GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, DIRECTOR.

REPORTS ON THE GEOLOGY

OF

BATH AND FLEMING COUNTIES,

BY W. M. LINNEY.

STEREOTYPED FOR THE SURVEY BY JOHN D. WOODS, PUBLIC PRINTER AND BINDER FRANKFORT, KY.

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INTRODUCTORY LETTER.

Hon. John R. Procter, Director of the Kentucky Geological Survey:

DEAR SIR: I hereby transmit to you reports on the geology of Bath and Fleming counties. To the report on Bath county I have added, as an appendix, a record of the amount of rainfall occurring at Sharpsburg during the last twenty-six years. This record was kept by Mr. Jonathan Vanarsdall, and makes a valuable addition to my report. My thanks are due to him and a large number of other gentlemen of those counties for favors shown during my work.

Yours very truly,

W. M. LINNEY.

HARRODSBURG, KY., January, 1886.

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GEOLOGY OF BATH COUNTY.

Historical, Topographical, Etc.

Bath county was created by the act of legislation as one of the Kentucky counties in 1811; its territory being, until that time, a part of Montgomery. In 1869 a portion of its original territory was taken to aid in the formation of Menifee.* Bath is situated in the northeast-central part of the State. The Licking river flows along its northeastern boundary, Menifee county is on its southeast, Montgomery on the southwest and Bourbon and Nicholas counties on the northwest. The topographical features are quite varied.

Around Preston Station, and near the head of Flat creek, the county is level or gently undulating. Some fine rolling lands are situated along the ridge between Little Flat and Flat creeks, and in some other parts of the county. Much of the surface is considerably broken—narrow ridges and deep-cut hollows, giving steep slopes, being the rule; while on the southeast side the hills become so high and abrupt that they might be called mountains. From some of these more elevated points far extended landscapes are presented to the view, and nearly the whole surface of the county can be seen from a single point. One does not easily forget or become tired of gazing from those hills over the plainlike surface of the blue-grass region, lying towards the north, or from the hills around Owingsville, at the panorama of mountains towards the south and east.

The whole drainage system of the county finds its way into the Ohio through the Licking river. The latter stream has many

* The portion of Bath given to Menifee county was along its southern border and extended into the rocks of the coal formation. Any one reading the notes of Dr. David D. Owen, in the first series of reports on the geology of Bath county, should remember that the coal beds and part of the iron ores there mentioned are now in Menifee county.

fine sites for the erection of mills and manufactories, but only a few of the former are built on its banks. During the high tides rafts of saw logs and a few barges of coal are floated down, industries which might be largely increased by intelligent enterprise. Hinkston creek runs along the county line for some miles. Flat creek and Little Flat are in the northern part of the county. Slate creek, a beautiful but very crooked stream, having considerable water power, winds nearly through the center of the county. It has a large number of small branches which enter it from the north and the south. Farther to the south is Salt Lick creek, with its many small tributaries, all rising in the mountain region. Clear, Caney, two Indian and one Little Indian, Clover, Cow and other creeks find their way into the Licking. The county is thus well drained and supplied, except in times of severe drouth, with an abundance of fresh, flowing water, for stock and other purposes.

The Chesapeake and Ohio railroad extends east and west through the south-central part of the county, and nearly the whole of the traffic and travel of the county is from the various stations along its line. At Olympia there is a track two and a half miles long, which extends to the Preston ore banks, and is used altogether in the shipment of iron ores. The northern part of Bath is fairly supplied with well-constructed turnpikes, but many of the roads in the southern portion are not macadamized, and in places are very rough and bad, especially in the winter season. The common school system has been better cared for than in many other counties, while higher schools have been maintained at Owingsville and Sharpsburg for a number of years. The county has an area of 275½ miles. or 176,064 acres of land, and in 1880 had a population of 11,982.

Owingsville is the seat of justice, and contains about 1,000 people. It is beautifully situated on a ridge, between Slate and Prickly Ash creeks. There is, perhaps, no town in the State from which such interesting and extended views can be seen, and commanding such perfect drainage in every direction. Sharpsburg, Bethel and Wyoming are small villages lying in the northern part of the county; while, in the southern portion, Preston, Olympia and Salt Lick are stations on the Chesapeake and Ohio railroad.

The following table gives the elevations of a number of points in the county, above the sea level, as well as the group of rocks upon which the various points are located. With the aid of the map, which exhibits the different formations as they are on the surface, and this table, the reader can obtain a good idea of the general topography and the unevenness or dip of the rocks as the county is traversed from northwest to southeast:

Slate Creek, railroad level	750	Top of Upper Hudson.
Mill Creek, railroad level	703	Upper Silurian.
Mud Lick Creek, railroad level	656	Upper Silurian.
Salt Lick Creek, railroad level	650	Upper Silurian.
Licking River, Farmer's Bridge, railroad level	668	Black Slate.
Preston, railroad level	741	Niagara Shale.
Olympia, railroad level	751	Niagara Shale.
Owingsville	995	Niagara Shale.
Slate Creek, south of Owingsville	688	Upper Hudson.
Prickly Ash Creek, north of Owingsville	735	Upper Hudson.
Ridge, northwest of Owingsville	1,020	Upper Hudson.
Top of Carrington's Rock	1,396	Conglomerate.
Flat Creek, about	650	Lower Hudson.

GENERAL GEOLOGY.

The general section of the rocks of the State is exhibited by the following diagram. Some of the figures are only approximate, as the details are not yet complete:

	FEET.
Tertiary and Quaternary	300
Coal Measures	2,000
Conglomerate	2,000
Subcarboniferous	1,200
Devonian	235
Upper Silurian	285
Lower Silurian	1,375
Total	7,395

In order to obtain this result the *maximum* thickness of each of the various groups should be added together. In no one county of the State does one-half of this thickness show, and often only a portion of one single formation is to be seen. Bath county has far more than an average exhibition of the various geological divisions within its borders, and from this and other facts it is of a more interesting character than some others in the State. The various groups of stratified rocks here approximate about fifteen hundred feet, and, beginning with a portion of the Lower Silurian, they extend to and include part of the Conglomerate, which lies at the base of the Coal Measures.

Nothing like the above thickness can be seen at any one point, but by beginning in the northwestern part of the county and passing to the southeastern border, we successively traverse the divisions in regular ascending order until we have reached the highest. The lowest rocks are to be seen in the northern part, in the valley of Flat creek, and the highest on top of Carrington's Rock. The whole system of rocks dip from the northern portion to the southeastern. This dip amounts to about seven hundred and fifty feet; so, while Carrington's Rock is only some seven hundred and fifty feet higher above the sea level than the valley of Flat creek, the rocks which show in Flat creek are some fifteen hundred feet beneath the top of the Rock, and this difference brings them beneath the level of the ocean.

This inequality of the rocky strata of the county was produced by a marked line of disturbance, which passes through the State from northeast to southwest, and where the rocks were elevated and displaced more than on either side of the line. This anticlinal passed through the county near its northern limit, and from it the rocks slope gently towards the northwest, but more strongly in the opposite direction. The dip is not regular, being greater at some points where the eye can trace it very plainly, and so slight at others that it requires nice study to determine it. In places there are short lines of minor disturbances in which the rocks can be seen to dip in opposite directions, either towards or from a given point. The details of the dips over a county form a very important study, as only by a knowledge of them can intelligent mining for coal, iron, clays, building stones, etc., be conducted; and the supplies of water from artesian

wells must be governed by a knowledge of their occurrence and persistence.

The annexed table gives the grouping and vertical extent of the smaller, as well as the larger, divisions occurring in Bath county:

Carboniferous.	Conglomerate		170
Subcarboniferous.	Upper beds	65	
	Lower beds	400	465
Devonian.	Black Slate	135	
	Cŏrniferous	12	
	Oriskany	3	150
Upper Silurian.	Niagara	100	
	Clinton	35	
	Medina	10	145
Lower Silurian.	Upper Hudson	350	
	Middle Hudson	175	
	Lower Hudson	40	565
Total	. . . . .	. . . .	1,495

It must be understood that these thicknesses must be approximate only, as the beds are not uniform in depth, being heavier sometimes on one side of the county than on the other. It is hoped that, with a careful study of the various groups as outlined on the map, the following descriptions may be fully understood:

LOWER SILURIAN.

Only the upper part of the above great formation is exhibited in Bath county. The Chazy and Birdseye divisions are exposed in the cliffs of the Kentucky river at Camp Nelson, High Bridge and other points; the Trenton on the surface of Fayette, Wood-

ford, Jessamine and other counties, but the Hudson only here, where the three beds are represented, the Lower in part and the Middle and Upper entire.

