GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, DIRECTOR.

REPORT

ON THE

GEOLOGY OF GARRARD COUNTY.

BY W. M. LINNEY.

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INTRODUCTORY LETTER.

HON. JOHN R. PROCTER,

Director of the Kentucky Geological Survey:

DEAR SIR: I have the pleasure of transmitting to you my Report on the Geology of Garrard County, accompanied by a map and profile section.

Owing to questions involved in the physical history of this region, I extended the profile section beyond the county, so as to include Mercer and a part of Rockcastle. This exhibits a continuous section of sixty miles, which illustrates the relation of the formations better than one limited to Garrard county

I am, very truly, yours,

W. M. LINNEY.

HARRODSBURG, KY., December, 1882.

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GEOLOGY OF GARRARD COUNTY.

TOPOGRAPHY, &C.

Garrard county dates its organization from 1796, in which year it was formed from parts of Mercer, Lincoln, and Madison. It is situated near the center of the State and has Jessamine and Madison on the north, Madison and Rockcastle on the east, Lincoln and Rockcastle on the south, and Lincoln, Boyle, and Mercer on the west. Its area comprises about one hundred and thirty-four thousand acres of land; and, in 1880, it had a population of eleven thousand seven hundred and four, having increased from ten thousand three hundred and seventy-six in the previous decade.

Lancaster, with one thousand two hundred and thirty-four inhabitants, is the county seat and the largest town. A number of villages and post-offices are scattered over the county. The boundary line is a very irregular one, being marked nearly all around by the sinuosities of creeks and rivers. The Kentucky river flows for some distance along its northern boundary. On its tides are brought down considerable quantities of coal and lumber—of which a part only supplies the citizens. Dix river flows along the western portion of Garrard, and furnishes fine milling facilities. Paint Lick, Boone, Sugar, and other creeks meander through the county, giving good drainage lines, and affording additional sites for a number of mills, some of which are already utilized.

All the drainage of the county flows into the Kentucky river; but the characters of the streams in various parts of the county are quite different. The northwestern part of the

county lies in an angle made by the Kentucky river and Dix river. Here those streams flow in cañon-like valleys four to six hundred feet below the higher parts of the surface. Narrow chasms, with almost perpendicular walls of solid rocks, from two to four hundred feet in height, are their characters; so narrow are the valleys, and so steep the escarpments, which rise frequently to the level of the country, that a stranger often finds himself on the brink before he is aware of his proximity to a river. Sometimes the surface even slopes back from the tops of the cliffs. The small streams which enter the rivers here have the same character of valleys. Under such conditions, one would expect to find a number of cascades in ascending their channels. This, however, is not the case to any extent; for while their fall is hundreds of feet in a few miles, yet this fall is so regularly distributed along their flow that they enter the rivers at their ordinary levels.

The only explanation of this fact is, that along this region the Kentucky river and Dix river flow in channels, which were originally open fractures in the crust of the earth, and that the small streams run in side fissures from these old fractures, and erosion has removed the broken material so regularly that, while the fall is rapid, no great benches are left. Through this part of the county there are lines of subterranean drainage, whose origin is intimately connected with the open fractures above described. These lines under the ground are marked on the surface by holes and depressions, into which the waters sink, only to reappear at some distant points as springs.

There are a number of fine bold springs in this region; yet they are rare as flowing immediately from the cliffs along the rivers. They are oftener found on or near the smaller branches, and are always connected in some way with the fractures and dips of the rocks. Usually the dip is away from the river on each side; this prevents the flow of spring waters directly into the streams, and causes them to issue further back in the country.

The water here is of the best potable character. The bottom lands along the streams are only little narrow patches, and are composed of materials which have been brought down by the rivers' action, and deposited in protected places over the talus from the cliffs. There are many striking views among these wild and picturesque cliffs. Massive and strong, they rise in smooth walls or broken ledges, with here and there some scrubby tree or clinging vine mantling the rocky walls, which are seamed with many a fracture, and pictured with many a stain. Sometimes overhanging walls, with beetling brows and buttresses bare, shade the flowing stream beneath. Chimney-rocks stand away from the line of walls, isolated and gray, and look as if reared by human hands. It is doubtful whether the famed Hudson has so many admirable scenes along its banks as the Kentucky.

Such is the character of these streams which bound the county up to the mouth of Cooper's Branch. In going up the river from this point the cliffs begin to diminish in height, and their walls to disappear, until, in a few miles, the perpendicular rocks give way to sloping hills, which are rounded to the water's edge. The creeks, which enter along and above this point, have their channels between steep, sloping hills of the last mentioned character. The rocky escarpments seen below have, by a rapid dip, been carried under the drainage lines, and softer rocks, more easily eroded into curved lines, have taken their places. On the opposite side of the county, Boone and other creeks partake of the same description; and, while cutting into the strata hundreds of feet, they are flanked by productive soils, extending down to the bottom from the highest points of the hills.

As one goes further to the southeast he finds a number of streams, whose beds are but slightly beneath the general surface. Their flow is not of the rapid character of the others. The surface of the county is more gently rolling, and, as agricultural land, more agreeable to the eye. Further to the southeast is a series of hills, several hundred feet high, elevated above the general surface, with steep declivities, be-

tween which are small branches that cut down rapidly here, but afterward flow gently through the more level country beyond.

The Kentucky river, during the season of high water, is navigable for steamboats along its entire length in the county, yet for some years none have passed up. The improvements now being erected in the river in the way of locks and dams will in time be extended to this county and above, thus making navigation continuous through the year. This will be of great convenience to the people of the county. The Kentucky Central Railroad extends through the county, and gives good facilities for all travel and shipments. The Cincinnati, New Orleans and Texas Pacific Railroad (Cincinnati Southern) is within easy reach, by several good roads, from the county.

GENERAL GEOLOGY.

The stratified rocks of Garrard county, in their connected exposures, have an aggregate thickness of over seventeen hundred feet of palaeozoic strata, ranging from the Lower Silurian to the Subcarboniferous Limestones. There is, perhaps, no county in the State whose geological features are more interesting to the student; for here lies in part the key to problems which bear not only upon the general geology of the State, but reach beyond its outlines, and include points of interest in other States. The following is a general grouping of the various outcrops in the county, as traced from one exposure to another; they are arranged under the general names which such rocks usually bear in the United States. It may be stated here that the thickness and general character of these groups are, in a large measure, very uniform over the region surrounding Garrard county, as far as they appear on the surface. They are open to the investigation of the geologist at many points:

Soils and Waste Beds.		Feet.	Feet.
Carboniferous— Subcarboniferous Period	Upper. . . . . Lower.	20 } 300 }	320
Devonian— Hamilton Period	Black Slate	. . . .	50
Corniferous Period	Corniferous	. . . .	15
Upper Silurian— Niagara Period	Clinton ?. . . . . Medina.	. . . } . . . }	60
Lower Silurian— Trenton Period	Hudson River . . . . . Trenton . . . . . Birdseye	650 } 160 } 130 }	940
Canadian Period	Chazy.	. . . .	350
Total	. . . . .	. . . .	1,735

These divisions are based upon the more remarkable changes in the composition and appearance of the rocks. Such changes make many marked differences in the character of the soils, and in the distribution of trees and smaller plants. They also modify largely the general appearance of the country as to levels and slopes Another and very important element, which serves to separate these groups, is the character and forms of the fossils. These distinctions have been made by geologists for the convenience of study and description. Rocks which appear to be the same to the superficial observer are often found in each of these divisions; but the more practiced eye distinguishes them by certain characteristics at a glance.

