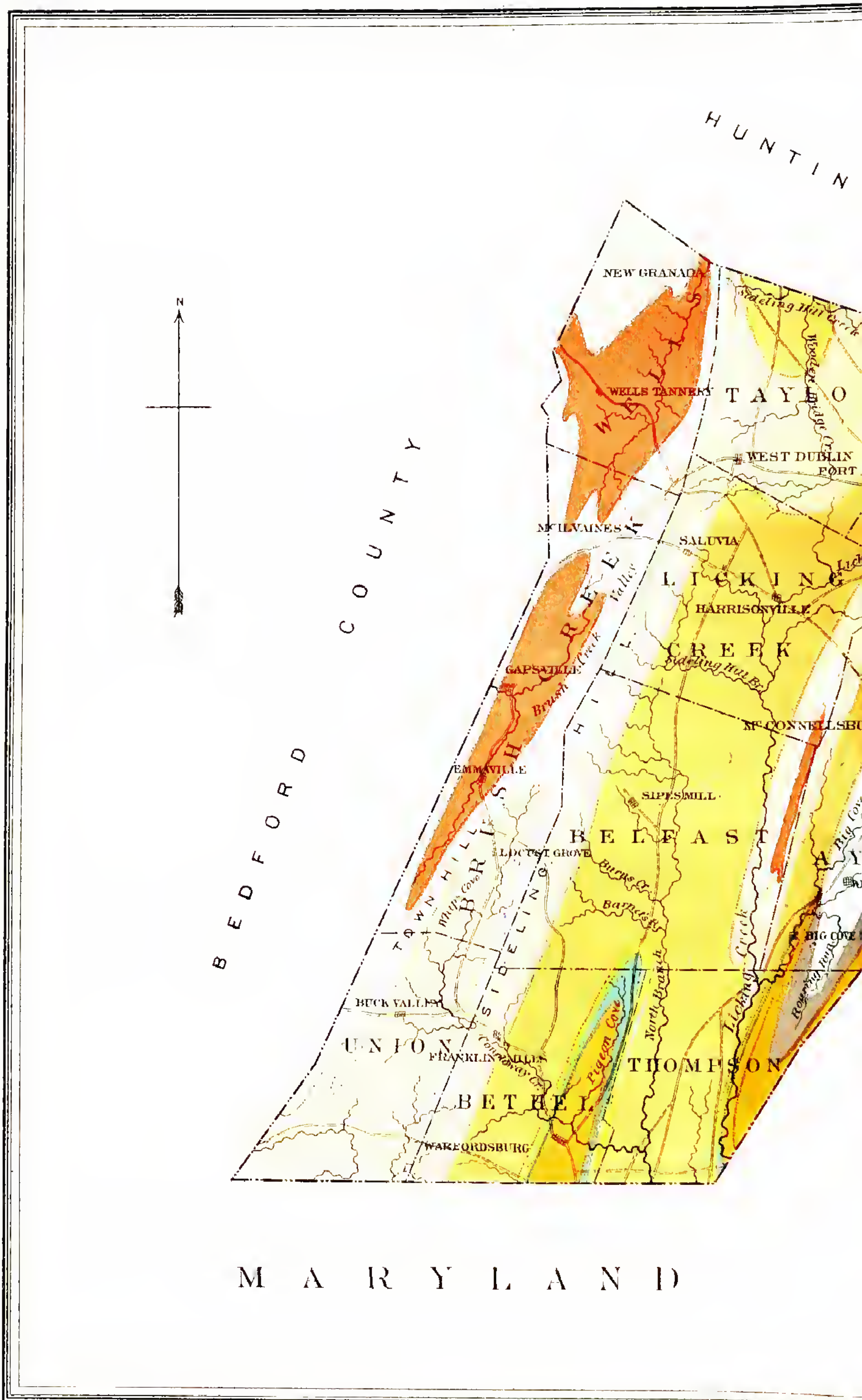
GEOLOGICAL MAP
OF
FRANKLIN COUNTY
1881

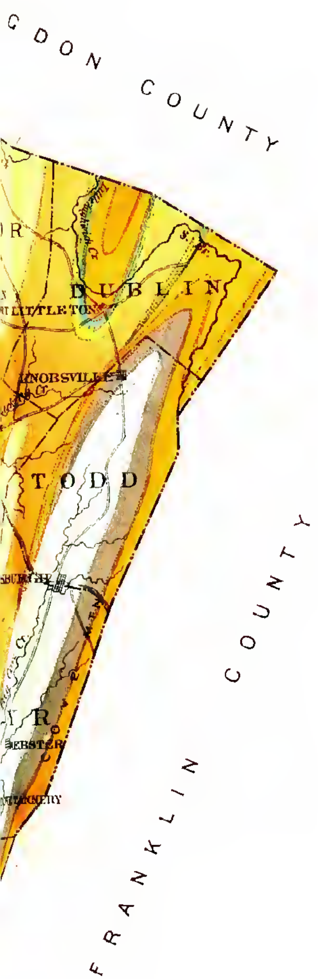
Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles




EXPLANATION OF COLORS
Chemung Hamilton Upper Helderberg | Shales VIII
Oriskany Sandstone VII
Lewistown (L.Held.) Limestone VI
Clinton Red Shales and Ore Group V
Medina Oneida | Sandstone IV
Hudson River Utica | Slates III
Trenton etc. Magnesian | Limestones II
Lower Division, Limestones and Slates
Ore Banks and Outcrops
Mountain Creek Rock Porphyry
PALEOZOIC
AZOIC HURONIAN
PERRY CO.
CUMBERLAND COUNTY
ADAMS COUNTY
MARYLAND
CONCORD P.O.
DOYLESBURG P.O.
ANDERSONS
NEWBRIDGE P.O.
ROXBURY P.O.
CENTRE
FAIRVIEW
PLEASANT HALL P.O.
STRASBURG P.O.
ROCKY SPRING
GREEN VILLAGE P.O.
SCOTLAND P.O.
SMOKETOWN
CHAMBERSBURG
FAYETTEVILLE
FALLING SPRING
BLACKS GAP P.O.
GREENWOOD
NEW GUILFORD
NEW FRANKLIN
MARION P.O.
BROWNS MILLS
ALTODALE
QUINCY P.O.
TOMSTOWN
MT HOPE
GREENCASTLE
SHADY GROVE P.O.
WAYNESBORO
MONTEREY SPRINGS P.O.
STATE LINE P.O.
MIDDLEBURG
DIXON
GUILFORD
QUINCY
WASHINGTON
ANTRIM
SOUTH MOUNTAINS
Conococheague Cr.
Philadelphia Turnpike
Cumberland Valley R.R.


HUNTIN
BEDFORD COUNTY
MARYLAND
NEW GRANADA
WELLS TANNERY
WELLS
TAYLO
WEST DUBLIN
FORT
MCILVAINES
SALUVIA
LICKING
HARRISONVILLE
CREEK
BRUSH CREEK
GAPSVILLE
MCONNELLSBU
EMMAVILLE
SIPES MILL
BELFAST
LOCUST GROVE
TOWN HILL
SIDELING HILL
BIG COVE
BUCK VALLEY
UNION
FRANKLIN MILLS
THOMPSON
BETHEL
WARFORDSBURG
Sideling Hill Creek
Brush Creek
Licking Creek
North Branch
Pigeon Cove
Barnetts Br.
Burns Cr.
Sideling Hill Br.



EXPLANATION OF COLORS

Pottsville Conglomerate and Coal Measures	XII
Mauch Chunk Red Shale	XI
Pocono Sandstone	X
Catskill Red Sandstone	IX
Chemung Shale, Portage Flags, Hamilton &c	VIII
Oriskany Sandstone	VII
Lewistown Limestone &c.	VI
Clinton / Water Lime, Onondaga	V
Medina and Oneida Sandstones	IV
Hudson River Shale and Utica Slate	III
Trenton Limestone	II

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

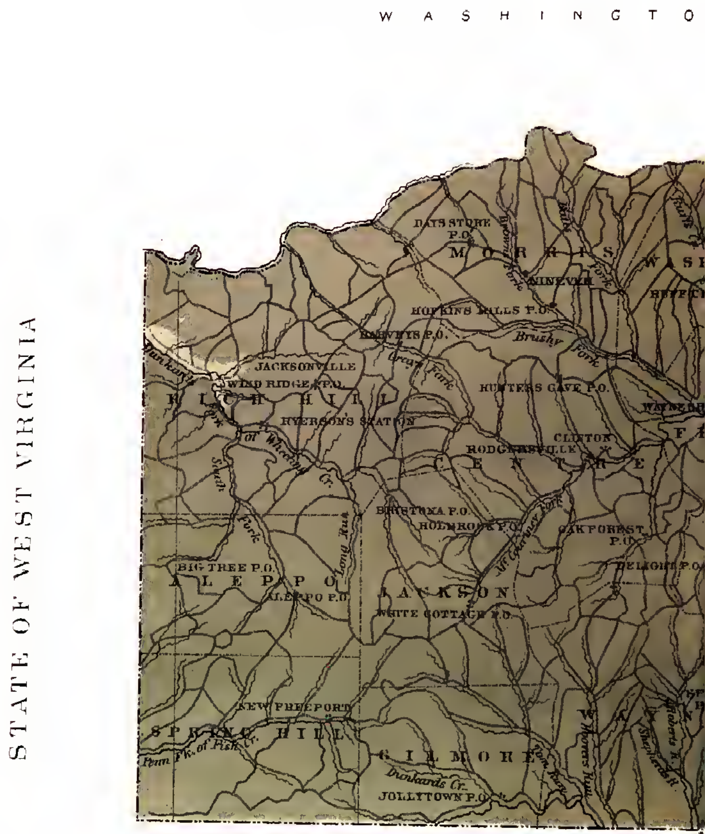
J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP
OF
FULTON COUNTY

1878.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J.P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

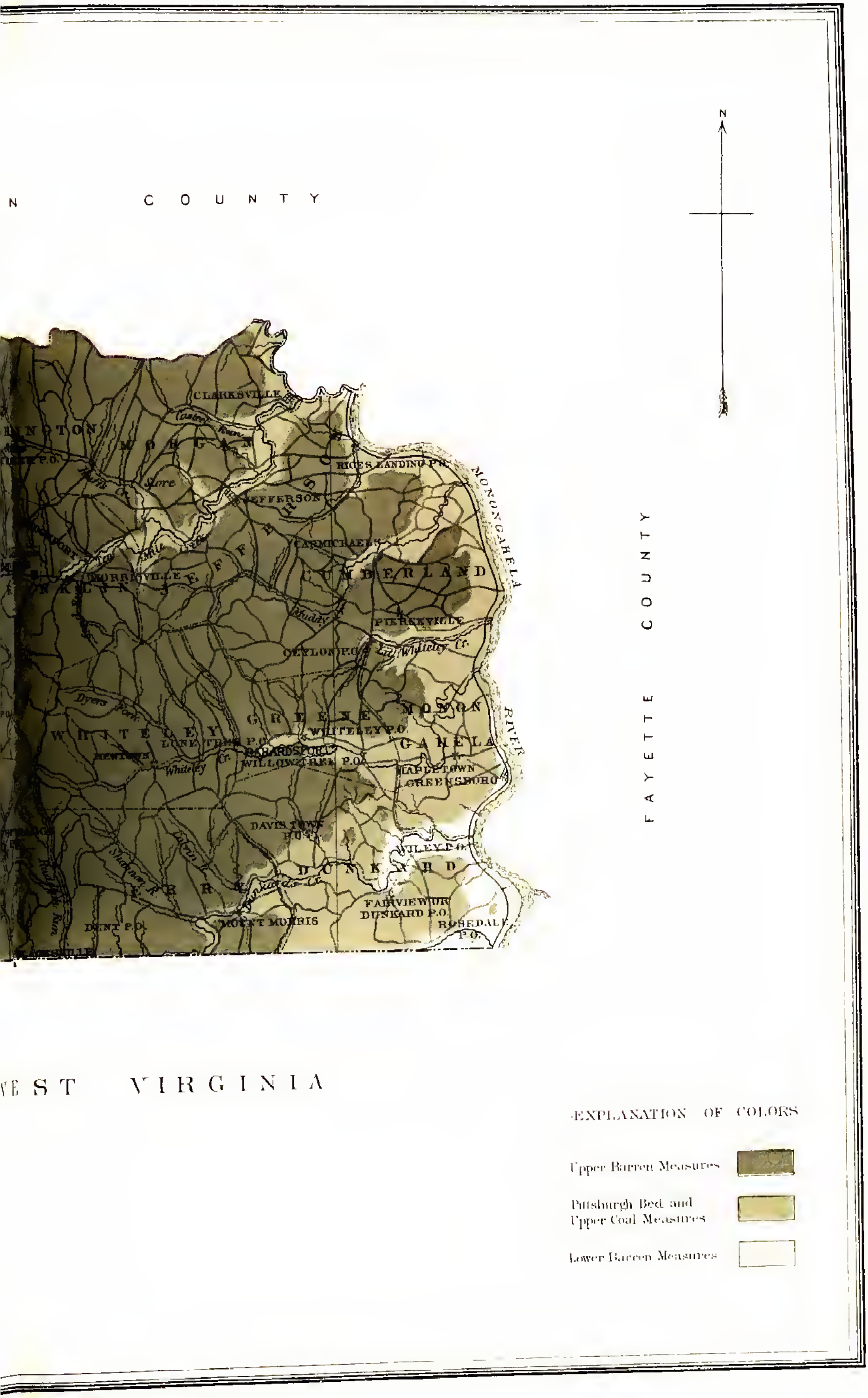
OF

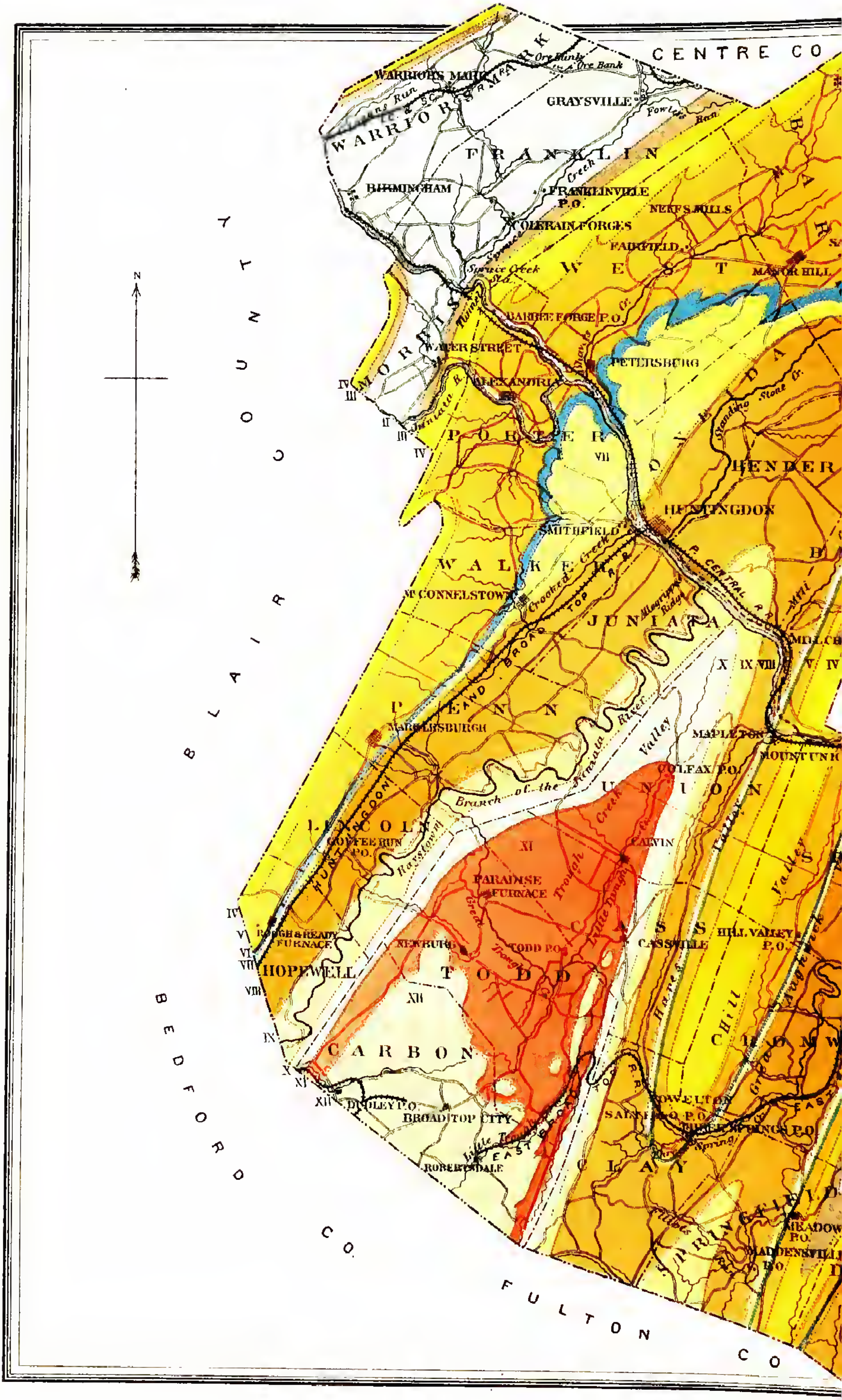
GREENE COUNTY

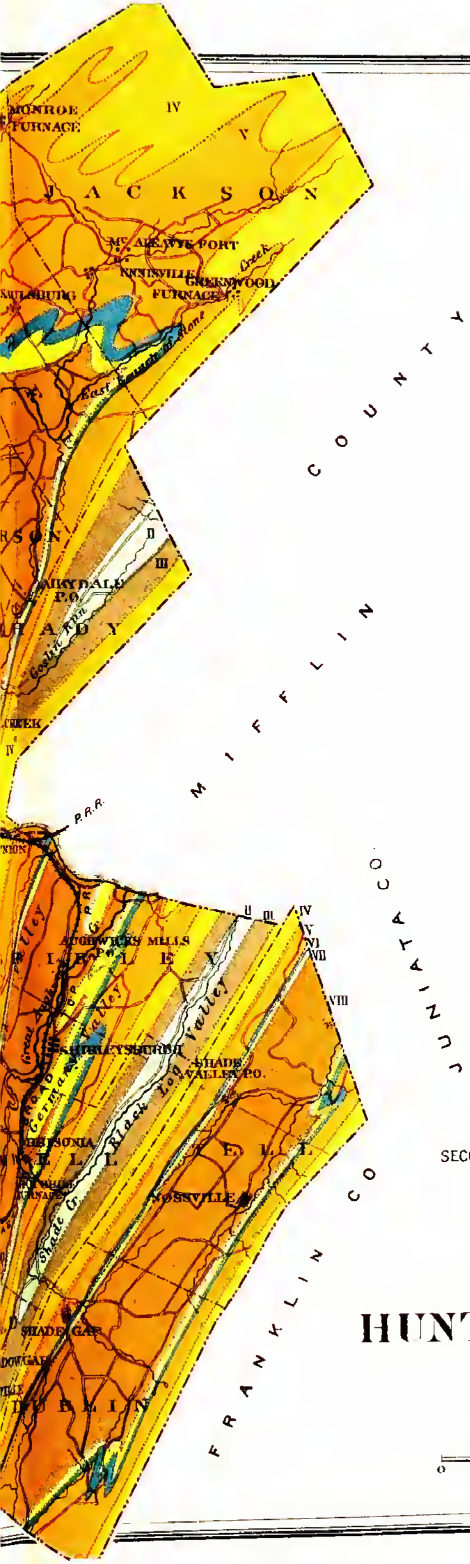
1878.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles


N
COUNTY
CLARKSVILLE
MORGAN
RICES LANDING P.O.
JEFFERSON
CARMICHAELS
CUMBERLAND
MORRISVILLE
PIERCEVILLE
CEYLON P.O.
Whiteley Cr.
MONONGAHELA
MONONGAHELA RIVER
GREENE
WHITELEY
WHITELEY P.O.
WILLOW TREE P.O.
MAPLETOWN
GREENSBORO
Whiteley
Dyers Fork
DAVISTOWN P.O.
WILEY P.O.
DUNKARD
FAIRVIEW
DUNKARD P.O.
ROSEDALE P.O.
MOUNT MORRIS
DENT P.O.
FAYETTE COUNTY
EST VIRGINIA
EXPLANATION OF COLORS
Upper Barren Measures
Pittsburgh Bed and Upper Coal Measures
Lower Barren Measures


CENTRE CO
WARRIORS MARK
GRAYSVILLE
FRANKLIN
BIRMINGHAM
FRANKLINVILLE P.O.
NEFFS MILLS
COLERAIN FORGES
FAIRFIELD
WEST
BARREE FORGE P.O.
WATER STREET
PETERSBURG
ALEXANDRIA
PORTER
HUNTINGDON
SMITHFIELD
WALKER
McCONNELSTOWN
JUNIATA
PENN
MARKLESBURGH
Juniata River
MAPLETON
COLFAX P.O.
UNION
LINCOLN
COFFEE RUN P.O.
CARVIN
PARADISE FURNACE
ROUGH & READY FURNACE
HOPEWELL
NEWBURG
TODD P.O.
TODD
CASS
CASSVILLE
HILL VALLEY P.O.
CARBON
DUDLEY P.O.
BROAD TOP CITY
ROBERTSDALE
CLAY
THREE SPRINGS P.O.
BLAIR CO.
BEDFORD CO.
FULTON CO



EXPLANATION OF COLORS.

Pottsville Conglomerate and Coal Measures	XII	
Mauch Chunk Red Shale	XI	
Pocono Sandstone	X	
Catskill Red Sandstone	IX	
Chemung Shale, Portage Flags, Hamilton Shale	VIII	
Oriskany Sandstone	VII	
Lewistown Limestone &c.	VI	
Clinton Shale	V	
Medina and Oneida Sandstones	IV	
Hudson River Shale and Utica Slate	III	
Trenton Limestone	II	

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

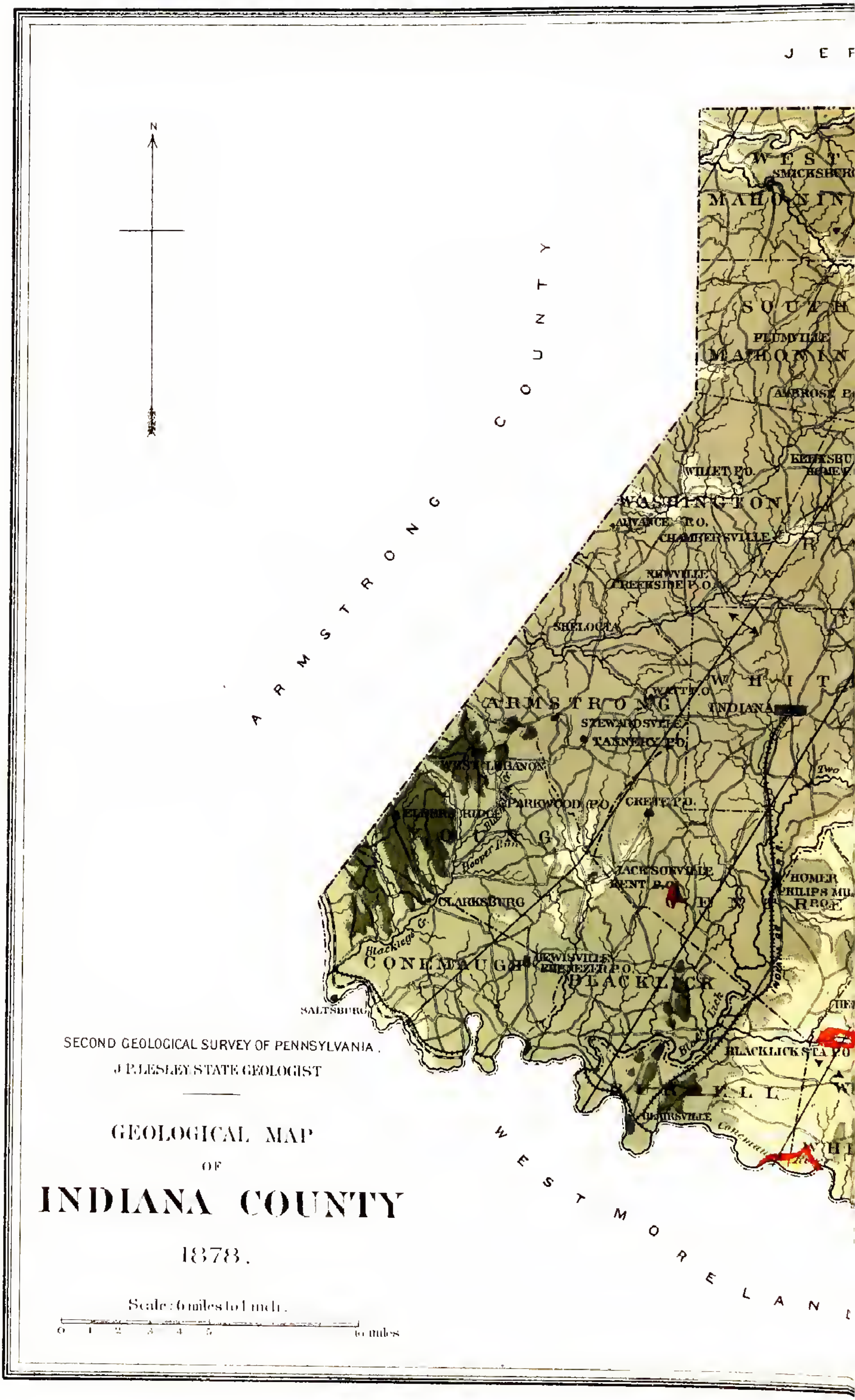
OF

HUNTINGDON COUNTY

1878.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

J. P. LESLEY STATE GEOLOGIST

GEOLOGICAL MAP

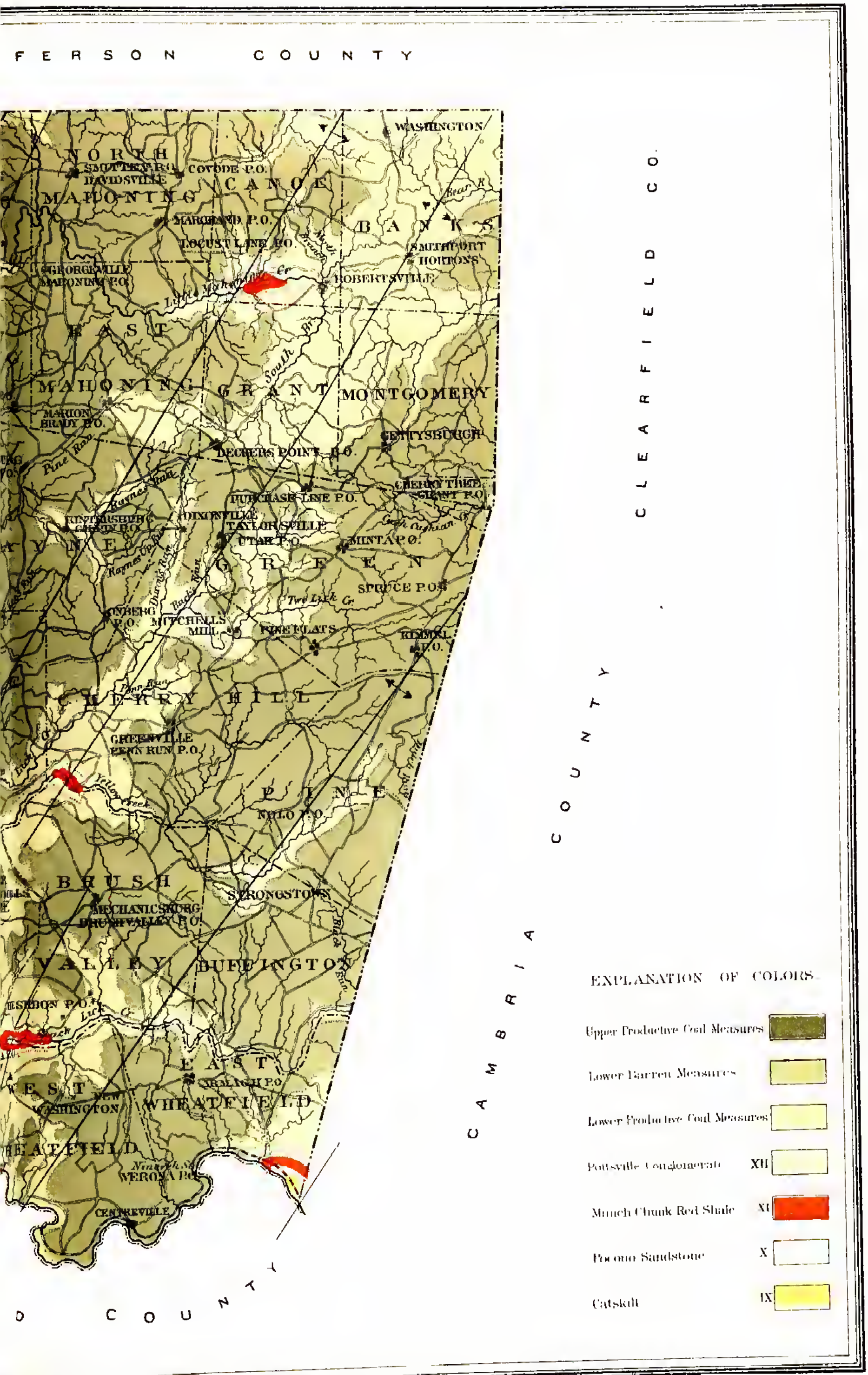
OF

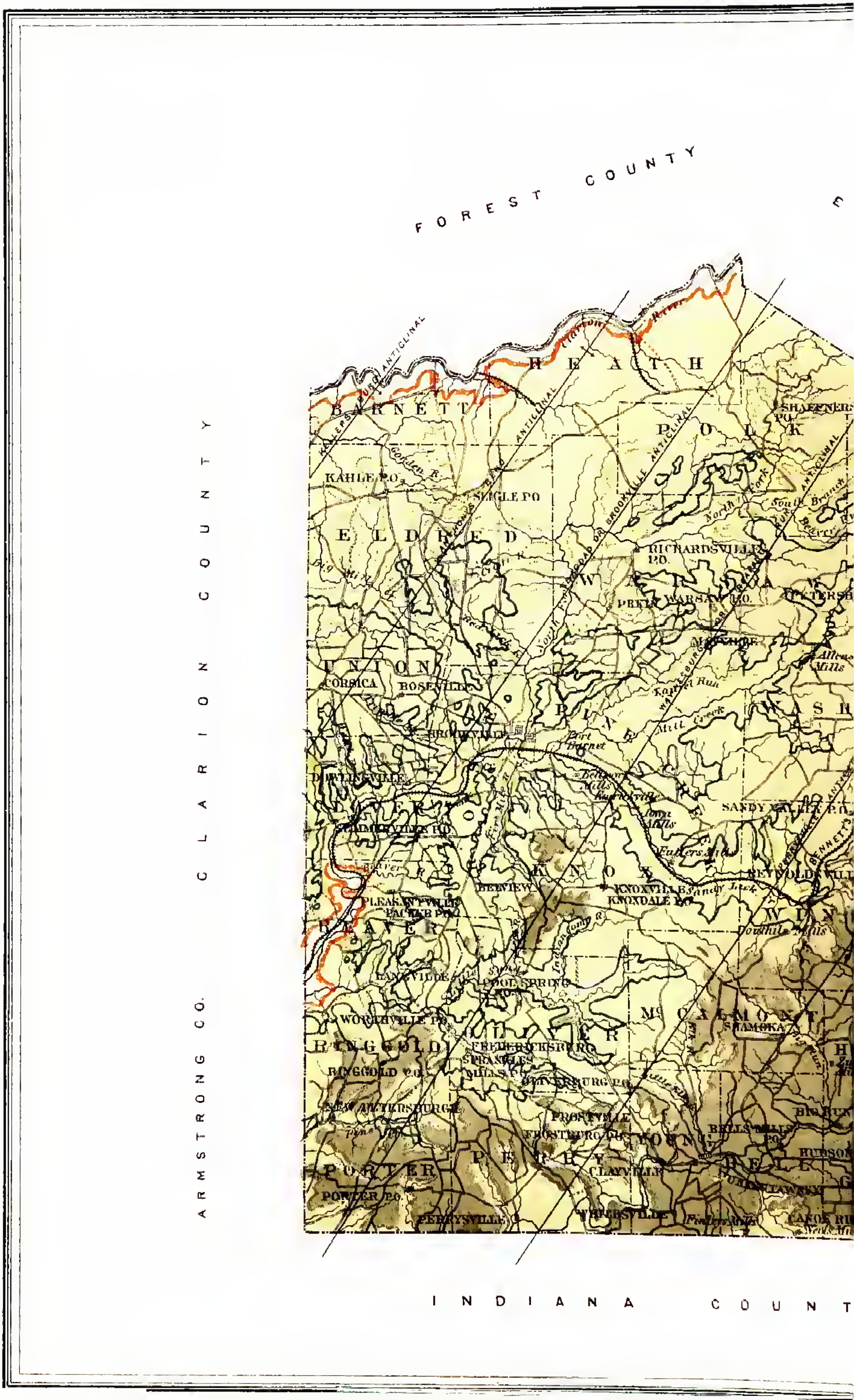
INDIANA COUNTY

1878.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 6 miles


FERSON COUNTY
CLEARFIELD CO.
CAMBRIA COUNTY
COUNTY
NORTH MAHONING
CANOE
BANKS
EAST MAHONING
GRANT
MONTGOMERY
GREEN
CHERRY HILL
PINE
BRUSH VALLEY
BUFFINGTON
EAST WHEATFIELD
WEST WASHINGTON
WHEATFIELD
WASHINGTON
COVODE P.O.
DAVIDSVILLE
MARCHAND P.O.
LOCUST LANE P.O.
SMITHPORT
HORTONS
ROBERTSVILLE
MARION
BRADY P.O.
DECHERS POINT P.O.
GETTYSBURGH
CHERRY TREE
PURCHASE LINE P.O.
DIXONVILLE
TAYLORSVILLE
UTAH P.O.
MINTA P.O.
SPRUCE P.O.
MITCHELLS MILL
PINE FLATS
KIMMEL P.O.
GREENVILLE
PENN RUN P.O.
NOLO P.O.
STRONGSTOWN
MECHANICSBURG
BRUSHVALLEY P.O.
ARMAGH P.O.
WEROXA P.O.
CENTREVILLE
South Br.
Yellow Creek
Black Lick
Two Lick Cr.
EXPLANATION OF COLORS.
Upper Productive Coal Measures
Lower Barren Measures
Lower Productive Coal Measures
Pottsville Conglomerate XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill IX



FOREST COUNTY
CLARION COUNTY
ARMSTRONG CO.
INDIANA COUNT
HEATH
BARNETT
POLK
ELDRED
KAHLE P.O.
UNION
CORSICA
RICHARDSVILLE P.O.
KNOX
KNOXDALE P.O.
BELLVIEW
BEAVER
PLEASANTVILLE
WORTHVILLE P.O.
RINGGOLD
RINGGOLD P.O.
PORTER
PORTER P.O.
PERRY
PERRYSVILLE
OLIVER
FREDERICKSBURG
CLAYVILLE
SANDY VALLEY P.O.
ANTICLINAL

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

OF

JEFFERSON COUNTY

1881

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles

EXPLANATION OF COLORS.