Lower Hudson.—These beds have a thickness of two hundred feet, all of which is shown in a large number of counties in Central Kentucky. In Bath they do not rise to the surface of the county at any point. Near the mouth of Lick Branch the tops of them are at the water's edge in the Licking river, and may be traced down the river to the Nicholas line, where they are some forty feet above the stream. They may also be seen along Hinkston, where it makes the county line, and up Flat and Little Flat creeks, for some miles. These beds have been described in several reports on the counties of Central Kentucky, and to give a detailed description of them here would only be a repetition of words. A few points will be mentioned, while the reader is referred to reports on Garrard, Mercer and Nelson counties.

The lower part of these beds is composed largely of shaly limestones and shales, the types of which can be seen in the banks of the Licking river, near the Upper Blue Lick Springs. The upper portion is of heavier, harder limestones, with but little admixture of shale. This solid character is so persistent that the top can nearly always be traced, where shown in this county, by the bench of resistent rocks which outcrop along the margin of the streams. The rocks above are softer, and consequently wear away faster than these, giving a different character to slopes. The great wave marks, which are everywhere, at this horizon, so noticeable, retain their character and persistency with much uniformity, so that, whether seen in Madison, Washington, Spencer or Bath, they present the same unvarying features.

Some of these layers of limestone make a fair article of building stone, and have been used for bridge masonry, foundations, fences and other purposes. The upper part is usually very rough bedded, and from this fact unfitted for any structural purposes. Where the conditions are favorable, springs issue from the line of the upper part, the close texture not allowing the water to pass below before it finds its exit from their surfaces. The exposures are so limited that the series here

does not give any distinctive soils, as those derived from these rocks are mixed from the decay of those that overlie them, and for the same reason the timbers are not characteristic.

Middle Hudson.—These beds which, in the earlier volumes of the Kentucky geological reports, received the name of Silicious Mudstones overlie the Lower Hudson, and are to be seen making up the principal slopes on the Licking river, from Day's Mill down to its northern extension with the county. On Hinkston creek and along the greater part of the drainage of Flat and Little Flat they have an aggregate thickness of one hundred and seventy-five feet. They here give quite a margin of outcrops but never rise entirely to the upper, general surface of the country.

The lower layer is composed of a massive concretionary rock of blue silicious limestone from which, on exposure, the lime largely leaches away, leaving a light silicious rock of a light brown color. These blocks often fall from exposures and look like so many huge kidneys composed of enveloping folds. One, and sometimes two, other layers of analogous character are seen in the series, and the composition of some of the even layers is of the same chemical character. Layers of gray and blue limestones come between them, some of which are even, and others rough bedded. Some of these are hard and resisting and do very well for foundations and fences, and a part of the sandy layers are often used with them. More than half of the series is made up of sandy or clay shales; these decompose easily, as do most of the harder layers. In the shales are quite a large per cent. of potash, and there is more than an ordinary proportion of phosphate of lime in some of the layers. The soils are, therefore, of a good character, and only need the care that an intelligent study of them should give, to keep them in fine condition. That they may be exhausted by injudicious culture, and ignorance of their character, is illustrated in too many cases.

With careful protection against excessive waste, judicious subsoiling and a return, in part, of the vegetable matters grown to these soils, would keep them valuable for many years. Some of the best soils around Sharpsburg are based on these rocks, and they have obtained a deserved reputation where they have remained in possession of owners who knew how to treat them.

Often, with quite steep slopes, these soils are easy to cultivate, but too often the tendency is to plough them in such a way that they are literally washed away. It would be advisable to re-forest many of the greater slopes, or plant in orchards, because they could thus be better protected than by yearly cultivation. Some kinds of fruit succeed well on them, and the growth of every plant is rapid.

By an examination of the notes on this series, contained in the reports mentioned under the Lower Hudson, it will be seen stated that the Middle beds in the State were largely covered with a forest of beech trees. On Hinkston there seem to have been but a limited number of trees of this species, but along the Licking and on Flat creek it was a very common tree in places. The other trees which characterized these beds in the county were largely yellow poplar, chinquapin oak, black walnut and sugar maple. The forests have been largely destroyed, and few trees of any great value remain. Where circumstances are favorable young trees spring up and grow with much rapidity.

Upper Hudson.—This division lies on top of the last beds mentioned, and makes up a larger part of the surface of the county than that of both the Lower and Middle beds combined. On this group are based the finest and most desirable lands in Bath. Near Bethel, Sharpsburg, and towards the head of Flat creek, part of the lands lie comparatively level, and the county is rich and beautiful. Over other portions there are small areas which lie well, but over much of it the country is either steeply rolling or else much broken. The total thickness is about three hundred and fifty feet, and near the Licking river, opposite Day's Mill, a section is exhibited of three hundred and thirty feet. The Middle beds disappear under the river, near this point, and from the water level to the top of the county only the Upper beds are present.

The section is composed of blue and gray limestones, in large part. Some shales come between some of the layers, and a few courses are brownish on exposure, containing some magnesia. The larger part of the limestones are, however, in the condition of carbonates—some quite pure, while others contain variable proportions of earthy matters. In a section recently exposed a

part of these beds show a very massive character, but in a few years they break down by crumbling and exfoliating into thin splintering layers. This is especially true of those parts of the beds so largely made up of the fossil remains of the ancient life, whose shells and other parts make up so large a proportion of these rocks. One large shell, about the size of a hulled walnut, with rough ribs—the *orthis lynx*—ranging nearly through all the strata, is the most persistent and noticeable of them all.

One horizon is well marked, through the county, by being very rough bedded and containing large masses of a sponge—*stromatapora*—specimens of which are often seen isolated from the rocks which weigh more than a hundred pounds. Through the part drained by Lower Indian creek the rocks are much broken into rectangular blocks, and these cover the surface in such profusion that it is impossible, in some places, to plough the land. The same condition is to be seen, on a smaller scale, across the county toward the west. This feature is due to its being on the line of the greater disturbance, and the immense force exerted here caused remarkable fractures along a continuous line. The extreme upper parts of these beds contain some sand in the clay shales, and from this reason are more inclined to wear away more easily. This, in part, accounts for the superiority of the lands on the Bethel ridge over those on the ridge between Flat creek and Prickly Ash.

Some of the farming lands based on the steeper slopes of this division have been very badly treated. The soils have been ploughed and left in such condition that they have been washed away, leaving only a chaos of rocks to cover the ground. This treatment has been worse in past years than more recently. Evidences are presented on many sides which show that, at least in part of the county, more interest has been given to the preservation and improvement of these lands, and that quite a number of farms, which were formerly considered as worn out, have been largely restored to fertility.

A number of analyses of the separate soils of the three divisions of the Hudson period have been made by the State Chemist, Dr. Robert Peter; from them the following table is compiled:

	Lower Hudson Soils. .	Middle Hudson Soils. .	Upper Hudson Soils. .
Organic and volatile matters	5.089	4.778	7.895
Alumina and iron and manganese oxides	6.782	7.064	8.664
Lime carbonate	.192	.101	.543
Magnesia	.332	.605	.665
Phosphoric acid	.166	.165	.369
Potash, extracted by acids	.180	.155	.315
Sand and insoluble silicates	87.005	86.551	81.690
Total	100.000	100.000	100.000

These results are from the average analyses of a number of soils, virgin and worn, and the subsoils beneath them. Those of the Upper Hudson were selected from Bath county, the others from several counties where the Lower and Middle Hudson are prominent and distinctive. As the latter show in this county quite a uniformity with the conditions present in other counties, they may be taken as fair representatives of the Lower and Middle Hudson of Bath county.

It will be seen from the table that the soils of the Upper Hudson have a much larger percentage of organic and volatile matters than is found in either of the other classes. This can be readily seen everywhere, in passing over the country, by the darker color of the soils. It is an important feature, and teaches us the necessity of furnishing to them organic waste by the turning under of certain crops, as a supply to every field. The proportion of potash, phosphoric acid and lime are also largely in excess in these soils, and on these elements is based their excellent character.

As both the Lower and Middle beds contain these substances in a necessary proportion, if they are in an available condition, it may be seen that the Upper beds are especially rich in these substances. Many of the commercial fertilizers, being composed largely of combinations whose worth depends upon potash and phosphoric acid, would be of little or no benefit here. This is one of the most important facts which can be brought before the farmers living on soils based upon the Hud-

son formation. Thousands of dollars have been so spent on these soils without any return, and, without the intelligent education of the agriculturist on this subject, a few more years will see hundreds of thousands dissipated in the same way.

That all of these soils could be materially benefited by more thorough culture, by deep ploughing, harrowing and rolling, producing a lighter and thoroughly mixed soil, admits of no doubt. Much in agriculture depends upon the mechanical condition of the earth, and it is a well-established fact that few farms which have been cultivated for any number of years have enough of organic matters in their soils. In freshly cleared lands the soils, from the presence of dead wood and roots and the rotten leaves, are dark and loose, warm and dry; the plough runs easily and the crops grow rapidly. In the course of prolonged cultivation this organic matter is removed in part as plant food, and in part by the leaching out by the waters which percolate through the earth. The soils then become less productive and more difficult to work. Where the lands are in grass and grazing takes the place of cultivation, or the grains or their refuse are fed on the land, or returned as manures, the removal is not so rapid as where all the crops are taken away from the fields.