The above thicknesses are approximate only, for it is very difficult in such a section, extending across an eroded region like this, to get accurate measurements of all the rocks. Measurements were made in some cases with an aneroid

barometer, and in others, when practicable, with a rule or line.

THE CANADIAN PERIOD.

The Chazy Limestone.—On the Kentucky river, at or near the mouth of Cooper's Branch, the lowest rocks brought to view in the State are to be seen. In their natural exposures, and in their superficial characters, they have a general resemblance for an elevation of three hundred and fifty feet; but at that point some ten feet of rocks, quite different in appearance, and also in chemical character, are brought to view. These three hundred and fifty feet of strata have been determined, from their position and other circumstances, to be in part the equivalents of the Chazy Limestones, a series of rocks first described and named as occurring at Chazy, in the State of New York.

They are here composed of a number of layers of very heavy-bedded rocks, compact in their structure, and usually quite tough, when tested under the hammer. They are of various colors—some are gray, some bluish, others of a dove-color, and even lighter. The most of them, however, have a mottled appearance, when closely examined, on their exposed surfaces, or when freshly broken. Of these, the base is a dark dove-color, with spots of dull yellow, which are rather sandy in their nature, and are the impressed remains of a class of sea-plants that grew in the ocean when and where these rocks were formed. Among these are the remains of shells, corals, and other forms of life; other layers have been largely made from shells alone, and some of them show only casts, while branching corals make up a large part of the whole. Often these have leached out, leaving the outer surfaces of the layers honey-combed with curious, tortuous holes. Some of the beds are close and fine-grained, and the structure of the old fossils is entirely obliterated, or their presence marked only by the faintest lines.

In composition, these rocks are mostly lime, but nearly all of them contain some silica, magnesia, and earthy matters.

Sometimes a little shaly or carbonaceous matter intervenes between the layers, though the proportion of this is quite small. Many of these rocks are well fitted for building purposes, being very tough, and resisting decomposition in a remarkable degree. Lime of an excellent quality can be burned from them. As yet, their use for these purposes is entirely local.

In wall-like cliffs, where only these rocks are shown, there is much difficulty in examining them for fossils; besides, the changes to which they have been subjected, have in a large measure destroyed the forms, or, at least, the finer lines of identification; so that, in most cases, they are rendered worthless as specimens, either for the cabinet or for critical determination.

Fortunately, however, a few places give a sufficient number of forms by which these rocks have been identified, and placed, at least the upper part of them, in the Chazy Limestone. The lower portion may in time be shown to belong to the Quebec group.

The upper portion of these strata contains numbers of a large coiled shell, the *Maclurea magna*, and, at about sixty-five feet below the top, a few thin layers yield numbers of *Orthis costalis*. Besides these forms, there have been found *Rhynchonella plena*, *Asaphus marginalis*, *Leperditia canadensis*, with some other fossils, which, with its position and relation to the upper groups, identify it, without doubt, as the equivalent of the Chazy.

This series of rocks is seen only along the gorges in this part of the State, and is lost beneath the drainage lines, both up and down the river. They give, therefore, no soils, for they do not rise to the surface of the uplands; yet, in their massive ruggedness, they add wild and picturesque features to the streams which flow between them, and are interesting as the oldest and lowest rocks seen in the State. At the mouth of Dix river they are over two hundred feet above the water; in ascending that stream, they sink beneath it at Green's old mill. In going up the Kentucky, from the

mouth of Dix river, they rise, as we have stated, to three hundred and fifty feet at Cooper's Branch, and are lost to view three miles above.

TRENTON PERIOD.

Birdseye Limestone.—Succeeding the Chazy Limestones is first seen the ten feet of rocks to which reference has been made. This is often termed the "Kentucky marble," and it has been used to some extent in the State, notably, as the material of the Clay Monument at Lexington and of the columns of the State-house at Frankfort. It averages about ten feet in thickness. On exposed surfaces it is buff in color, but internally it has a gray ground, with blotches of blue, which near the surface often change to a brown. There are no fossils in it; yet it is evidently part of the Trenton, as, in New York, and also at one or two points in the northwest, a buff limestone of near this thickness makes the base of the Trenton. It is a magnesian limestone, containing usually thirty-five to forty per cent. of magnesia.

Succeeding this magnesian limestone is one hundred and twenty feet of limestone, the larger part of which is of a light or a dark dove-color, brittle, heavy-bedded, and fine-grained. Shale is formed between some of the layers, and some thin limestones in the shale. Many beds are of such quality that they would make handsome building stones. Impressions of plants ramify through many of them, and quite a large proportion show strings of lime crystals imbedded in them. The impressions in some of these layers have the identical character of a plant figured in the reports of the State of New York, and described as *Phytopsis tubulosa*. The worn or ground surfaces have round crystalline spots which to some extent resembles the eyes of birds, hence the name Birdseye Limestone. Some of the layers show the lamination perfectly when worn in their natural exposures, and are susceptible of being split into slate-like pieces. The shales are quite earthy, nearly white, and seem to have been deposited as fine clay sediment.

Near the top are several layers, containing masses of hornstone, which give them a rugged aspect when worn, the lime having leached away from around the chert, and left it protruding from their sides or tops. The top layer is plated everywhere with a reddish hornstone from one to three inches in thickness.

Evidences through all these rocks show, that while the materials of which they are composed were being laid down on the bottom of the old ocean, life existed abundantly in many forms. Scarcely a fragment can be examined which does not show markings of organic life; yet, from subsequent changes made in this series here, few of these remains have been so preserved as to make their determination as certain or definite as we would like. Little crustaceans of the genus *Leperditia* are wonderfully numerous; *Bryozoa* are equally so. Some corals and shells have been identified with enough certainty to enable us to determine the position of the beds.

These rocks have but a limited distribution away from the rivers mentioned, and give, therefore, little soil. Fine quarries might be opened in them at a number of places, and beautiful building stones secured. Some of them are susceptible of a fine polish, and a few are fine enough for lithographic stones, but for some minute specks of iron and lime which they contain.

Trenton Limestones.—Succeeding the last mentioned rocks are seen about one hundred and sixty feet of mostly thin blue and gray limestones, with thin beds of shale often between them. These might, with great propriety, receive the name of "Blue Grass" beds, for they are preëminently the rocks upon which that richest and best of grasses thrives. Their rapid decomposition furnishes the best of soils, and they outline and define the most beautiful and most highly-prized part of the State. In Garrard they are confined to the northwestern part of the county.