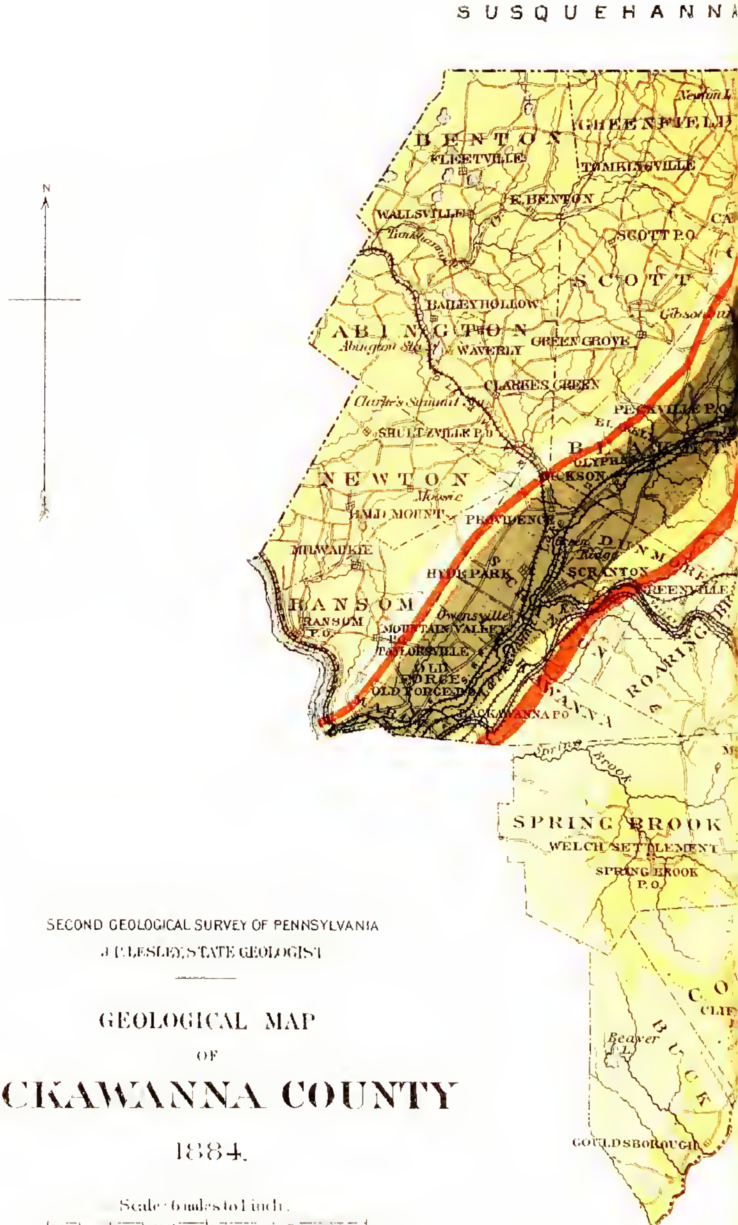
Barren Measures

Lower Productive
Ferriferous Limestone
Coal Measures

Pottsville Conglomerate XII

Mauch Chunk Red Shale XI

Pocono Sandstone X



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

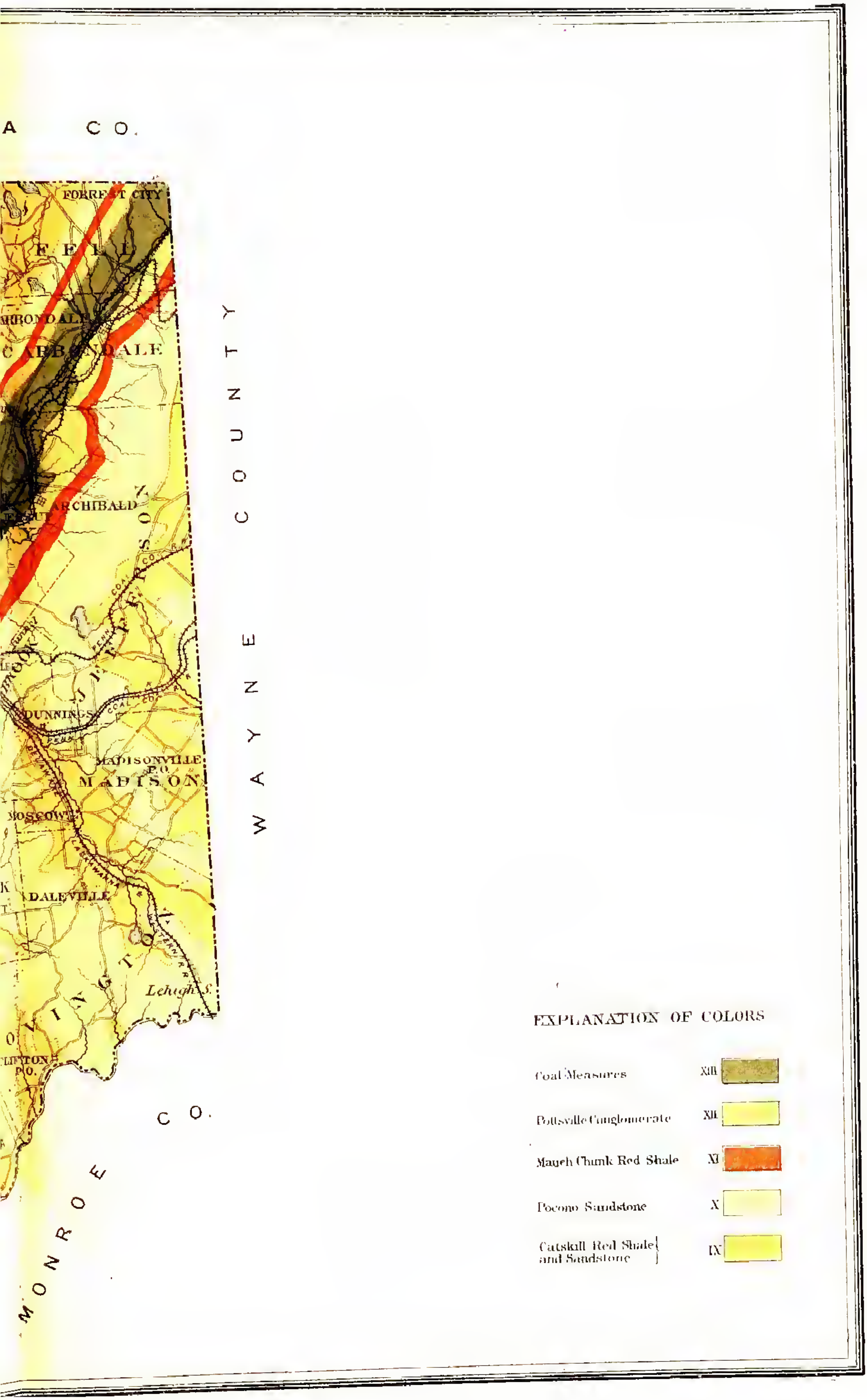
OF

LACKAWANNA COUNTY

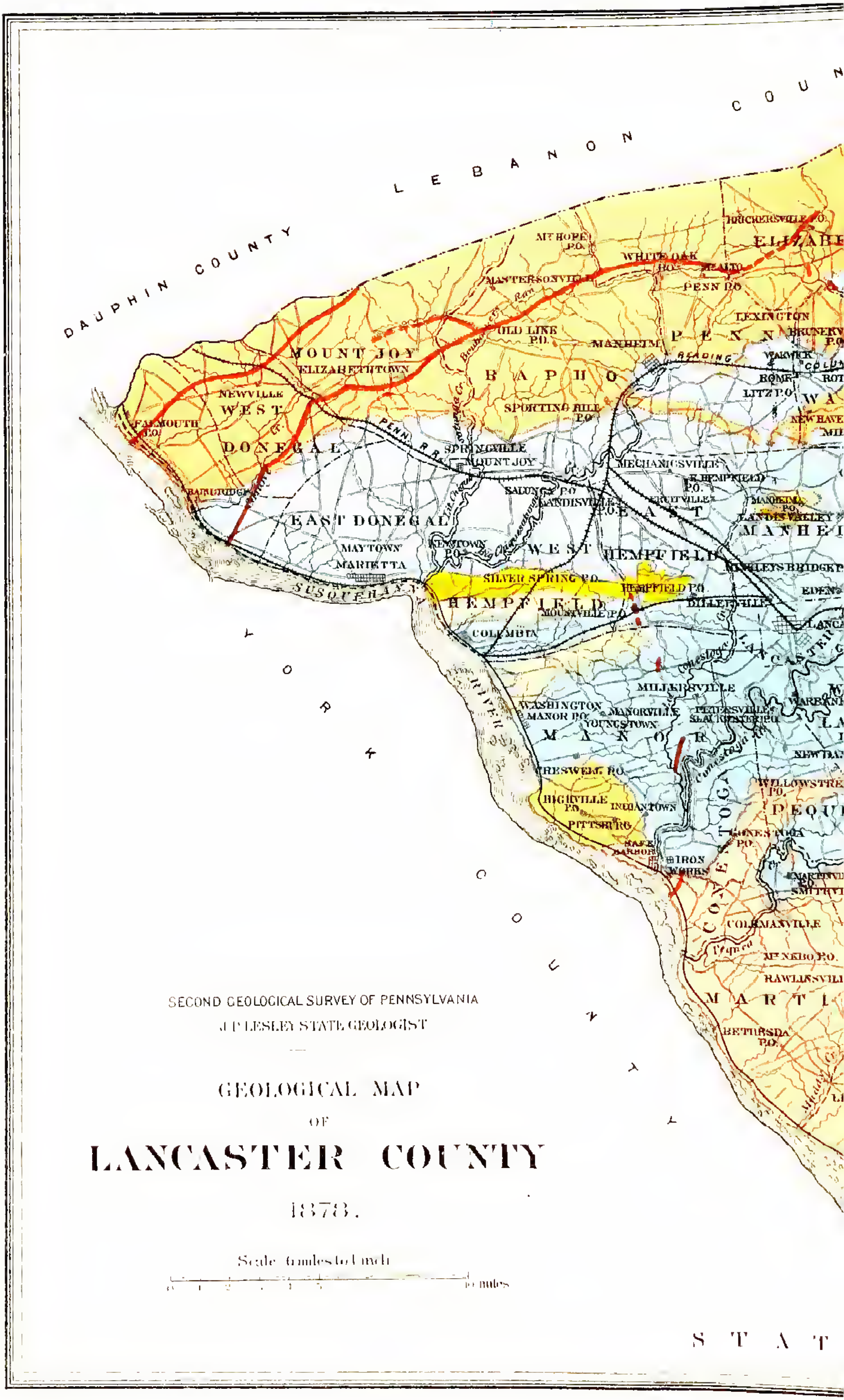
1884.

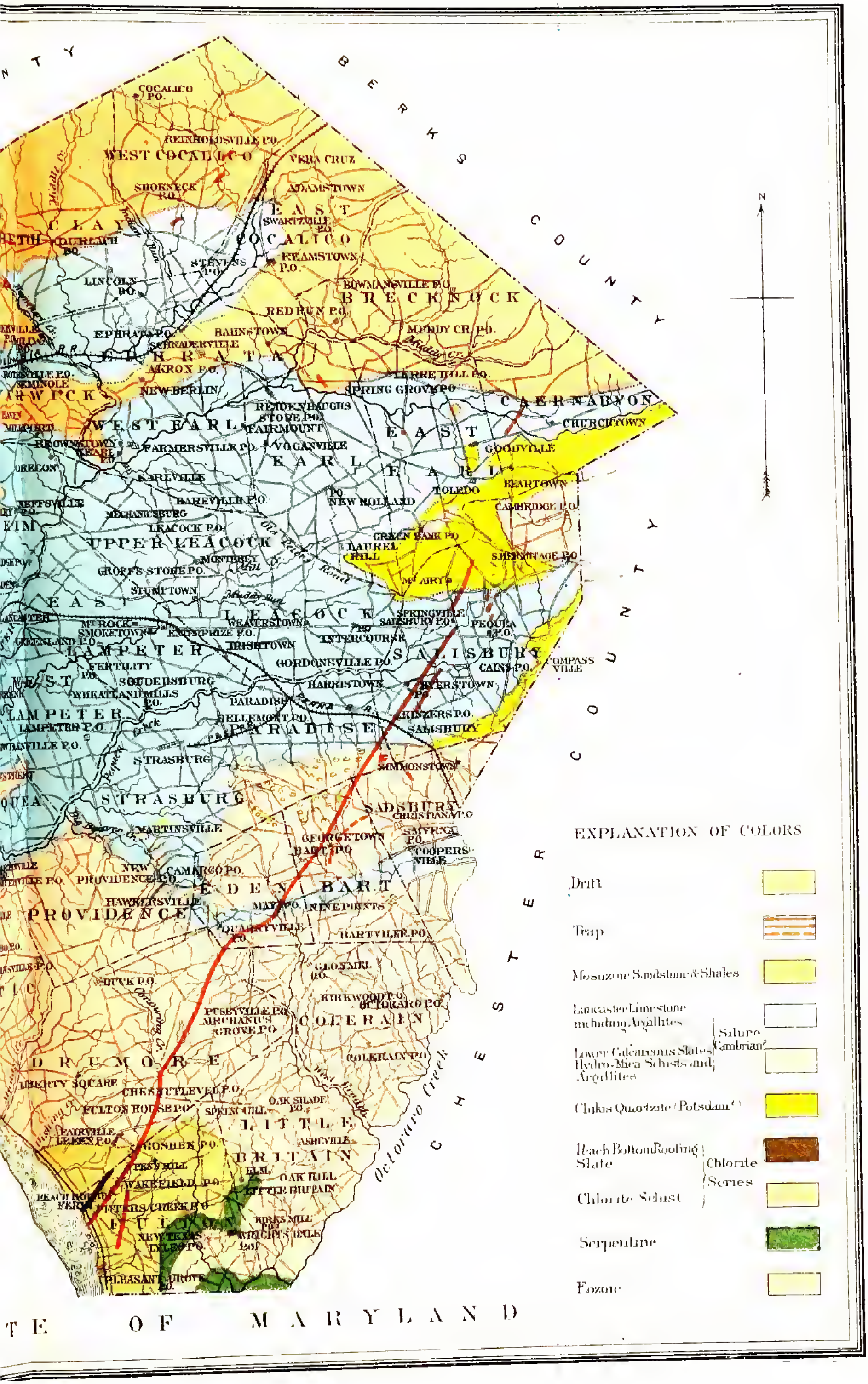
Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles



A CO.
FORREST CITY
FELL
CARBONDALE
ARCHIBALD
WAYNE COUNTY
DUNNINGS
MADISONVILLE P.O.
MADISON
MOSCOW
DALEVILLE
Lehigh R.
CLIFTON P.O.
MONROE CO.
EXPLANATION OF COLORS
Coal Measures XIII
Pottsville Conglomerate XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Shale and Sandstone IX


DAUPHIN COUNTY
LEBANON COUN
YORK
COUNTY
STAT
MOUNT JOY
ELIZABETHTOWN
NEWVILLE
WEST DONEGAL
FALMOUTH P.O.
BAINBRIDGE
EAST DONEGAL
MAYTOWN
MARIETTA
SUSQUEHANNA
SPRINGVILLE
MOUNT JOY
SALUNGA P.O.
LANDISVILLE
NEWTOWN P.O.
WEST HEMPFIELD
EAST
SILVER SPRING P.O.
HEMPFIELD
MOUNTVILLE P.O.
HEMPFIELD P.O.
COLUMBIA
RAPHO
SPORTING HILL P.O.
OLD LINE P.O.
MANHEIM
MT HOPE P.O.
MASTERSONVILLE
WHITE OAK P.O.
PENN P.O.
LEXINGTON
PENN
BRICKERSVILLE P.O.
ELIZABE
MECHANICSVILLE
E. HEMPFIELD P.O.
FRUITVILLE
MANHEIM P.O.
LANDIS VALLEY
MANHE
ROHRERSTOWN
MILLERSVILLE
WASHINGTON
MANOR P.O.
MANORVILLE
YOUNGSTOWN
PETERSVILLE
SLACKWATER P.O.
MANOR
CRESWELL P.O.
HIGHVILLE P.O.
INDIANTOWN
PITTSBURG
SAFE HARBOR
IRON WORKS
CONESTOGA
COLEMANVILLE
MT NEBO P.O.
RAWLINSVILLE
MARTIC
BETHESDA P.O.
NEW DAN
WILLOWSTREET P.O.
PEQU
RIVER
PENN. R.R.
READING
LITTZ P.O.
ROME
WARWICK
NEW HAVEN
LANCASTER
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY STATE GEOLOGIST
GEOLOGICAL MAP
OF
LANCASTER COUNTY
1878.
Scale 6 miles to 1 inch
10 miles


BERKS COUNTY
CHESTER COUNTY
STATE OF MARYLAND
WEST COCALICO
EAST COCALICO
BRECKNOCK
CLAY
EPHRATA
CAERNARVON
WEST EARL
EAST EARL
EARL
UPPER LEACOCK
LEACOCK
EAST LAMPETER
WEST LAMPETER
SALISBURY
PARADISE
STRASBURG
SADSBURY
PROVIDENCE
EDEN
BART
COLERAIN
DRUMORE
LITTLE BRITAIN
FULTON
Octoraro Creek
N
EXPLANATION OF COLORS
Drift
Trap
Mesozoic Sandstone & Shales
Lancaster Limestone including Argillites
Lower Calcareous Slates, Hydro-Mica Schists and Argillites
Siluro Cambrian?
Chikis Quartzite (Potsdam?)
Peach Bottom Roofing Slate
Chlorite Schist
Chlorite Series
Serpentine
Eozoic

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

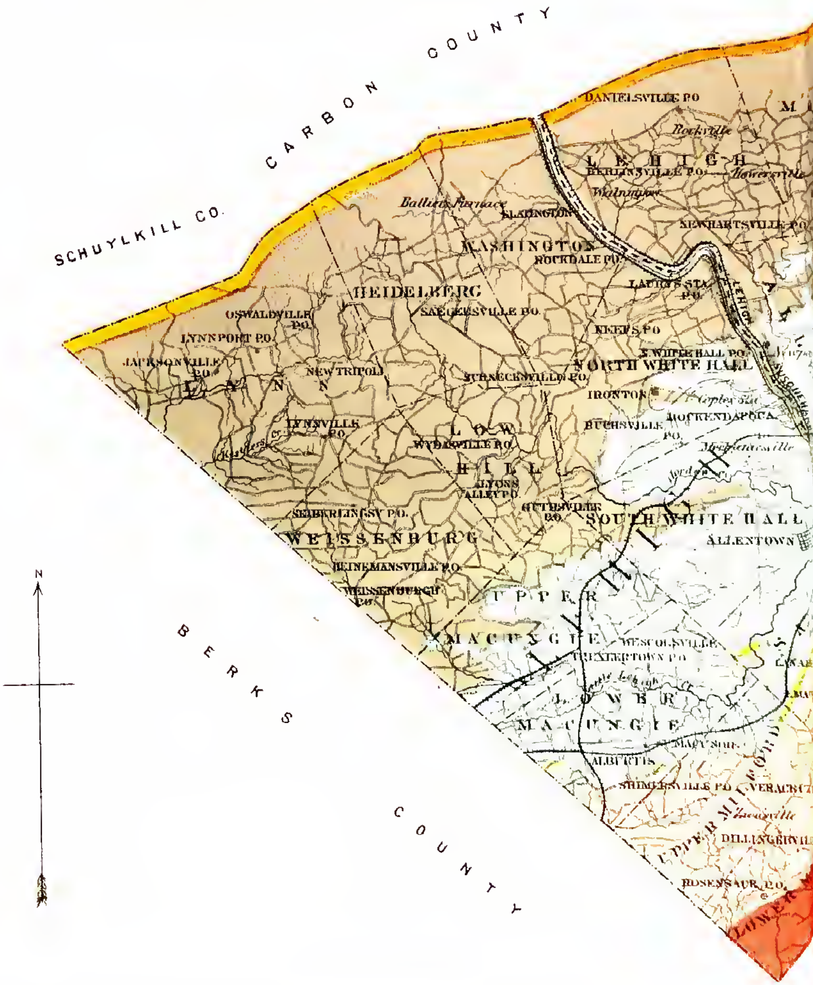
J. P. LESLEY, STATE GEOLOGIST.

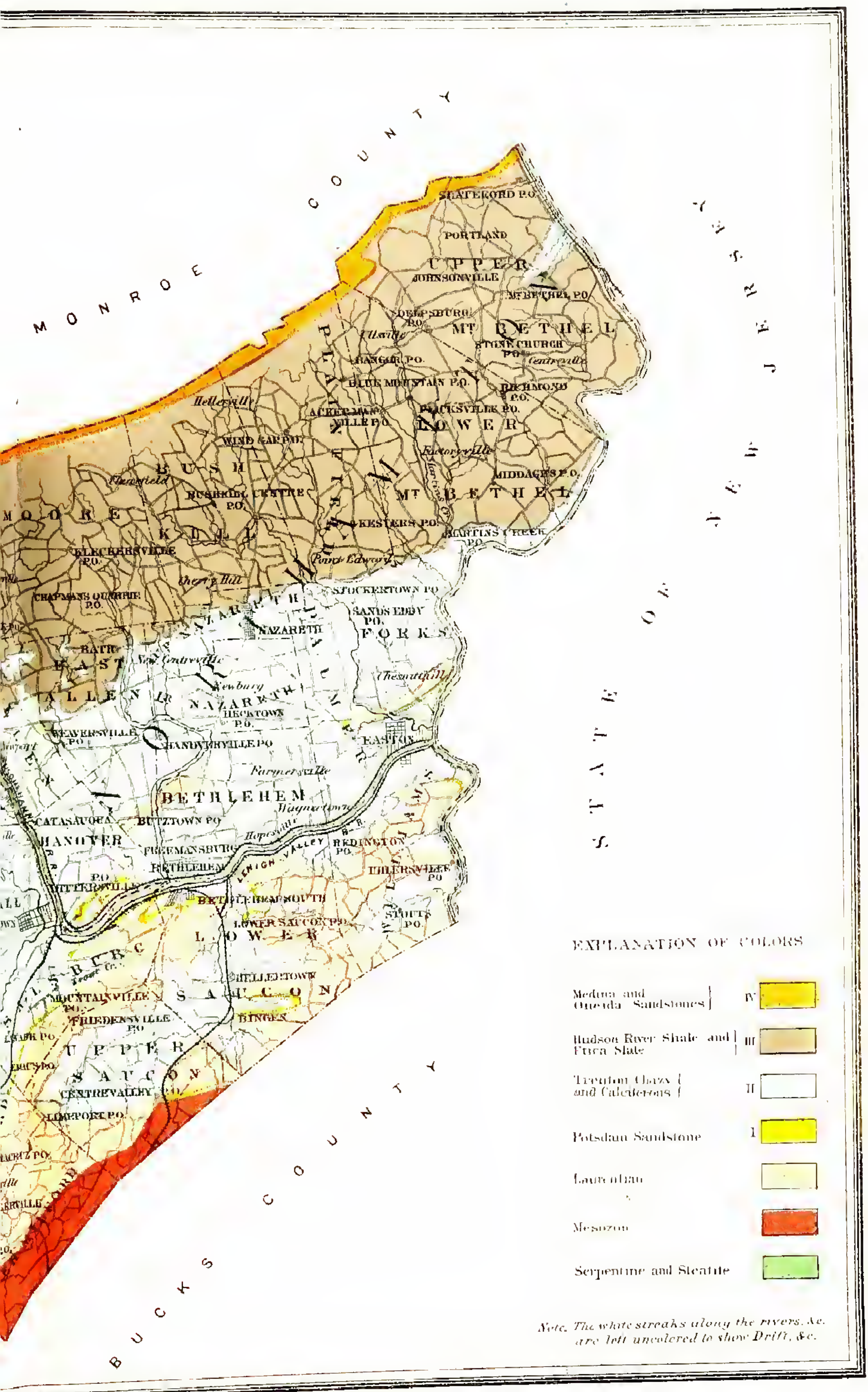
GEOLOGICAL MAP OF LEHIGH AND NORTHAMPTON COUNTIES

1878.

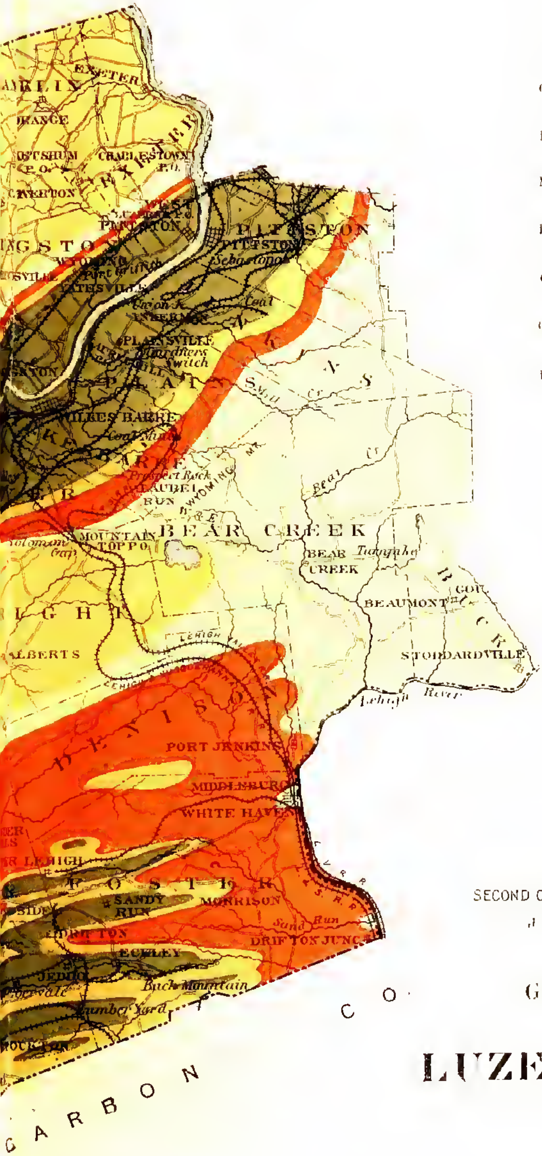
Scale. 6 miles to 1 inch

0 1 2 3 4 5 6 miles




MONROE COUNTY
STATE OF NEW JERSEY
BUCKS COUNTY
UPPER MT BETHEL
LOWER MT BETHEL
PORTLAND
NAZARETH
EASTON
BETHLEHEM
HANOVER
FORKS
PALMER
LOWER SAUCON
UPPER SAUCON
EXPLANATION OF COLORS
Medina and Oneida Sandstones IV
Hudson River Shale and Utica Slate III
Trenton Chazy and Calciferous II
Potsdam Sandstone I
Laurentian
Mesozoic
Serpentine and Steatite
Note. The white streaks along the rivers, &c. are left uncolored to show Drift, &c.