The changes which result in soils by the exhaustion of organic matters can be seen on every side in the continuous changes in many of them to lighter colors, and a consequent toughness and coldness. Where fields have had a sod of grass, or a crop of clover, rye or other green crop ploughed under, the rotting of these matters returns organic matters to the land, and the improvement in color, composition and richness can be directly seen. In Kentucky too little of this kind of treatment has been followed. This is the proper way, and in a large measure, the only thing necessary to restore the soils on the Hudson group to a fair share of fertility.

One thing is very evident, in many parts of the State, in seeding the lands to grass, not enough seed is sown to the acre, and the number of grasses are too few. If farmers would sow plenty of seed and several other grasses with their clover and timothy, they might be assured of better stands; and while some might fail, yet the others would grow all the better. Often this

failure to sow enough results in having a worthless pasture or in losing a year without any return.

The soils derived from the wasting away of the lower rocks of the Upper Hudson are the richest in Bath county. These soils were marked here, as elsewhere in the State, with a forest composd largely of blue ash, chinquapin oak, sugar maple, wild cherry, hackberry, Kentucky coffee tree and some other species. The natural soil is quite dark, often nearly black, and very friable. The Upper portions contained white oak, red oak, black oak, walnut, black hickory, scattering beech and other kinds.

The fossils, which everywhere in the Ohio Valley mark these beds, are to be seen in great profusion at many of the outcrops. The great masses of *columnaria alveolata* are not in such profusion as in the counties more to the west, but may be seen at several places on Slate creek. Here they are about seventy-five feet below the top of the Hudson. *Orthis occidentalis*, *orthis lynx*, *orthis subquadrata*, *pterina demissa*, *streptelasma corniculum*, *tetradium minus* and other forms are to be collected in numbers. Slate creek cuts down into these beds, and the hill-sides are often very rich, while some very desirable bottoms are found on it and the Licking river. At the mouth of Slate creek the action of these streams, with their currents cutting against each other, have eroded a broad valley in the soft layers in the Upper Hudson. Here in places is to be seen an upper bottom, formed while those streams ran at a higher level than they occupy to-day.

UPPER SILURIAN.

The Upper Silurian is one of the great geological formations, being, in places, thousands of feet in thickness. In Kentucky it is quite limited in its distribution and the depth of its beds. Three only of its divisions are present in the State, and all added together only amount to something like three hundred feet. The Medina, the Clinton and the Niagara periods all have a limited representation in Bath county; the Clinton being the most important, as well as interesting, from the presence, here, of an iron ore peculiar to the group.

Medina.—The Medina is here composed of ten feet of rocks which contain some lime and clay, as well as a variable propor-

tion of sand. On fresh surfaces they are bluish, but on exposure they are changed into a dirty yellow. These rocks here are thin bedded, and have between them more or less shale; all these break down rapidly when exposed, and form, sometimes, bare places covered with a yellow sand which marks the Medina everywhere in its outcrop in the State. This sand is unlike any other. A number of plant-markings cover the surfaces of some of the layers, and usually there can be found casts of a few fossils derived from the Hudson beds, in some of the strata, or at least the species are the same. The exposures of these rocks are only a few yards wide, and of no particular importance, except to exhibit the extension of the group.

Clinton.—The series of rocks, shales and ores, which make up the division named the Clinton period, are of wide extent and of much importance. In Bath county they have a maximum thickness of about thirty-four feet. They are variable in their bedding, thinning out in one place and thickening in another. This is due here more to the amount of shales between the rocky layers than to any other cause, although the solid parts are not often even-bedded themselves. An average section of these beds would be nearly represented by the following details:

SECTION OF THE CLINTON IN BATH COUNTY.

	Ft.	In.
Thin limestones and shales	2	0
Limestone	0	10
Shale	1	9
Limestones	...	11
Shales and thin limestones	4	0
Iron ore	2	0
Thin limestone	3	0
Limestone layer	1	0
Wave-marked layer	1	3
Thin limestones	3	0
Shales	6	0
Heavy limestones with chert	9	0
Total	34	9

The heavy layers at the bottom range from five feet, on the western side of the county, to nine feet on the eastern, are massive and rough bedded, and filled with large quantities of flinty nodules and masses. Where the limestones have broken down, these nodules, whole or in fragments, cover the ground and are mixed in the soil in large quantities. The limestones are rather a grayish blue, often mottled with light tints of greenish blue and yellow. Though largely of lime, they contain some magnesia, and enough iron to give them a yellow color on exposure. The limestones above are of nearly the same composition, though some of them have sand in them. The shales are blue and soon *melt* down, on exposure, to a stiff, tenacious clay. Three of these beds are very persistent in their relations--the wave-marked layer, the iron ore and the heavy beds with chert. These are to be seen at nearly every outcrop, and about the same distance intervening between them, the wave-marked layer coming in about ten or twelve feet above the chert bed, and the iron ore four feet above that. This wave-marked rock is very even, and, as we have said, persistent in its character. First seen in Montgomery county, it extends through Bath and Fleming into Lewis. It is from ten to fourteen inches in thickness, marked with ridges from four to six inches in height and about twenty-six inches from crest to crest. The ridges are not a regular curve, but are somewhat sharpened at the top. This layer and the chert bed are invaluable guides in determining the place of the bed of iron ore above.

The bed of iron ore which is shown in the section is part of a wide extended deposit, being known in Wisconsin, New York, Pennsylvania, Virginia, Tennessee, Alabama, Ohio and Kentucky. It has received a number of names—as dye-stone, flaxseed, fossil, lenticular and concretionary ore. It was called Clinton ore from its presence in the Clinton group of New York, and is by this name most generally known. It is a hematite or red ore, but, where it is exposed, changes into a yellowish limonite. It is largely composed of little rounded and flattened grains, which are often due to the replacement of fossil forms. It is peculiarly rich in fossils, but, from the softness of the ore and its liability to change, they can not be preserved with any perfection. The following forms were seen in the associated

rocks and part of them in the bed of ore: *Zaphrentis bilateralis*, small, short forms of *Atrypa reticularis*, *Favosites Niagarensis*, a short oval form of *Pentamarus*, a *Chætetes*, and large numbers of crinoid fragments, the last making up a large part of some of the layers. Quite a number of others are present in these layers, but they are generally in such condition that they can not be determined.

The Clinton ore, except along Pine Mountain, is confined to Montgomery, Bath and Fleming counties, but it is only in Bath that it is found in quantities sufficient to make it of any economic value. In this county its extent is with the outcrops of the Clinton group entirely through its breadth. It varies in thickness from a few inches of poor ore, on the Montgomery line, to near three feet of valuable ore on the eastern side. Its distribution as a workable deposit is confined to the section of the county drained by Rose run, Bracken's branch, Clover and Indian creeks.

Three samples of this ore were collected from as many different places and submitted to Dr. Peter for chemical analysis. The following is his report:

Analysis of Bath County Clinton iron ores, collected by W. M. Linney, June, 1885.

COMPOSITION—AIR-DRIED.

	1	2	3
Iron peroxide	47.630	51.430	58.570
Alumina	5.468	5.132	3.720
Lime carbonate	16.560	13.080	15.160
Magnesia carbonate	9.974	9.444	4.528
Phosphoric acid (P_2O_5)	1.202	1.138	1.010
Silica	7.160	7.800	6.960
Moisture expelled at 212° F.	1.143	.693	1.607
Undetermined, carbonic acid, water, organic matter, etc.	10.863	11.283	8.445
Total	100.000	100.000	100.000
Percentage of Iron	33.341	36.001	40.999

A note from Dr. Peter says: "In each of these samples some of the iron was in the form of *carbonate*, varying in proportion in the several samples.

No. 1 was taken from Camel Rice's, No. 2 from the Purvis lands and No. 3 from the farm of William Warren. In each of these places an excavation had been made to examine the ore, and the selections were made in order to get as fair average samples as could be done by handling.

The following partial analyses of the Clinton ore have been made to determine principally the amount of metallic iron, silica and phosphorus.