The superficial character of these beds has often confounded them with another group, which lies higher in the

geological scale. They are generally of a light, gray color, and are massive in the fresh quarries, and at some distance from long-exposed surfaces; but, with few exceptions, they wear thin-bedded after long exposure. Near the base there are several strata which have a large amount of cherty matter included in them. Near the top are some heavy layers also, more than half crystallized, and sometimes with a pinkish tinge. The shales are soft and of clay, and are in small proportion to the mass. Through the whole series there are no good building stones, except near the top, and in this county these have not been put to any use. Just at the top, there are twelve or fifteen feet of fine-grained dove-colored stones, heavily bedded, which, from their resemblance to the lower group, I have characterized as the Upper Birdseye. Their extent in Garrard is very limited; they will be described more fully in the report on Mercer county, where they are seen to a better advantage.

The greater part of these rocks decomposes rapidly, owing probably to there being more or less earthy matter in them. Fences are often constructed of stones from these layers, which look very well when first put up; but in a few years they melt down into soil. Some beds are composed of branching corals almost entirely, and in their decomposition these are liberated in great quantities. In the lower layers, where the chert is seen, many of the fossils are silicified, and hence are better preserved. *Orthis testudinaria*, *Orthis pectinella*, *Orthis tricenaria*, *Leptæna sericea*, *Petraia aperta*, *Streptelasma profundum*, and a number of other forms, are common in places.

These rocks are in great contrast with the Birdseye Limestone below in colors, bedding, and fossils. The conditions of the old ocean, in which they were deposited, must have undergone great changes. The former must have been deposited in deeper, clearer water, where the surroundings remained unchanged for long periods of time; the latter, where the water was more shallow, and the currents brought in quantities of earthy sediments. Oscillations must have

occurred at times, for some of the layers are very irregular in their bedding; some show wave-marks, and others a beach-like structure.

The whole series terminate with the heavy layers of Upper Birdseye filled with great number of *Leperditia*, and with a few thin beds of concretionary limestones, marked with a small form of *Orthis lynx*, *Orthis borealis*, *Rhynchonella increbescens*, &c. Very often, too, are seen masses of a large coral, *Stromatopora rugosum*, and some rounded pebbles, which mark a period of change at this time. All these beds of the Trenton are carried down by a steep dip to the southeast, which soon brings the Hudson River Group on a level with that of the Trenton.

HUDSON RIVER GROUP.

We come now to the consideration of a great and important group of rocks, which covers a considerable portion of our State, and extends unbroken into Ohio and Indiana, and whose proper correlation and position may solve a number of problems of unusual interest connected with the States lying in the Ohio Valley.

They are from six hundred and fifty to seven hundred feet in thickness in this part of the State, and have received the name of "Hudson River Beds," in the Reports on the Geology of New York. In that State, they are divided into three divisions—the Utica slates, the Lorraine shales, and the Oswego sandstone. They are here conveniently separated into three series by the differences, which are well marked in the rocks themselves, and also by the soils which are derived from them.

Lower Hudson River Beds.—This division has a thickness of about two hundred feet in the county, and begins at the base with a few layers of blue earthy limestones, composed largely of two species of branching corals. There is a layer of crinoidal limestone that comes in between those beds, which is quite hard, and contains much less clay. Next

is seen a considerable thickness of clay shales, with thin plates of limestone intercalated, and above heavier limestones with the proportion of shales much reduced. The rocks of this division make but few exposures in the county that can be seen to any advantage, being usually covered with vegetation, or, if the areas come to the surface, being cumbered with loose stones, so that their character has had to be studied to some extent in contiguous counties, where good sections can be examined. The great wave-marks, which are a curious feature of the upper part of these beds in Mercer and Washington, are seen in Garrard wherever their horizon is exposed.

Their position here places them with the lower beds, exposed at Cincinnati. The shales and limestones are very similar in character to those at that place, while the ranges of fossils are so much alike that their identity is unquestioned by those who have carefully examined both regions. They do not fully answer to the descriptions of the Utica shales in New York; but enough facts have been elicited to demonstrate that, in part, at least, they hold the same position in the series.

The soils given by these beds are of a heavy clayey character, and are usually covered with large fragments of the limestones which are included in their upper strata. These soils are very limited; they extend only in a narrow strip across the county, from northeast to southwest, in an irregular curve, and are otherwise seen only in the lower part of some of the drainage lines which have cut into them. Full consideration is given them in the reports on Mercer and Washington counties.

Middle Hudson River Beds.—Superimposed on the foregoing division of rocks is one hundred and fifty feet of sandstones, shales, and a few intercalated beds of impure limestones, called in the old volumes of the Kentucky Reports "Silicious Mudstone." The sandstones are not hard grit as many other sandstones are; but, on the other hand, they are

quite soft, and contain a large per cent. of clay, with more or less silicious and calcareous matter. Some of them are, however, to be ranked as sandstones, being heavy-bedded, and to some extent gritty. The shales are of much the same order, but thinner-bedded, and hence more easily decomposed. The whole thickness is easily reduced to soils, and it is not often that one can see a section where their general characteristics may be studied.

Some of the sandstones harden on exposure, and have been used for building fences, chimneys, &c. They break out very irregularly in the quarry, and are not valued where other stones can be procured. Their exposed surfaces are of a dull yellow color; but, when seen fresh in a quarry, they are blue, as are the shales imbedded in them. There are in this series usually two layers quite heavily-bedded, which have a concretionary structure, and wear often into great bowl-shaped masses, which are very peculiar. The beds of limestone on exposed faces are rather of an olive color, and split into thin flaggy layers. They usually show, when thus split, some dendritic markings. The sandstones and shales are often stained with thin, black, shining incrustations, due to oxide of manganese. Many of their surfaces are covered with the impressions of plants, and the casts of shells, corals, and trilobites are common throughout.

Many of the soils of the county are based on these rocks, notably those on Sugar creek, Scott's Fork, and Boone's creek, and are highly esteemed as corn lands. The decomposition of this series is rapid and deep; and, although the soils are washed off by rains, this fact is hardly noticed, for another turning by the plow leaves them as fresh as ever. The drainage lines have cut into them very deep, and the slopes are very steep. The whole thickness is often seen in the side of one field with the Lower Hudson beds at the base. The farms are here cultivated, with hill-side ploughs, where the slopes approach to forty-five degrees. I was informed that some fields had been, for fifty years or more, annually cultivated in corn, without apparent injury to them

The preservation of so much of this division of rocks, with their soft character, is due to the fact that they lie in a trough-like depression, the KENTUCKY SYNCLINAL, which includes more than one half the length of the county.

There are not many springs that flow from these rocks, and the water is not of an excellent character, being impregnated with earthy salts, sometimes to an injurious extent. The positions of these beds are those of the Lorraine shales of New York, and in part of the Eden shales of Cincinnati.