WYOMING COUN
COLUMBIA COUNTY
SCHUYLKILL CO.
L A K E
LAKE P.O.
KUNCKLE
DALLAS
LEHMAN
R O S S
L E H M A N
RED ROCK
P.O.
FAIRMOUNT
FAIRMOUNT SPRINGS
SWEET VALLEY
HUNTSVILLE
HARVEYVILLE
CAMBRA
H U N T I N G T O N
TOWN HILL
NEW COLUMBUS
U N I O N
WEST NANTICOKE
SHICKSHINNY
HARTVILLE
N E W P O R T
SUGAR NOTCH
S L O C U M
S A L E M
BEACH HAVEN
D O R R A N C E
DORRANCE
NESCOPECK
N E S C O P E C K
BRIGGSVILLE P.O.
DRUMS
S U G A R
B L A C K
L O A F
CONYNGHAM
BLACK CREEK
C R E E K
HAZLETON
BEAVER MEADOW
JEANSVILLE
FRENCH TOWN
N



EXPLANATION OF COLORS

Coal Measures	XIII	
Pottsville Conglomerate	XII	
Mauch Chunk Red Shale	XI	
Pocono Sandstone	X	
Catskill Formation	IX	
Chemung Formation	VIII	
Hamilton Formation		

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

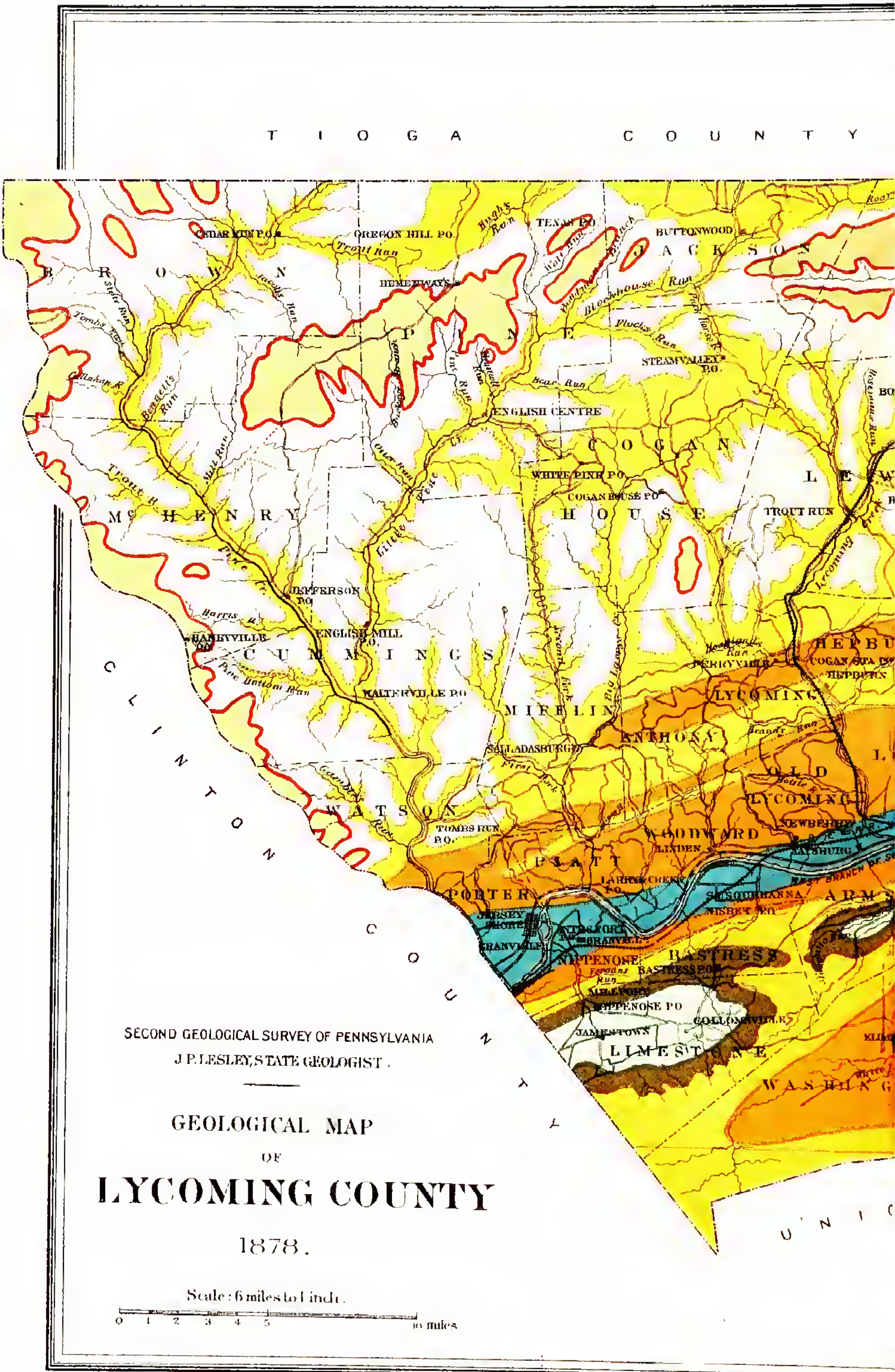
J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP OF LUZERNE COUNTY

1884.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

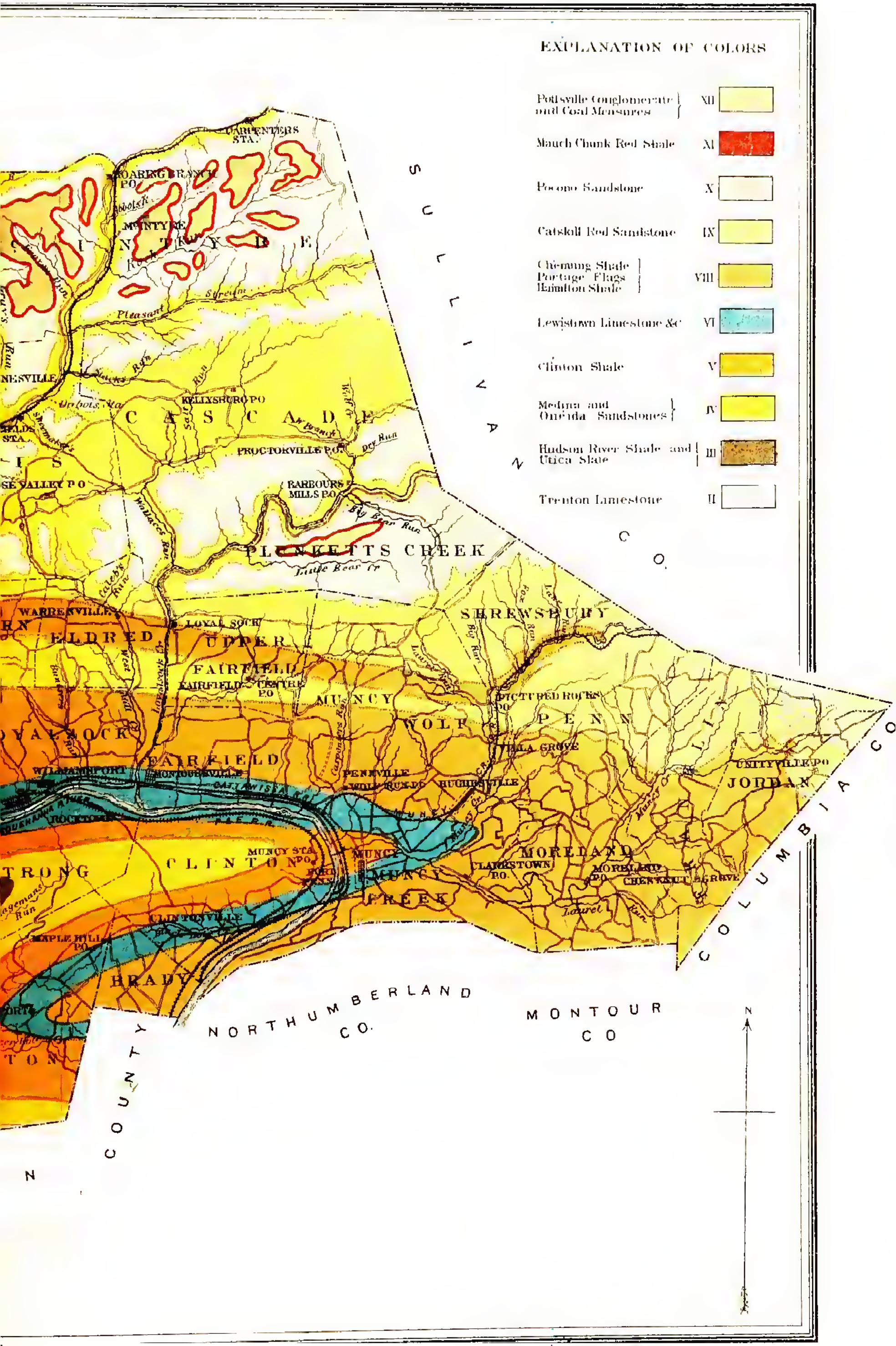
GEOLOGICAL MAP

OF

LYCOMING COUNTY

1878.

Scale: 6 miles to 1 inch.


EXPLANATION OF COLORS
Pottsville Conglomerate and Coal Measures XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
Chemung Shale Portage Flags Hamilton Shale VIII
Lewistown Limestone &c VI
Clinton Shale V
Medina and Oneida Sandstones IV
Hudson River Shale and Utica Slate III
Trenton Limestone II
SULLIVAN CO.
COLUMBIA CO.
NORTHUMBERLAND CO.
MONTOUR CO
CARPENTERS STA.
ROARING BRANCH P.O.
McINTYRE
CASCADE
KELLYSBURG P.O.
PROCTORVILLE P.O.
BARBOURS MILLS P.O.
PLUNKETTS CREEK
Little Bear Cr
Big Bear Run
Dry Run
Pleasant Stream
SHREWSBURY
WARRENSVILLE
ELDRED
LOYAL SOCK
UPPER FAIRFIELD
FAIRFIELD CENTRE P.O.
MUNCY
WOLF
PICTURED ROCKS P.O.
PENN
VILLA GROVE
UNITYVILLE P.O.
JORDAN
FAIRFIELD
WILLIAMSPORT
MONTOURSVILLE
PENNSVILLE
HUGHESVILLE
MUNCY STA.
MUNCY CREEK
MORELAND
CLARKSTOWN P.O.
MORELAND P.O.
CLINTON
CLINTONVILLE
MAPLE HILL P.O.
BRADY
Laurel Run
N

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

OF

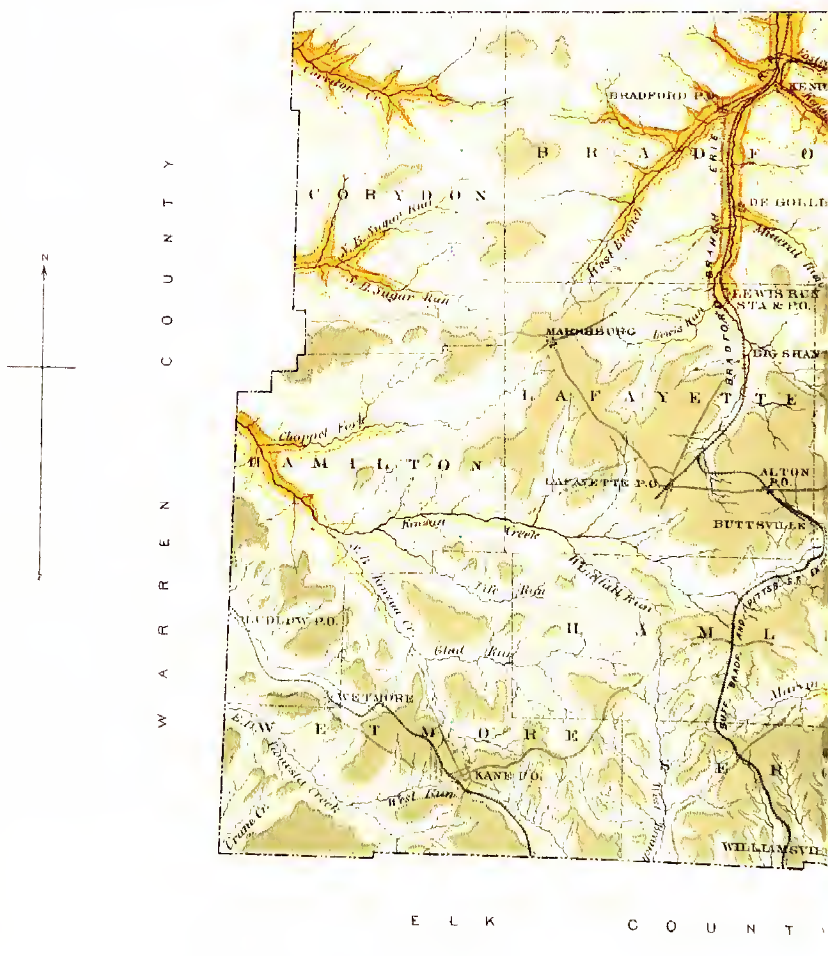
M^c KEAN COUNTY

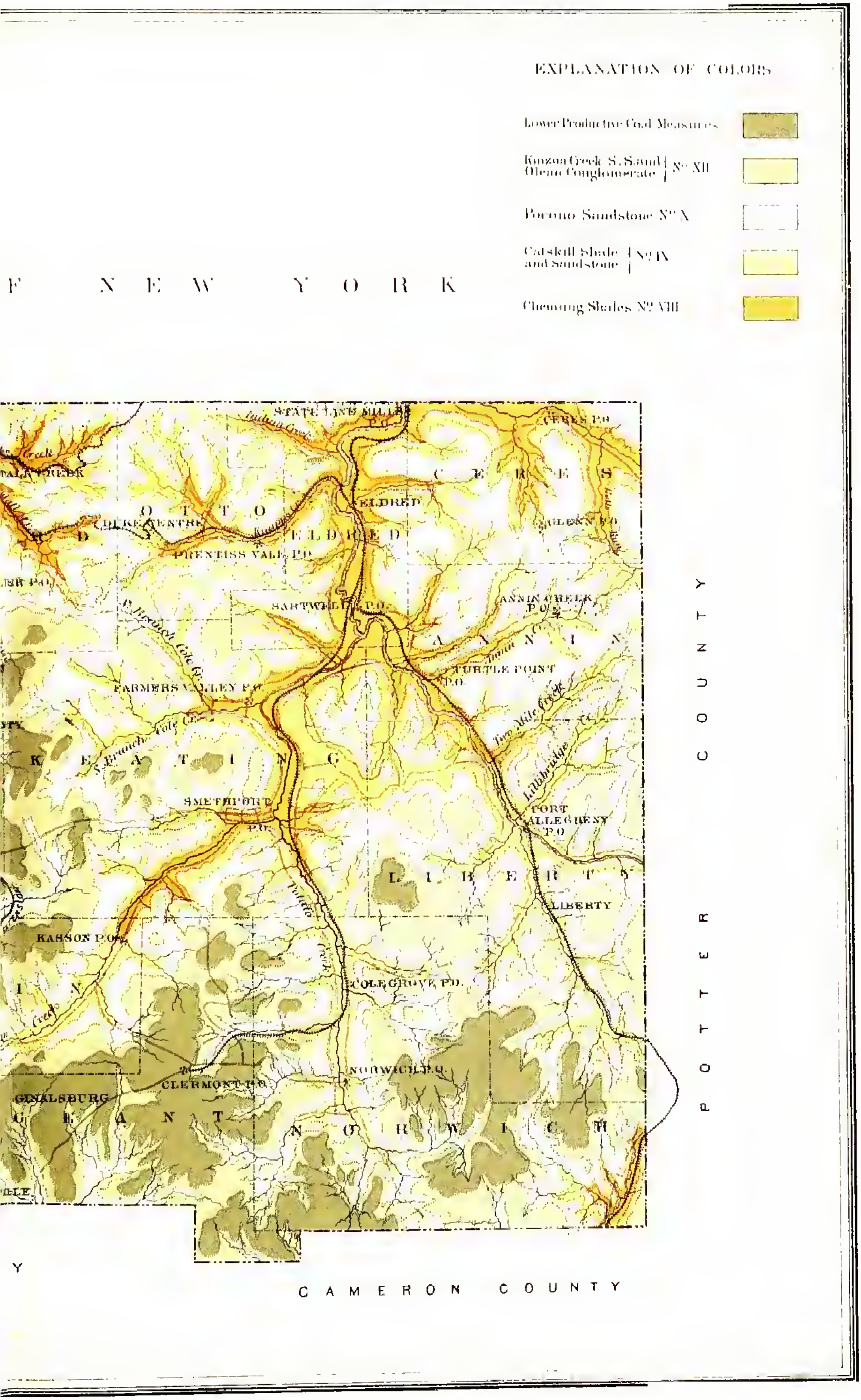
1878.

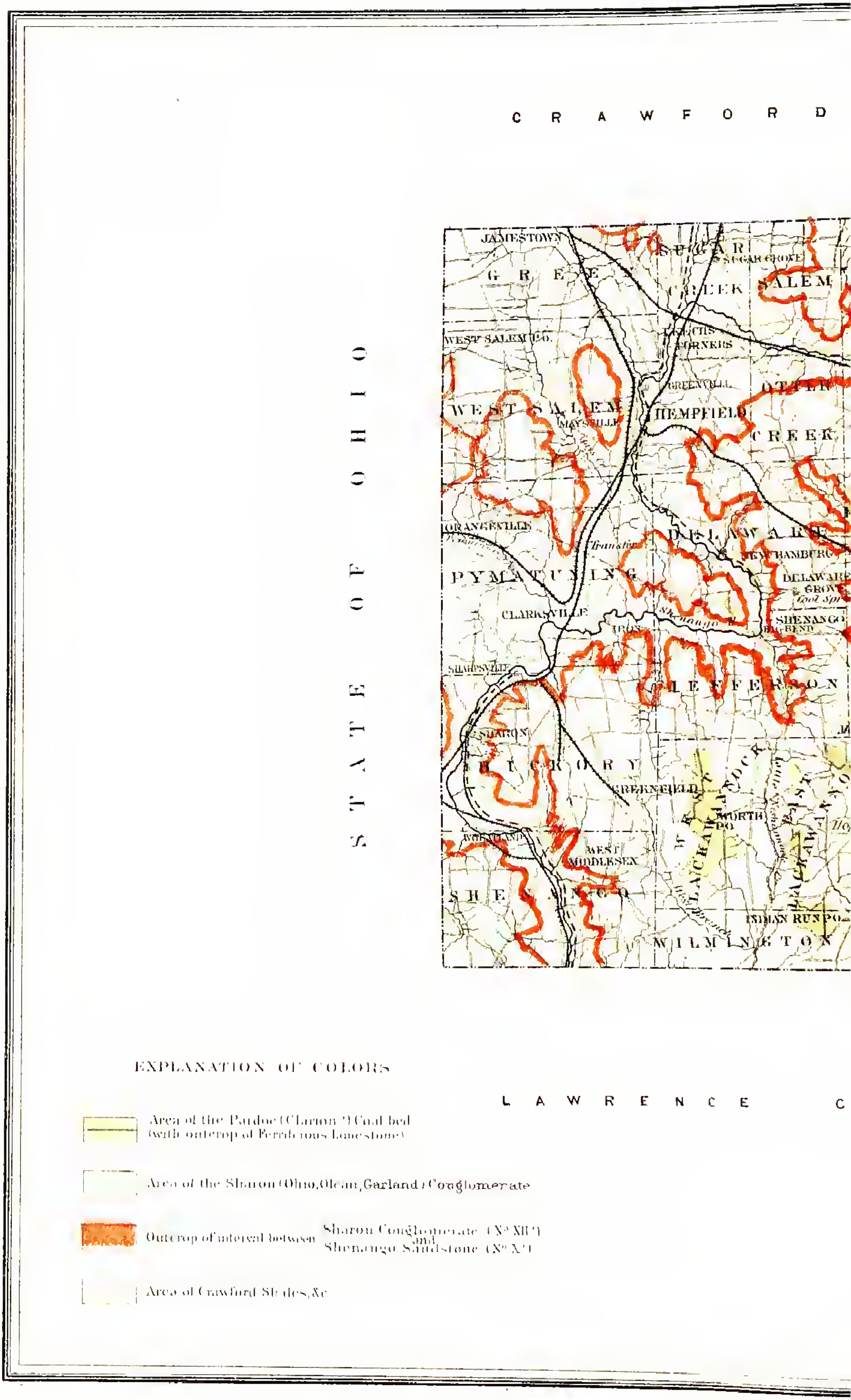
S T A T E O

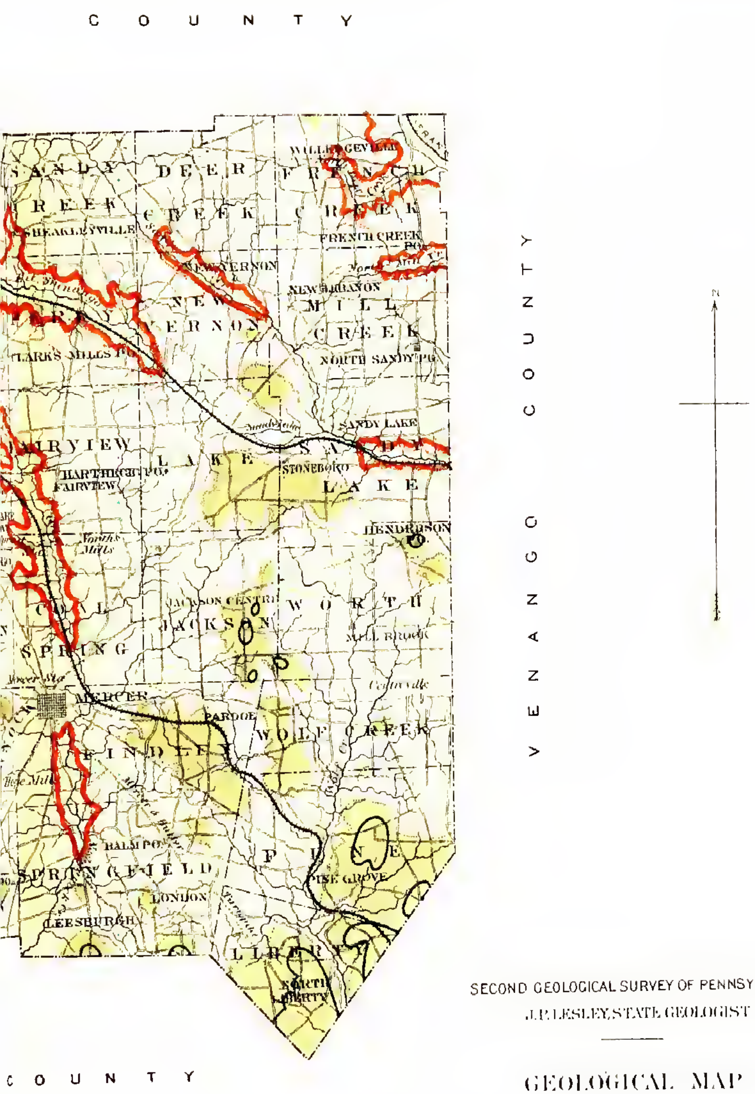
Scale: 6 miles to 1 inch

0 1 2 3 4 5 10 miles




EXPLANATION OF COLORS
Lower Productive Coal Measures
Kinzua Creek S. Sand / Olean Conglomerate No XII
Pocono Sandstone No X
Catskill Shale and Sandstone No IX
Chemung Shales No VIII
NEW YORK
STATE LINE MILLS
CERES P.O.
CERES
ELDRED
OTTO
DUKE CENTRE
ELDRED
PRENTISS VALE P.O.
GLENN P.O.
SARTWELL P.O.
ANNIN CREEK P.O.
ANNIN
TURTLE POINT P.O.
FARMERS VALLEY P.O.
KEATING
SMETHPORT P.O.
PORT ALLEGHENY P.O.
LIBERTY
LIBERTY
KASSON P.O.
COLEGROVE P.O.
NORWICH P.O.
CLERMONT P.O.
GINALSBURG
GRANT
NORWICH
POTTER COUNTY
CAMERON COUNTY


C R A W F O R D
STATE OF OHIO
L A W R E N C E
JAMESTOWN
GREENE
SALEM
WEST SALEM P.O.
WEST SALEM
MAYSVILLE
GREENVILLE
HEMPFIELD
CREEK
ORANGEVILLE
DELAWARE
NEW HAMBURG
DELAWARE GROVE
PYMATUNING
CLARKSVILLE
SHENANGO
BIG BEND
SHARPSVILLE
JEFFERSON
SHARON
HICKORY
WHEATLAND
WEST MIDDLESEX
SHENANGO
INDIAN RUN P.O.
WILMINGTON
EXPLANATION OF COLORS
Area of the Pardoe (Clarion ?) Coal bed (with outcrop of Ferriferous Limestone)
Area of the Sharon (Ohio, Olean, Garland) Conglomerate
Outcrop of interval between Sharon Conglomerate (No XII) and Shenango Sandstone (No X)
Area of Crawford Shales, &c



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

OF

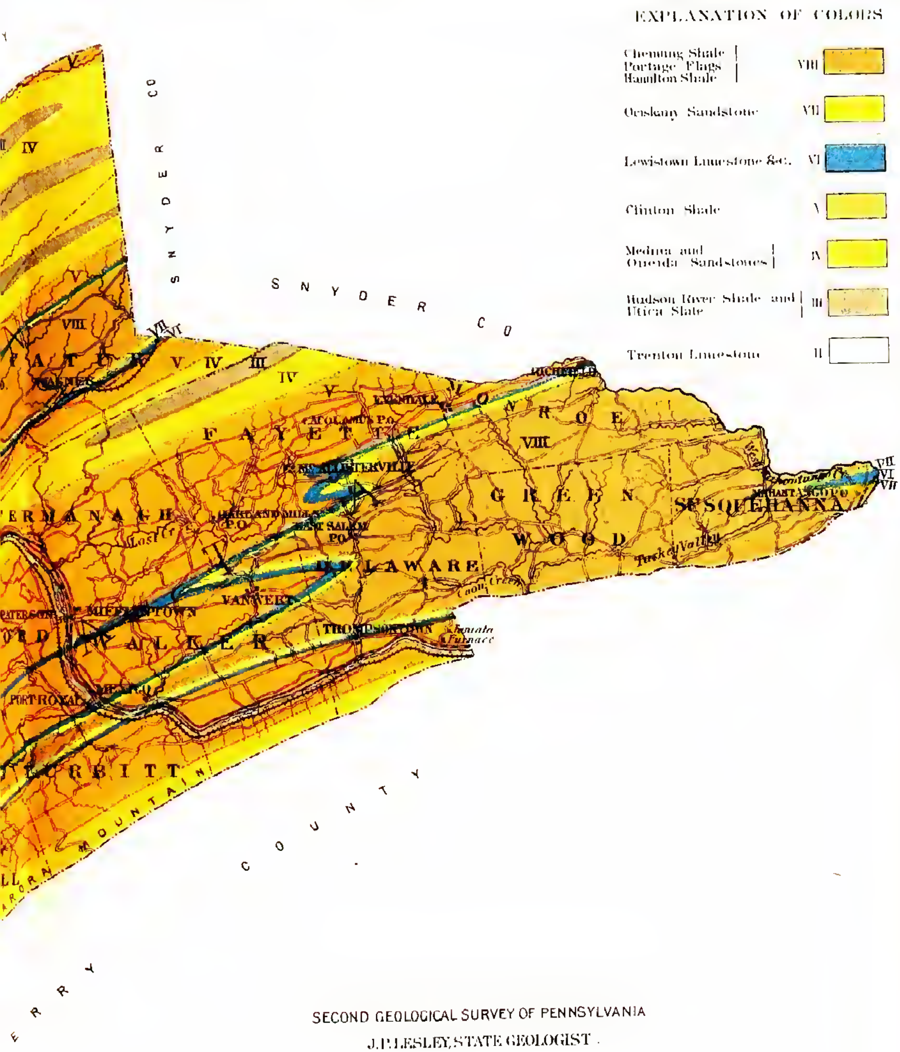
MERCER COUNTY

1878.

Scale. 6 miles to 1 inch.

0 1 2 3 4 5 10 miles

CENTRE COUNTY
HUNTINGDON COUNTY
HUNTINGDON COUNTY
SIGLERSVILLE P.O.
ARMAGH
MILROY P.O.
LOCKS MILLS
DECATUR P.O.
BROWN
REEDSVILLE P.O.
KISHACOQUILLAS P.O.
YEAGERTOWN
UNION
BELLEVILLE
LEWISTOWN
MENNO P.O.
MENNO
ALLENSVILLE
GRANVILLE
GRANVILLE P.O.
STROUDS MILL
BLUE RIDGE
JOHNSTOWN
WALNUT P.O.
ALLENDALE
BEALE
ACADEMIA P.O.
OLIVER
NEWTOWN
BRATTON
MOUNTAIN
ATKINSONS MILLS
REEDS GAP P.O.
SPRUCE HILL
TUSCARORA
Long Hollow
WAYNE
NEWTON HAMILTON
SHADE
BLUE RIDGE
HONEY GROVE
PERRU MILLS
EAST WATERFORD
LACK
Blue Rock
WATERLOO



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

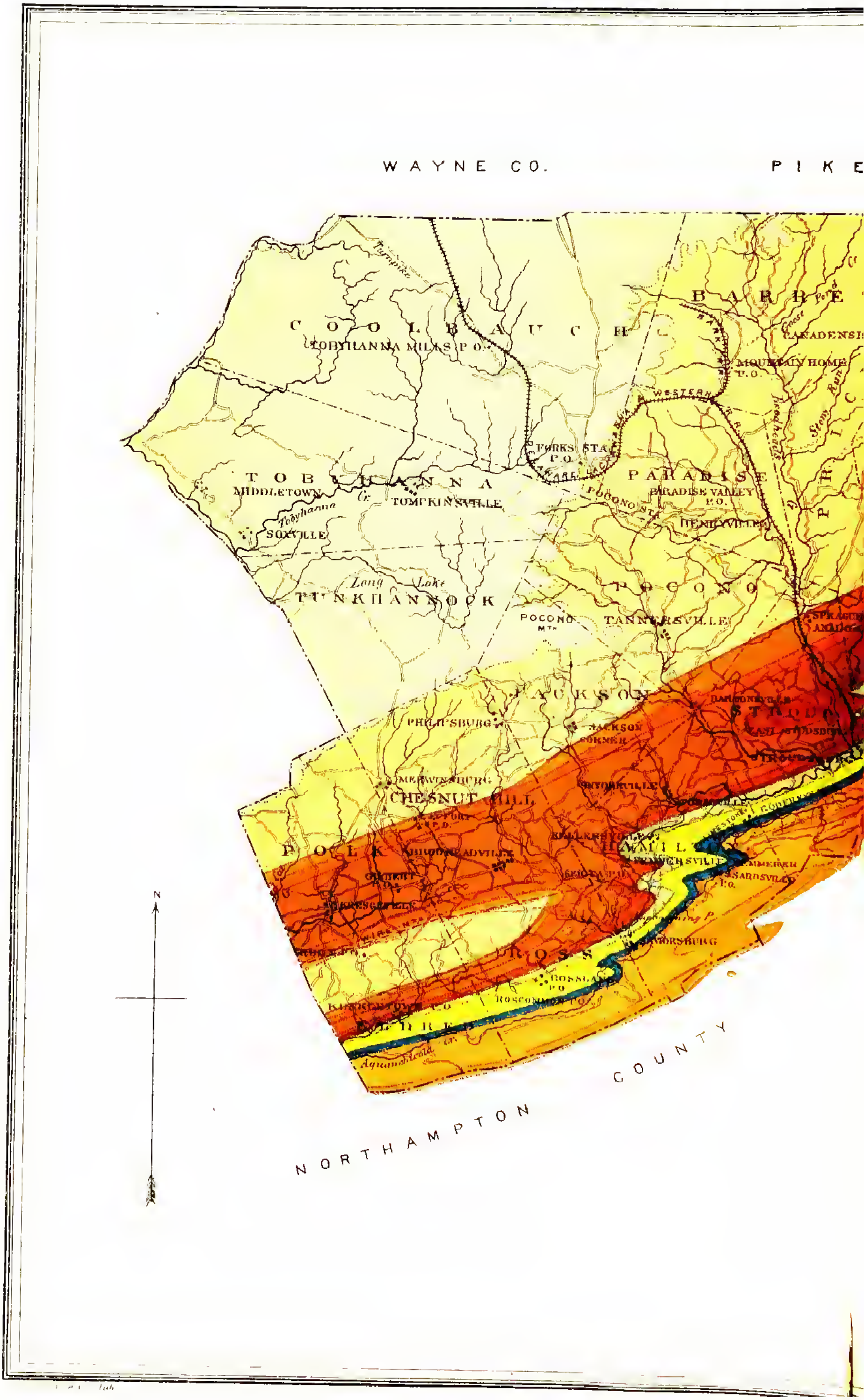
OF

MIFFLIN AND JUNIATA COUNTIES

1878.