	Purvis Lands	Moore's Lands.	Kinkaid Lands.	Minor Lands.	Warren Lands
Sesqui-oxide of Iron	44.30	42.64	55.10	. . .	. . .
Carbonate of Lime	55.10	20.50	16.50	. . .	. . .
Carbonic Acid, Water, Organic Matter	26.30	25.60	19.20	. . .	. . .
Phosphoric Acid	1.59	1.09	1.83	. . .	. . .
Silica	5.00	5.00	5.50	. . .	. . .
Metallic Iron	31.00	29.85	38.60	51.6	52.7
Phosphorus	.69	0.47	.75	.40	.41

This ore underlies several thousand acres of land which could be mined by a small amount of stripping. It has nowhere been mined, but a few tons have been removed and several small mill tests have been made. It is easily mined, gives a satisfactory quality of iron, being what is called a soft fluid foundry iron, somewhat cold short. The amount of carbonate of lime in this ore is a valuable quality and recommends it to more than ordinary consideration, and the time must soon come when this ore will be mined in very large quantities.*

Capt. W. C. Allen, of Owingsville, who owns large interests in these lands, very kindly guided me to many of the outcrops of ore which I should have undoubtedly missed seeing only for him.

The surface exposure of the Clinton is limited to narrow lines overlaid by a shale which belongs to the group next to be described. This shale on top has decomposed into a tough, wet,

* The recent discovery of a very thick bed of coking coal of great excellence in South-eastern Kentucky, and the probability that the region containing this coal will, at an early day, be brought into direct rail communication with these Bath county iron ores, add to their value; and it is to be hoped that they will soon contribute greatly to the industries of the State. J. R. P.

clay soil which, though cultivated here to some little extent, does not give profitable returns. It is wanting in a looser mechanical arrangement, in phosphoric acid, lime and organic matters. The Clinton soils rank as quite good, because they contain these necessary conditions. These lands overlying the Clinton ore, independent of the value of the iron deposits, are cheap, and if put in the hands of immigrants who are given to mining as well as agriculture, many good homes could be made here. In the stripping and removal of the clay shales, and the carting away of the wastes from the limestones, ores and Clinton shales, a system of mixing and spreading, if pursued with a little pains, would not only level up the lands, but this incorporation would give a deep, rich soil, far better than any of the soils which now lie higher than the Clinton in the county. Here, then, the small farmer could cultivate his land, and pay for it by mining the ore at times when he was not employed at his other work. Observation shows that, where the wastes have been scattered about the few openings made in the Clinton, corn and other plants will grow immediately, and as thriftily as on any of the best soils.

Some of the Clinton limestones are used for building purposes, but only to a small extent. The iron which is in them comes to the surface, and discolors them very badly. Some of them, where even-bedded, wear very well.

Niagara.—The Niagara in Bath county is composed almost entirely of a great mass of shales, being some twenty feet thick on the western side of the county, and a hundred feet on the eastern. Its character is best represented at Knob Lick, near Polksville, where it has been cut through and gullied in every direction, giving one a view of its whole section. Here are to be seen, laid bare, the thin clay shales, crumbling down into clay, which is carried down the drains, and, to some extent, deposited in the valley below. They are of various colors—red, green, yellow, blue and black. These take on various shades, which give a peculiar mottled appearance to them, wherever exposed, in Ohio as well as Kentucky.

There are usually to be seen, in this division, thin limestone plates, generally only a fraction of an inch in thickness; these are often filled with holes, as if bored by worms, or penetrated

by roots of plants, while the lamination is curiously curved. Mud markings, or perhaps plant impressions, are often to be seen on them. These are thicker here than they have been seen in other counties. All the peculiar features of these shales are to be seen in the south-eastern part of Nelson, and around Crab Orchard, in Lincoln county. There are to be seen, in several places in the county, one, and sometimes two, layers of blue limestone, which comes in the base of the Niagara. These are some ten and twelve inches thick, and make a very durable building stone. They were used for the construction of the foundations of the court-house in Owingsville, and promise great endurance. The salts of iron which they contain come to the surface, and give, in their oxidation, a very rusty coating to them. These layers are probably the equivalents of the Dayton stone of Ohio, which is considered one of the best building stones of that State.

Hardly a fossil form has been found in these shales; the only species seen are a single specimen each of *Favosites Niagarensis* and a *Stictopora*, perhaps *simulis*, with a few specimens of *Strombodes pentagonus*. The timbers were largely oaks, with some black hickory associated with occasional trees of other species. In places there are remaining some bodies of white oak. In the years in which Bourbon furnace, and one or two forge mills, were making iron, large tracts of land had all the forests destroyed for the burning of coal; these, where not kept permanently cleared, have a second growth of red oak, black oak, post oak, black hickory and other species. Other notes on the Niagara shales will be found in the report on Fleming county.

DEVONIAN.

The Devonian formation has only three of its periods represented in Bath county—the Oriskany, the Corniferous and the Black Slate of the Hamilton period. Each of these is thin here, as compared with what it exhibits at some other places, only aggregating some one hundred and fifty feet altogether.

Oriskany.—This is one of the thinnest series which have any representation in Kentucky. As far as it can be recognized in the State, it is confined to the counties of Marion, Boyle, Lin-

coln, Garrard, Madison, Clark, Montgomery and Bath. It usually consists of a single layer of a dirty, bluish gray, tough stone, containing sand, lime and alumina, and marked, especially in places, with an ancient sea-weed, which has received the name of *cauda-galli* from its resemblance to the tail of a cock. The most noticeable feature is, however, the presence in the lower part, at nearly every exposure, of quantities of the remains of the bones, fins and teeth of fish, with phosphatic nodular masses, which may have been the excrement of the same forms of life. Rarely, a few casts of shells have been seen, and a well preserved fragment of a *conularia*, perhaps the species *lata*. The percentage of phosphoric acid is quite large and could be made valuable for the purpose of fertilizing poor soils. This layer has a thickness of from twelve to eighteen inches, but in Bath it rises to about three feet. Resting on the Niagara shale, it is not always possible to see its bedding, but there are many places in the Tanyard precinct where it can be seen sometimes in blocks of large size, broken down by the weight of the Corniferous above.

Corniferous.- The rocks which compose this group in Kentucky are nowhere thick, and in Bath county have a maximum of from twelve to thirteen feet. They are not regular, however, at this thickness. They are from eight to ten feet on the Montgomery side of the county, not more than three or four feet near the Rowan line, and seem to reach their greatest thickness near Judge Ewing's, north of Slate creek. They are exposed in a very narrow line, usually as a wall of heavy layers of moss-covered stones. The outcrop is so narrow that the line of exposure can only be judged on the map by the line which separates the Upper Silurian from the Black Slate.

The beds are composed of several massive layers, with some thin beds near the top. One of them is nearly five feet thick, and one other nearly as heavy. They are true limestones, but containing some magnesia. The heavy layers are filled, usually, with mosses and extensive layers of hornstone (flint), while the fossils distributed through them are of the same material, except at the top. These heavy layers have been quite extensive beyond their present outcrops, but have been broken down, de-

composed and removed, leaving the hard, flinty matter distributed through the soils and on the surface. This is finely illustrated on the hill at Owingsville, where the rocks have entirely disappeared, leaving their earthy matters as a red clay soil, filled with vast quantities of flints, among which are many species of corals, etc., which belong to this period. They rest now, as the series did, on the top of the blue shales of the Niagara, which is here reached in digging wells and other excavations.

These flinty remains can be seen in many places in the Tanyard precinct, and near Mr. Green Botts' several acres of ground are thickly covered with them. Here the *debris* seems to have come from one continuous layer, and so uniform and noticeable is the deposit that it has been referred to as artificial work, done by some prehistoric race of people. This feature is not an uncommon one, where limestones are filled with such material, and the phase can be seen in many places in Kentucky in other limestones, as well as the Corniferous. The thinner layers at the top are more earthy, and in places approach a cement rock; these are easily decomposed, and not often to be seen, even when looked for. They are, perhaps, referable to the Hamilton group. In the descriptions in this State they have been included with the Corniferous.

Among the fossils seen are several species of *favosite* corals —those which resemble the nests of bees and wasps, quite a number of horn-shaped corals, a few shells and trilobites, and commonly a round form of sponge, about the size of a walnut. As has been stated, nearly all of these are silicified, and though to be seen in numbers, at times, are generally poorly preserved. Some little iron is usually present in these beds, and the deep red color of the soil, derived from them, is due to the presence of this mineral.

The soils based on the Corniferous, or derived from its destruction, are quite limited in the county. The top of the ridge on which Owingsville is situated is in part of these beds, and south of Slate creek, in the western part of the county, there are a number of farms which are, in part, based on these soils; all of it together, however, makes comparatively but a few acres. The soils are usually good and highly productive; the forests have

been removed from them, but they usually have been covered largely with sugar maple, interspersed with large yellow poplars. Besides the fossils noticed farther on, in connection with the iron ore of this horizon, the following were seen: *Cyathophyllum gigas*, *C. Halli*, *C. juvenis*, *Zaphrentis proliferum*, *Z. raffinesqui*, *Amplexus Yandelli*, *Blothyphyllum Americanum*, *Chonophyllum gigas*, *Phillipsastrea gigas*, *Favosites linutaris*, *Favosites Troosti*, with quite a number of other species common to these beds, wherever they are seen exposed in the State.