Upper Hudson River Beds.—The upper part of the Hudson River Group is not so uniform in its general character as the several series so far described, yet sufficiently so to be retained as one division. It comes in at the base with a number of feet of thin, shelly, blue limestones, which are usually very uniform in appearance, having always their thin partings of shale. These layers are extremely rich in fossils, and form the second best soils in the State. At this horizon, and confined to a limit of less than one hundred feet of rocks, there is an assemblage of fossils, many species of which are not seen at any other horizon, but which mark a position that can be observed in a number of contiguous counties. These fossils are in part *Ptilodictya hilli*, *Ptilodictya falciformis*, *Cyrtoceras vallandinghami*, *Orthis linneyi*, *Retepora angulata*, *Conchicolites corrugatus*, *Streptorhynchus plano-convexus*, *Protarca vetusta*, *Stellipora antheloidea*, *Chaetetes ortoni*. Above these, and ranging through the rest of this division, are the beds of *Orthis lynx*, with its numerous varieties, associated with a number of other well-known forms found through the West at this horizon. A number of heavy layers of earthy limestones, barren of fossils, or only preserving them as casts, are associated above them.

Near the top are layers of what has been termed by Prof. N. S. Shaler, the "Cumberland Sandstone." The color is usually a blueish-green, but weathering to a yellowish-green on the outside. It contains some silicious matter, but is largely argillaceous in its composition. This is its character

in Garrard, but in other counties it is more sandy. In a freshly opened quarry it promises to make a fine durable building stone; it is, however, worthless as such, for, on exposure, it breaks up into square blocks, and soon crumbles into soil. There are, however, several layers of beautiful limestone, six to ten inches in thickness, found in these beds, which make excellent stones for building purposes.

These beds all make fair qualities of soil, and have a wider exposure than any other group of rocks in the county; and, while nowhere very level, they are the most gently rolling lands in the county. The potable water which issues from these rocks, especially from their lower part, is very good. The whole thickness is something over three hundred feet; but the dip of the series and the exposures, where a good section of any part of it can be seen, are few.

There are a number of places where these soils have been allowed to become badly worn under a poor system of ploughing and grazing. Those places are generally based on the clay soils, which do not hold together very well in dry weather, but crumble down when exposed to the air. On the other hand, they do not form over them a very close sod, and in a wet season, heavy stock tramping on the hillsides are apt to cut through it with their hoofs and start washes, which, if not soon repaired, create bad places in the fields or pastures.

The top of these beds and of the Lower Silurian is marked in places by an irregular mass of limestone, which is filled with large corals of the genus *Columnaria*, and associated with those are many other forms, such as *Tetradium*, *Streptelasma*, &c.; but often the Cumberland Sandstone is at the top, making it difficult to determine the dividing line between it and the next.

UPPER SILURIAN.

The rocks of the Upper Silurian in Garrard amount only to a thickness of some sixty feet, and have at the base thirty-five feet of sandstones, which are the probable equivalents

of the Medina sandstone of New York. The greater part of this is a soft, easily pulverized sandstone, sometimes concretionary, containing in places some layers which have been used for building purposes. They quarry very easily, and in good well-shaped blocks. They are of a dull yellow, but are much lighter in color than the rocks from the middle beds of the Hudson River in other parts of the county. They harden, when placed above drainage, and become very durable.

The soils derived from these rocks are sandy and easily eroded, consequently one sees many sterile spots in the parts of the county where they exist. They are better exposed in what are called the Bald Hills, than at any other locality. They range across the county from Madison to Lincoln, never forming very wide exposures, and are heavier on the Lincoln side. A single layer of this stone contains a small amount of petroleum, and sometimes through some of the heavier beds are seen crystals of celestine, and, in a few instances, small lumps of zinc blende. Casts of a small form of *Atrypa reticularis*, and some other, but indeterminable, forms are found in the sandstone. At the top of this sandstone are often a few inches of limestone, vesicular in structure. This structure is due to former inclusion of fossils, which have been removed. While interiorly blue, this stratum turns red on exposure, owing to the oxidation of the iron that it contains.

Lying on this limestone are from sixteen to twenty-five feet of mud shales or marls, with a few thin plates of limestone intercalated. The shales are blue, black, olive, and brownish-red; are soft and fragile, and decompose directly into a stiff, tenacious clay. Crystals of selenite and iron pyrites are common, and the whole series is impregnated with magnesia. These shales are usually seen in the hillsides as white clays and sterile spots, but in one place they cover several miles of surface, except where cut through by hollows. These are the shales from which the celebrated Crab Orchard Salts are manufactured, and which are more particularly noticed in my Report of Lincoln County. The shales may belong

to the Clinton Group, but until they are connected with rocks which are undoubtedly Clinton, we may retain the name of "Crab Orchard Shales."

Above this shale is sometimes one, or even two, layers of limestone, which contain small rounded grains of clear quartz; but usually these are absent. From the absence of fossils of a determinative character, it is as yet impossible to tell the exact relation of these beds to the separate divisions of the Upper Silurian, to which they belong. This can probably be done when they have been followed through other counties, where they show in heavier masses, and perhaps include fossils in such conditions as will give the required data.

Some shot iron ore is distributed through the soils made by these rocks, and comes from some part of the shales; but I was unable to see it in place. It is in sufficient quantity to form large beds of gravel in the creeks. Some geodes, including crystals of lime, and, in a few instances, of quartz, were seen in the heavier layers. The upper portions probably represent the Oriskany sandstone, seen in Boyle and Marion counties; if so, they do not exhibit exactly the same character here, but are changed somewhat in color and general appearance. I was unable to find the fish remains which mark this bed in other counties; but this was owing, perhaps, to there being no cuts or quarries exposed where a careful examination of it could be made.

DEVONIAN AGE.

Corniferous Period.—The limestones of the Corniferous Period in Garrard county are seen in from six to fifteen feet of rocks, that wear to a buff color on the outside. One layer is internally blue, one has a brecciated appearance, looking as if made from broken, angular pieces of rocks, cemented in a base of another shade. I have been unable to determine whether it is a true breccia, or whether the appearance that it presents has been produced by a change resulting from the alteration and removal of fossils.

A very heavy buff layer at the base contains usually masses of hornstone (flint!) that sometimes amount to one half of its bulk. Nothing can be rougher than this layer, as seen at times, where the limestone has leached away from a large part of the rock, exposing the hornstone on the surface. Great numbers of horn-shaped and honey-comb corals are also included in the limestone. These are all silicified. The limestone, which is magnesian, when decomposed forms a red clay soil, well marked in all exposures, which generally contains quantities of cherty matter from the limestone. Where the Corniferous immediately overlies the Crab Orchard shale, it is broken down in long ledges by the removal of the shale beneath, and exhibits some peculiar features where great blocks have fallen from the hills.

The fossils are a mixture of Corniferous and Hamilton forms, and the few layers here may represent the time when the limestones of both periods were forming of great thickness in other States. The soils rate very well when of sufficient extent to be characteristic, producing a better quality of wheat than any other in the State. In this county they have but little surface extent, and are hardly individual in character, being mixed more or less with those from above and below.