Scale: 6 miles to 1 inch

0 1 2 3 4 5 10 miles


WAYNE CO.
PIKE
COOLBAUGH
TOBYHANNA MILLS P.O.
Turnpike
BARRE
CANADENSIS
MOUNTAIN HOME P.O.
WESTERN
FORKS STA. P.O.
TOBYHANNA
MIDDLETOWN
Tobyhanna Cr.
TOMPKINSVILLE
SOXVILLE
PARADISE
PARADISE VALLEY P.O.
POCONO STA.
HENRYVILLE
Long Lake
TUNKHANNOCK
POCONO
POCONO MTN
TANNERSVILLE
JACKSON
PHILIPSBURG
JACKSON CORNER
MERWINSBURG
CHESNUT HILL
SNYDERSVILLE
POLK
BRODHEADVILLE
GILBERT P.O.
KRESGEVILLE
SCIOTA P.O.
HAMILTON
ROSS
ROSSLAND P.O.
ROSCOMMON P.O.
KUNKLETOWN P.O.
ELDRED
Aquanshicola Cr.
NORTHAMPTON COUNTY
N

EXPLANATION OF COLORS

Pocono Sandstone	X	
Catskill Red Sandstone	IX	
Chemung	VIII	
Genesee		
Hamilton		
Marcellus		
Upper Helderberg Limestone		
Cauda-galli and Oriskany Sandstone	VII	
Lower Helderberg Limestone	VI	
Clinton Red Shale	V	
Medina and Oneida Conglomerate	IV	

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

OF

MONROE COUNTY

1884.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

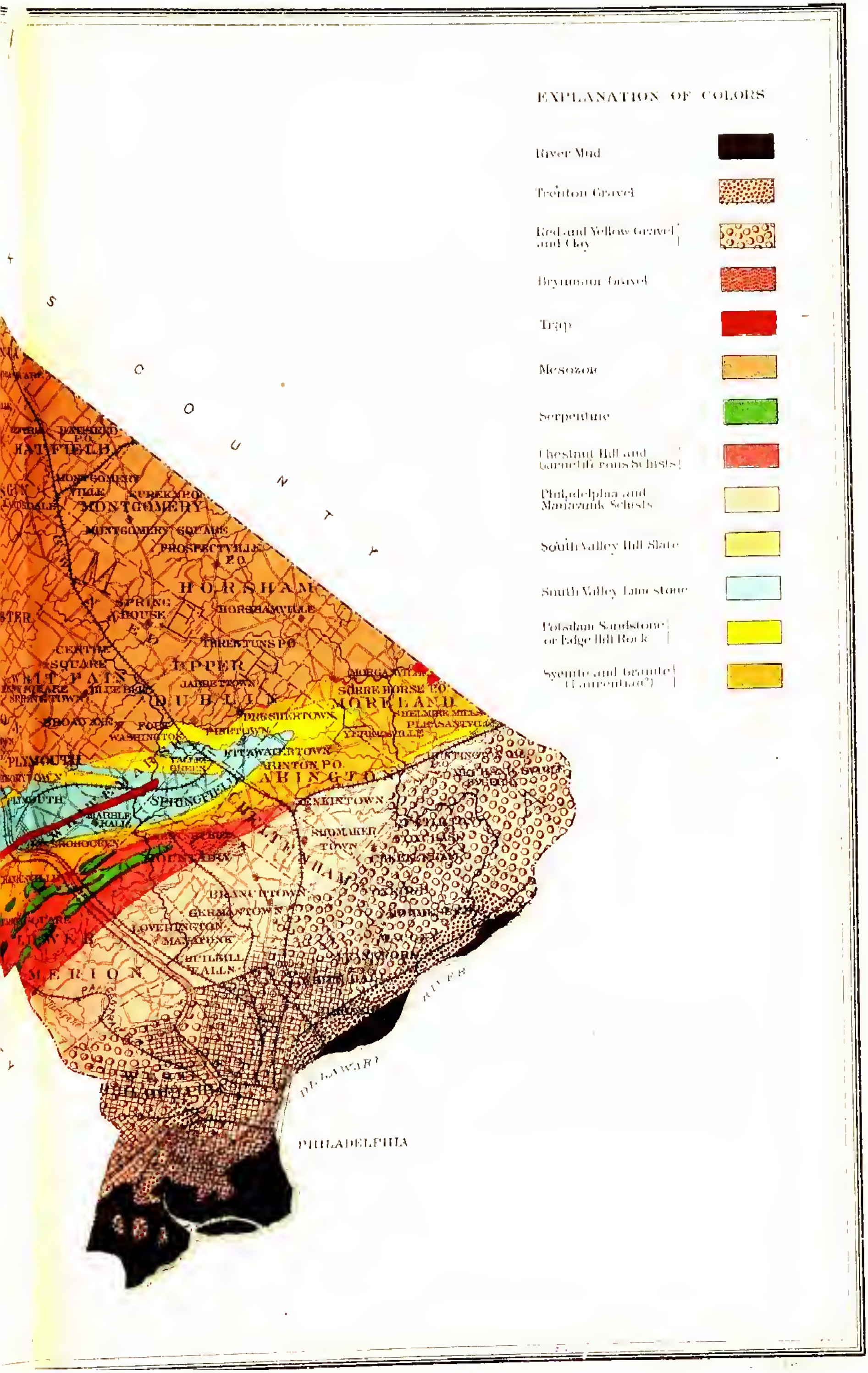
OF

MONTGOMERY COUNTY

1884.

Scale. 6 miles to 1 inch

0 1 2 3 4 5 6 miles


EXPLANATION OF COLORS
River Mud
Trenton Gravel
Red and Yellow Gravel and Clay
Brynmawr Gravel
Trap
Mesozoic
Serpentine
Chestnut Hill and Garnetiferous Schists
Philadelphia and Manayunk Schists
South Valley Hill Slate
South Valley Lime stone
Potsdam Sandstone or Edge Hill Rock
Syenite and Granite (Laurentian?)
HATFIELD
MONTGOMERY
MONTGOMERY SQUARE
PROSPECTVILLE P.O.
HORSHAM
HORSHAMVILLE
UPPER
DUBLIN
MORELAND
ABINGTON
JENKINTOWN
GERMANTOWN
MANAYUNK
MERION
PHILADELPHIA
DELAWARE RIVER


LYCOMING COUNTY
UNION COUNTY
SNYDER COUNTY
DAUPHIN COUNTY
N
DELAWARE
COMLY P.O.
WHITE HALL
EXCHANGE
TURBUTVILLE
LIMESTONE
DERRY
LIBERTY VALLEY
POTTSGROVE
MOORESBURG
OLD LIBERTY FURNACE
UPPER AUGUSTA
SNYDERTOWN
PAXINOS
LOWER AUGUSTA
LITTLE MOUNTAIN
TREVORTON
LITTLE MAHANOY
ZERBE
UPPER MAHANOY
WASHINGTON
JACKSON
LOWER MAHANOY
GEORGETOWN
JORDAN

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

OF

NORTHUMBERLAND AND MONTOUR COUNTIES

1878.

Scale. 6 miles to 1 inch.

0 1 2 3 4 5 10 miles

EXPLANATION OF COLORS

Pottsville Conglomerate and Coal Measures	XII	
Mauch Chunk Red Shale	XI	
Pocono Sandstone	X	
Catskill Red Sandstone	IX	
Chemung Shale, Portage Flags, Hamilton &c.	VIII	
Oriskany Sandstone	VII	
Lewistown Limestone &c.	VI	
Clinton Shale (Fossil ore beds)	V	

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

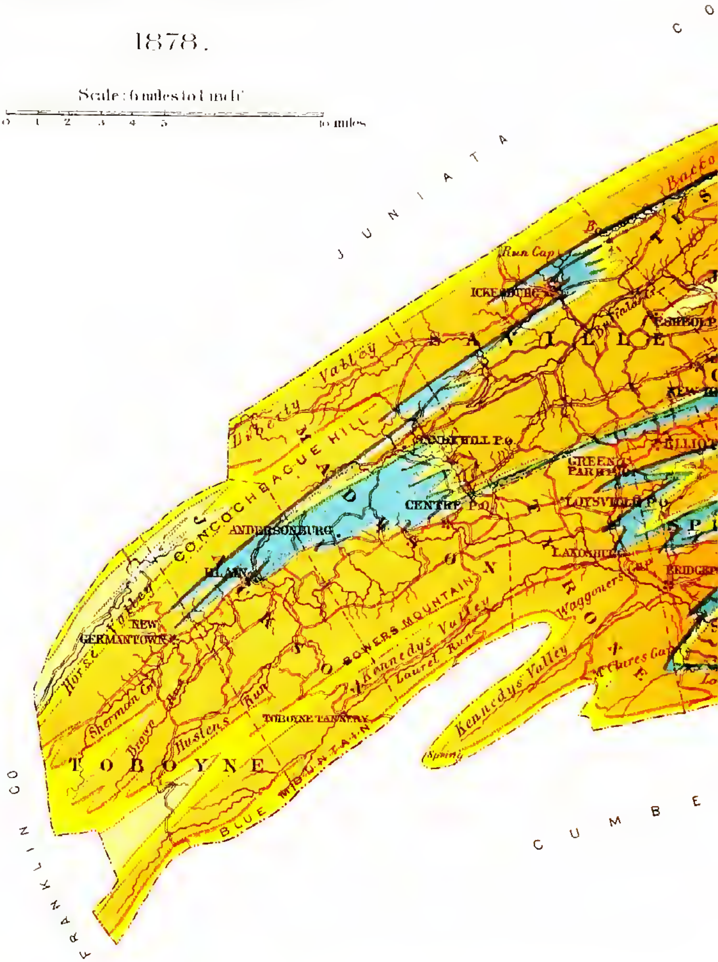
OF

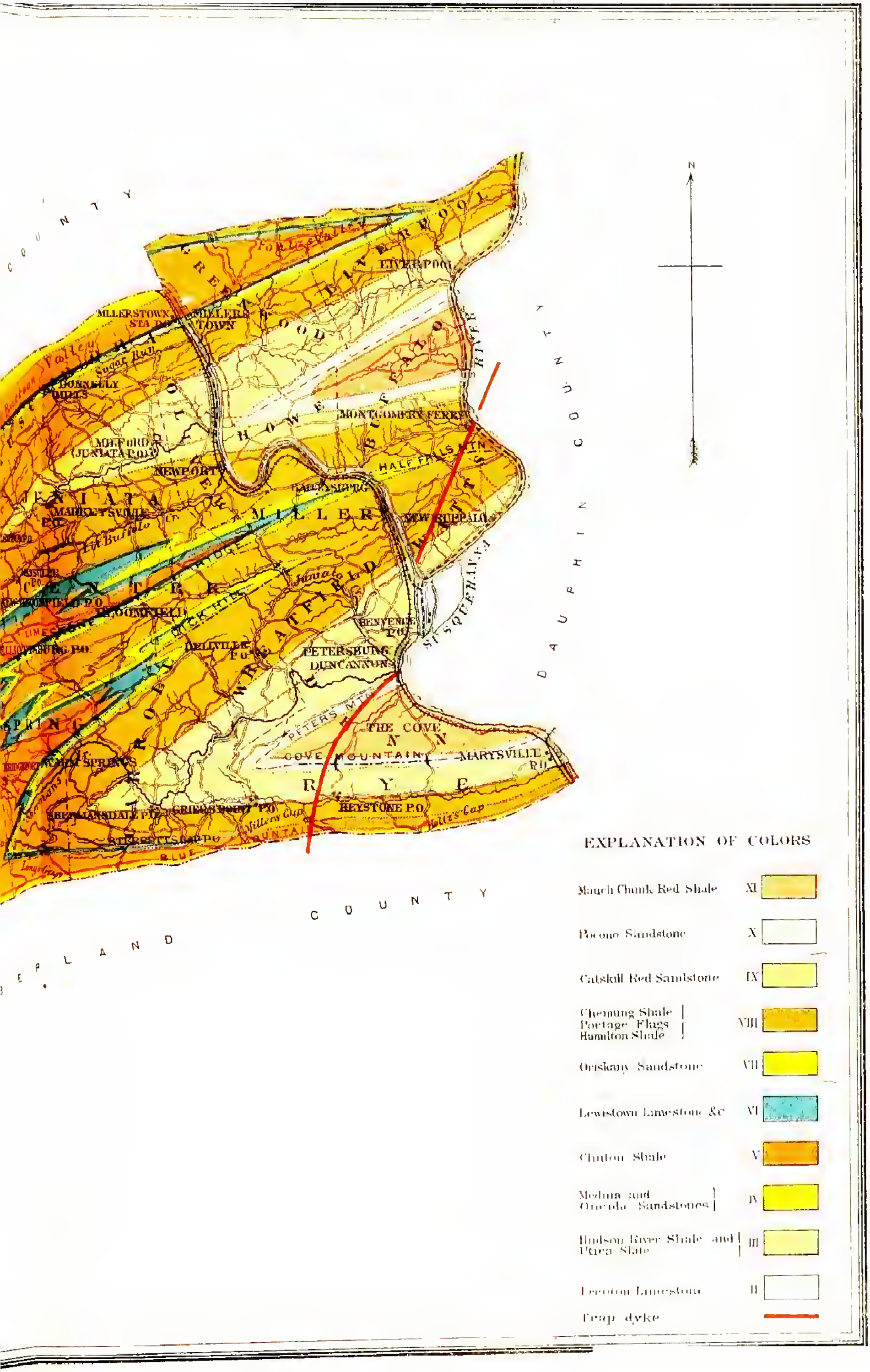
PERRY COUNTY

1878.

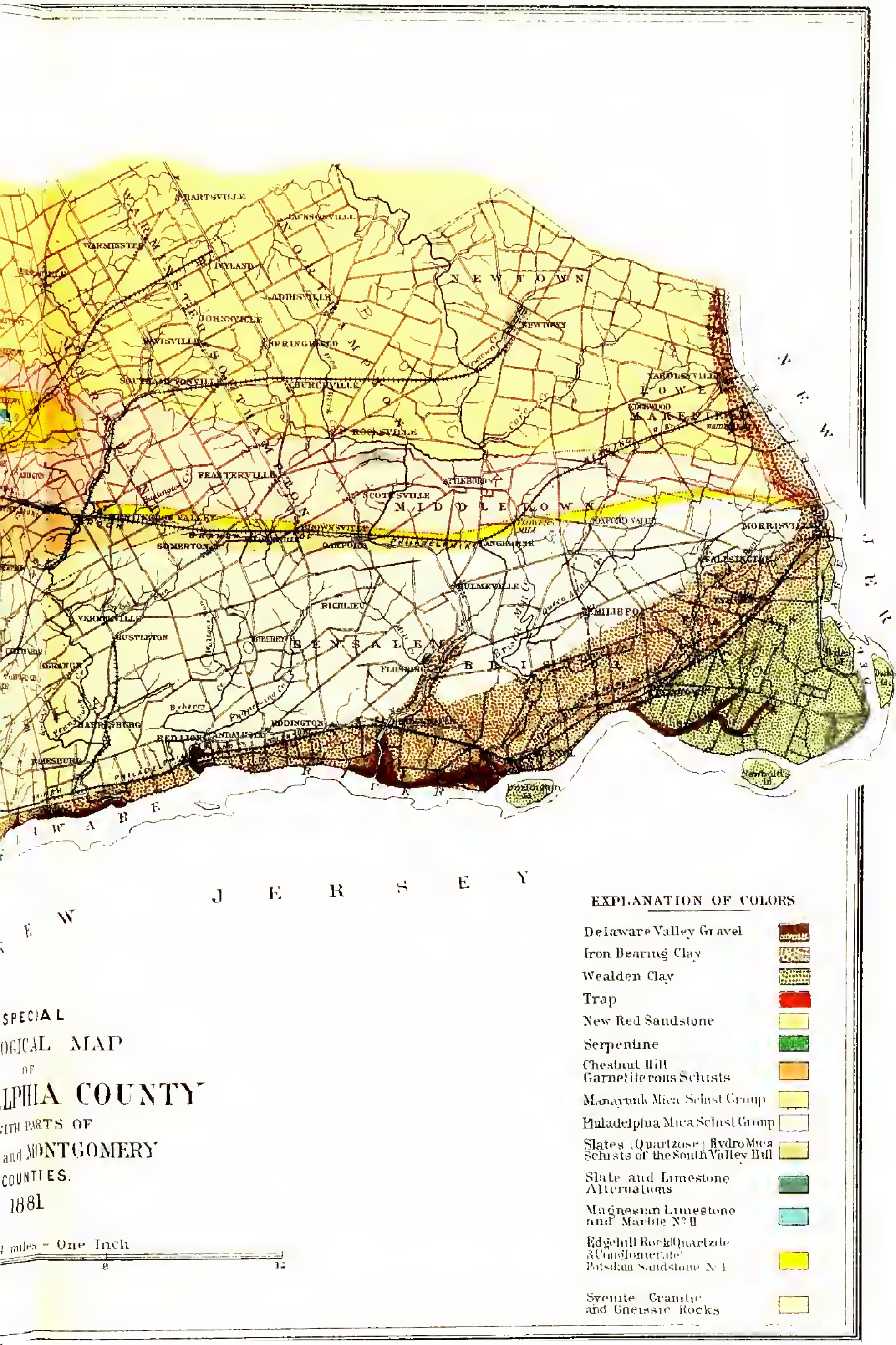
Scale: 6 miles to 1 inch

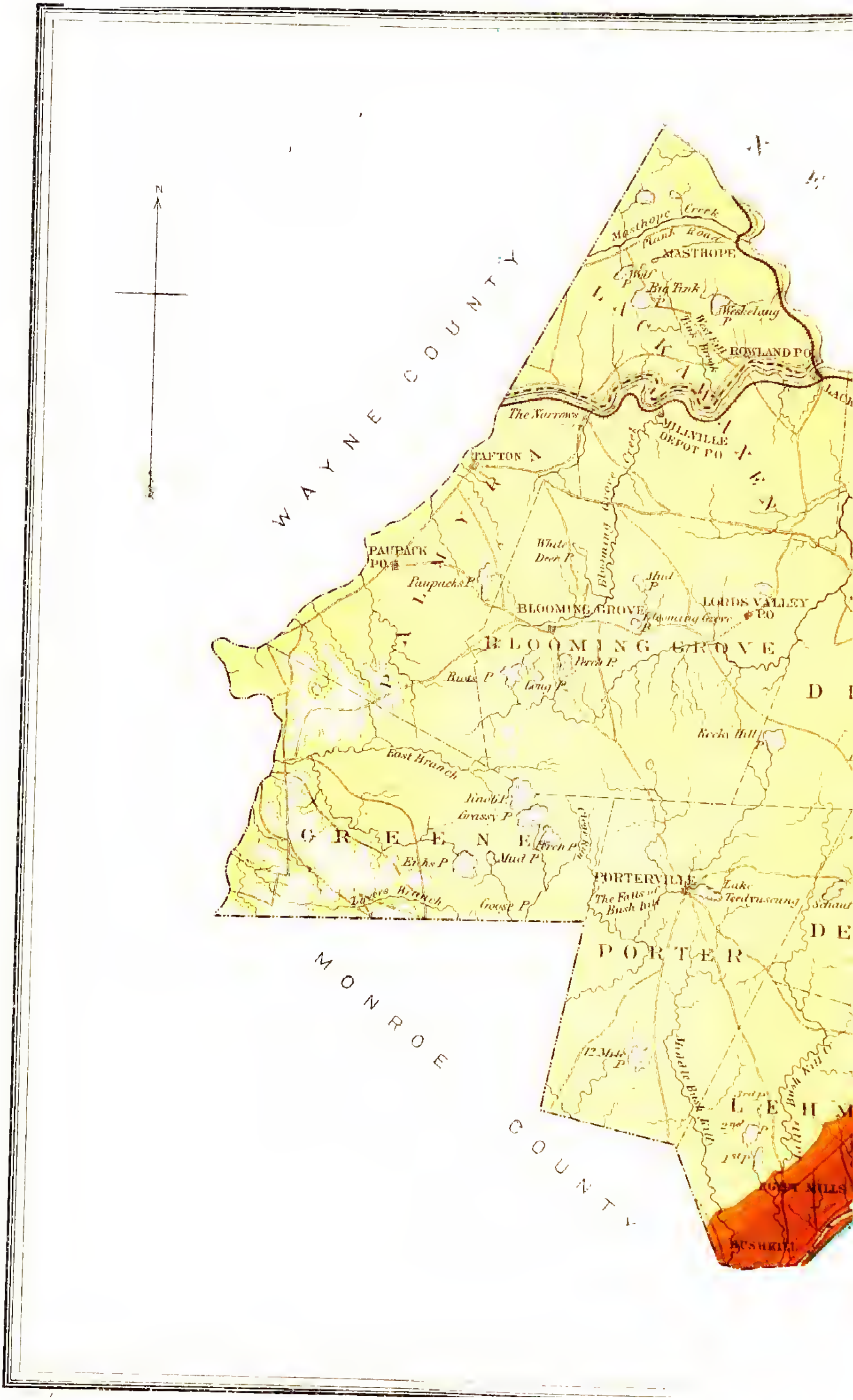
0 1 2 3 4 5 10 miles

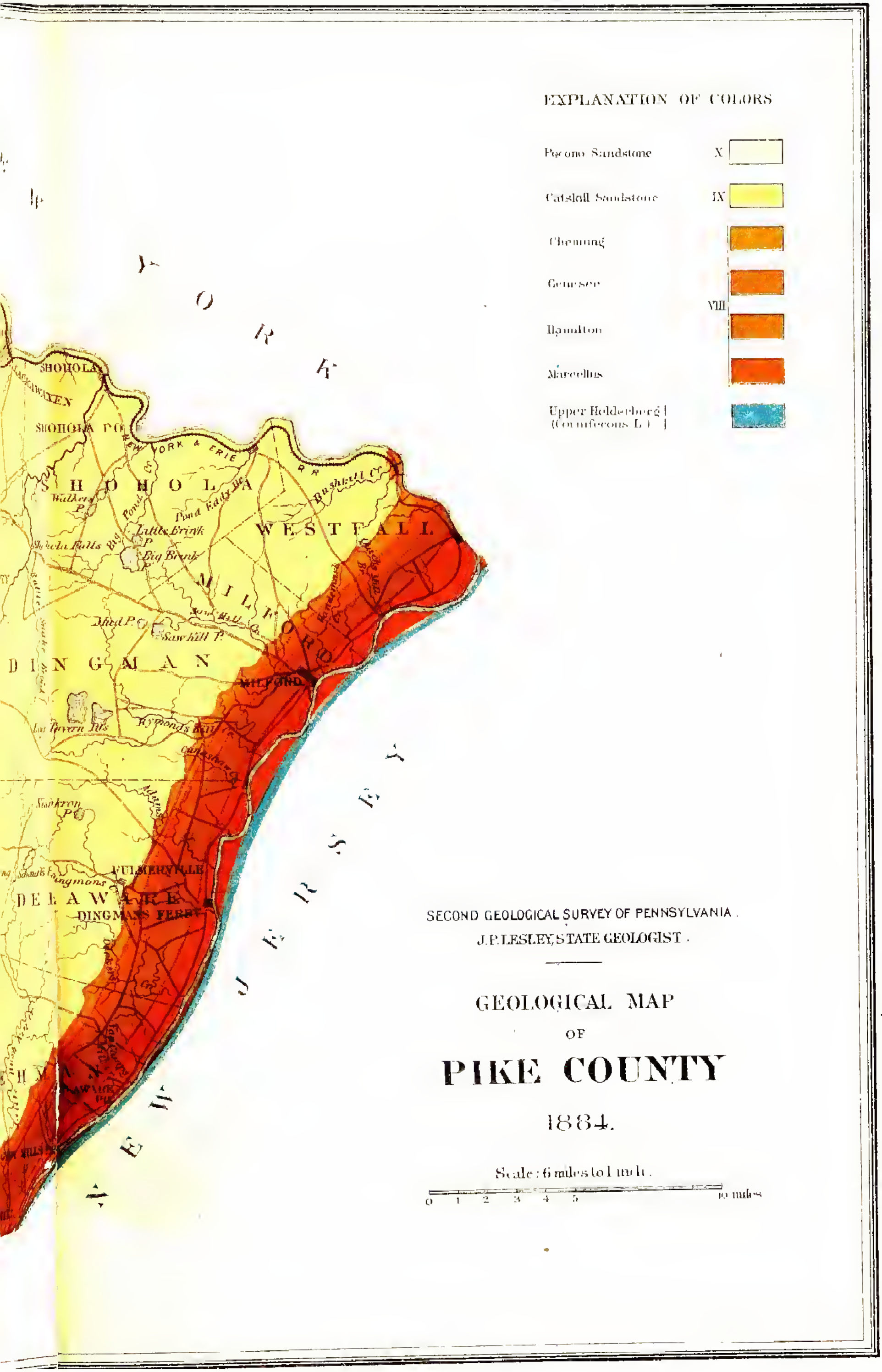



LIVERPOOL
MILLERSTOWN STA
MILLERS TOWN
DONNELLY MILLS
MILFORD (JUNIATA P.O.)
NEWPORT
MONTGOMERY FERRY
HALF FALLS MTN.
BAILYSBURG
NEW BUFFALO
BLOOMFIELD
DELVILLE P.O.
PETERSBURG
DUNCANNON
BENVENUE P.O.
THE COVE
COVE MOUNTAIN
MARYSVILLE P.O.
KEYSTONE P.O.
STERRETTS GAP P.O.
WARM SPRINGS
SHERMANSDALE P.O.
SUSQUEHANNA RIVER
DAUPHIN COUNTY
CUMBERLAND COUNTY
N
EXPLANATION OF COLORS
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
Chemung Shale / Portage Flags / Hamilton Shale VIII
Oriskany Sandstone VII
Lewistown Limestone &c VI
Clinton Shale V
Medina and Oneida Sandstones IV
Hudson River Shale and Utica Slate III
Trenton Limestone II
Trap dyke

C H E S T E R CO.
D E L A W A R E C O U N T Y
PORT KENNEDY
U P P E R
P L Y M O U T H
W H I T P A I N
PENLLYN
SANDY HILL
BROAD AXE
JARRETTOWN
CONSHOHOCKEN
WELDON
ABINGTON
BALA
MERIONVILLE
HADDINGTON
FRANKFORD
CHELTENHAM
OXFORD CH
BRIDESBURG
FT MIFFLIN
SPECI
GEOLOGICA
OF
PHILADELPHI
WITH PA
BUCKS and MC
COUNT
188
Scale 4 miles

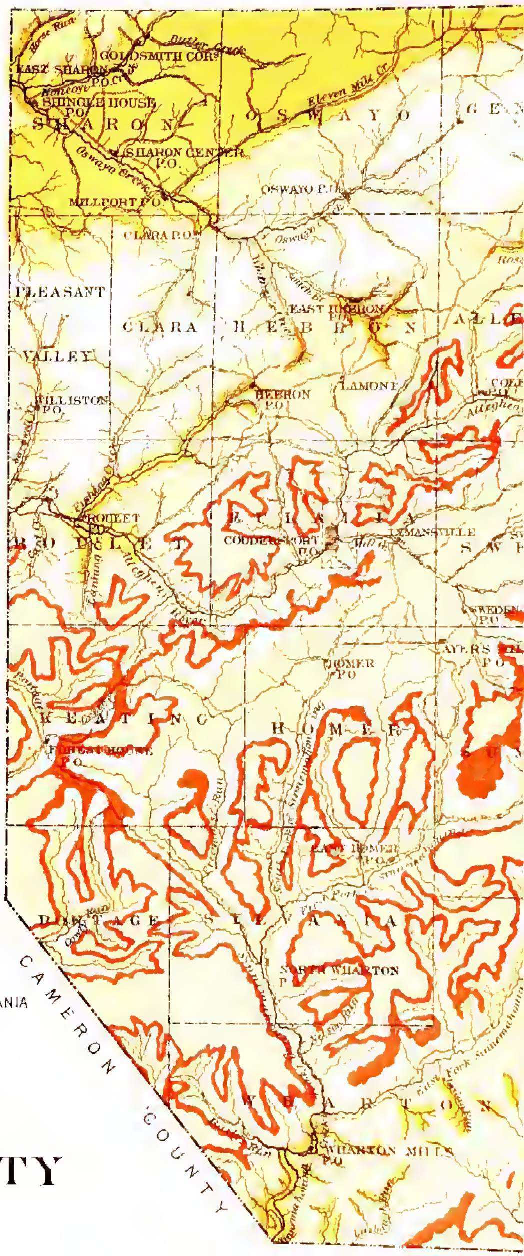

HARTSVILLE
JACKSONVILLE
WARMINSTER
IVYLAND
ADDISVILLE
JOHNSVILLE
SPRINGFIELD
NEWTOWN
CHURCHVILLE
ROCKSVILLE
FEASTERVILLE
SCOTTSVILLE
MIDDLETOWN
SOMERTON
OAKFORD
MORRISVILLE
BUSTLETON
BENSALEM
BRISTOL
EDDINGTON
J E R S E Y
EXPLANATION OF COLORS
Delaware Valley Gravel
Iron Bearing Clay
Wealden Clay
Trap
New Red Sandstone
Serpentine
Chesbut Hill Garnetiferous Schists
Manayunk Mica Schist Group
Philadelphia Mica Schist Group
Slates (Quartzose) Hydro Mica Schists of the South Valley Hill
Slate and Limestone Alternations
Magnesian Limestone and Marble Nº II
Edgehill Rock (Quartzite & Conglomerate) Potsdam Sandstone Nº I
Syenite Granite and Gneissic Rocks
SPECIAL
OGICAL MAP
OF
LPHIA COUNTY
WITH PARTS OF
and MONTGOMERY
COUNTIES.
1881
One Inch
8
12


WAYNE COUNTY
MONROE COUNTY
Masthope Creek
Plank Road
MASTHOPE
ROWLAND P.O.
The Narrows
MILLVILLE DEPOT P.O.
TAFTON
PAUPACK P.O.
Paupacks P.
White Deer P.
BLOOMING GROVE
LORDS VALLEY P.O.
Perch P.
Long P.
Keeks Hill
East Branch
Grassy P.
GREENE
Mud P.
Goose P.
PORTERVILLE
Lake Teedruscung
The Falls of Bush Kill
PORTER
12 Mile P.
Middle Bush Kill
Bush Kill
BUSHKILL


EXPLANATION OF COLORS
Pocono Sandstone X
Catskill Sandstone IX
Chemung
Genesee
VIII
Hamilton
Marcellus
Upper Helderberg (Corniferous L.)
NEW YORK
NEW JERSEY
NEW YORK & ERIE R.R.
SHOHOLA
LACKAWAXEN
SHOHOLA P.O.
S H O H O L A
W E S T F A L L
M I L F O R D
MILFORD
D I N G M A N
D E L A W A R E
DINGMANS FERRY
FULMERVILLE
Bushkill Cr.
Walkers P.
Shohola Falls
Little Brink P.
Big Brink
Pond Eddy Br.
Sawkill P.
Mud P.
Raymonds Kill Cr.
Sawkill Cr.
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.
J.P. LESLEY, STATE GEOLOGIST.
GEOLOGICAL MAP
OF
PIKE COUNTY
1884.
Scale: 6 miles to 1 inch.
0 1 2 3 4 5 10 miles

STATE OF

Mc KEAN COUNTY



CAMERON COUNTY

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J.P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

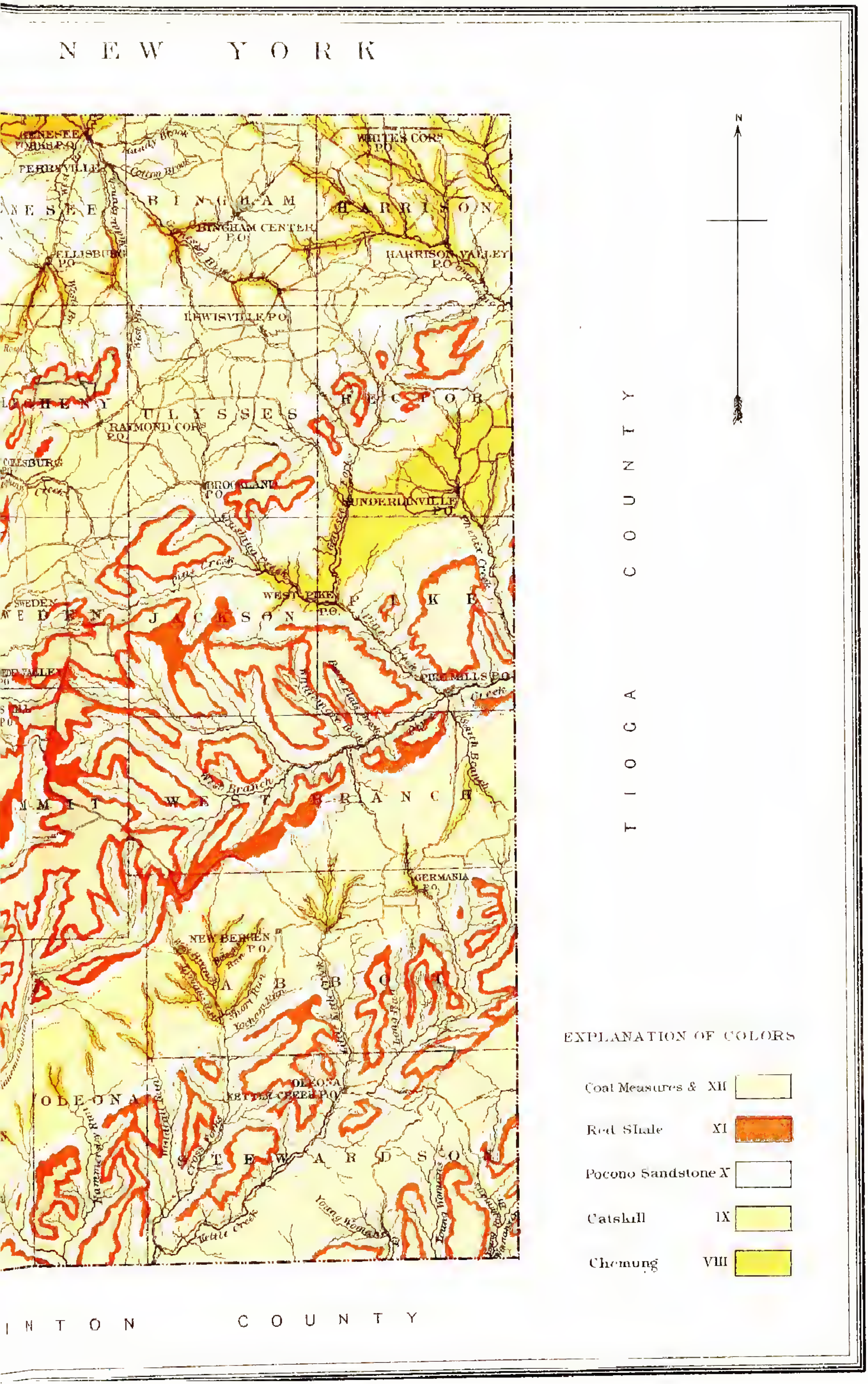
OF

POTTER COUNTY

1878.