Preston Ore Banks.—This unique and remarkable deposit of iron ore occupies the place of Devonian rocks, the Oriskany and the Corniferous; peculiar to a small area, and existing only in Bath county in workable quantity, it is, on some accounts, a very interesting accumulation. It occupies a narrow line just south-east of the disturbance mentioned some pages back in this report. It has been seen in Casey county, near Concord church; near Moreland, in Lincoln; near Brumfield Station, in Boyle; the Indian Old Fields, in Clark, and at several places in Montgomery. Increasing in quantity from west to east, it culminates in Block-house and Howard's hills in Bath, and isto be seen but little farther east. In all its extent it is only on the above hills that it is in sufficient force to make it a workable ore. That its former extension, as a large deposit, must have been greater than at present, is most certain, but its lateral extension must have been very narrow, and its deposition controlled entirely by the conditions left by the elevation of the Kentucky anticlinal. When that uplift took place, there must have been not less than two thousand feet of rocks, which overlaid the horizon now occupied by this ore, rocks which were rich in iron, at several levels, and with more or less of it distributed everywhere in them. As this great mass of superincumbent strata was broken up, dissolved and carried away, the iron from it was either borne away by the drainage lines, or redeposited in the rocks below.

Along the south-east slope, from the fracture of the greater disturbance, there are a number of small elevations and depressions in the strata, and it was down into one or more of these

that the iron in solution penetrated and was deposited. This ore bed evidently was less than a mile in width, and perhaps less than half of that of any economic thickness. About one mile north of Preston Ore Banks, at Judge Ewing's, the Corniferous is in place in its full thickness, and with the same character as seen in a number of counties, but here does not contain more than its normal amount of iron. Yet at the Banks the whole thickness of the Oriskany and the Corniferous has been replaced with this mineral.

A close examination of this bed of ore shows all the essential features belonging to the groups which it has replaced. At the bottom the ore is, usually, a carbonate, as the whole bed has probably been in time. In fracture and appearance, outside of the deeper blue which it has as an ore, as well as of the thickness and bedding, it is like that of the Oriskany, and at the same time it contains the fossil bones, teeth and spines, as well as the *conularia* and phosphatic nodules, which are only seen in the layer of that rocks in the State.

Above, the ore holds about the same thickness as the Corniferous; there is some resemblance in the bedding, and I was enabled to find enough fossils in it to fully make out the position, a *Zaphrentis* and a *favosite* coral, *Spirifer raricosta*, *Spirifer Oweni*, *Orthis Vanauxemi*, the large form of *Atrypa reticularis*, the presence of more or less hornstone, more or less decomposed, and the peculiar fossil sponge, *Astylospongia praemorsa*. Near the top was seen *Phacops bufo*, *Spirifer umbonata* and *Athyris spiriferoides*, showing in the whole section just such an association as is found in the beds where not more than ordinarily changed. The silica of the hornstone, and the alumina near it, released by decomposition, have in places formed a clay very much like halloysite.

This iron ore all has an oolitic structure, composed of little rounded grains, and this extends to the chert and to the nodular masses at the bottom. Near Peeled Oak creek, on the western side of the county, one of the layers, near the top of the Corniferous, has been converted into iron, but without the oolitic feature, yet near the same point the phosphatic nodules in the Oriskany have been changed, while none of the balance of the section has been altered. These are the most

beautiful illustrations of the structure that are exhibited in the whole series. The Corniferous along this line of disturbance has been much fractured, and the fractures have widened by running water dissolving away the edges of the layers; springs issue from some of these, while others are barely separated. In mining a breast of the ore the same system of original fracture is observable, the ore in the opened spaces being curiously contorted, while that in the massive wall, between, appears to have been deposited by displacement in the regular bedding. Something like a small arch runs between Block House and Howard's hills, and there is evidence that the ore has been carried down through the fractures to the almost impervious beds of the Niagara Shale; that it here found a chemical condition under which it began to deposit, first filling the fractured lines, and then, the water having borne away the lime, leaving the iron to occupy its place in these beds. The little shell, *Spirifer umbonata*, is usually found in a thin, marly layer, containing quite a percentage of phosphate of lime, while the Oriskany has, in places, more than ten per cent. of the same material; this fact may have furnished the necessary condition for the deposition of the iron, and well accounts for the large proportion of phosphorus in it. The Preston ore has usually been described as the Clinton ore, and in some of the former reports of the Survey, as well as in the table of analyses heretofore published, it has been so written. The two ores occupy quite different positions, as will be seen by these descriptions, and their character is altogether different. The Clinton is always a hematite, while the Preston ore is a limonite, and, in part, a carbonate. The former sometimes contains a little corbonate, sometimes a band about two inches thick, and the latter, in rare cases, a little turgite and minute particles of vivianite.

In 1791 the first iron furnace built in Kentucky, perhaps west of the Allegheny mountains, was erected on Slate creek, near these banks, for the purpose of working this ore. It was first called the Bourbon Furnace, but afterwards known as the Old Slate Furnace, and the deposit of ore as the old Slate Furnace Banks. It was in operation, making charcoal iron, during a period of forty-seven years, when, the lease expiring, it went out of blast, and work has never been resumed. No ore was mined here for a number of years; but recently the

banks were leased by the Slate Creek Iron Company, of which Mr. P. N. Moore, formerly of the State Geological Survey, is Superintendent, and the ore has been regularly shipped in large quantities over the Chesapeake and Ohio Railroad to Ashland and other points. Mr. Moore, before the present company was formed, calculated that the crest of those two hills contained more than one million eight hundred thousand tons of ore, and it is probable that the estimate was quite low.

The breast of ore is from seven to near fifteen feet in thickness, overlain by a few feet of clay and decomposed ore. The stripping is comparatively thin, and easy of removal, and the ore is not difficult to mine. A railroad track runs to the banks, and the cars are loaded and the ore is screened from a tipple. Everything is arranged so well that the ore is mined, loaded and shipped at the least possible cost, and the business is perhaps one of reasonable profit. During the progress of the Survey, under the charge of Dr. Owen, he collected samples of this ore, which were examined by Dr. Peter, chemist to the Survey, with the following results:

*Analyses of four samples of limonite ores from old Slate Furnace Banks, dried at 212° F.:

Number in report	777	778	779	780
Oxide of iron	76.680	76.774	52.660	80.520
Alumina	.440	.800	2.642	3.482
Carbonate of lime	None.	None.	A trace.	None.
Magnesia	.685	1.018	.781	.558
Brown oxide of manganese	.580	.680	.580	.220
Phosphoric acid	.886	1.206	.438	.758
Sulphuric acid	.235	.221	.235	.201
Potash	.358	.258	.509	.386
Soda	.197	.202	.230	.132
Silex and insoluble silicates	8.080	7.280	32.780	3.280
Combined water	11.200	11.760	9.300	10.900
Loss	.659	.....	.....	....
Total	100.000	100.199	100.155	100.437
Moisture expelled at 217° F.	1.300	1.740	1.900	1.500
Percentage of iron	53.400	53.766	36.878	56.369

* From page 62, Vol. IV. Old Series Ky. Geol. Rpts.

The following results have been obtained on these ores from analyses made by Dr. Peter and Mr. John H. Talbutt, some of them only to determine the percentage of iron. No. 1269 is from page 16, Nos. 1652 and 1653 from page 200, Chemical Analyses A, Kentucky Geological Reports; the others have not heretofore been published, but were kindly given me by Mr. Moore from the books of the company:

Number.	1269	1652	1653	A	B	C	D
Iron peroxide	76.077	70.060	69.728	73.570	....	....	....
Alumina	2.592	4.540	8.642	4.890	5.670	....	....
Manganese	.430	....	....	.370	....	....	....
Lime, carbonate	.130	.040	.170	1.150	....	....	....
Magnesia	.281	.021	.045	.630	....	....	....
Phosphoric acid	.731	1.620	1.154	2.890	....	....	....
Sulphuric acid	.030	.031	.134	....	....	....	....
Silica and insol. silicates	8.180	11.530	7.930	4.940	....	6.950	4.080
Water	12.300	12.300	12.650	14.200	....	....	....
Phosphorus	.319	.707	.504	1.260	1.220	.800	.690
Metallic iron	53.254	49.042	48.809	49.500	45.220	46.620	52.220
Sulphur	.011	.012	.053	....	....	....	....

There are several hills not far from the Preston Ore Banks with a waste of the same class of ore on them; but the quantity is, perhaps, too small to invoke the ironmaster's attention. Along the outcrop of the Black Slate, south of this point, there are in places some thin layers of this ore exposed, in fragments, on the surface, but the indications are that it is in small force, and not worth prospecting for.