Black Slate.—The Black Slate has often been noticed in the geological reports of the State, and is, therefore, a well known division. It holds an average thickness in the county of about fifty feet, and rests immediately on the Corniferous limestone. It is internally black and very fissile, splitting into thin sheets, or crumbling to powder when exposed. It is somewhat bituminous, and efforts have been made to obtain oil from it; but though some little petroleum was found, yet the quantity was so limited that the money thus invested was thrown away. While this is an oil-producing shale, yet here the conditions are such as to forbid the occurrence of petroleum in quantities that would pay. The shales are too thin in the aggregate; their edges are every-

where too much exposed to the decomposing influences of air and moisture, so that the product escapes as fast as evolved; and besides, no reservoirs can occur to hold and preserve it in any quantity. Very little surface is marked in the county by this formation, for it is soon lost from its outcrop beneath the next division of rocks above.

The soils on the Black Slate are generally poor; unless well drained, they are too wet; but where this is not the case, and they have decomposed to some depth, and have a mixture derived from higher rocks, or an abundance of leaf mold, they produce fair crops. The slate has been used to some extent in road-making; and when the harder layers are selected, they form a very fair material for turnpikes.

As is usual in many other places, attempts have been made to find coal in these slates, and much time has been thus wasted; for every inch of the whole thickness is exposed in the county, and it is evident that no coal can exist in it; besides, in several of the surrounding States, and in many other counties of Kentucky, this slate is well known in its every layer as non-coal-bearing. No coals of any value exist in rocks as low as these.

The two inches of worthless asphaltum coal, which sometimes is seen in these beds, was noticed not far from Dripping Springs. It is here filled with veins of satin spar. At the base of the Black Slate a few layers contain some rounded grains of transparent quartz sand. Higher up, patches of yellow sand are seen in it, marks of plants are not uncommon, and small shells of *Lingula* and *Discina* are often met with.

SUBCARBONIFEROUS PERIOD.

Lower Beds.—Three hundred feet of the Lower Subcarboniferous rocks rest on the Black Slate in this county. They begin at the bottom with about one hundred feet of ash-colored shales, which contain three or four horizons of iron ore at intervals. The shales are thin, and are covered with markings of sea-plants of two kinds—one of which resembles

worm-markings, and the other the tail of a cock. Above these, the shales become harder; and some thin layers of limestone intervene, in which occur a great many fossils heretofore described as from the Keokuk Group of the Northwest.

Still above ppear some hard shales and sandstones, holding great numbers of those round masses of quartz, here, too, as elsewhere, termed "negro-heads" and "bowlders." They are the geodes so often seen in this horizon in Kentucky and other States. There are several layers of crinoidal limestone near the top, and the whole series is capped with a soft earthy sandstone, usually ten or twelve feet thick.

These rocks are the materials of the knobs in the southeast part of the county. They make an inferior soil, and very little land has been cleared and cultivated over them. The higher areas are very well suited for fruit-growing; yet they have been but little used for this purpose. They were once clothed with fine timber; but this has been nearly exhausted. The horizon is too low for coal. Great care should be taken of the young trees now growing on these tracts, as, in the future, much may depend on the supply which they might yield.

Upper Beds.—The upper beds of the Subcarboniferous have only a small thickness, which caps a few of the higher knobs. They are limestones, but being exposed here to the action of the atmosphere, they present externally but little character. They are, however, the base of the St. Louis Group, often called the Mountain Limestone.

To note the relation of those beds with the coal measures, a reconnoissance was made across Copper creek into Rockcastle county. Here the St. Louis Limestone was found about two hundred feet thick, resting on the sandstone at the top of the Lower Subcarboniferous beds. Some shales and limestones of the Chester Group were seen next, and on these the sub-conglomerate coal, the lowest found in Kentuckv.

An examination of the profile will show that the lowest coals are more than three hundred feet above the highest rocks seen in Garrard county. The profile exhibits the position of all the rocks seen in the county, and also the relation they bear to one another. If these rocks were horizontal, the surface features of the county would be widely different. When this central part of the State was elevated to its present height above the level of the sea, a long line or ridge was produced across the State from northeast to southwest. The rocky masses, thus thrust up higher, sloped in two directions. These slopes are to the northwest and to the southeast, being much more gentle to the northwest, and steeper in the opposite direction. This uplift broke and fissured the rocks to a great extent. As has been stated, the gorges of the Kentucky and the Dix rivers lie in those old fractures, and the whole surface of the country, with all the drainage lines, were determined originally by these fractures and dips in the rocks. Since that elevation was produced, hundreds, probably thousands, of feet of rocks have been worn off from a portion of Garrard county. Once in time, the coal measures which lie so high above the lowest rocks here seen were in place over, and far above, the present surface. Time has been long enough for all the forces at work since to dissolve and carry off all the material once in such great thickness here.

Burdett's Knob is an outlier in the northern portion of the county, and holds rocks of the Upper Silurian, Devonian, and Subcarboniferous; and yet it is more than twelve miles from any other outcrop of these formations, which were once continuous over the intervening region. "Poor Ridge" takes its name from the fact that the pebbles from the base of the coal measures, and from strata higher than the coal on Roundstone, cover the soil to a great depth. In the lower part of the county remains of the Corniferous, the St. Louis, and the Conglomerate are scattered over many farms. The disturbance of which we speak produced some local faults near its line. They are of small extent, and have added no percepti-

ble change of features where they are located. The principal one is near Burdett's Knob.

Besides the KENTUCKY ANTICLINAL, or that greater uplift which crossed the lower part of Garrard, there is another to be seen about two miles above the railroad station, on Paint Lick creek. This can be traced across the county to Lincoln, and following through a number of places in the latter county also. Between these two disturbances is a synclinal or valley-like depression—the KENTUCKY SYNCLINAL—in all the rocks, and this feature has preserved much of the rocks seen in the county. Sugar creek valley is a marked characteristic of this synclinal, One may stand on high ridges, either on the northwest or the southeast sides, and look across for twelve or fifteen miles to the other rim, while between lies the valley far beneath, dotted with hundreds of residences and farms, and threaded with a multitude of drainage lines; yet the high ridges and the low valley are alike based on the middle beds of the Hudson River Group, bent into a graceful curve. These are old lines of disturbance, and with them, many minor ones exist, which were produced at the same time. Some little fractures in the creek beds are of recent date, and have only involved one or two layers of rocks, breaking them in lines parallel with the greater or older uplifts.

PALAEONTOLOGY.

The lower portions of Trenton limestones in Garrard county are characterized by *Orthis pectinella*, *Orthis testudinaria*, *Orthis tricenaria*, *Ambonychia bellistriata*, *Raphistoma subtilistriata*, and *Leptaena sericea*. These are more often seen in the chert which remains from the waste of the limestone.

The upper part is marked with the Upper Birdseye, holding immense numbers of *Leperditia* and silicified masses of *Tetradium fibrosum*. Near the same horizon is seen nearly everywhere a small variety of *Orthis lynx*, associated with *Rhynchonella increbescens* and *Orthis borealis*; *Stromatopora rugosum* is often present.