Scale: 6 miles to 1 inch

0 1 2 3 4 5 10 miles


NEW YORK
TIOGA COUNTY
CLINTON COUNTY
BINGHAM
HARRISON
ULYSSES
HECTOR
JACKSON
PIKE
WEST BRANCH
ABBOTT
STEWARDSON
OLEONA
GENESEE
ALLEGHENY
SWEDEN
SUMMIT
WHITES CORS. P.O.
PERRYVILLE
BINGHAM CENTER P.O.
ELLISBURG P.O.
HARRISON VALLEY P.O.
LEWISVILLE P.O.
RAYMOND CORS. P.O.
BROOKLAND P.O.
UNDERLINVILLE P.O.
WEST PIKE P.O.
PIKE MILLS P.O.
GERMANIA P.O.
NEW BERGEN P.O.
OLEONA
KETTLE CREEK P.O.
Cowanesque River
Genesee Fork
Pine Creek
West Branch
Kettle Creek
Young Womans Creek
Cross Fork
Little Kettle Creek
South Branch
N
EXPLANATION OF COLORS
Coal Measures & XII
Red Shale XI
Pocono Sandstone X
Catskill IX
Chemung VIII

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

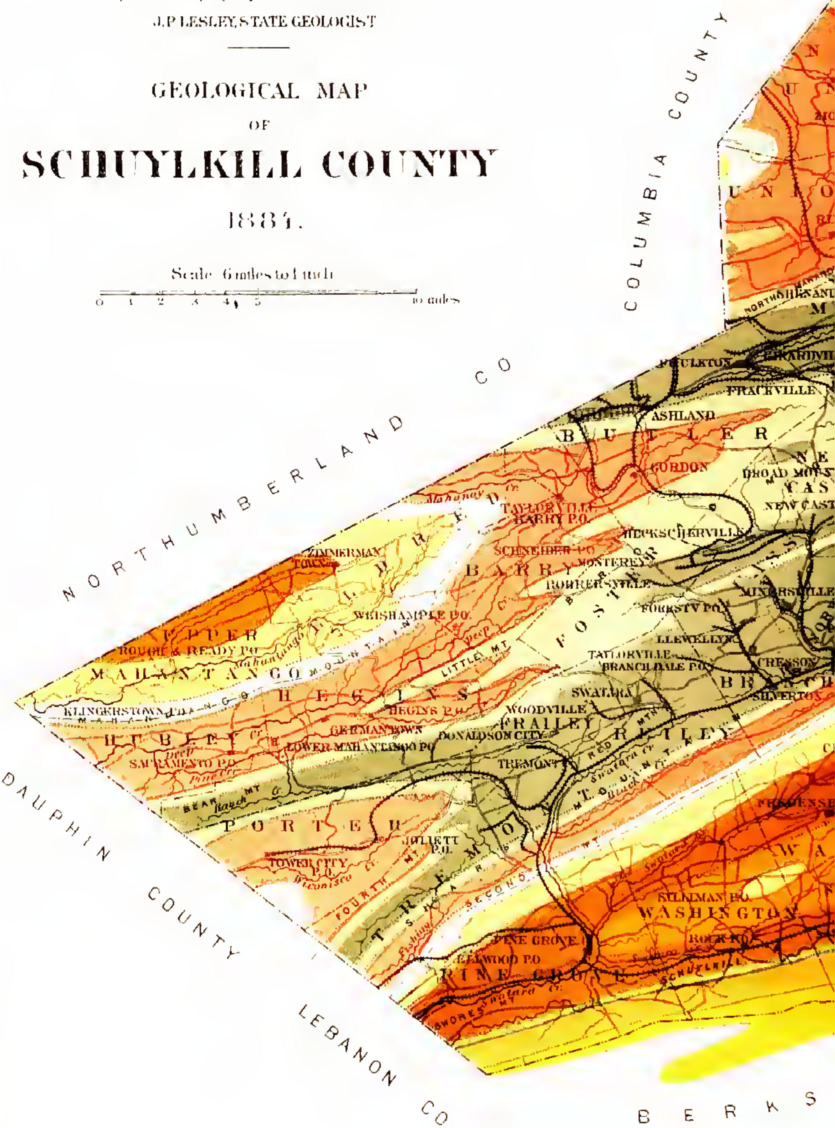
J. P. LESLEY, STATE GEOLOGIST

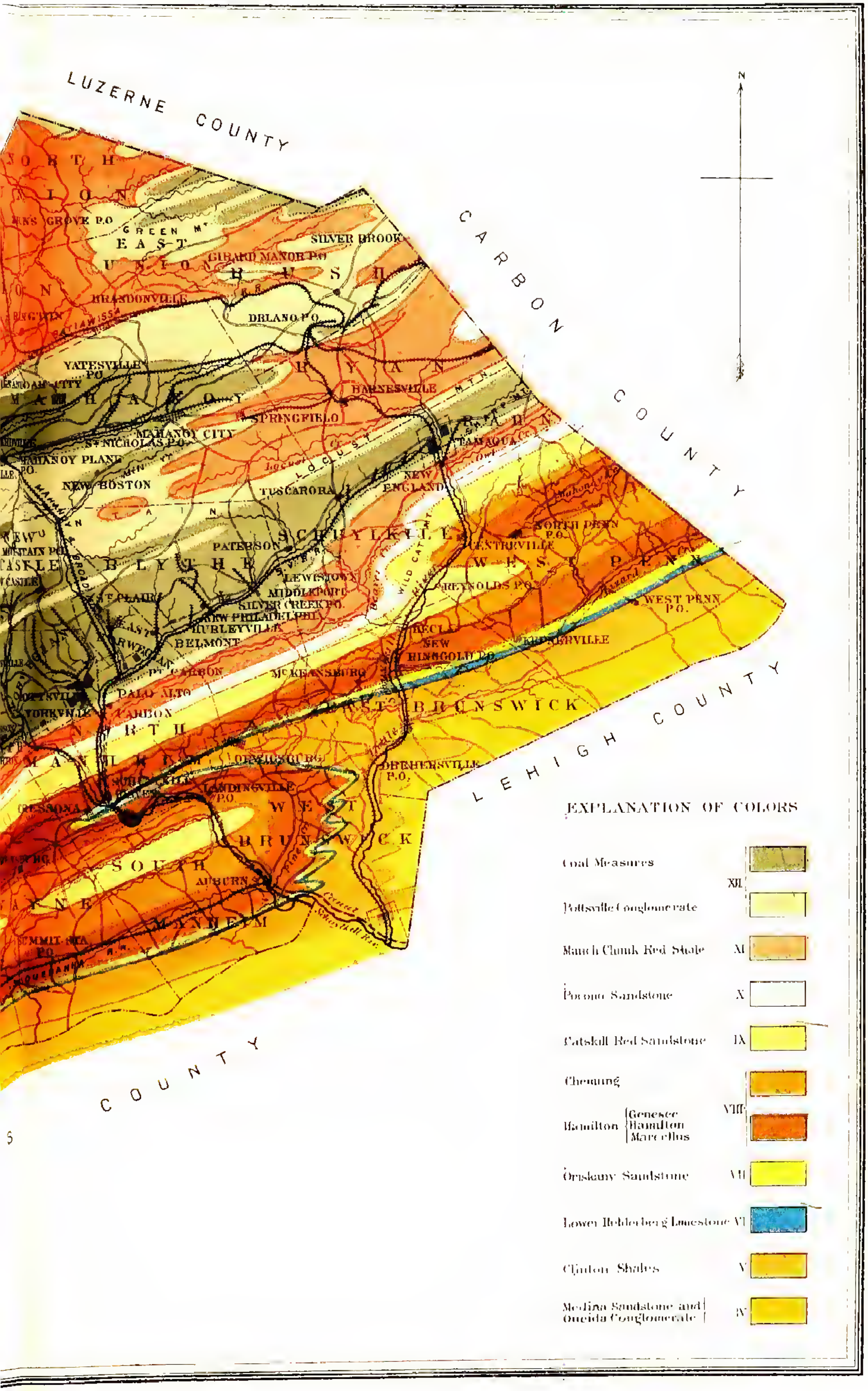
GEOLOGICAL MAP OF SCHUYLKILL COUNTY

1884.

Scale 6 miles to 1 inch

0 1 2 3 4 5 10 miles




LUZERNE COUNTY
CARBON COUNTY
LEHIGH COUNTY
COUNTY
N
SILVER BROOK
GIRARD MANOR P.O.
BRANDONVILLE
ORLANO P.O.
YATESVILLE P.O.
BARNESVILLE
SPRINGFIELD
MAHANOY CITY
ST NICHOLAS P.O.
MAHANOY PLANE
NEW BOSTON
TUSCARORA
TAMAQUA
NEW ENGLAND
NORTH PENN P.O.
CENTREVILLE
PATERSON
LEWISTOWN
MIDDLEPORT
SILVER CREEK P.O.
REYNOLDS P.O.
WEST PENN P.O.
NEW PHILADELPHIA
BELMONT
NEW RINGGOLD P.O.
McKEANSBURG
PALO ALTO
ORWIGSBURG
LANDINGVILLE P.O.
DREHERSVILLE P.O.
CRESSONA
AUBURN
SUMMIT STA P.O.
WEST BRUNSWICK
SOUTH MANHEIM
EXPLANATION OF COLORS
Coal Measures XII
Pottsville Conglomerate
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
Chemung
Hamilton: Genesee, Hamilton, Marcellus VIII
Oriskany Sandstone VII
Lower Helderberg Limestone VI
Clinton Shales V
Medina Sandstone and Oneida Conglomerate IV

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

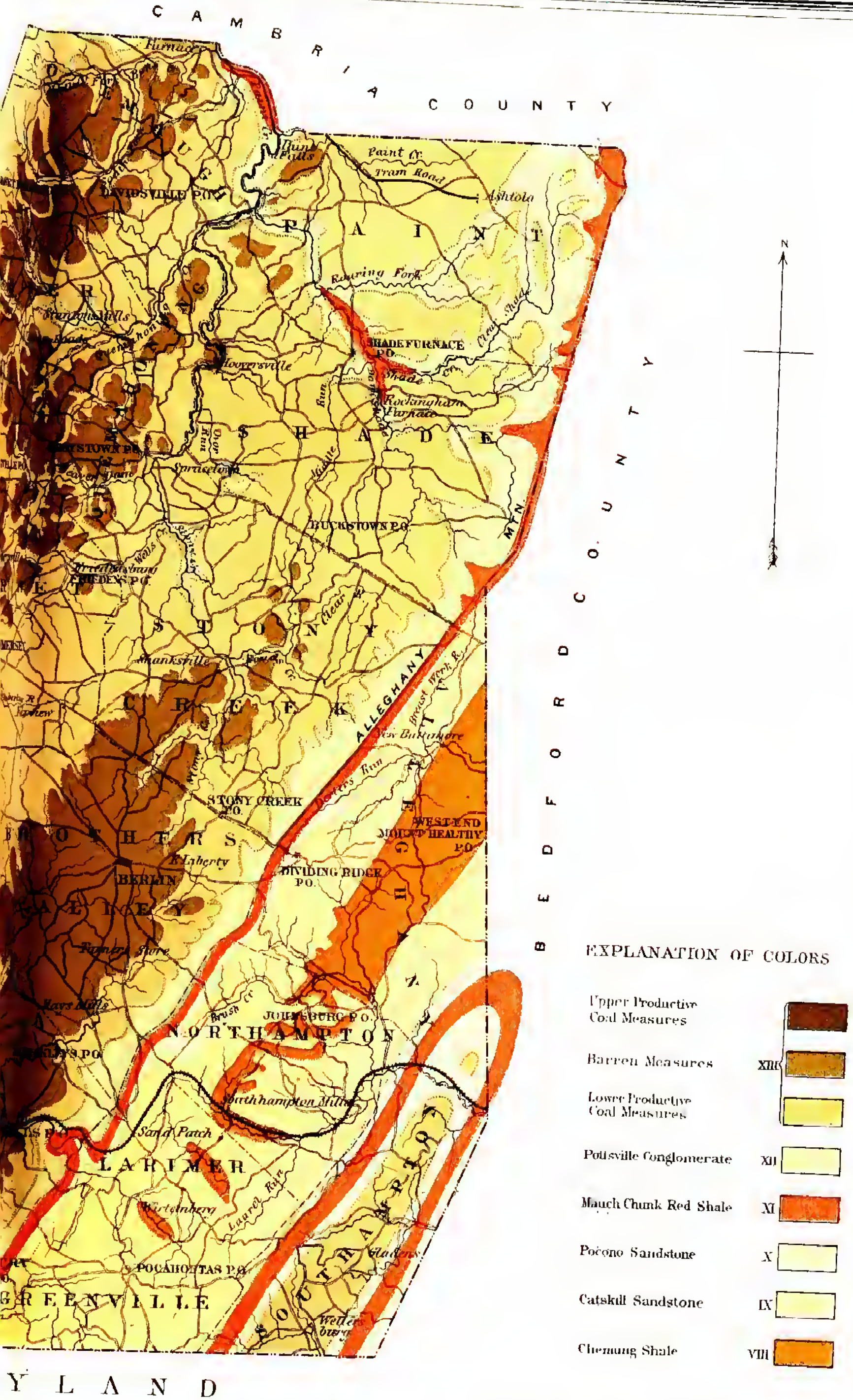
OF

SOMERSET COUNTY

1884.

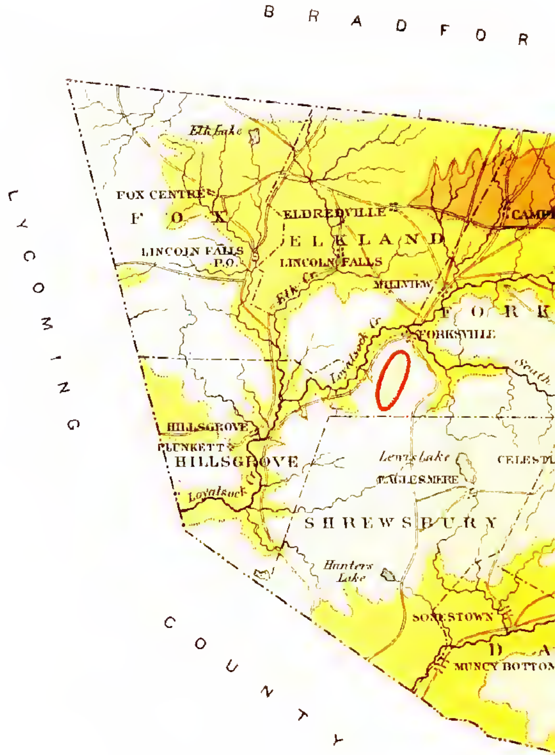
Scale: 6 miles to 1 inch

0 1 2 3 4 5 10 miles



EXPLANATION OF COLORS

Upper Productive Coal Measures		
Barren Measures	XIII	
Lower Productive Coal Measures		
Pottsville Conglomerate	XII	
Mauch Chunk Red Shale	XI	
Pocono Sandstone	X	
Catskill Sandstone	IX	
Chemung Shale	VIII	



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J P LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

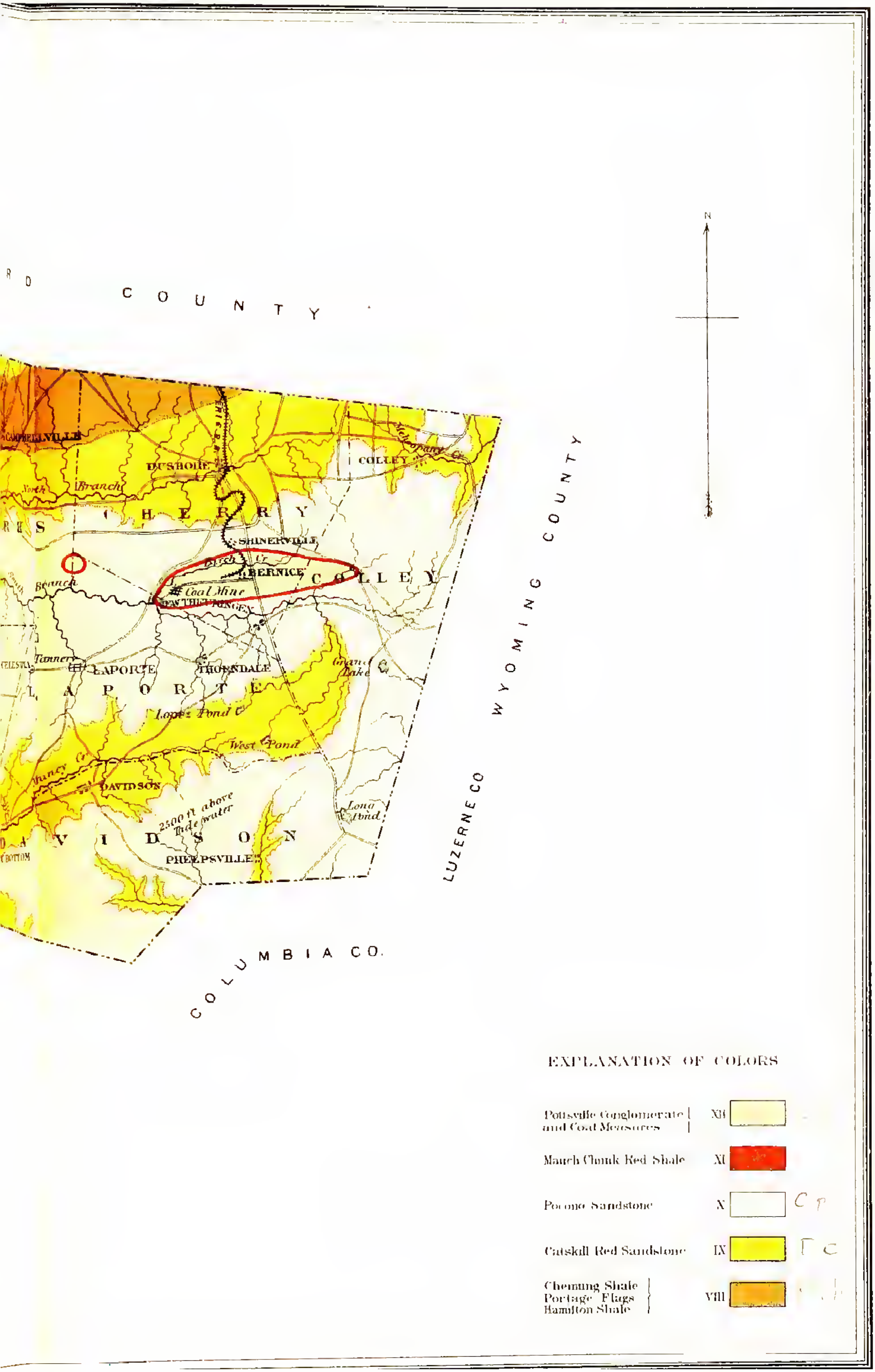
OF

SULLIVAN COUNTY

1878.

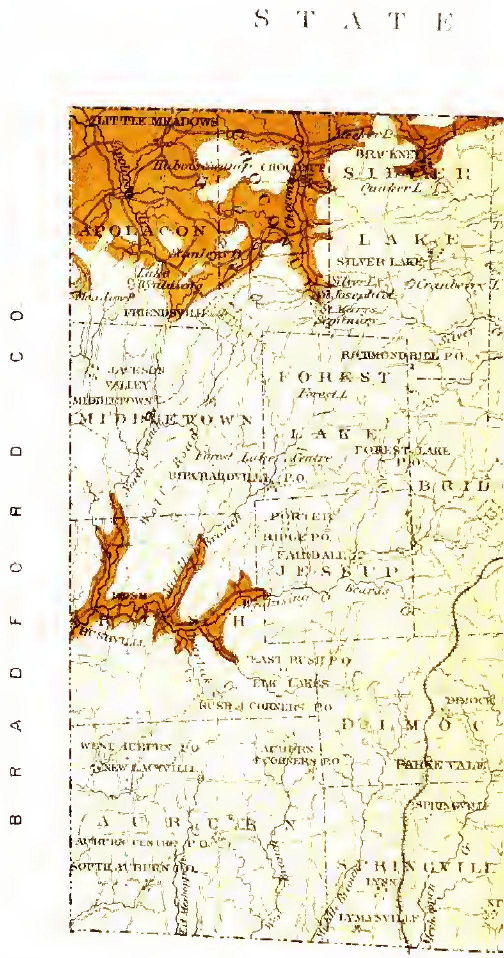
Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles


COUNTY
CAMPBELLVILLE
DUSHORE
North Branch
CHERRY
COLLEY
SHINERVILLE
BERNICE
Coal Mine
Tannery
LAPORTE
THORNDALE
LAPORTE
Lopez Pond
West Pond
DAVIDSON
2500 ft above Tide water
DAVIDSON
PHELPSVILLE
Long Pond
WYOMING COUNTY
LUZERNE CO.
COLUMBIA CO.
N
EXPLANATION OF COLORS
Pottsville Conglomerate and Coal Measures XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
Chemung Shale Portage Flags Hamilton Shale VIII

EXPLANATION OF COLORS

- XII Pottsville Conglomerate
- XI Mauch Chunk Red Shale
- X Pocono Sandstone
- IX Catskill Red Sandstone
- VIII Chemung Shale



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

W Y O M I N G C

GEOLOGICAL MAP

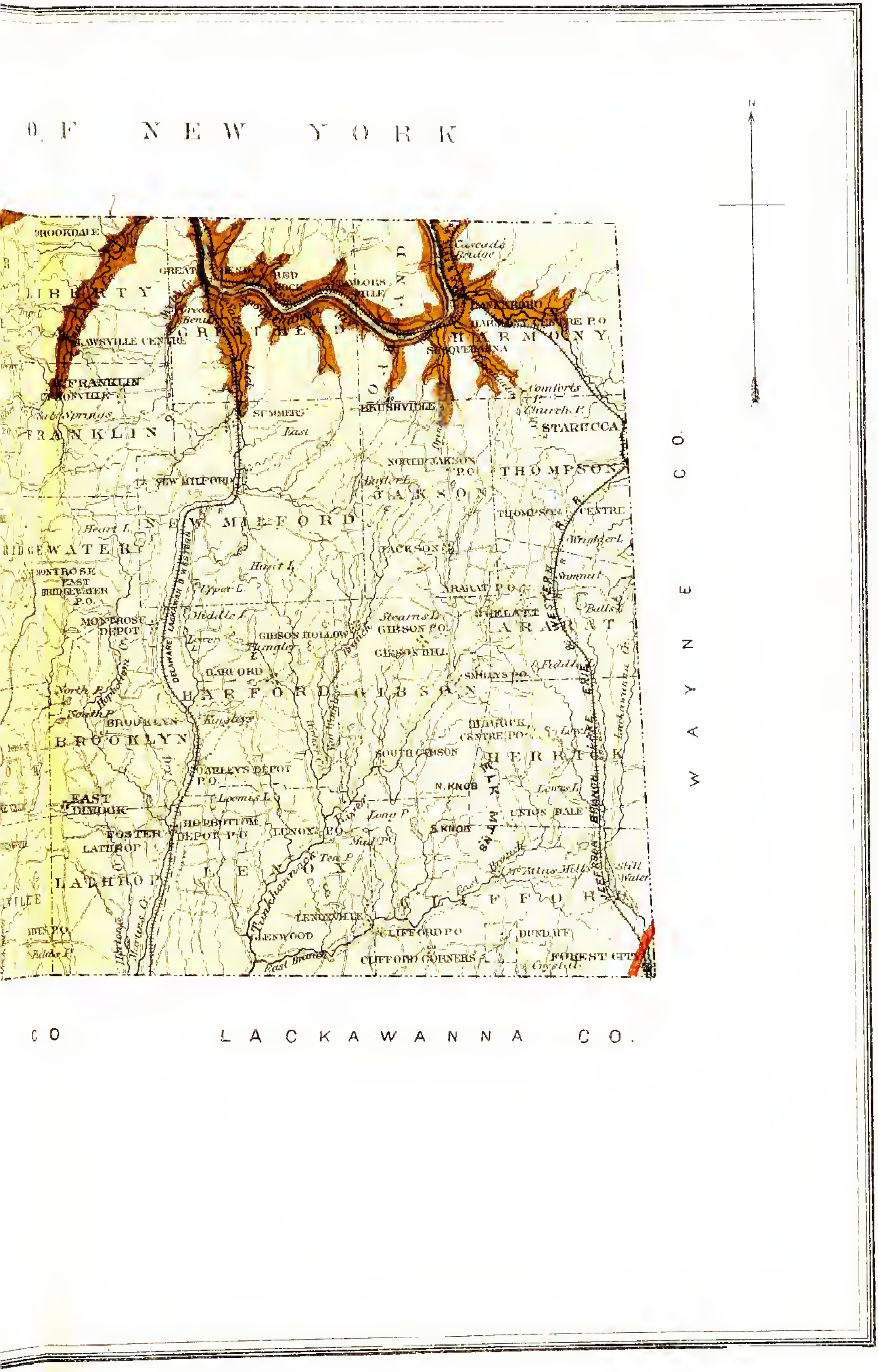
OF

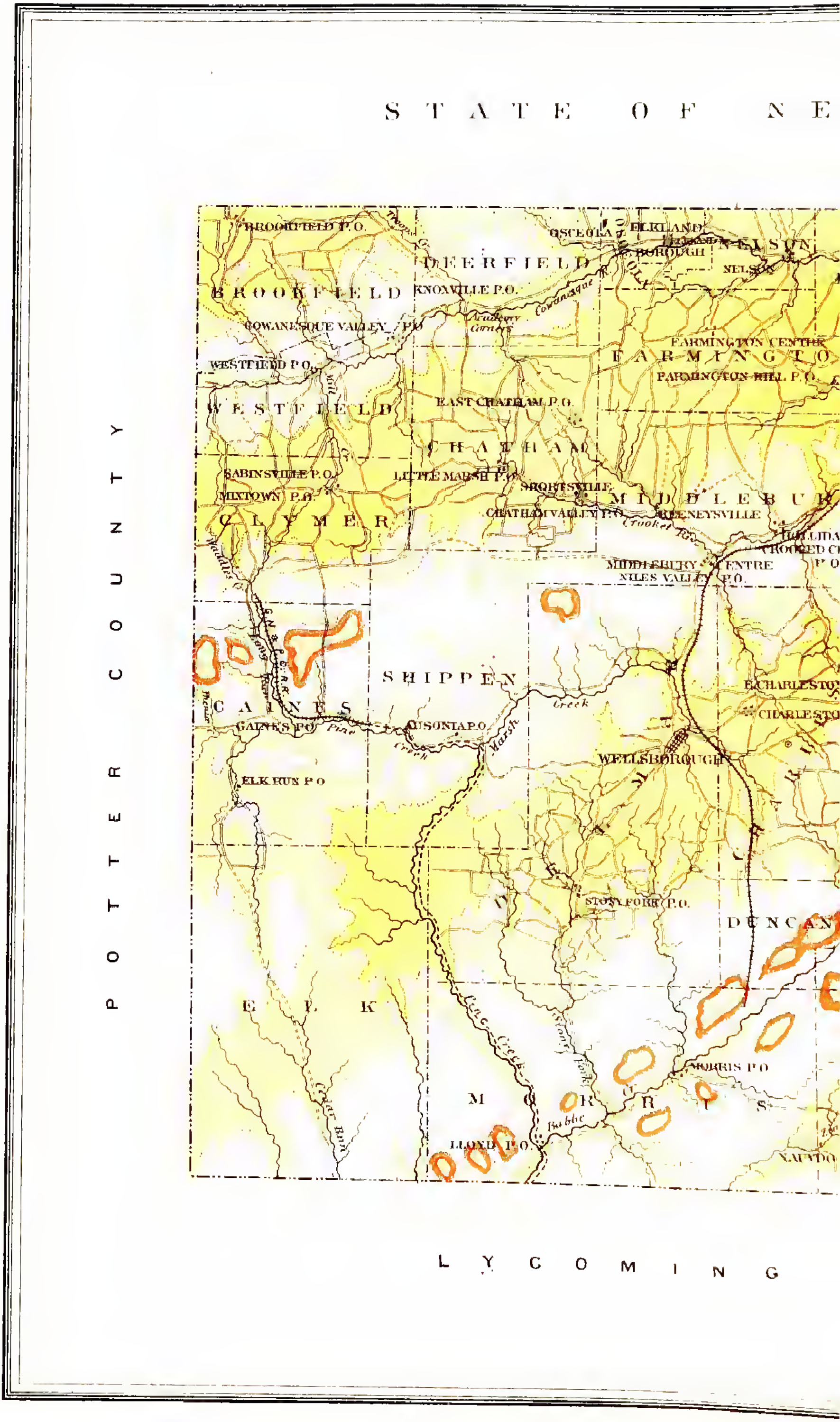
SUSQUEHANNA COUNTY

1881.

Scale: 6 miles to 1 inch

0 1 2 3 4 5 10 miles.


O F N E W Y O R K
W A Y N E C O.
L A C K A W A N N A C O.
C O
L I B E R T Y
F R A N K L I N
N E W M I L F O R D
J A C K S O N
T H O M P S O N
H A R M O N Y
A R A R A T
H A R F O R D
G I B S O N
B R O O K L Y N
H E R R I C K
L A T H R O P
C L I F F O R D
STARUCCA
NEW MILFORD
GIBSON HOLLOW
HARFORD
BRUSHVILLE
SUMMERS
N. KNOB
S. KNOB
UNION DALE
LENOXVILLE
CLIFFORD P.O.
CLIFFORD CORNERS
DUNDAFF
FOREST CITY
SOUTH GIBSON
GIBSON P.O.
MONTROSE DEPOT
BROOKLYN
EAST DIMOCK
LATHROP
KINGSLEY
HOPBOTTOM
FOSTER
BROOKDALE


STATE OF NE
POTTER COUNTY
LYCOMING
BROOKFIELD P.O.
BROOKFIELD
DEERFIELD
KNOXVILLE P.O.
OSCEOLA
ELKLAND
BOROUGH
NELSON
COWANESQUE VALLEY P.O.
Cowanesque R.
WESTFIELD P.O.
WESTFIELD
FARMINGTON CENTRE
FARMINGTON HILL P.O.
EAST CHATHAM P.O.
CHATHAM
SABINSVILLE P.O.
MIXTOWN P.O.
LITTLE MARSH P.O.
SHORTSVILLE
CHATHAM VALLEY P.O.
KEENEYSVILLE
CLYMER
MIDDLEBURY
MIDDLEBURY CENTRE P.O.
NILES VALLEY P.O.
Crooked Cr.
SHIPPEN
GAINES
GAINES P.O.
Pine Creek
AUSONIA P.O.
Marsh Creek
ELK RUN P.O.
WELLSBOROUGH
CHARLESTON
STONY FORK P.O.
DUNCAN
ELK
Cedar Run
Pine Creek
Stony Fork
MORRIS P.O.
MORRIS
LLOYD P.O.
Babbs Cr.