Black Slate.—This formation, which, from the Ohio river at Louisville, circles around the blue limestone rim of Central Kentucky, always resting immediately on the rocks of the Corniferous group, is the most readily determined of any. Being only forty or fifty feet thick in Boyle and Marion counties, it increases in thickness towards the east, quite regularly, and on the side of Bath near the Montgomery line is some one hundred and twenty feet in depth, and, in crossing the county to the Licking river, has run up to one hundred and thirty-five, perhaps to one hundred and sixty feet in thickness. Seen

in the southern part of the county only, it there presents but a small outcrop. With a few small level places it rises into the foot-hills, and then dips away to the south-east under the Subcarboniferous rocks.

As, wherever found, it here also is a thin, fissile shale, ash-colored when exposed for a length of time, but intensely black when under cover. On exposures it crumbles into small thin plates, which often, on steep slopes, cover the ground and leave the earth almost bare. Decomposing easily, it wears on the surface, and in the beds of branches, into fine particles of clay, or into soils which are usually cold, stiff and poor. When freshly quarried it is hard, and, in the absence of better material, has some value in road-making. Containing more or less of the material which produces coal oil, this product is often seen escaping from the beds, on the surface of the water which comes from it. Some pyrites in the form of cubic crystals are often imbedded in it, and by their decomposition give rise to a number of mineral springs which have their sources in these beds, or just beneath them. Some of these springs will be noticed farther on in this report.

Near Young's Springs, and at several other places in the county, were seen in this slate two horizons of a blue clay in beds about sixteen and twenty-four inches in thickness, which do not usually occur in it. These are very probably the thin southern equivalent of the Erie Shale of the Ohio section—which Prof. Edward Orton has demonstrated to be but an intercalated bed in the Black Slate (Huron Shale of the Ohio reports).

Very little land in Bath county has been cleared on the Black Slate for agricultural purposes; but this fact is due, perhaps, more to its steep character than to any other cause. In other counties like soils make fair lands, where they are well drained and properly fertilized. They are here, probably, not so good as they are in Boyle and Lincoln, owing to absence, here, of the numerous phosphatic nodules which are found near the top of it, in those counties, and which add to its fertility. I failed to see any specimens of the petrified wood in this county, which are of frequent occurrence in this formation.

The forests cover nearly all of the Black Slate here. White

oak is the most valuable as well as the most numerous species, while red and black oak, black gum, beech and sweet gum make up a large part of the remainder. On some parts of these lands the forests have been cleared years since, and the wood burned into charcoal, for use in iron making; but the second growth has now grown into trees of fair size.

SUBCARBONIFEROUS.

The rocks composing this member rest directly on the Black Slate, and, in Bath county, are some four hundred and sixty-five feet thick. They are here, as elsewhere, separated into two natural divisions—the lower silicious, and the upper calcareous. In some of the States they have been separated into five or more groups, but in Kentucky all of these are not recognizable.

Lower Subcarboniferous.—These beds are composed of four hundred feet of sandstones and shales, being much thicker in the Eastern part of the State than in Casey, Boyle and other counties, where the exposures are very fine. This subdivision was named the Knobstone Group, by Dr. Owen, and in Ohio it has received the name of the Waverly Group. It is made up of a succession of heavy and thin-bedded sandstones, between many of which are beds of clay shale of various depths. These layers of shale contain beds of iron ore, sometimes amounting to seven or eight or more in number. These beds of ore, while not often quite continuous, are composed of rounded, flattened or kidney-shaped masses, ranging from a few to hundreds of pounds in weight. Only two or three of these ore beds are more than a few inches thick; but some of them are one or two feet thick, and nearly uniformly distributed at their horizon.

This ore is a carbonate, and evidently holds its present position by having, in a large measure, displaced the lime which was formerly included in the position now occupied by it. It occupies the same position as, and is very much like, the ore of Nelson and Bullitt counties, which was for a long time worked at the furnaces situated at Nelsonville and Belmont. In 1838 a furnace was erected on Caney creek, in this county, and for

ten years this ore was mined and made into iron, the fuel used being charcoal. It does not, however, seem to have been profitably conducted. The impossibility of stripping this ore, the difficulties of drifting it, and the remoteness from market and the cost of transportation of iron and supplies, added to the thinness of the beds, all greatly increased the cost of production. These ores contain more sulphur and phosphoric acid than the best of ores, while the percentage of metallic iron is comparatively small. The composition of them can be seen by the analyses appended. These were made by Dr. Peter from samples collected on Clear creek by Dr. Owen. (See Kentucky Geological Report, First Series, Vol. IV, pages 65 and 66.)

Composition of these carbonates of iron dried at 212° F. :

Number.	787	789	794
Carbonate of iron	47.330	43.716	....
Oxide of iron	11.888	3.937	38.009
Alumina	4.180	1.881	3.265
Carbonate of lime	5.480	1.184	1.284
Carbonate of magnesia	7.754	5.903	1.565
Carbonate of manganese	1.987	.873	.780
Phosphoric acid	.886	.499	1.015
Sulphuric acid	.475	.303	.853
Potash	.674	.355	.583
Soda	.071	.286	.147
Silex and insoluble silicates	19.580	40.880	44.880
Loss and water	....	.183	7.900
Total	100.305	100.000	100.272
Moisture expelled at 212° F.	.600	.300	1.240
Percentage of metallic iron	31.192	23.838½	26.612

No. 794 is a limonite ore from just over the Black Slate. This seems to be present at many places about a foot, or a little more, thick.

The layers of sandstone throughout this group vary very much in their bedding and in their enduring character. A few of them are very smoothly bedded in proper thickness for building stones. These are, as a rule, solid, firm stones, which

wear very well in their natural exposures, while others are softer, from more or less admixture of earthy matter. Some of these promise well when freshly quarried, but prove poor stones when exposed to atmospheric changes. They have, to some extent, been worked on the knobs near Salt Lick Station, but cannot be classed with the more desirable building stones. Sometimes balls of iron pyrite, by their decomposition, mar these stones, and the salts, from other forms of iron in them, work to the surface and discolor them. These knob stones have been more or less quarried and shipped from several eastern Kentucky counties, and though, when freshly finished, they present a handsome appearance, most of them deteriorate more or less in a few years. It was used in the lintels and facings of the court-house in Owingsville, and now, after less than twenty-three years' wear, every stone is cracked, scaled or badly discolored by iron stains.

There are two layers near the base, which have a concretionary structure, and split into bowl-shaped fragments. The Black Slate, as a support to these heavy sandstone layers, is dissolved from beneath them, so they fall and break up in such manner that the tops of the knobs and ridges are entirely covered with them, often having the arrangement as if they had been quarried by human agency. The knob stone was used in the construction of the iron-furnaces built in this county, and seems to have answered the purpose very well.

The soils of the series are considered as poor, the ridges being narrow and the slopes steep. The sandy nature of the soil is such, that it allows the rapid leaching away of the plant food, after clearing. Very little agricultural clearing has been done upon them, and nearly the whole of the surface is in forests. Many parts of the forests have been cut over, in time, to supply Caney and Clear creek furnaces with coal; but since then young trees have grown in vast numbers over these tracts. Considerable areas are still covered with old trees, and quite an amount of valuable timber is yet uncut. White oak and pine are the prevailing growth of the merchantable species, and every year sees additional encroachments upon them by lumbermen. Fires break out sometimes among this timber, and great destruction over many acres is caused.

Some few clearings are made on these lands by belting the trees and allowing them to stand until they fall, when they are fired and destroyed, and this on land which, from the way it is treated, is rendered valueless in a half dozen years. The white pine is peculiar, in Kentucky, to three or four counties lying near Bath, and a small tree is rarely seen here. White oak, red oak, black oak, beech, poplar, hickory, chestnut, chestnut oak, sweet and river birch, yellow and black pine, cucumber are common, while among the rare species may be mentioned the umbrella and fringe trees.

Upper Subcarboniferous.—This group consists largely of limestones, sometimes forming whole mountains elsewhere, which fact has suggested the term Mountain Limestone for it. It is seen near St. Louis, Missouri, and in Illinois, and part of it has obtained the name of St. Louis Limestone. In Western Kentucky it is six hundred feet thick, and embraces the Mammoth and other caves in the Green river region. Unlike the beds last described, which become thicker towards the east, these limestones thin out in that direction until, in Bath county, there is only some sixty-five feet of them. These are to be seen only in the extreme southern part of the county, resting on the sandstones below. Back on the hills from Salt Lick and Clear creeks there are some fine exposures of them. Here they may be seen in rising walls of massive-bedded rocks, carved and fissured by time, or in immense blocks lying on the slopes below. Those present in this county all belong to the St. Louis Group. The heavy layers are fine and coarse textured, half crystalized, gray and light gray in color, largely made up of fossils, stems and fragments of crinoids. The thin layers are more earthy, and are colored dark red and yellow. There are some good building stones among them, but none have been quarried for any purpose. Some little lime of good quality has been burned from them, only for local use however. The principal interest which has been attached to these rocks, up to the present time, is a bed of iron ore which lies at the top of the group. It is the limestone ore of Estill, Bath and other counties, and the iron made from it enjoyed quite a widespread reputation as a car-wheel iron. The ore is here imbedded in

clay, and ranges from a few inches to three feet in thickness. It is a soft limonite, and makes a very tough, strong iron. Bath furnace was erected on Clear creek, and was run on this ore for a number of years, but it has been out of blast for a long time.