The Hudson River Group closes with a bed in which are associated *Columnaria alveolata*, *Columnaria stellata*, *Columnopora cribriformis*, *Streptelasma corniculum*, *Tetradium minus*, *Beatricea nodulosa*, *Beatricea undulata*, and often other forms.

In the Corniferous may be found *Platyceras ventricosum*, *Atrypa reticularis*, *Heliophyllum halli*, *Zaphrentis gigantea*, *Zaphrentis prolifera*, *Orthis vanuxemi*, *Cystiphyllum americanum*, *Blothrophyllum decorticatum*, *Spirifer oweni*, *Phillipsastrea gigas*, &c.

On Button Lick Knob I collected the following Keokuk fossils: *Spirifer fastigata*, *Streptorhynchus umbraculum*, *Athyris lamellosa*, *Productus punctatus*, *Productus semireticularis*, *Zaphrentis spinulifera*, *Cyathaxonia cynodon*, *Evactinopora sexradiata*.

Those wishing further information on the life history of the formations seen in this and the surrounding counties are referred to my "NOTES ON THE ROCKS OF CENTRAL KENTUCKY."

MINERALS, &c.

Sulphate of Baryta.—Barytes, or heavy spar, is seen at a number of places in Garrard county, usually associated with calc. spar, filling perpendicular veins in the rocks below the Hudson River beds; but it has not been seen in the latter. These veins have a northeast and southwest direction (north 20° east), and are from an inch or less to a number of feet in width. This mineral, as we have said before, is valueless for any legitimate purpose. It is largely used for the adulteration of white lead. A few crystals of galena and zinc blende are often present in these veins. Efforts have been made several times to work these deposits with the hope of finding silver ore, or some other precious mineral. Such enterprises most always result in failure, for there is no probability that in Central Kentucky any precious minerals will ever be found.

The lead and zinc in this county are in far too small quantities to be worth anything.

Fluor Spar.—Some little calcium fluoride is seen at the

top of the Trenton beds, both in veins and cavities, from which fossils have been removed. The quantity is unimportant.

Calcite.—This is of frequent occurrence in all the limestones of the county in its two or more common forms of crystals.

Gypsum.—Sulphate of lime is found in the Crab Orchard shale, and in the lower shales of the Subcarboniferous group in the form of selenite. The quantity is always small.

Silica.—In the geodes, of the Subcarboniferous, crystals of quartz are always found; and often in some of the beds of limestones fossil shells have their cavities filled with them. Chalcedony is a form that is not uncommon. In the Corniferous and Subcarboniferous, jasper has resulted from changes made in the hornstone and in the geodized fossils.

Springs.—Beside the common springs of water, there is a number of mineral springs in the county, the principal ones of which have been analyzed by Dr. Peter, and reported on in published volumes of the State Survey. Those containing an excess of magnesia flow from the Crab Orchard shale. The rest, with an exception or two, come from the Black Slate; the excepted ones are located where sufficient quantities of iron pyrites are held in the limestone rocks to produce, on decomposition, a sulphur or chalybeate water.

Caves.—Some caves are seen in the rocks making up the cliffs in the lower part of the county. They are small and unattractive. Their origin is connected with the fractures so common in that part of the county. (See Appendix.)

ARCHAEOLOGY.

Garrard county contains no large mounds or fortifications erected by a prehistoric people; yet there are evidences of its former occupation by the mound-builders. On the farm of J. K. Nevius there is situated, near the bluff overlooking the Kentucky river, a large pile of stones, which were evidently

placed there for some purpose many centuries ago. They have become so disarranged by parties seeking curiosities or hidden wealth that it is now impossible to determine its former height or shape.

An ancient grave is situated near the residence of C. J. Spillman, and near it have been found quite a number of celts and other implements.

Near the mouth of Dix river, on the farm of Hon. Chas. E. Bowman, a greenstone axe, weighing thirteen pounds, was found. This axe is now in the collection of Centre College, Danville, Kentucky.

Near Paint Lick and Lowell there were a number of small burial mounds, which have all been opened, and found to contain the bones of human beings and relics which were buried with them. Over the whole county celts, arrow-heads, and other implements are occasionally found.

At the time of the first settlements in Garrard county a wealth of timber grew over all its surface. From the top of the tallest knob down over the sloping hills and valleys to the fringe which skirted the banks of the streams, was an unbroken forest. With the proper care, which might have been given in the clearing of the forests, and in the protection of the young trees, it might still have an abundance of timber. To-day the melancholy fact stares us in the face that nearly all the trees valuable for lumber are gone, and that the present needs of the people have to be supplied from other counties, and in part from other States. Over the knob region, where the land is not cleared for cultivation, and in restricted areas in other sections, young trees are growing in numbers. No care is taken of them; they are broken and bent, run over or cut down, as if they would never be of any value. Fires sometimes sweep through them, doing much damage. From all these, little can be expected in the future. With proper care, however, in time these timbered lands would be worth more than any others in the county. Young trees of all the better species thrive in many places where lands have been thrown out from wasted cultivation. If thinned

out from the poorer kinds, they would in time make splendid trees.

The Map.—The county map, accompanying this report, represents by different colors the approximate outcrops of the divisions of rocks, as they occur in the whole county. As the soils are immediately derived, with few exceptions, from the underlying rocks, it also becomes a soil-map, exhibiting the various qualities of land which make the general surface. Should, at any time in the future, an effort be made to cultivate timbers in the county, a knowledge of their former distribution over the separate soils, with their qualities and sizes, would go far toward an intelligent success.

TABLE OF ELEVATIONS ABOVE SEA LEVEL.

Mouth of Dix river (Chazy Limestone)	503 feet.
Mouth of Jessamine creek (Chazy Limestone)	512 feet.
Mouth of Cooper's Branch (Chazy Limestone)	525 feet.
Lancaster Court-house	1100 feet.
Lancaster railroad level (Upper Hudson River)	999 feet.
Hyattsville railroad level (Upper Hudson River)	1004 feet.
Lowell railroad level (Upper Hudson River)	789 feet.
Paint Lick railroad level (Upper Hudson River)	794 feet.
Burdett's Knob (Lower Subcarboniferous)	1090 feet.