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

OF

TIOGA COUNTY

1878.

Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles

EXPLANATION OF COLORS

Coal Measures &	XII	
Red Shale	XI	
Pocono Sandstone	X	
Catskill	IX	
Chemung	VIII	

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

J. P. LESLEY, STATE GEOLOGIST.

GEOLOGICAL MAP

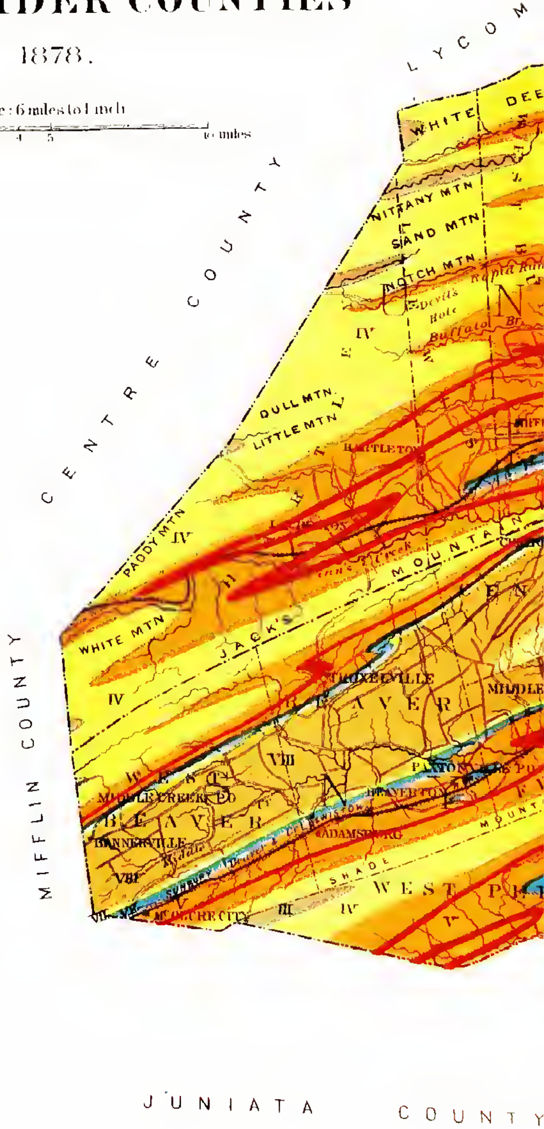
OF

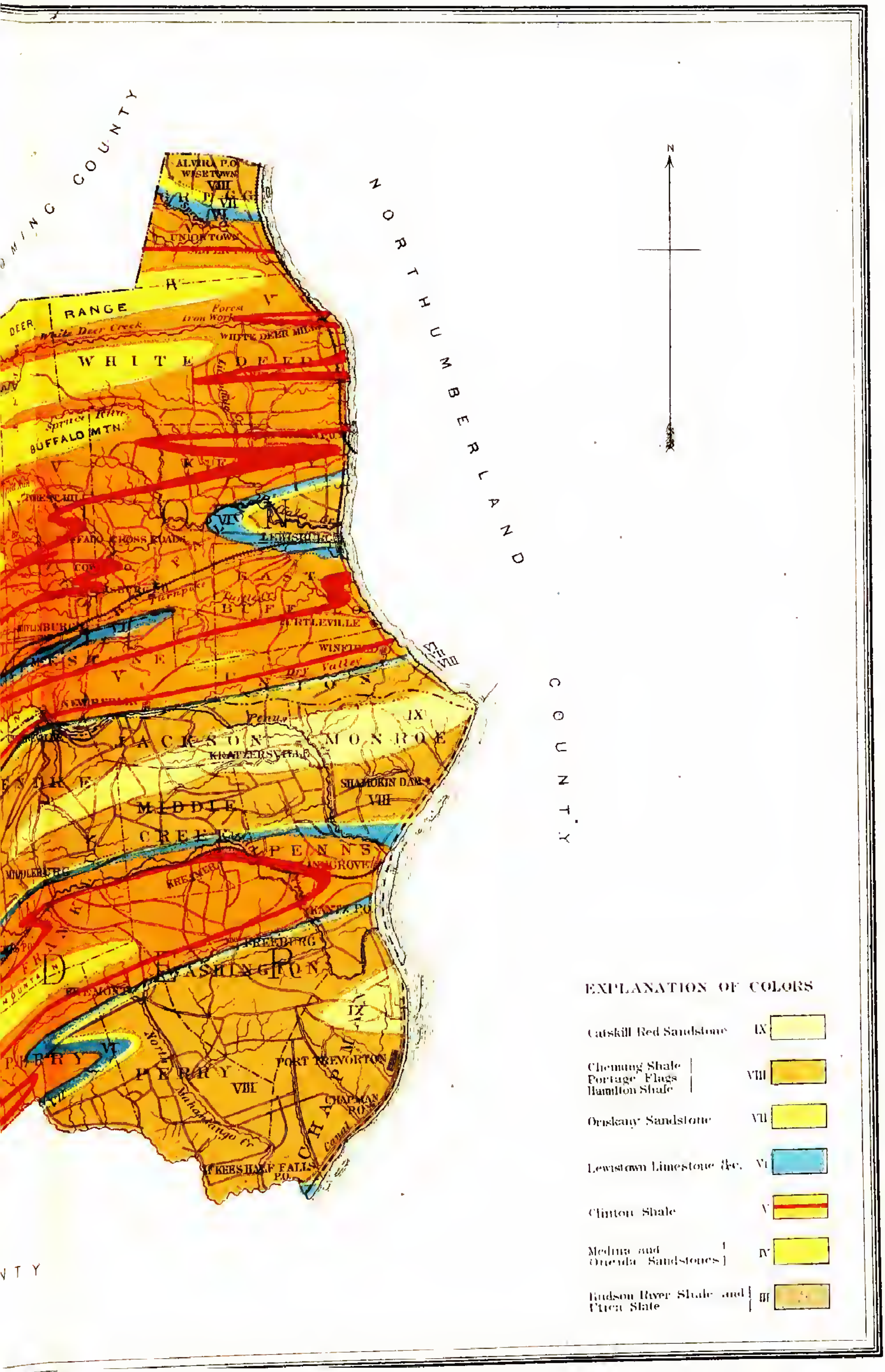
UNION AND SNYDER COUNTIES

1878.

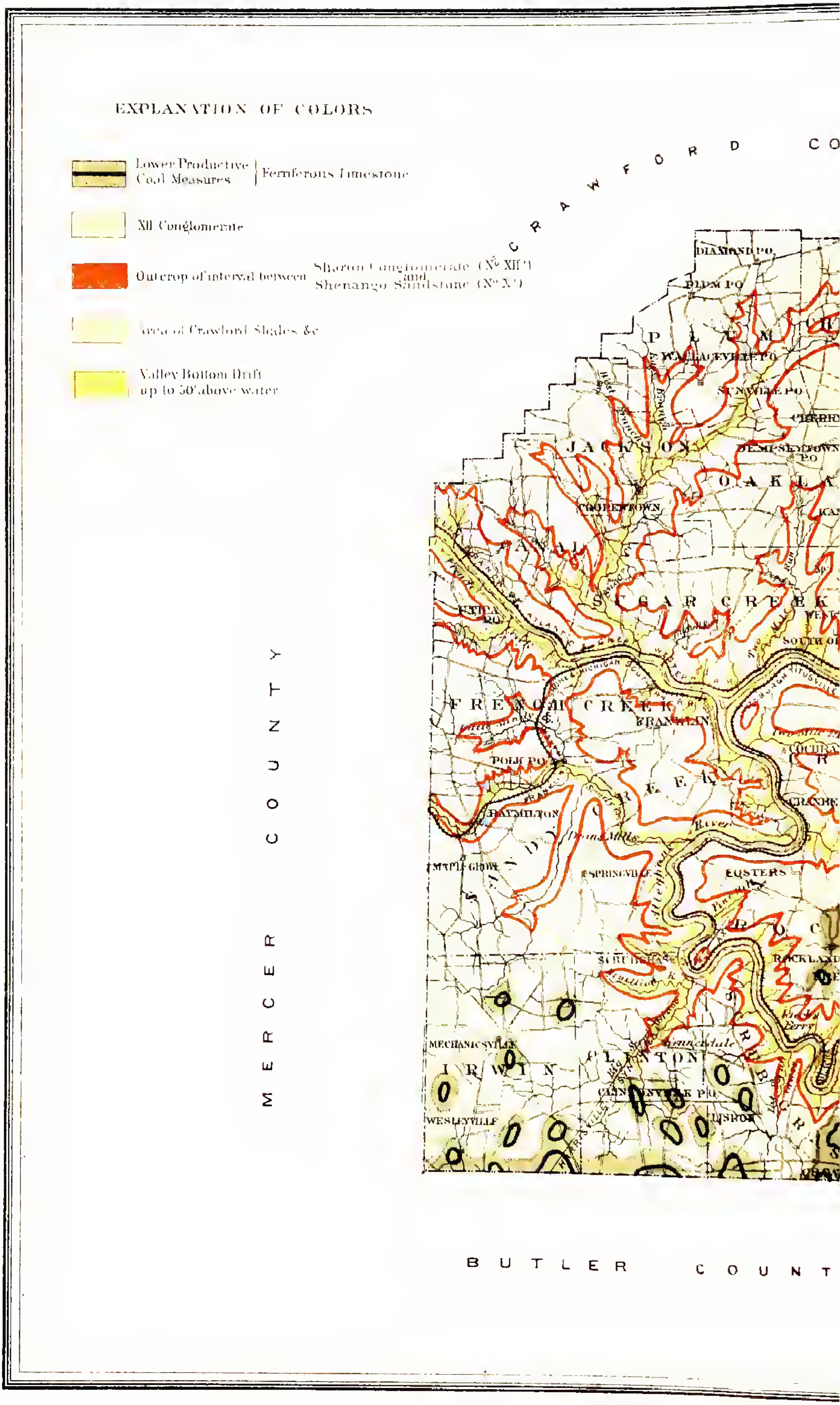
Scale: 6 miles to 1 inch

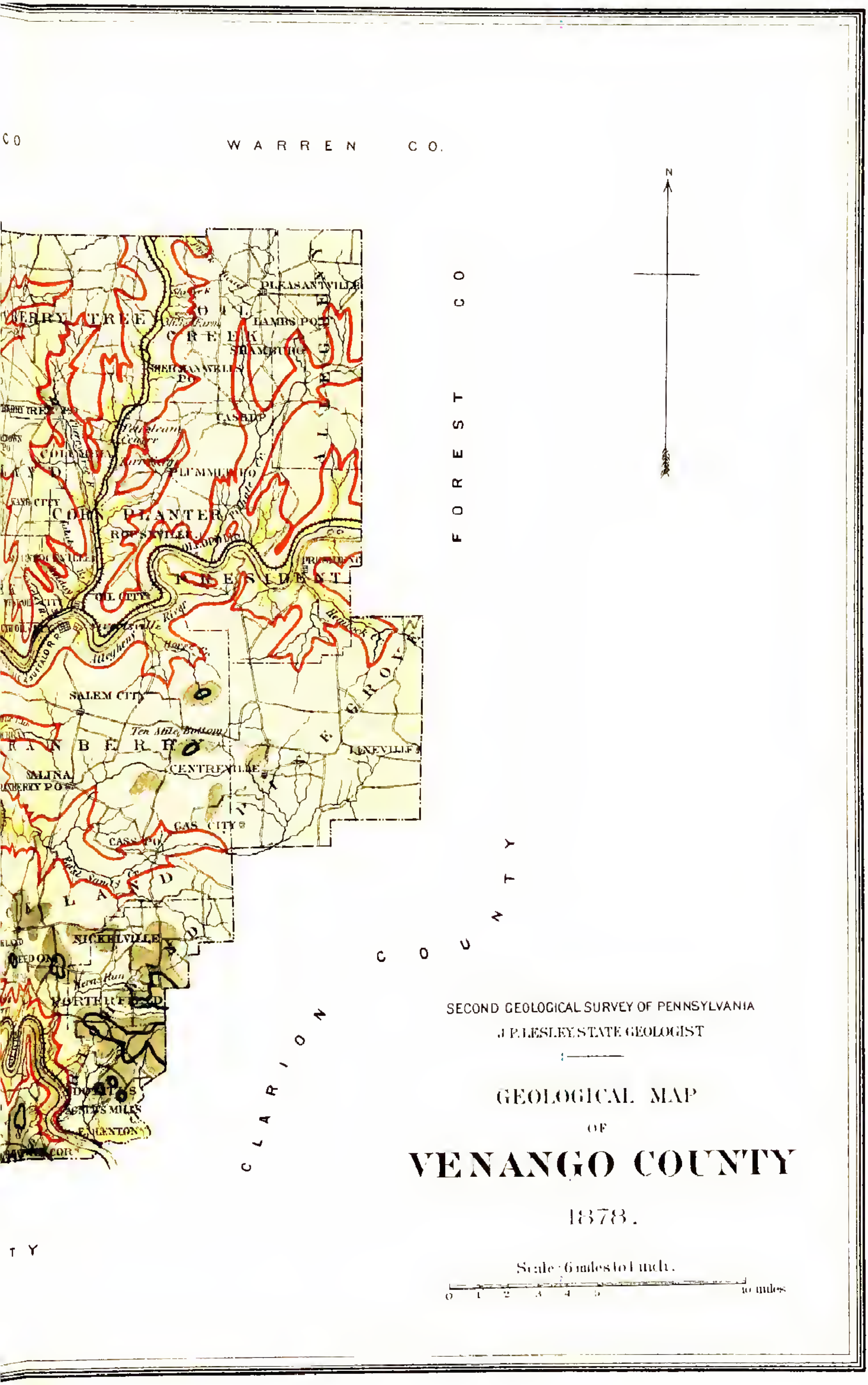
0 1 2 3 4 5 10 miles

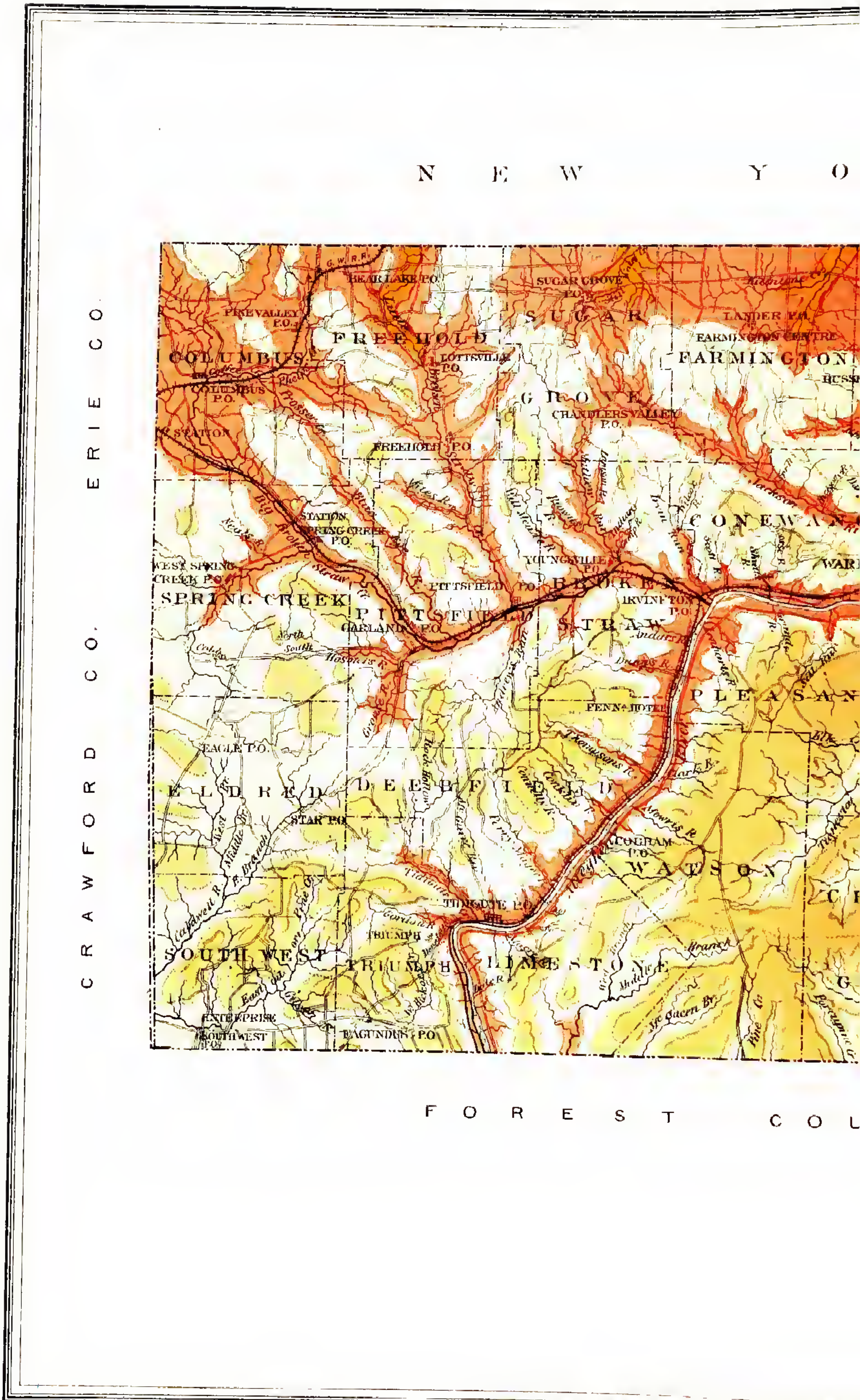




NORTHUMBERLAND COUNTY
ALVIRA P.O.
WISETOWN
UNION TOWN
RANGE
Forest Iron Works
White Deer Creek
WHITE DEER MILLS
WHITE DEER
BUFFALO MTN.
CROSS ROADS
LEWISBURG
Turnpike
Turtle Cr.
EAST BUFFALO
HARTLEVILLE
WINFIELD
Dry Valley
UNION
JACKSON
KRATZERSVILLE
MONROE
SHAMOKIN DAM
MIDDLE CREEK
PENNS
SELINSGROVE
MIDDLEBURG
KREAMER
KANTZ P.O.
FREEBURG
WASHINGTON
TREMONT
PERRY
North Mahantango Cr.
PORT TREVORTON
CHAPMAN
CHAPMAN RUN
Canal
MCKEES HALF FALLS P.O.
N
IX
VIII
VII
VI
EXPLANATION OF COLORS
Catskill Red Sandstone IX
Chemung Shale
Portage Flags
Hamilton Shale VIII
Oriskany Sandstone VII
Lewistown Limestone &c. VI
Clinton Shale V
Medina and
Oneida Sandstones IV
Hudson River Shale and
Utica Slate III


EXPLANATION OF COLORS
Lower Productive Coal Measures | Ferriferous Limestone
XII Conglomerate
Outcrop of interval between Sharon Conglomerate (N° XII) and Shenango Sandstone (N° X)
Area of Crawford Shales &c
Valley Bottom Drift up to 50' above water
CRAWFORD
MERCER COUNTY
BUTLER
DIAMOND PO
PLUM PO
WALLACEVILLE PO
SUNVILLE PO
JACKSON
COOPERSTOWN
CANAL
SUGAR CREEK
UTICA PO
FRENCH CREEK
FRANKLIN
POLK PO
HAMILTON
MAPLE GROVE
SPRINGVILLE
SCRUBGRASS
MECHANICSVILLE
IRWIN
CLINTON
WESLEYVILLE
LISBON


WARREN CO.
FOREST CO.
CLARION COUNTY
PLEASANTVILLE
LAMBS PO.
SHAMBURG
PLUMMER PO.
CORN PLANTER
PRESIDENT
OIL CITY
SALEM CITY
Ten Mile Bottom
CENTREVILLE
GAS CITY
NICKELVILLE
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY STATE GEOLOGIST
GEOLOGICAL MAP
OF
VENANGO COUNTY
1878.



N E W Y O
E R I E C O.
C R A W F O R D C O.
F O R E S T C O
BEAR LAKE P.O.
PINE VALLEY P.O.
SUGAR GROVE P.O.
S U G A R G R O V E
LANDER P.O.
FARMINGTON CENTRE
F A R M I N G T O N
F R E E H O L D
C O L U M B U S
COLUMBUS P.O.
LOTTSVILLE P.O.
CHANDLERS VALLEY P.O.
STATION
FREEHOLD P.O.
SPRING CREEK P.O.
WEST SPRING CREEK P.O.
S P R I N G C R E E K
YOUNGSVILLE P.O.
PITTSFIELD P.O.
P I T T S F I E L D
GARLAND P.O.
B R O K E N S T R A W
IRVINETON P.O.
FENN'S HOTEL
EAGLE P.O.
E L D R E D
D E E R F I E L D
STAR P.O.
COBHAM P.O.
W A T S O N
TIDIOUTE P.O.
TRIUMPH P.O.
S O U T H W E S T
T R I U M P H
L I M E S T O N E
ENTERPRISE
SOUTHWEST P.O.
FAGUNDUS P.O.

EXPLANATION OF COLORS

Coal Measures and Conglomerate XII

Sub-Olean Shales and Conglomerate

Crawford Shales

Venango Oil Sands (of J. F. Carll)

Chemung Flags (of I. C. White)

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

J. P. LESLEY, STATE GEOLOGIST

GEOLOGICAL MAP

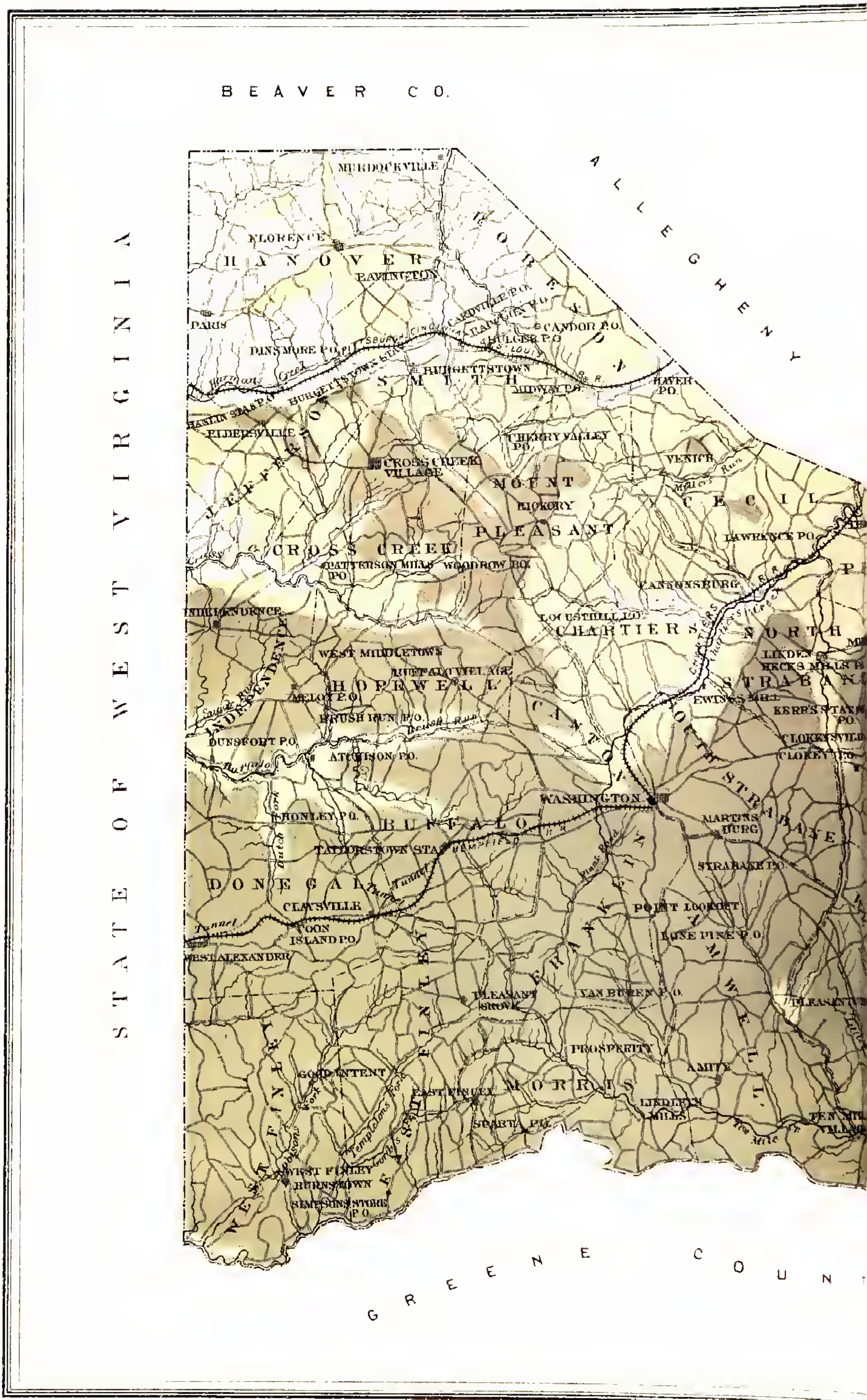
OF

WARREN COUNTY

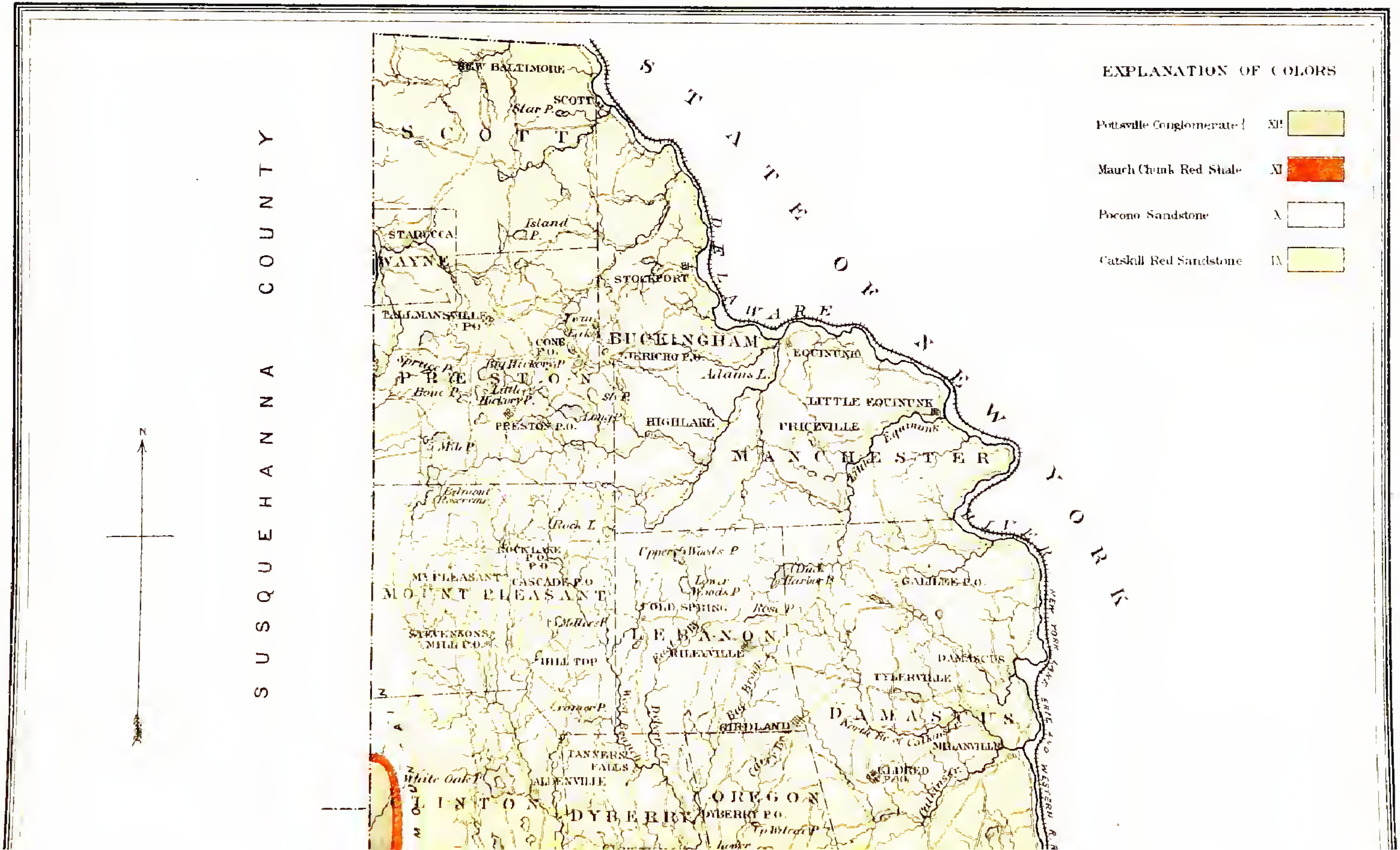
1884.