Composition of Limestone ores of Bath county:

NUMBER.	782	783	784	785	786
Oxide of iron	82.120	70.935	72.886	68.140	64.306
Alumina	.820	.900	.980	2.733	3.080
Carbonate of lime	trace.	trace.	trace.	trace.	trace.
Magnesia	1.010	1.129	.551	1.171	1.003
Brown oxide of manganese	1.340	1.780	.380	1.680	2.440
Phosphoric acid	.220	.505	.694	.247	.374
Sulphuric acid	.386	.290	.283	.336	.290
Potash	.193	.291	.321	.413	.703
Soda	.180	.180	.048	.132	.312
Silica and insoluble silicates	8.980	18.640	11.880	16.080	21.407
Combined water	5.420	5.400	12.200	9.040	6.200
Total	100.669	100.050	100.223	100.000	100.115
Moisture expelled at 212° F.	3.040	2.700	1 200	4.060	3.400
Percentage of iron	57.510	49.677	51.043	47.719	45.034

The above analyses are from the work of the State Chemist, and further information can be obtained in regard to this ore by reference to Vol. IV, pages 61 to 67, Old Series, and P. N. MOORE'S REPORT ON THE IRON ORES AND IRON MANUFACTURE OF THE RED RIVER REGION, Vol. C of the New Series.

CARBONIFEROUS.

Resting on the limestones of the Subcarboniferous, at Carrington's Rock, are some one hundred and seventy feet of sandstone, part of the great bed which lies farther south, and is known as the Millstone Grit or Conglomerate Sandstone. This sandstone has several other exposures on the higher points near the rock, but they are much reduced in thickness. Blocks of it are also sometimes found remaining on the hills, or tumbled down their sides. Elsewhere in the State one, and some-

times more, seams of coal are occasionally found, which come between the limestone and this sandstone, but in Bath county they seem to be absent.

Carrington's Rock is a narrow, short ridge, lying between Carrington's and Salt Lick creeks, which is crossed by the county line between Bath and Menifee. It is the highest elevation in the county, and a popular resort for local tourists. The conglomerate stands on one side in a nearly perpendicular wall, and has the appearance of being in only three or four layers. Part of it is made up of rounded pebbles of quartz cemented with iron, but the larger portion is coarse sand. The amount of iron in some parts of this rock is considerable, and some of the lower beds of ore are evidently derived from it, in part. The "jack rocks," which are so frequent throughout the county, have been derived from the waste of the pebbly portion. The conglomerate is here covered with pine trees, and a number of small and rare plants are to be found growing in its fractures, or its *debris*. This concludes the series of rocks in Bath county; but a short distance to the south we find the coal-measures, with their coal-beds resting on a greater thickness of the conglomerate. There are other features in the county which deserve some notice.

MINERAL SPRINGS.

Bath county, Kentucky, owing to the number of mineral springs the region contains, received its name from Bath, England, so long celebrated for the medicinal waters which are located there. There are numerous places in this county from whence flow salt, sulphur, chalybeate and other springs; and several of these localities have been popular resorts as summering places for invalids and pleasure seekers. One of these, the Olympian Springs, is still kept up as a watering-place, yet the attendance is not as large as in former years.

These springs are situated near the head of Mud Lick creek, two and a half miles from the Chesapeake and Ohio Railroad, at Olympia Station, and consist of a salt well, a salt-sulphur well, black sulphur well, two chalybeate springs, and a well and a spring whose waters are alkaline saline. Some of these

have been known and used nearly since the first settlers came to this part of the State. The geological position of these waters is the same which gives rise to the majority of mineral waters in the State. They arise from near the union of the rocks of the Corniferous limestone with the Black Slate. This is a horizon in which Magnesian limestones, clay shales, salt, sulphide, carbonate and other forms of iron, and minute quantities of other minerals, are found in close proximity. Water penetrating the rocks dissolves the mineral matters in various proportions, new combinations are formed, and thus originate these various mineral springs. The surroundings here are very beautiful: a lovely little valley, which opens out into a cove, hemmed in by hills on every side, through which flows a small stream, usually of remarkably clear water. Within a short distance the hills rise into mountains, from whose summits magnificent views are presented. The trees and smaller plants, many of them rare ones, are so different from those of the forests of Central Kentucky, that they attract the attention of, and invite study from, every one. The pure mountain air, loaded with the odors of wild grapes and honeysuckles and the breath of pines, invigorates the feeble and gives pleasure to the other classes of visitors. The annexed table gives the composition of these waters.

The following comments on, and analyses of, the mineral waters at the springs, are taken from Geological Survey of Kentucky, part VII, Vol. V, Second Series. They were prepared by Dr. Robert Peter, of the Geological Survey:

"MINERAL WATERS, ETC., OF THE OLYMPIAN SPRINGS.

"The principal waters of these celebrated springs were qualitatively examined by the writer about the year 1848–9, and the results were published in Volume III of the First Series of Reports of the Geological Survey of Kentucky, pages 208–210. About ten years thereafter (in 1858–9) more extended quantitative analyses were made by him of samples of these waters, sent to his laboratory in bottles by Mr. H. Gill, the proprietor. As such analyses of the waters forwarded in bottles could not include the gases, and, moreover, were liable to accidental errors, the writer visited these springs in August last (1877),

accompanied by his son Alfred M. Peter, in order to quantitatively estimate the gases in the recent waters; to evaporate a sufficient quantity on the spot to enable him to estimate their minuter saline ingredients, and to collect with care, in very clean glass-stoppered bottles, enough of the waters of the several springs for complete quantitative analyses in his laboratory in Lexington.

"The hydrogen sulphide was estimated, in the recent waters at the springs, by the volumetric process, with the use of a decinormal iodine solution, &c., and the carbonic acid, thrown down in a measured quantity of the waters by an ammoniacal solution of barium chloride, was separated and weighed at the laboratory.

"THE SULPHUR WATERS OF THE OLYMPIAN SPRINGS.

"No. 1984—'*Salt Sulphur Water.*' Well at the saloon, near the main house or hotel. The water is raised by a pump in the well, which is eight to ten feet deep. The spring is said to yield about two hundred and seventy gallons per hour. The temperature of the water was found to be 56° F., when that of the atmosphere was 75° F. The water forms a slightly yellowish or ochreous incrustation on the glass tumblers used at the well. It exhibits a slightly alkaline reaction.

"No. 1985—'*Black Sulphur Water.*' From an open well, about a quarter of a mile nearly south of the main house, in the bottom ground, just at the foot of the hill. The water is confined in a barrel without heads, sunk into the ground. The temperature of the water in the barrel was 57° F. Its sediment is nearly black, and it exhibits a slightly alkaline reaction.

"These waters, and particularly those of the salt sulphur well, are applicable to the treatment of a great variety of chronic diseases, under judicious medical advice, combining, as they do, saline, alkaline, and chalybeate properties, with those of the hydrogen sulphide, and the bromides and iodides. They are found to be diuretic, diaphoretic, tonic, and alterative, when used internally, not usually exerting much aperient action; and when employed in the bath, for which purpose the salt-sulphur is used exclusively, they are valuable in the treatment of cutaneous affections, &c.

"The very small proportions of barium, strontium, aluminum, and lithium compounds, together with those of boracic and phosphoric acids, which were detected in this recent reexamination of these waters, interesting as their discovery may be to the philosopher, can not be supposed to exert much influence in their medicinal action, yet, doubtless, they are not without effect.

"Since the detection of barium and strontium compounds in these waters containing sulphates, the attention of the writer was drawn to a recent communication of M. Dieulafait to the

Academy of Science of Paris, as to the very general presence of strontium carbonate or sulphate in the sea waters, as well as in limestone, gypsum, and the fossil remains of the mollusca, and saline mineral waters generally. According to his statement, only forty-four out of eight hundred of such waters, &c., failed to show distinct evidence of the presence of strontium.