GEOLOGICAL SURVEY
OF
KENTUCKY

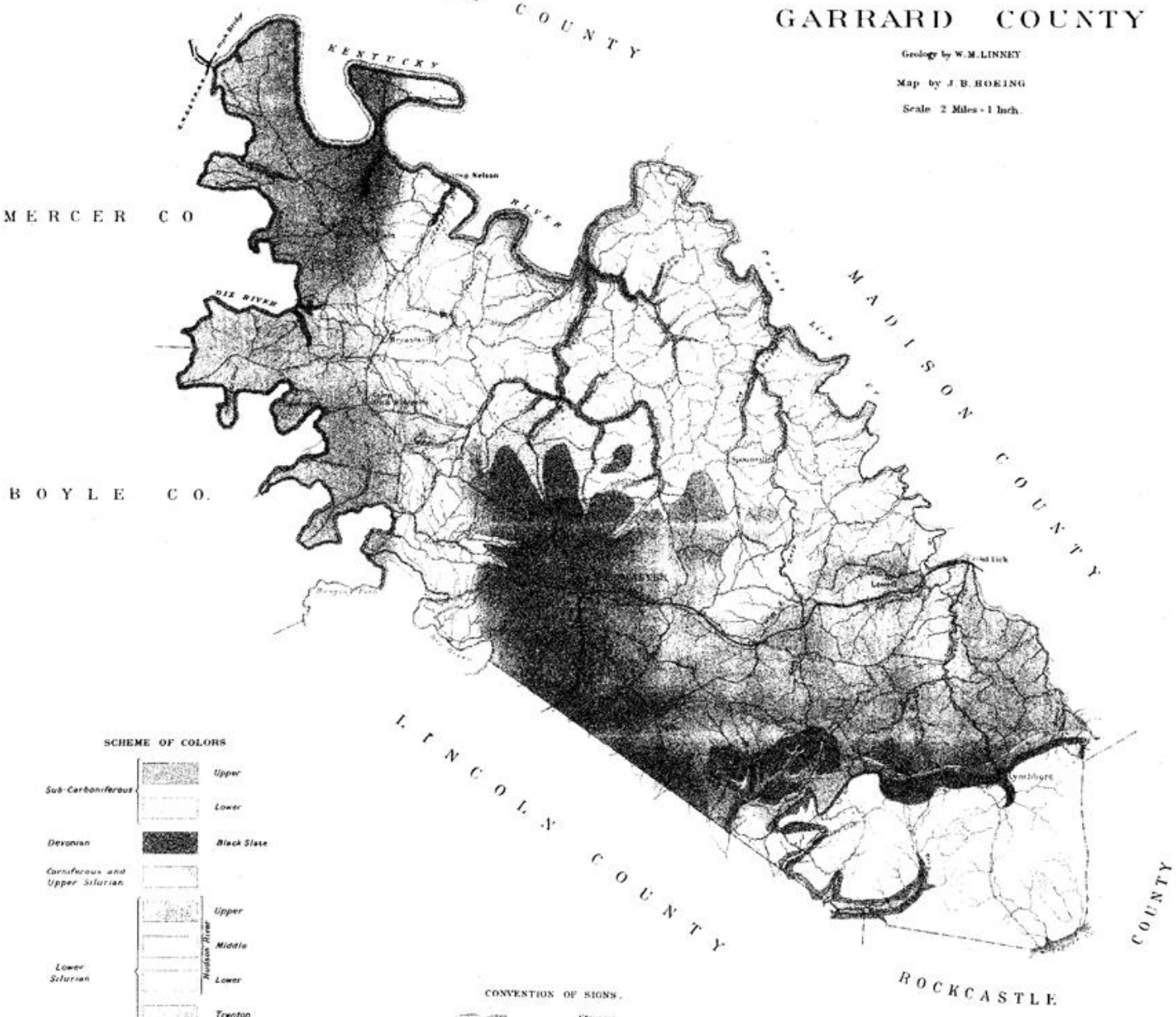
JNO. R. PROCTER, DIRECTOR.

GARRARD COUNTY

Geology by W. M. LINNEY

Map by J. B. HOKING

Scale 2 Miles - 1 Inch.

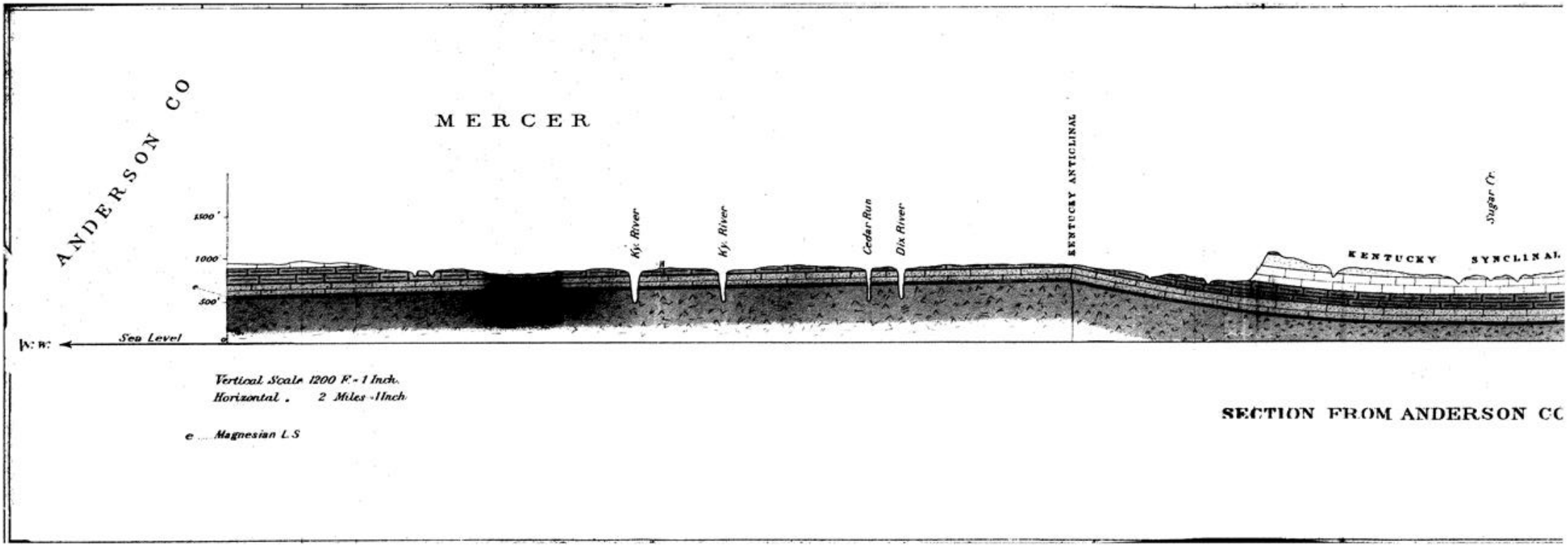


SCHEME OF COLORS

Sub-Carboniferous		Upper
		Lower
Devonian		Black Slate
Carniferous and Upper Silurian		
Lower Silurian	Hudson River	Upper
		Middle
		Lower
		Trenton
		Birdseye
Cambrian		Chazy & L. S

CONVENTION OF SIGNS.