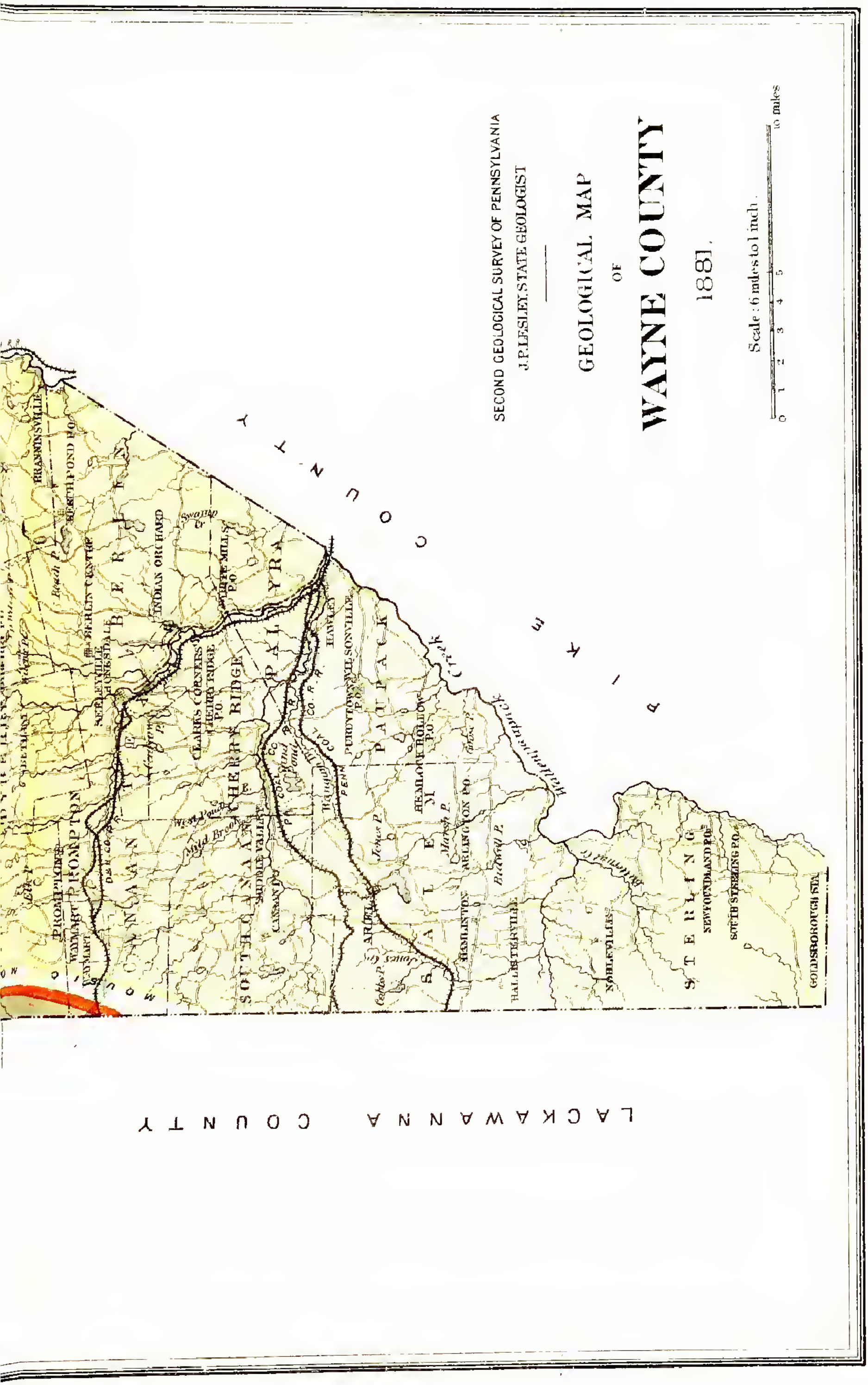
Scale: 6 miles to 1 inch

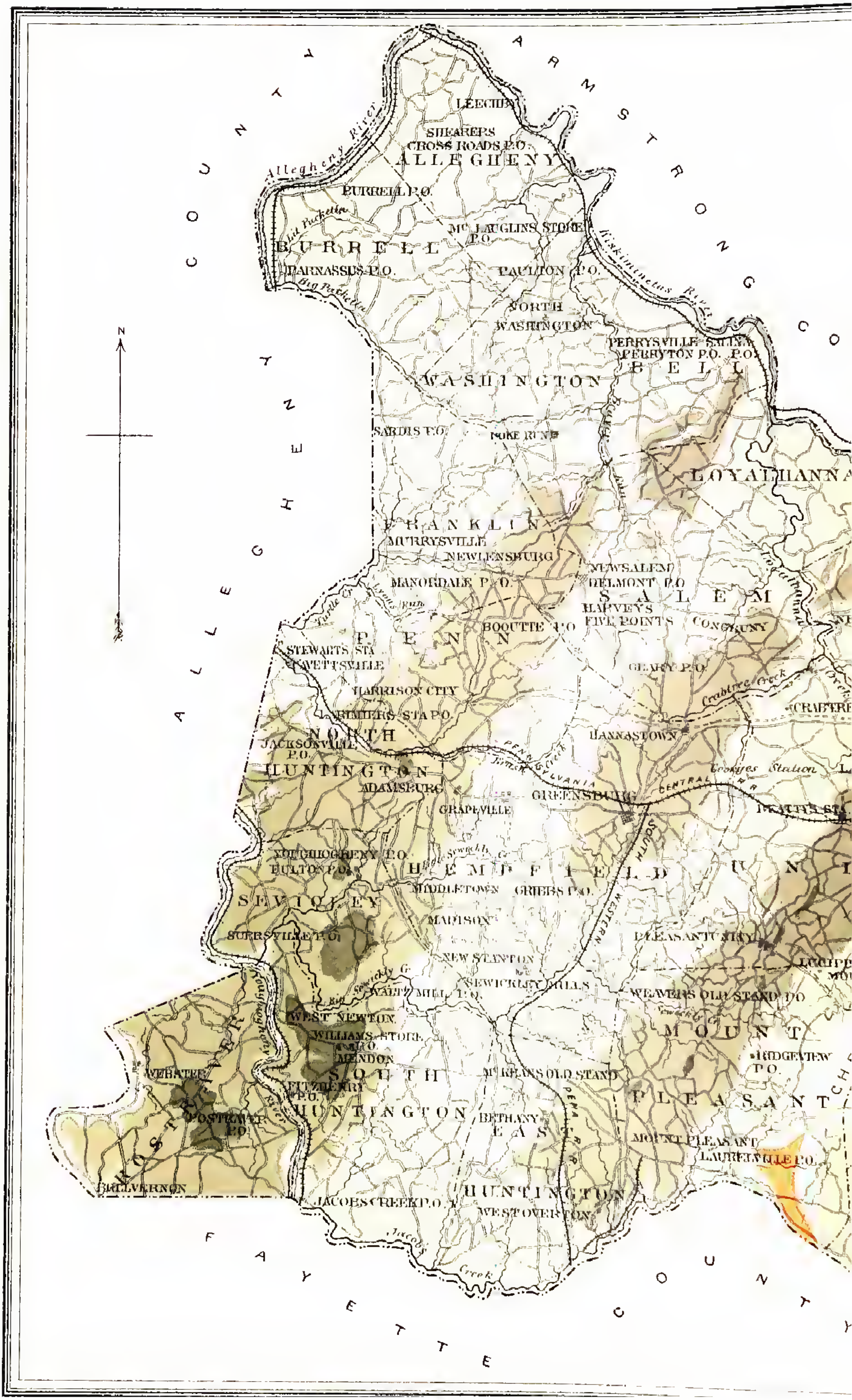
0 1 2 3 4 5 10 miles

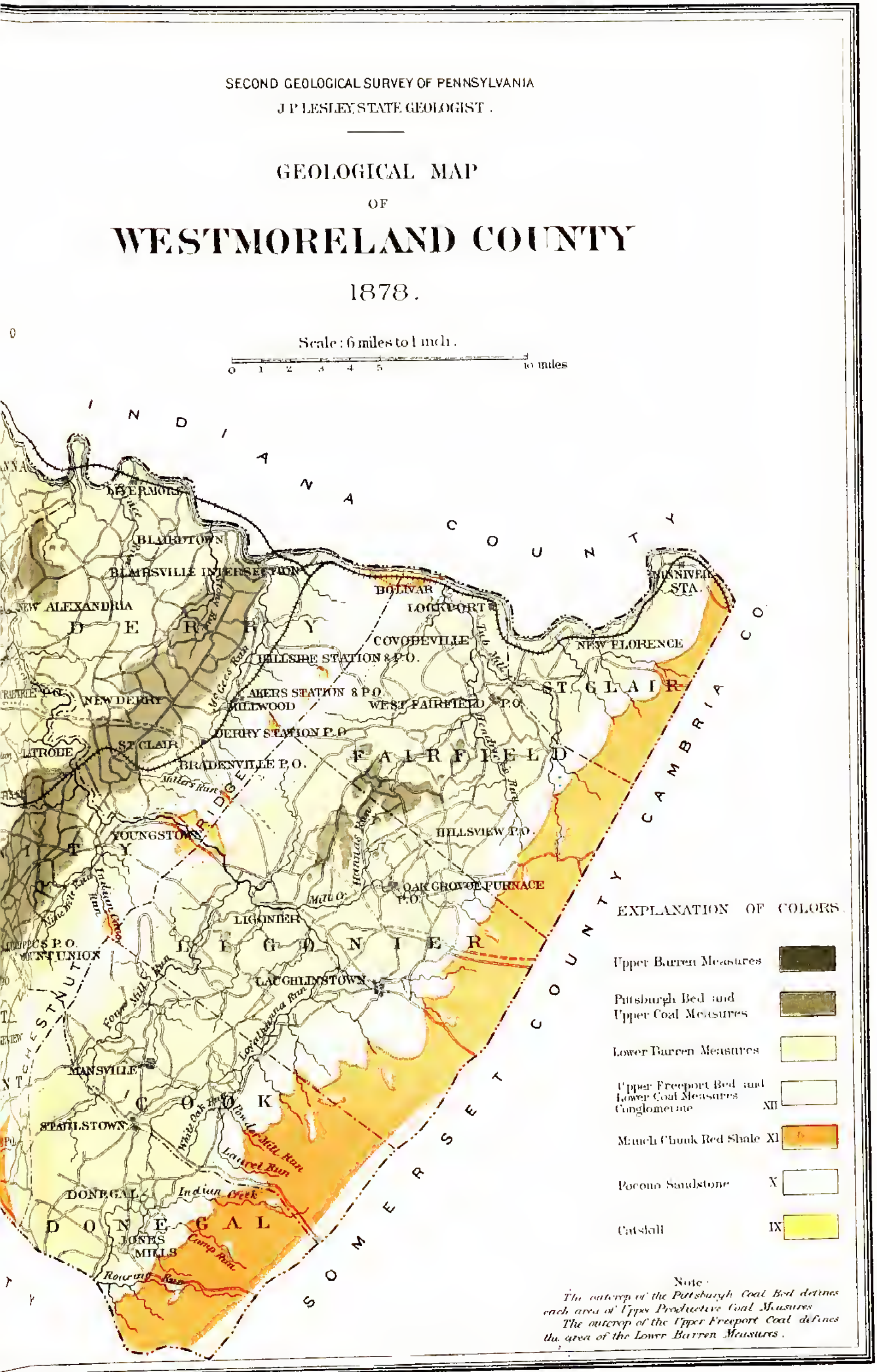

BEAVER CO.
ALLEGHENY
STATE OF WEST VIRGINIA
GREENE COUNTY
MURDOCKVILLE
FLORENCE
HANOVER
RAVINGTON
PARIS
DINSMORE P.O.
CANDOR P.O.
BULGER P.O.
BURGETTSTOWN
SMITH
MIDWAY P.O.
HAVER P.O.
ELDERSVILLE
CROSS CREEK VILLAGE
CHERRY VALLEY P.O.
VENICE
MOUNT PLEASANT
HICKORY
CECIL
LAWRENCE P.O.
CROSS CREEK
PATTERSON MILLS P.O.
WOODROW P.O.
CANONSBURG
INDEPENDENCE
LOCUST HILL P.O.
CHARTIERS
NORTH STRABANE
WEST MIDDLETOWN
BUFFALO VILLAGE
HOPEWELL
MELOY P.O.
BRUSH RUN P.O.
EWINGS MILL
KERR'S STATION P.O.
CANTON
DUNSFORT P.O.
ATKINSON P.O.
WASHINGTON
SOUTH STRABANE
HONLEY P.O.
BUFFALO
MARTINSBURG
TAYLORSTOWN STA.
STRABANE P.O.
DONEGAL
CLAYSVILLE
POINT LOOKOUT
COON ISLAND P.O.
LONE PINE P.O.
WEST ALEXANDER
PLEASANT GROVE
VAN BUREN P.O.
FRANKLIN
AMWELL
PROSPERITY
AMITY
GOOD INTENT
EAST FINLEY
MORRIS
LINDLEY'S MILLS
SPARTA P.O.
TEN MILE VILLAGE
WEST FINLEY
BURNSTOWN
SIMPSON'S STORE P.O.
WEST FINLEY
EAST FINLEY
Buffalo
Dutch Fork
Brush Run
Chartiers Creek
Millers Run
Ten Mile
Templeton's Fork
Plank Road
Tunnel


SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J.P. LESLEY, STATE GEOLOGIST
GEOLOGICAL MAP
OF
WASHINGTON COUNTY
1878.
Scale: 6 miles to 1 inch
0 1 2 3 4 5 10 miles
N
COUNTY
WESTMORELAND CO.
FAYETTE CO.
NTY
NOTTINGHAM
SOMERSET
FALLOWFIELD
CARROLL
WEST PIKE RUN
EAST BETHLEHEM
WEST BETHLEHEM
BOWER HILL
CURRYVILLE
MONONGAHELA CITY
GINGER HILL
COLUMBIA
LOCK No. 4 P.O.
JONES STORE
BENTLEYVILLE
HILLSBOROUGH
GRANVILLE
CALIFORNIA
BEALLSVILLE
CENTREVILLE
W. BROWNSVILLE
BRIDGEPORT
ZOLLARSVILLE
MILLSBOROUGH
MONONGAHELA RIVER
EXPLANATION OF COLORS.
Upper Barren Measures
Pittsburgh Bed and Upper Coal Measures
Lower Barren Measures


EXPLANATION OF COLORS
Pottsville Conglomerate XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill Red Sandstone IX
STATE OF NEW YORK
SUSQUEHANNA COUNTY
DELAWARE RIVER
NEW YORK LAKE ERIE AND WESTERN R.R.
SCOTT
NEW BALTIMORE
STARUCCA
WAYNE
STOCKPORT
BUCKINGHAM
JERICHO P.O.
EQUINUNK
LITTLE EQUINUNK
PRICEVILLE
MANCHESTER
PRESTON
TALLMANSVILLE P.O.
CONE P.O.
PRESTON P.O.
HIGHLAKE
MOUNT PLEASANT
CASCADE P.O.
STEVENSONS MILL P.O.
HILL TOP
LEBANON
COLD SPRING
GALILEE P.O.
DAMASCUS
TYLERVILLE
GIRDLAND
TANNERS FALLS
ALDENVILLE
MILANVILLE
ELDRED P.O.
CLINTON
DYBERRY
DYBERRY P.O.
OREGON


SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J.P. LESLEY, STATE GEOLOGIST
GEOLOGICAL MAP
OF
WAYNE COUNTY
1881.
Scale: 6 miles to 1 inch.
PIKE COUNTY
LACKAWANNA COUNTY


ARMSTRONG CO
ALLEGHENY COUNTY
FAYETTE COUNTY
ALLEGHENY
BURRELL
WASHINGTON
BELL
LOYALHANNA
FRANKLIN
SALEM
PENN
NORTH HUNTINGTON
HEMPFIELD
SEWICKLEY
ROSTRAVER
SOUTH HUNTINGTON
EAST HUNTINGTON
MOUNT PLEASANT
LEECHBURG
SHEARERS CROSS ROADS P.O.
BURRELL P.O.
PARNASSUS P.O.
PAULTON P.O.
NORTH WASHINGTON
SARDIS P.O.
MURRYSVILLE
NEWLENSBURG
MANORDALE P.O.
NEW SALEM
DELMONT P.O.
HARVEYS FIVE POINTS
BOQUTTE P.O.
STEWARTS STA
HARRISON CITY
JACKSONVILLE P.O.
ADAMSBURG
GRAPEVILLE
GREENSBURG
HANNASTOWN
GEARY P.O.
YOUGHIOGHENY P.O.
FULTON P.O.
MIDDLETOWN
GRIBBS P.O.
MADISON
NEW STANTON
SEWICKLEY MILLS
WEST NEWTON
WEBSTER
BELLVERNON
FITZHENRY P.O.
BETHANY
MOUNT PLEASANT
LAURELVILLE P.O.
JACOBS CREEK P.O.
WESTOVERTON
Allegheny River
Kiskiminetas River
Crabtree Creek
Jacobs Creek
PENNSYLVANIA CENTRAL R.R.
SOUTH WESTERN
PENNA R.R.
N

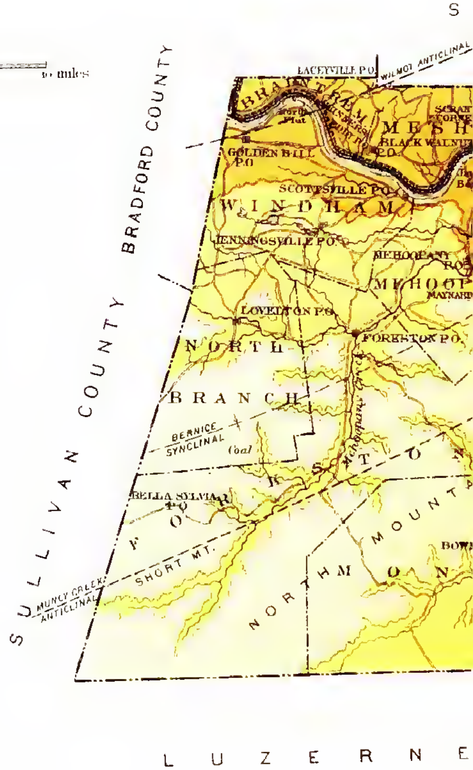

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST.
GEOLOGICAL MAP
OF
WESTMORELAND COUNTY
1878.
Scale: 6 miles to 1 inch.
0 1 2 3 4 5 10 miles
INDIANA COUNTY
CAMBRIA CO.
SOMERSET COUNTY
DERRY
FAIRFIELD
ST. CLAIR
LIGONIER
COOK
DONEGAL
CHESTNUT RIDGE
LIVERMORE
BLAIRSTOWN
BLAIRSVILLE INTERSECTION
NEW ALEXANDRIA
BOLIVAR
LOCKPORT
COVODEVILLE
HILLSIDE STATION & P.O.
AKERS STATION & P.O.
MILLWOOD
WEST FAIRFIELD P.O.
NEW FLORENCE
NINEVEH STA.
NEW DERRY
DERRY STATION P.O.
ST. CLAIR
LATROBE
BRADENVILLE P.O.
YOUNGSTOWN
HILLSVIEW P.O.
OAK GROVE FURNACE P.O.
LIGONIER
MOUNT UNION
LAUGHLINSTOWN
MANSVILLE
STAHLSTOWN
DONEGAL
JONES MILLS
Millers Run
Indian Creek
Four Mile Run
Loyalhanna Run
White Oak Run
Powder Mill Run
Laurel Run
Camp Run
Roaring Run
Mill Cr.
Hannas Run
Tub Mill
EXPLANATION OF COLORS.
Upper Barren Measures
Pittsburgh Bed and Upper Coal Measures
Lower Barren Measures
Upper Freeport Bed and Lower Coal Measures
Conglomerate XII
Mauch Chunk Red Shale XI
Pocono Sandstone X
Catskill IX
Note:
The outcrop of the Pittsburgh Coal Bed defines each area of Upper Productive Coal Measures.
The outcrop of the Upper Freeport Coal defines the area of the Lower Barren Measures.

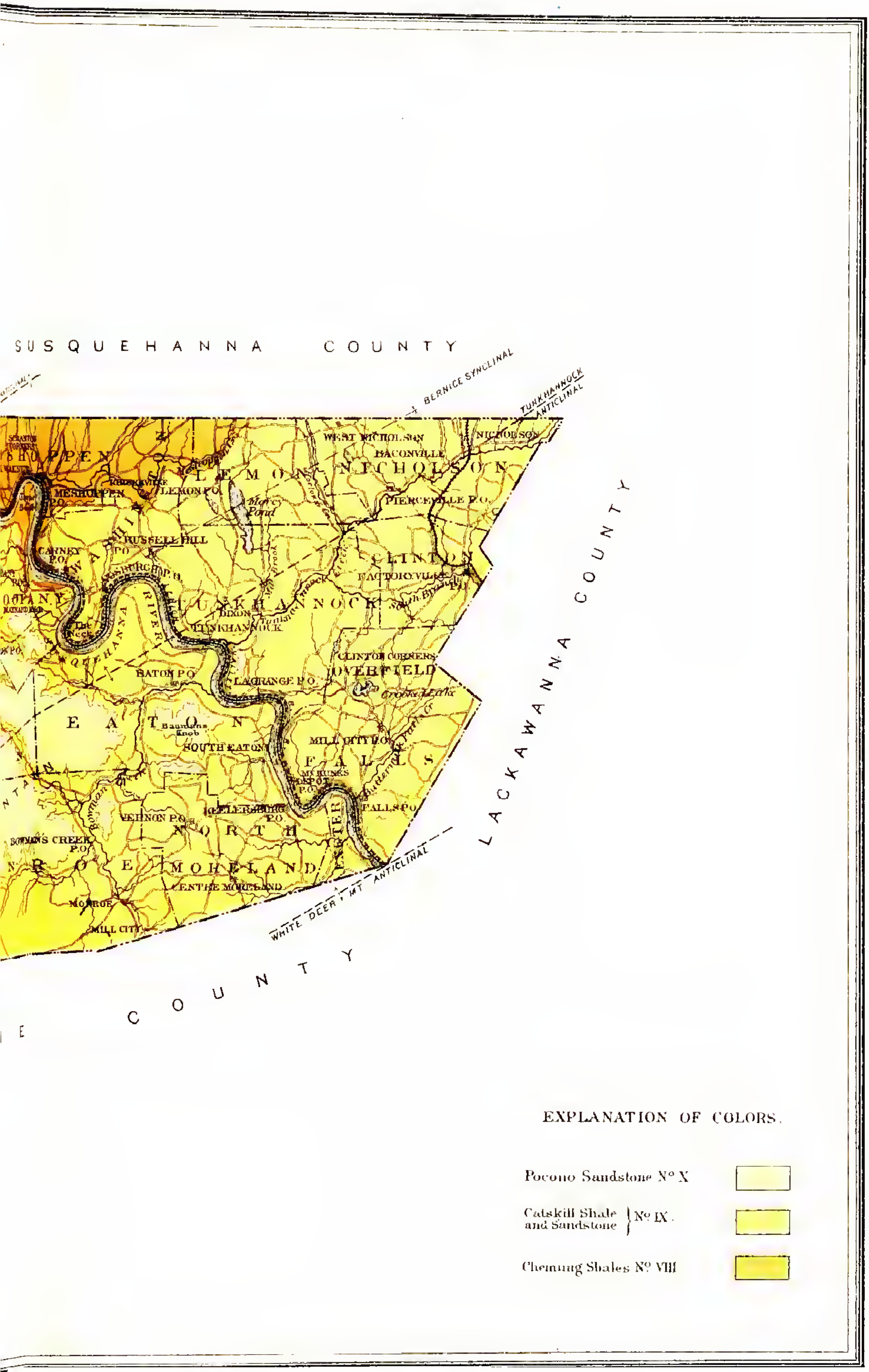
SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST.

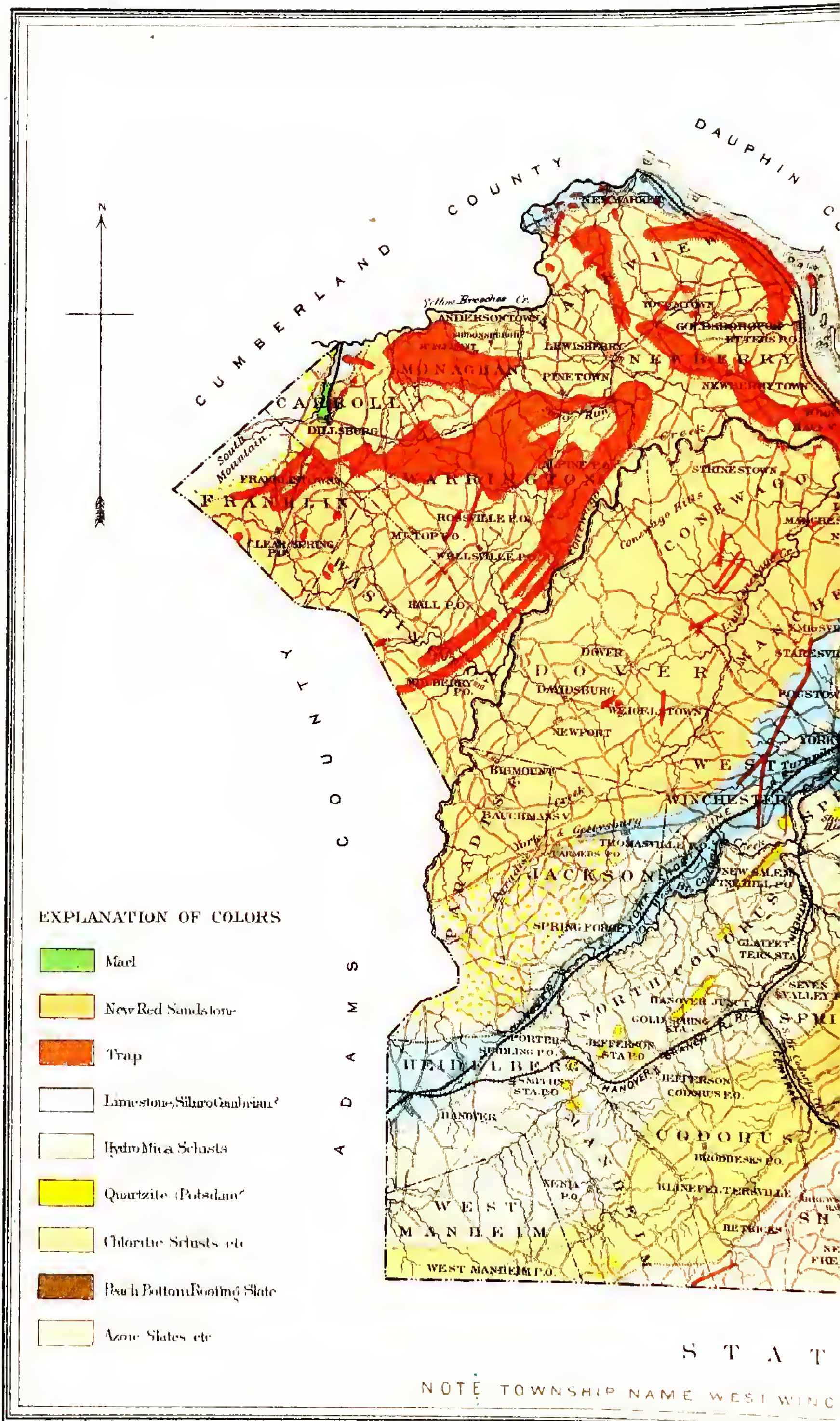
GEOLOGICAL MAP
OF
WYOMING COUNTY
1881

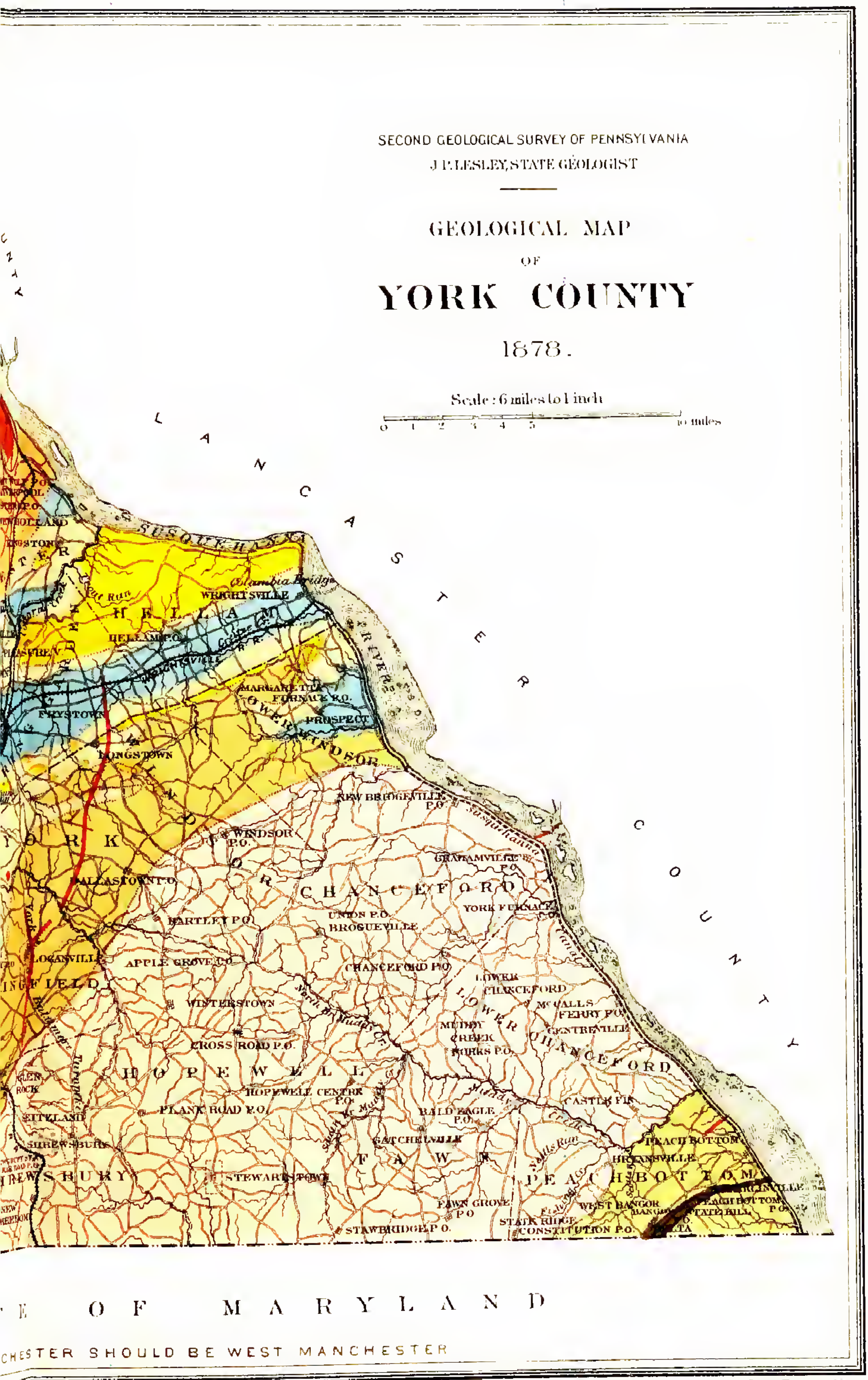
Scale: 6 miles to 1 inch.

0 1 2 3 4 5 10 miles




SUSQUEHANNA COUNTY
BERNICE SYNCLINAL
TUNKHANNOCK ANTICLINAL
LACKAWANNA COUNTY
WHITE DEER MT ANTICLINAL
COUNTY
WEST NICHOLSON
BACONVILLE
NICHOLSON
LEMON
LEMON P.O.
MESHOPPEN P.O.
RUSSELL HILL
CARNEY P.O.
PIERCEVILLE P.O.
CLINTON
FACTORYVILLE
TUNKHANNOCK
DIXON
RIVER
EATON P.O.
LAGRANGE P.O.
CLINTON CORNERS
OVERFIELD
EATON
SOUTH EATON
MILL CITY P.O.
FALLS
FALLS P.O.
VERNON P.O.
NORTH MORELAND
BOWMANS CREEK P.O.
CENTRE MORELAND
MONROE
MILL CITY
EXPLANATION OF COLORS.
Pocono Sandstone N° X
Catskill Shale and Sandstone } N° IX.
Chemung Shales N° VIII


CUMBERLAND COUNTY
DAUPHIN
ADAMS COUNTY
Yellow Breeches Cr.
NEWMARKET
ANDERSONTOWN
LEWISBERRY
NEWBERRY
NEWBERRYTOWN
GOLDSBOROUGH
PINETOWN
MONAGHAN
CARROLL
DILLSBURG
South Mountain
FRANKLINTOWN
FRANKLIN
WARRINGTON
ROSSVILLE P.O.
CLEAR SPRING P.O.
WELLSVILLE P.O.
BALL P.O.
STRINESTOWN
CONEWAGO
Conewago Hills
DOVER
DAVIDSBURG
WEIGELSTOWN
NEWPORT
WEST
WINCHESTER
BAUGHMANS V.
THOMASVILLE P.O.
JACKSON
SPRING FORGE P.O.
NORTH CODORUS
PARADISE
HANOVER JUNCT.
GLATFELT
SEVEN VALLEYS
JEFFERSON STA. P.O.
PORTERS SIDING P.O.
HEIDELBERG
HANOVER
CODORUS
BRODBECKS P.O.
KLINEFELTERSVILLE
WEST MANHEIM
WEST MANHEIM P.O.
MANHEIM
YORK
EXPLANATION OF COLORS
Marl
New Red Sandstone
Trap
Limestone, Siluro Cambrian
Hydro Mica Schists
Quartzite (Potsdam)
Chloritic Schists etc
Peach Bottom Roofing Slate
Azoic Slates etc
S T A T
NOTE. TOWNSHIP NAME WEST WINC


SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA
J. P. LESLEY, STATE GEOLOGIST
GEOLOGICAL MAP
OF
YORK COUNTY
1878.
Scale: 6 miles to 1 inch
0 1 2 3 4 5 10 miles
LANCASTER
COUNTY
SUSQUEHANNA
HELLAM
WRIGHTSVILLE
Columbia Bridge
HELLAM P.O.
FRYSTOWN
MARGARETTA FURNACE P.O.
PROSPECT
LOWER WINDSOR
LONGSTOWN
NEW BRIDGEVILLE P.O.
WINDSOR P.O.
DALLASTOWN P.O.
GRAHAMVILLE P.O.
CHANCEFORD
YORK FURNACE
UNION P.O.
BROGUEVILLE
HARTLEY P.O.
LOGANVILLE
APPLE GROVE P.O.
CHANCEFORD P.O.
LOWER CHANCEFORD
McCALLS FERRY P.O.
WINTERSTOWN
CENTREVILLE
MUDDY CREEK FORKS P.O.
CROSS ROAD P.O.
HOPEWELL
HOPEWELL CENTRE P.O.
CASTLE FIN
PLANK ROAD P.O.
BALD EAGLE P.O.
GATCHELLVILLE
PEACH BOTTOM
FAWN
SHREWSBURY
STEWARTSTOWN
FAWN GROVE P.O.
WEST BANGOR
STATE RIDGE
CONSTITUTION P.O.
STAWBRIDGE P.O.
OF MARYLAND
CHESTER SHOULD BE WEST MANCHESTER

THE PUBLICATIONS

OF THE

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

FROM 1874 TO 1885.