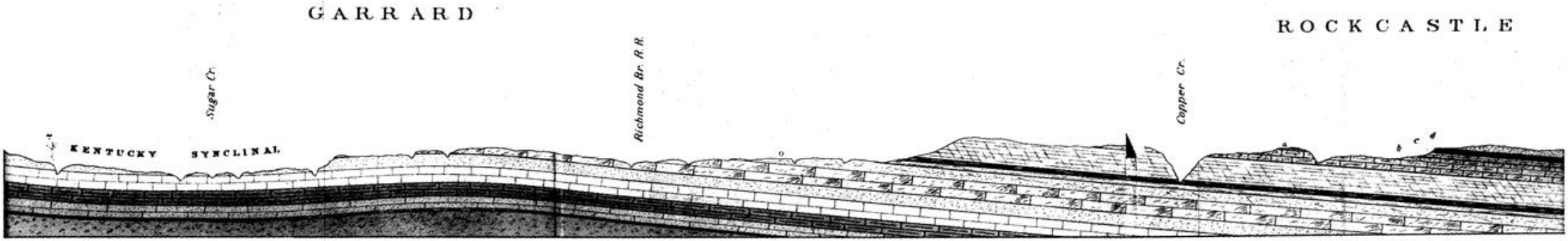
- Streams
- Roads
- Rail Roads
- Indian Mounds
- Nursery
- County Lines



Vertical Scale 1200 F. - 1 Inch.
Horizontal . 2 Miles - 1 Inch.

e .... Magnesian L.S

SECTION FROM ANDERSON CO



GEOLOGICAL SURVEY OF KENTUCKY

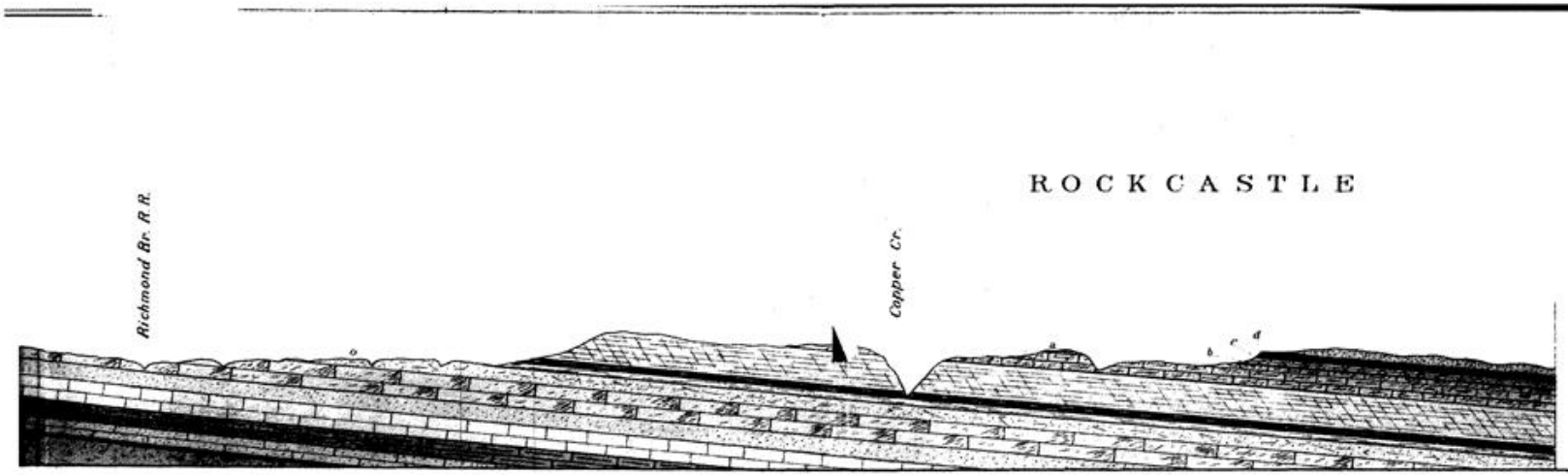
JNO. R. PROCTER, DIRECTOR.

ON FROM ANDERSON CO THROUGH MERCER AND GARRARD TO SUB-CONGLOMERATE COAL IN ROCKCASTLE.

SHOWING KENTUCKY ANTICLINAL AND SYNCLINAL.)

GEOLOGY BY W. M. LINNEY.

a ... *St. Louis L.S.*
b ... *Chester*
c ... *Sub Conglomerate Coal*
d ... *Shale*
o ... *Cumberland S.S.*



RVEY OF KENTUCKY

CTER, DIRECTOR.

ND GARRARD TO SUB-CONGLOMERATE COAL IN ROCKCASTLE.

NTICLINAL AND SYNCLINAL.)

BY W. M. LINNEY.

a St. Louis L.S.
b Chester
c Sub Conglomerate Coal
d " " " Shale
o Cumberland S.S.

Conglomerate S.S.

Sub Carboniferous — Upper; Lower

Devonian — Black Shale

Cornyferous and Upper Silurian

Lower Silurian or Cambriap — Hudson River: Upper; Middle; Lower; Trenton; Birdseye; Chazy L.S.

APPENDIX A.

STATISTICS OF GARRARD COUNTY, COMPILED FROM THE REPORTS OF THE 10TH UNITED STATES CENSUS, 1880.

1880. Total population	11,704
1870. Total "	10,376
1860. Total "	10,531
1880. White "	8,009
1870. White "	6,972
1860. White "	6,857
1880. Colored "	3,695
1870. Colored "	3,404
1860. Colored "	3,674
1880. Native "	11,654
1870. Native "	10,338
1860. Native "	10,443
1880. Foreign "	50
1870. Foreign "	38
1860. Foreign "	88
1880. Lancaster "	1,234
1880. Bryantsville, population	119
Number of farms	1,099
Acres of improved land	118,055
Value of farms, including buildings and fences	$3,035,958
Value of farming implements and machinery	$71,529
Value of live stock	$545,969
Cost of building and repairing fences, 1879	$31,629
Cost of fertilizers, 1879	$145
Estimated value of all farm products, 1879	$474,184
Assessed valuation, real estate,	$2,427,986
Assessed valuation, per'l prop'ty,	$604,179
Assessed valuation, total	$3,032,165
Taxation, State	$13,796
Taxation, county	$12,129
Taxation, town and school dist.	$1,172
Taxation, total	$27,097
*Miles of railroad	14
*Valuation of railroads in the county	$168,000
*Miles of turnpikes	72
*Average cost of turn'kes per mile,	$2,000
*Total cost of turnpikes	$144,000
Number of horses	3,702
Number of mules and asses	1,133
Number of working oxen	416
Number of milch cows	2,390
Number of other cattle	6,335
Number of sheep	10,266
Number of swine	25,221
Pounds of wool	60,725
Pounds of butter	114,998
Pounds of cheese	906
Gallons of milk	310
Bushels of Indian corn	828,173
Bushels of wheat	143,960
Bushels of oats	21,356
Bushels of rye	18,423
Bushels of Irish potatoes	6,361
Bushels of sweet potatoes	3,646
Bushels of barley	1,030
Bushels of buckwheat	95
Tons of hay	1,078
Value of orchard products	$6,027
Pounds of tobacco	45,612
Manufact'ing establishments, No.,	34
Capital invested in	$72,425
Number of hands employed in	49
Amount paid in wages	$15,544
Cost of material	$81,525
Value of products	$130,231
Bonded debt	$152,266
Floating debt	$690
Total debt	$152,956
Sinking fund	$50,000
Net debt	$102,956
†Total No. of acres of land, 1881	138,711
†Average listed value per acre, 1881	$16.15

*Derived from other sources.

†Auditor's Report.