Reports have been issued by the Board of Commissioners, and the prices thereof fixed in accordance with the law authorizing their publication, as follows:

MISCELLANEOUS REPORTS.

A. A history of the FIRST GEOLOGICAL SURVEY of Pennsylvania from 1856 to 1858, by J. P. Lesley. With the annual reports of the Board to the Legislature for 1874 and 1875. 8°, pp. 226, 1876. Price in paper $0 25, postage $0 06.

B. Report on the MINERALS of Pennsylvania, by F. A. Genth; and on the hydro-carbon compounds, by S. P. Sadtler. With a reference map of the State. 8°, pp. 206, 1875. Price in paper $0 50, postage $0 08; in cloth $0 75, postage $0 10.

B 2. Report on the MINERALS, by F. A. Genth, continued from page 207 to page 238. 8°, in paper cover, pp. 31, 1876. (Bound with B.)

M. Report of CHEMICAL ANALYSES in 1874-5, in the Laboratory at Harrisburg, by A. S. McCreath. 8°, pp. 105, 1875. Price in paper $0 50, postage $0 05.

M 2. Report of CHEMICAL ANALYSES in 1876-8, by A. S. McCreath: Classification of coals, by P. Frazer; Fire-brick tests, by F. Platt; Dolomitic limestone beds, by J. P. Lesley; Utilization of anthracite slack, by F. Platt; Determination of Carbon in iron or steel, by A. S. McCreath. With one folded plate (section at Harrisburg) and four page plates. 8°, pp. 438, 1879. Price $0 65, postage $0 18.

M 3. Report of CHEMICAL ANALYSES in 1879-80, by A. S. McCreath. With a reference map of 93 iron ore mines in the Cumberland valley. 8°, pp. 126, 1881. Price $0 40, postage $0 10.

N. Report on the LEVELS above tide of railroad, canal and turnpike stations, mountain tops, &c., in and around Pennsylvania, in 200 tables, by C. Allen. With a map. 8°, pp. 279, 1878. Price $0 70, postage $0 15.

O. CATALOGUE of specimens collected by the survey (No. 1 to No. 4,264) by C. E. Hall. 8°, pp. 217, 1878. Price $0 40, postage $0 10.

O 2. CATALOGUE (continued from No. 4,265 to No. 8,974); also catalogue of fossils (pp. 231 to 239.) 8°, pp. 272, 1880. Price $0 40, postage $0 12.

O 3. CATALOGUE (continued from No. 8,975 to No. .) 8°, pp. , 1885. Price $, postage $. (*Waiting to go to press.*)

P. Report on the COAL FLORA of Pennsylvania and the United States, Vols. 1 and 2, (bound together,) by L. Lesquereux. 8°, pp. 694, 1880. Price $0 80, postage $0 28.

P. Report on the COAL FLORA of Pennsylvania and the United States, Vol. 3, with 24 double page plates (lithographed) of coal plants, to accompany P. Vols. 1 and 2. 8°, pp. 283, 1884. Price $1 20, postage $0 18.

(P.) ATLAS of 87 double page plates (lithographed) of coal plants, to accompany P. Vols. 1 and 2. 8°, 1879. Prico $3 35, postage $0 22.

P 2. Report on Permo-Carboniferous plants from W. Va. and Greene county, Pennsylvania, by W. M. Fontaine and I. C. White. With 38 double page plates (lithographed.) 8°, pp. 143, 1880. Price $2 25, postage $0 17.

P 3. Description of *Ceratiocaridæ*, by C. E. Beecher; and of *Eurypteridæ*, by James Hall. With 8 plates. 8°, pp. 39, 1884. Price $0 60, postage $0 07.

Z. Report on the TERMINAL MORAINE across Pennsylvania, by H. C. Lewis; including extracts from descriptions of the Moraine in New Jersey, by G. H. Cook, and in Ohio, Kentucky, and Indiana, by G. F. Wright. With a map of the State, 18 photographic views of the moraine, and 32 page plate maps and sections. 8°, pp. lvi and 299, 1884. Price $1 40, postage $0 17.

GRAND ATLAS, Div. I, Pt. I, 1885, port-folio containing maps of 56 counties and parts of counties (scale 2 miles to 1 inch) on 49 sheets (26″×32″). The maps of the remaining counties will be published in Part II. These maps are duplicate prints on heavy paper of the county maps contained in the reports of progress. Price $7 25, expressage from Harrisburg, $

ANTHRACITE REGION.

A 2. Report on the causes, kinds, and amount of WASTE in mining anthracite, by F. Platt; with a chapter on METHODS of mining, by J. P. Wetherill. Illustrated by 35 figures of mining operations, a plan of the Hammond breaker, and a specimen sheet of the maps of the Anthracite coal fields. 8°, pp. 134, 1881. Price $1 10, postage $0 12.

AC. Report on MINING METHODS, &c., in the anthracite coal fields, by H. M. Chance. Illustrated with 54 plates and 60 illustrations in the text. 8°, pp. 574, 1883. Price $1 40, postage $0 25.

AC. ATLAS containing 25 plates illustrating coal mining, to accompany Report AC, by H. M. Chance. 8°, 1883. Price $1 40, postage $0 12.

AA. First report of progress of the anthracite survey; PANTHER CREEK BASIN, by C. A. Ashburner; with a determination of the latitude and longitude of Wilkes Barre and Pottsville, by C. L. Doolittle; and a theory of stadia measurements, by A. Winslow. 8°, pp. 407, 1883. Price $0 58, postage $0 18.

(AA.) ATLAS of SOUTHERN anthracite field, Part I, containing 13 sheets: 3 mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topographical map sheet, and 1 coal bed area sheet, relating to the PANTHER CREEK BASIN; 1 general map of the anthracite region, and 1 chart of anthracite production from 1820 to 1881. 8°. 1882. Chas. A. Ashburner, Geologist in charge; A. W. Sheafer and Frank A. Hill, Assistant Geologists. Price $1 50, postage $0 12.

(AA.) ATLAS of WESTERN MIDDLE anthracite field, Part I, containing 11 sheets: 4 mine sheets between Delano and Locust Dale, 3 topographical sheets between Quakake Junction and Mount Carmel, and 4 cross section sheets. 8°,

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NOTES.—Single sheets of the Anthracite Survey, with the exception of those in the Panther Creek atlas, can be purchased by addressing Chas. A. Ashburner, Geologist in Charge, 907 Walnut street, Philadelphia. See page 9.

1884. Chas. A. Ashburner, Geologist in charge; A. W. Sheafer and Bard Wells, Assistant Geologists. Price $1 65, postage $0 11.

(AA.) ATLAS of NORTHERN anthracite field, Part I, containing 6 mine sheets between Wilkes Barre and Nanticoke, 3 cross section sheets, and 4 columnar section sheets. 8°, 1885. Chas. A. Ashburner, Geologist in charge; Frank A. Hill, Assistant Geologist. Price $, postage $.

(AA.) GRAND ATLAS, Div. II, Pt. I, 1884, port-folio containing 26 sheets (26″×32″) as follows: 13 sheets Atlas Southern Anthracite Field, Part I, 11 sheets Atlas Western Middle Anthracite Field Part I, 1 sheet photo views of plaster models in Western Middle and Southern Fields, and 1 specimen sheet Report A 2. Price $4 25, expressage from Harrisburg $.

For anthracite coal in SULLIVAN county, see G 2.

For Conglomerate beds near Carbondale, Pittston, &c., see G 5, G 7.

For Utilization of anthracite slack, see M 2.

For single sheets see page 9.

BITUMINOUS COAL FIELDS AND SURROUNDING AREAS.

H. First report on CLEARFIELD and JEFFERSON counties, by F. Platt. With 8 maps, 2 sections, and 139 cuts in the text. 8°, pp. 296, 1875. Price unbound $1 50, postage $0 13 (*For second report see H 6, H 7.*)

H 2. Report on CAMBRIA county, by F. & W. G. Platt. With 4 maps and sections and 84 cuts in the text. 8°, pp. 194, 1877. Price $1 00, postage $0 12.

H 3. Report on SOMERSET county, by F. & W. G. Platt. With 6 maps and sections and 110 cuts in the text. 8°, pp. 348, 1877. Price $0 85, postage $0 18.

H 4. Report on INDIANA county, by W. G. Platt. With a colored geological county map and 87 cuts in the text. 8°, pp. 316, 1878. Price $0 80, postage $0 14.

H 5. Report on ARMSTRONG county, by W. G. Platt. With a colored geological county map, and 58 cuts in the text. 8°, pp. 338, 1880. $0 75, postage $0 16.

H 6. Second report on JEFFERSON county, (*See H above,*) by W. G. Platt. With a colored geological county map, and 57 cuts in the text. 8°, pp. 218, 1881. Price $0 60, postage $0 12.

H 7. Second report on CLEARFIELD county, (*see H above,*) by H. M. Chance. With a colored geological county map, an outcrop map of the Houtzdale basin, and 58 cuts in the text. 8°, pp. 197, 1884. Price $0 85, postage $0 11.

I. Report on VENANGO county, by J. F. Carll. The geology around Warren, by F. A. Randall. Notes on the comparative geology of N. E. O., N. W. Pa. and W. N. Y., by J. P. Lesley. With one small map of the Venango oil region; one small map of the region south and east of Lake Erie; one long section of the rocks at Warren; and 7 cuts in the text. 8°, pp. 127, 1875. Price in paper, $0 60, postage $0 05.

I 2. Report of oil well records and levels in VENANGO, WARREN, CRAWFORD, CLARION, ARMSTRONG, BUTLER, &c., by J. F. Carll. 8°, pp. 398, 1877. Price $0 60, postage $0 18.

I 3. Report on the VENANGO, WARREN, CLARION, and BUTLER OIL REGIONS; descriptions of rig, tools, &c.; survey of the Garland and Panama conglomerates, &c.: discussion of preglacial and post glacial drainage; by J. F. Carll. With 23 page plates, and an atlas. 8°, pp. 482, 1880. Price (of volume and atlas together) $2 30, postage $0 30.

(**I 3.**) ATLAS of 22 sheets. Map of Venango county, colored geologically; map of lower oil field (Butler, Armstrong, and Clarion) in 2 sheets; 3 local contour maps at Franklin, Titusville, and Spring creek; two maps of N. W. Pennsylvania showing the past and present drainage; long section across W. Pennsylvania; vertical section of the formations from the Upper Coal Measures down to the bottom of the Devonian; diagram map and section of Third sand; profile section from Meadville, S. W.; 5 sheets of grouped oil well sections; 5 sheets of working drawings for well boring, &c.; diagram of daily rate of drilling six wells at Petrolia. (*Sold only with the report.*)

I 4. Report on WARREN county, by J. F. Carll. With a colored geological county map, a map of the Warren oil region, and 2 sheets of oil well sections. 8°, pp. 439, 1883. Price $1 12, postage $0 20. (*Note. The first 147 pages of this book contain oil well records: see under Petroleum Fields below.*)

J. Report on the OIL REGION, by H. E. Wrigley; map and profile of line of levels through Butler, Armstrong, and Clarion, by D. J. Lucas; map and profile of Slippery Rock creek, by J. P. Lesley. 5 maps and sections, a plate and 5 cuts. 8°, pp. 122, 1875. Price in paper $0 75, postage $0 06.

K. Report on GREENE and WASHINGTON counties, by J. J. Stevenson. With two county maps. (Showing the calculated local depths of the Pittsburg and Waynesburg coal beds beneath the surface,) and 3 page plates of general sections. 8°, pp. 419, 1876. Price, in paper, $0 65, postage $0 16. (*Note.—Since the publication of this book, two colored geological county maps have been published, and will be found in pocket of volume K 3 described below.*)

K 2. First report on FAYETTE, WESTMORELAND, and S. E. ALLEGHENY counties, (*i. e.* west of Chestnut ridge,) by J. J. Stevenson. With 3 colored geological county maps, and 50 cuts in the text. 8°, pp. 437, 1877. Price $1 40, postage $0 20.

K 3. Second report on FAYETTE and WESTMORELAND counties, (the Ligonier valley,) by J. J. Stevenson. With 4 page plates, and 107 cuts in text. 8°, pp. 331, 1878. Price $1 40, postage $0 16. (*Note.—In a pocket in this volume will be found the colored geological maps of Greene and Washington counties, alluded to above.*)

K 4. Pt. I, Report on the MONONGAHELA river COAL MINES, from the West Virginia State line to Pittsburgh, (including some on the Youghiogheny and other streams,) by J. Sutton Wall. With a map of the region in a pocket, 12 heliotype pictures, and 26 page plates. 8°, pp. 231, 1884. Price $1 15, postage $0 14.

L. Report on the YOUGHIOGHENY coke manufacture, by F. Platt; Notes on the coal and iron ore beds, by C. A. Young; Report on methods of coking, by J. Fulton, (*See G* below;) Report on the use of natural gas in the iron manufacture, by J. B. Pearse and F. Platt; The Boyd's hill gas well at Pittsburg, by J. P. Lesley. With a map of the coke region, two folded plates of coke ovens, and page plates and cuts in the text. 8°, pp. 252, 1876. Price $1 00, postage $0 13.

Q. Report on BEAVER, N. W. ALLEGHANY, and S. BUTLER counties, by I. C. White. With 3 colored geological county maps, and 21 page plates of sections. 8°, pp. 337, 1878. Price $1 40, postage $0 20.

Q 2. Report on LAWRENCE county, and special Report on Correlation of the Pennsylvania and Ohio coal beds, by I. C. White. With a colored geological county map, and 134 cuts in the text. 8°, pp. 336, 1879. Price $0 70, postage $0 15.

Q 3. Report on MERCER county, by I. C. White. With colored geological county map, and 119 cuts in the text. 8°, pp. 233, 1880. Price $0 60, postage $0 11.

Q 4. Report on CRAWFORD AND ERIE counties, by I. C. White. With two colored geological county maps, and 107 cuts in the text. Also, a Report on a preglacial outlet for Lake Erie, by J. W. Spencer. With two maps of the Lake region. 8°, pp. 406, 1881. Price $1 17, postage $0 18.

R. Report on McKEAN county, and its geological connections with Cameron, Elk, and Forest counties, by C. A. Ashburner. With 33 page plates of vertical and columnar sections, pictures of Rock city and Olean conglomerate, Wilcox and Kane spouting wells, map of Howard Hill coal field, &c., and an atlas of 8 sheets. 8°, pp. 371, 1880. Price of Volume and Atlas together $1 70, postage $0 22.

(R.) ATLAS for McKean county of 8 sheets:—Colored geological county map; three topographical maps; of Buffalo Coal Company tract, Alton coal basin, and Potato Creek coal basin; map of McKean oil district; one sheet of columnar sections between Bradford and Ridgway; and 2 diagram sheets of the Well account and Production account in the Bradford district. *(Only sold with Report R.)*

R 2. Part II, Report on township geology of CAMERON, ELK AND FOREST counties, by C. A. Ashburner. *(To appear about March 15, 1885.)*

(R 2.) ATLAS for CAMERON, ELK AND FOREST counties, of 11 sheets *(published November, 1884, in advance of the report)*:—3 colored geological county maps; 1 anticlinal and synclinal map; 1 topographical map McKean county; 2 tract maps Forest and Elk counties; 1 map Straight Creek coal basin; 2 sheets oil well sections; and 1 sheet coal sections. Price $0 65, postage $0 08.

V. Report on N. BUTLER county; and (Part 2) special report on the Beaver and Shenango river coal measures, by H. M. Chance. With a colored geological map of N. Butler; a contour local map around Parker; a map of the anticlinal rolls in the 6th basin; a chart of the Beaver and Shenango rivers; profile section from Homewood to Sharon; Oil well records and surface sections; and 154 cuts in the text. 8°, pp. 248, 1879. Price $0 70, postage $0 15.

V 2. Report on CLARION county, by H. M. Chance. With a colored geological county map; a map of the anticlinals and oil-belt; a contoured map of the old river channel at Parker; 4 page plates, and 83 cuts in the text. 8°, pp. 232, 1880. Price $0 43, postage $0 12.

For the coal basins of BRADFORD and TIOGA counties see report G.

For the coal basins of LYCOMING and SULLIVAN see report G 2.

For the coal basins of POTTER county see G 3.

For the coal basins of CLINTON county see G 4.

For the coal in WAYNE county see G 5.

For the East Broad Top coal basin in HUNTINGDON county see F.

For the mountain coals in BLAIR county see T.

For the Broad Top coal measures in BEDFORD and FULTON counties see T 2.

For the coal basins in CENTRE county see T 4.

For coal analyses, see M, M 2, M 3.

For classification of coals, see in M 2.

For coal plants, see P, P 2.

For fossil crustaceans in coal slate, see P 3.

PETROLEUM AND GAS.

See reports I, I 2, I 3, I 4, and J under Bituminons Coal Fields.

See L, for the Pittsburgh gas well, and the use of gas in the iron manufacture.

See Q, Q 2, Q 3, Q 4, for references to oil rocks in Beaver, Lawrence, Mercer, Crawford, Erie, and S. Butler counties.

See K for the Dunkard creek oil wells of Greene county.

See R, R2, for descriptions of oil rocks in McKean, Elk, and Forest counties.

See V, V 2, for notes on the oil rocks of N. Butler, and Clarion counties.

See H 2 for oil boring at Cherry Tree, Cambria county.

See G 5 for oil boring in Wayne county.

NORTH-EASTERN AND MIDDLE PENNSYLVANIA.

(*Palæozoic formations from the Coal down.*)

D. First report on LEHIGH county iron mines, by F. Prime. With a contour line map of the ore region, and 8 page plates. 8°, pp. 73, 1875. Price in paper $0 50, postage $0 04.

D 2. Second report on LEHIGH county iron mines, by F. Prime. With a colored geological contour line map of the iron region, (in 4 sheets,) a colored geological contour line map of the Ironton mines, 4 double page lithograph pictures of Limestone quarries, and one page plate of *Monocraterion.* 8°, pp. 99, 1878. Price $1 60, postage $0 12.

D 3. Vol. 1. Report on LEHIGH and NORTHAMPTON counties. Introduction, by J. P. Lesley; Slate belt, by R. A. Saunders; Limestone belt and iron mines, by F. Prime; South mountain rocks, by F. Prime and C. E. Hall. With 3 lithograph pictures of quarries, 4 pictures of triangulation stations, 14 page plates of sections, and an atlas of maps. 8°, pp. 283, 1883. Price $0 65, postage $0 13. (*Note, for atlas see below.*)

D 3. Vol. II, part I. Report on BERKS county, (*South Mountain belt,*) by E. V. D'Invilliers. With 10 page plates of sections and Indian relics, and 3 pictures of rock exposures. 8°, pp. 441, 1883. Price $0 55, postage $0 18. (*Note, for atlas see below, as before.*)

(**D 3.**) ATLAS: One colored geological map of *Lehigh* and Northampton counties, (*one sheet*); one colored geological contour line map of Southern Northampton county, (*six sheets*); a contour line map of the mountains from the Delaware to the Schuylkill, (*eighteen sheets*); a colored geological contour line index map to the 22 sheets, (*one sheet*); and 4 sheets of maps of Iron mines. Price of Atlas $2 80, postage $0 17.

D 5. ATLAS of colored geological county maps of CUMBERLAND, FRANKLIN, and Adams, (*three sheets*); and first instalment of contour line map of the South mountains, Sheets A 1, A 2, B 1, B 2, (*four sheets,*) by A. E. Lehman. Price of Atlas $1 25, postage $0 08.

F. Report on the JUNIATA RIVER district in MIFFLIN, SNYDER and HUNTINGDON counties, by J. H. Dewees; and on the Aughwick valley and East Broad Top region in HUNTINGDON county, by C. A. Ashburner. With colored geological maps of East Broad Top R. R. and Orbisonia vicinity (2 sheets); Three Springs map and section (2 sheets); Sideling Hill creek map and section (2 sheets); and Isometric projection at Three Springs (1 sheet); six folded cross sections and 22 page plates of local maps, and columnar sections. 8°, pp. 305, 1878. Price $2 55, postage $0 20.

F 2. Report on PERRY county, (*Part I, geology,*) by E. W. Claypole. With two colored geological maps of the county; 17 geological outline township maps as page plates; and 30 page plate cross and columnar sections. 8°, pp. , 1884. Price $, postage, . (*In press, October, 1884.*)

G. Report on BRADFORD and TIOGA counties, by A. Sherwood; Report on their coal fields (including forks of Pine creek in Potter county), by F. Platt; Report on the COKING of bituminous coal, by J. Fulton. (*See L above.*) With 2 colored geological county maps, 3 page plates, and 35 cuts in the text. 8°, pp. 271, 1878. Price $1 00, postage $0 12.

G 2. Report on LYCOMING and SULLIVAN counties: field notes by A. Sherwood; coal basins by F. Platt. With 2 colored geological county maps (of Lycoming and Sullivan), a topographical map (in two sheets) of the Little Pine creek coal basin, and 24 page plates of columnar sections. 8°, pp. 268, 1880. Price $1 06, postage $0 14.

G 3. Report on POTTER county, by A. Sherwood. Report on its COAL FIELDS, by F. Platt. With a colored geological county map, 2 folded plates, and 2 page plates of sections. 8°, pp. 121, 1880. Price $0 58, postage $0 08.

G 4. Report on CLINTON county, by H. M. Chance; including a description of the Renovo coal basin, by C. A. Ashburner; and notes on the Tangascootac coal basin, by F. Platt. With a colored geological county map, 1 sheet of sections, local Renovo map, 6 page plates, and 21 sections in the text. 8°, pp. 183, 1880. Price $1 05, postage $0 12.

G 5. Report on SUSQUEHANNA and WAYNE counties. by I. C. White. With a colored geological map of the two counties, and 58 cuts in the text. 8°, pp. 243, 1881. Price $0 70, postage $0 12.

G 6. Report on PIKE and MONROE counties, by I. C. White. With two colored geological county maps, (1 sheet Pike and Monroe, and 1 sheet Wyoming,) a map of glacial scratches, and 7 small sections. Report on the Delaware and Lehigh water gaps, with two contoured maps and five sections of the gaps, by H. M. Chance. 8°, pp. 407, 1882. Price $1 15, postage $0 15.

G 7. Report on WYOMING, LACKAWANNA, LUZERNE, COLUMBIA, MONTOUR, and NORTHUMBERLAND counties, (*i. e.* the parts lying *outside* of the anthracite coal fields,) by I. C. White. With a colored geological map of these counties, (in two sheets,) and 31 page plates in the text. 8°, 464, 1883. Price $0 85 and postage $0 20. (*Note.—The colored geological map of* WYOMING *county is published in G 6.*)

S. Report on the Seven mountains in HUNTINGDON, UNION, AND SNYDER counties, by C. E. Billin. With a colored geological contour line map of the mountains (1 sheet); maps of the fossil ore outcrops, and Stone mountain fault; and colored geological cross sections, (2 sheets.) 8°, pp. , 1885. Price $, postage $. (*In press.*)

T. Report on Blair county, by F. Platt. With 35 cuts in the text, and an Atlas of maps and sections, (See below.) 8°, pp. 311, 1881. Price *with atlas* $4 55, postage $0 28.

(T.) ATLAS of colored geological contour line map of Morrison's cove, Canoe valley, Sinking valley, and country west to the Cambria county line, (14 sheets); Index map of the same (1 sheet); colored sections, (2 sheets.) 8°, 1881. (Note.—*The Atlas is not sold separately.*)

T 2. Report on BEDFORD and FULTON counties, by J. J. Stevenson. With two colored geological maps of the two counties. 8°, pp. 382, 1882. Price $0 80, postage $0 20.

T 3. Report on HUNTINGDON county, by I. C. White. With a colored geological map of the county; and numerous sections. 8O, pp. , 1885. Price $, postage $. (*In press.*)

T 4. Report on CENTRE county, by E. V. D'Invilliers; also, special report by A. L. Ewing; and extracts from report to Lyon, Shorb & Co., by J. P. Lesley. With a colored geological map of the county, 13 page plates of local maps and sections, and 15 cuts in the text. 8O, pp. 464, 1884. Price $0 80, postage $0 19.

See also report on the line of the Terminal Moraine, Z.

SOUTH-EASTERN PENNSYLVANIA.

C. Report on YORK and ADAMS counties, by P. Frazer. With one folded map of a belt of York county through York and Hanover, 6 folded cross sections, and two page plate, microscopic slices of dolerite. 8O, pp. 198, 1876. Price in paper $0 85, postage $0 10. (*Note.—The colored geological county map of* YORK *is published in the* ATLAS *to C 3.*)

C 2. Report on YORK and ADAMS counties, (South Mountain rocks, iron ores, &c.,) by P. Frazer. With one general map of the district; 10 folded cross sections; and 5 page plates. 8O, pp. 400, 1877. Price $1 25, postage $0 12. (*Note.—The colored geological county maps of* ADAMS *is published in* D 5.)

C 3. Report on Lancaster county by P. Frazer. With nine double page lithographic views of slate quarries, and Indian-pictured rocks; one plate of impressions on slate and one page plate microscopic section of trap; and an atlas. 8O, pp. 350, 1880. Price of report and atlas $2 20, postage $0 25.

(C 3.) ATLAS of 13 sheets:—Colored geological map of YORK county; colored geological map of LANCASTER county; Susquehanna river section (Sheets 1, 1A, 2, 2A, 3, 4); Lancaster section; Pequea section; Muddy run section; Chestnut-hill mines; Gap nickel mine. (*Note.—Atlas sold only with report.*)

C 4. Report on CHESTER county; General description, pp. 214, by J. P. Lesley; Field notes in the townships, pp. 215–354, by P. Frazer. With a colored geological county map, a photographic view of contorted schists, and 12 page plates. 8O, pp. 394, 1883. Price $0 75, postage $0 18.

C 5. Report on DELAWARE county, by C. E. Hall. With a colored geological county map; a contour line map around Media; 30 photographic page-plate views of granite quarries, Kaolin pits, &c., and 4 page plates of altered micas. 8O, pp. , 1885. Price $, postage $. (*Partly printed: but publication delayed.*)

C 6. Report on PHILADELPHIA and the southern parts of MONTGOMERY and BUCKS counties, by C. E. Hall. With a colored geological map of the belt of country between Trenton and Delaware county (in 3 sheets); a sheet of colored cross-sections, and 24 cuts in the text. 8O, pp. 145, 1882. Price $1 65, postage $0 13.

E. Part I of (historical introduction to) a report on the AZOIC rocks, by T. S. Hunt. 8O, pp. 253, 1878. Price $0 48, postage $0 12.

VOLUMES PUBLISHED AND ON SALE, MARCH 1, 1885.

A.
A 2.
AC.
AC atlas.
AA.
AA atlas (1.)
AA atlas (2.)
Grand atlas, Div. II, Pt. I.
Grand atlas, Div. I, Pt. I.
B.
B 2, (exhausted.)
C.
C 2.
C 3.
C 3 atlas.
C 4.
C 6.
D.
D 2.
D 3, Vol. I.
D 3, Vol. II, part I.
D 3 atlas.
D 5 atlas.
E.
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Q 3.
Q 4.
R.
R atlas.
R 2 atlas.
T.
T atlas.
T 2.
T 4.
V.
V 2.
Z.

75.

Other reports of the Survey are in the hands of the State Printer and will soon be published.

SINGLE SHEETS ANTHRACITE REGION.

In order to make the results of the survey in this region immediately available, 200 copies of each sheet (size 26×32 inches) will be sold singly as soon as printed. Remittances* for the same and communications respecting the Anthracite Survey should be addressed to

CHAS. A. ASHBURNER, *Geologist in Charge,*
907 Walnut street, Philadelphia.

General Map Anthracite Coal Fields, scale $\frac{1}{300000}$ths of nature (about $4\frac{3}{4}$ miles to one inch) showing the outlines of the coal basins and outlets to market; with list of working mines during 1882 and 1883 with their annual production,

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MAUCH CHUNK SHEET[4], Southern Field, in vicinity of Mauch Chunk and Nesquehoning. (See foot-note, page 4.)

LANSFORD SHEET[4], Southern Field, in vicinity of Lansford and Summit Hill. (See foot-note, page 4.)

TAMAQUA SHEET[4], Southern Field, in the vicinity of Coaldale and Tamaqua. (See foot-note, page 4.)

Topographical Sheets, scale 1600 feet to 1 inch $\frac{1}{19200}$ths of nature, showing surface topography in contour curve lines 10 feet vertically apart.

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SHEET NO. III, WESTERN MIDDLE FIELD[1]	in vicinity of Centralia, Ashland, Mt. Carmel, &c, ...	Price $0 11
SHEET NO. 1, SOUTHERN FIELD[4],	in vicinity of Mauch Chunk, Lansford, Tamaqua, &c. (See foot-note, page 4.)	

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1. Contained in Atlas W. M. A. F. Part I.
2. Contained in Atlas N. A. F. Part I.
3. Contained in Atlas E. M. A. F. Part I.
4. Contained in Atlas S. A. F. Part I.

Cross Section Sheets contain vertical cross sections, scale 400 feet to 1 inch, $\frac{1}{4800}$ths of nature; reference maps scale 1 mile to 1 inch, $\frac{1}{63360}$ths of nature; &c.

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SHEET NO. III, WESTERN MIDDLE FIELD[1]	4 sections through Girard Mammoth, Cuyler, Hammond, Continental, North Ashland, Preston Nos. 1, 2, 3, and 4, Centralia, Hazle Dell, Bast, Tunnel, Big Run, Keystone, Potts and Franklin collieries, ...	Price $0 09
SHEET NO. IV, WESTERN MIDDLE FIELD[1]	Sections through Mt. Carmel, Rough and Ready, Coal Ridge No. 3, Bellmore and Reno collieries; longitudinal section Mahanoy basin and geological map between Delano and Ashland, (scale 3200 feet=1 inch,)	Price $0 11
SHEET NO. III, NORTHERN FIELD[2],	10 sections; through Boston, Plymouth Nos. 1, 2, and 4, Dodson, Gaylord, Avondale, Nottingham, Reynolds, Franklin, and Sugar Notch Nos. 9 and 10 collieries, .	Price $0 09
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SHEET NO. I, EASTERN MIDDLE FIELD[3],	5 general sections, scale 800 feet to 1 inch: through Highland, Eckley, Woodside, Stockton, Hollywood, Hazleton, Mt. Pleasant, &c., collieries, ...	Price $
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SHEET NOS. I, II and III, SOUTHERN FIELD[4],	25 sections; through collieries L. C. and Nav. Co., between Mauch Chunk and Tamaqua, (See foot-note, page 4.)	

Columnar Section Sheets contain sections showing thickness and character of coal measures, scale 40 feet to 1 inch, of coal beds scale 10 feet to 1 inch, &c., &c.

SHEET NO. I, NORTHERN FIELD[2],	contains sections at Bennett, Pine Ridge, Enterprise, Henry, Wyoming, Oakwood, Prospect, Conyngham, Baltimore, Diamond, Hollenback, Laurel Run, Mineral Spring, and Red Ash collieries, ...	Price $0 11
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SHEETS NOS. I, II & III, SOUTHERN FIELD[4],	contains 79 sections at collieries L. C. and Nav. Co., between Mauch Chunk and Tamaqua, (See foot-note, page 4.)	

Other Anthracite sheets are in the hands of the State Printer and will soon be printed.

The sale of the reports is conducted in accordance with the provisions of Section 10 of the Act of the 14th day of May, 1874, which directs that copies of the Reports, with all maps and supplements, shall be furnished *at cost of publication to all applicants for them.*

All the printed volumes and maps in stock have been transferred by the Board of Commissioners to the Department of Internal Affairs, where the sales thereof will hereafter be conducted.

Communications relating to the work of the Survey should be addressed to J. P. Lesley, State Geologist, No. 1008 Clinton street, Philadelphia, and those intended for the Board of Commissioners to William A. Ingham, Secretary, No. 907 Walnut street, Philadelphia.

For instructions for purchase of single sheets of the Anthracite Survey, see page 9.

All letters and orders concerning the purchase of Reports and remittances for the same, should be addressed to

J. SIMPSON AFRICA,
Secretary of Internal Affairs
Harrisburg, Pa.

March 1, 1885.