"On examining Liebig's analysis of the celebrated *Kaiserquelle* (Emperor well), at Aix-la-Chapelle, in Rheinish Prussia, one of the most noted waters of Europe, and an early resort of the Romans, a remarkable resemblance in general composition may be seen between this and the salt-sulphur water of the Olympian Springs, as the following comparative table shows:

	Salt-sulphur Water of Olympian Sp'gs.	Water of Emperor Well, Aix-la-Chapelle.
Lime carbonate	0.1975	0.1580
Magnesia carbonate	.0506	.0510
Baryta carbonate	.0128	. . . . .
Strontia carbonate	.0045	.0002
Iron carbonate	.0025	.0096
Alumina	.0006	traces.
Manganese, phosphoric acid	traces.	
Lime sulphate	.0083	traces.
Potash sulphate	. . . . .	.1540
Soda sulphate	. . . . .	.2830
Soda carbonate	traces.	.6500
Lithia carbonate	. . . . .	.0003
Lithium chloride	.0008	. . . . .
Calcium chloride	.0213	. . . . .
Magnesium chloride	.1089	. . . . .
Sodium chloride	4.8997	2.6390
Potassium chloride	.0355	. . . . .
Sodium bromide	.0166	.0036
Magnesium bromide	. . . . .	.0006
Sodium sulphide	traces.	.0195
Sodium iodide	traces.	traces.
Boracic acid	traces.	. . . . .
Silica	.0232	.0661
Organic matters, etc	.0340	.0752
Total saline matters in 1,000 parts	5.4168	4.1020
Temperature	56° F.	131° F.

"The Aix-la-Chapelle are hot springs, and the water contains more alkaline sulphates and carbonates, with less of chlorides and bromides than our salt-sulphur water; but the general resemblance of their chemical composition is close, especially as they contain nearly the same gaseous ingredients.

"One object in view in the re-examination of the Olympian Spring waters was to ascertain whether their proportion of saline matters had been diminished in the lapse of nearly twenty years since the first analyses were made by the writer. It is interesting to see that no notable change in this respect has occurred. (See Vol. IV, page 69, Reports Geological Survey of Kentucky, First Series.) The slight apparent difference being probably due to less perfect drying of total saline matter in the former analyses.

"CHALYBEATE MINERAL WATERS OF THE OLYMPIAN SPRINGS.

"No. 1987—'*Main Chalybeate Spring;* in a valley, about half a mile north of the main building, Olympian Springs.'

"The water runs, over a wooden gutter, out of the ferruginous magnesian limestone, which lies under the Devonian shale, at the base of the hill, about four feet above the bed of the so-called 'Chalybeate Branch,' which runs into Mud Lick. The spring yields about three litres of water per minute (*i. e.*, somewhat more than three quarts). The temperature of the water is 54° Fahrenheit. It deposits a sediment in its channel of outflow which is of a ferruginous-brown color. The water, as it flows out of its source, is remarkably clear, but exposure to the air, by the removal of carbonic acid and the substitution of oxygen, converts the dissolved iron carbonate into the hydrated peroxide, which is insoluble in water.

"The dried *ferruginous sediment*, on analysis, was found to contain about 65 per cent. of *iron peroxide*, about 20 per cent. of *soluble silica*, with notable proportions of *lime* and *magnesia carbonates*, and traces of *manganese*, *phosphoric* and *apocrenic acids*. Hydrosulphuric acid did not detect the presence of arsenic or any metal of that group.

"No. 1988—'*Chalybeate Spring*, flowing out of a crevice in the ferruginous magnesian limestone in the bed of the Chalyb-

eate Branch, about sixty yards above the main chalybeate spring above described.'

"It deposits a ferruginous sediment in the bed of the branch of a light brownish-orange color.

COMPOSITION OF THESE OLYMPIAN SPRINGS CHALYBEATE WATERS.

In the 1,000 parts

	No. 1987	No. 1988	
Free carbonic acid gas	0.1214	0.1269	
Iron carbonate	0.0242	0.0100	Held in solution by free carbonic acid.
Lime carbonate	.0998	.0890	
Magnesia carbonate	.0143	.0103	
Manganese carbonate	trace.	trace.	
Phosphoric acid	trace.	trace.	
Lime sulphate	.0554	.0366	
Magnesia sulphate	.1170	.0693	
Potash sulphate	.0125	.0117	
Soda sulphate	.....	.0238	
Sodium chloride	.0308	.0060	
Magnesium chloride	.0031	.....	
Lithium chloride	trace.	trace.	
Apocrenic acid	trace.	trace.	
Silica	.0332	.0198	
Loss	.0194	.0168	
Total saline matters in 1,000 parts of the waters	0.4097	0.2935	

"The main chalybeate spring water is in every respect very good of its kind, and may be used in all cases in which chalybeate remedies are indicated. The principal difference in composition between the two springs is, that the main spring is more than twice as strong in iron carbonate, making it a better chalybeate remedy than the other. It also contains more sulphate of magnesia, but less sulphate of soda. They form a valuable addition to the Olympian Springs.

"As the chalybeate and other saline ingredients of these

waters seem evidently to have been derived mainly from the ferruginous magnesian limestone out of which they flow, and which the waters have worn and perforated in a remarkable manner, the writer collected some of the limestone and submitted it to analysis, with the following result:

"No. 1989—*Ferruginous Magnesian Limestone*, out of which flow the chalybeate springs above described, as well as many others in this region, and which forms the bed of the Chalybeate Branch, at and near those chalybeate springs. It lies immediately under Black Devonian Shale. Collected by Robert Peter.

"A crystalline-granular limestone; grey, of various tints in the interior—generally light grey; light ferruginous or brownish-ochreous on the exterior. Adheres slightly to the tongue, and is more or less porous. The water has worn it irregularly, and in some places perforated it by enlarging the small crevices or cavities in it:

COMPOSITION, DRIED AT 212° F.

Lime carbonate	54.000
Magnesia carbonate	34.027
Iron carbonate	11.532
Phosphoric acid	.006
Potash	.143
Soda	.040
Silica	.280
Total	100.028

"The main agent in the solution of this ferruginous limestone is, undoubtedly, the carbonic acid dissolved in the water which flows over or percolates it. The greater part of this carbonic acid is no doubt derived from the gradual decomposition of the vegetable matters on the surface of the hill at the base of which the springs and this rock are located. At present this and the neighboring hills are covered with the primeval pine forest, which keeps the surface continually covered with its vegetable *debris*, which. by slow decomposition and oxidation, yields an abundance of carbonic acid to the atmospheric water which falls upon it, thus making it, what the pure water itself is not, a good solvent of the iron and other carbonates of the ferruginous magnesian limestone beneath. It appears, therefore, that the character or strength of these springs is greatly dependent on the forest growth on the surface of the hill or hills above them; and that if these woods on the hills above should be at any time cleared off, and the surface of the land deprived of its present carpet of decaying vegetable matters, the springs would measurably lose their strength and value. Another deplorable result from clearing off these woods and bringing the soil into

arable culture would be, that more of the atmospheric water would run off from the surface of the hills, and less of it would sink into the depth of the soil and subsoil to feed springs; so that, if the springs were not entirely dried up, except in a rainy season, their outflow would be greatly diminished. Moreover, the beauty, salubrity, and attractiveness of this favorite sylvan watering-place depend greatly on the native pine forest which clothes the neighboring hills.

"In addition to the sulphur, salt-sulphur and chalybeate waters of this locality, there are others, saline and alkaline, of various qualities, deriving their dissolved ingredients, some from the salts of the primeval ocean under which the rocks were deposited, some from the action of the atmospheric waters and gases on the Devonian and other strata. One of the oldest known, which formerly was called a salt lick, to which the wild denizens of the forests resorted, and around which the buffaloes made their wallows, may be described as follows:

"No. 1990—'*Salt Water* from the old well at the original salt lick, near the remains of the old barracks of the volunteers of 1812, about one hundred to one hundred and fifty yards south from the main house.'

"The water flows out in a small stream, running into Mud Lick creek. The ground about is covered with an efflorescence of salt. The water tastes like that of the salt-sulphur well, but it has only a slight odor of hydrogen sulphide.

COMPOSITION OF THIS SALT WATER.

Carbonic acid gas not estimated; hydrogen sulphide, a trace. In 1,000 parts of the water.

Lime carbonate	0.1844	Held in solution by the carbonic acid.
Magnesia carbonate	.0458	
Baryta carbonate	.0099	
Strontia carbonate	.0045	
Iron and manganese carbonate, and phosphate	.0019	
Lime sulphate	.0036	
Soda carbonate	.2241	
Calcium chloride	.0152	
Magnesium chloride	.1188	
Sodium chloride	4.7121	
Potassium chloride	.0375	
Lithium chloride	trace.	
Bromine, boracic acid	trace.	
Silica	.0232	
Loss	.0130	
Total saline contents in 1,000 parts of the water	5.3940	

"This water resembles that of the salt-sulphur well in the relative proportions of its common salt and other chlorides; but it is more decidedly alkaline, because of its larger proportion of carbonate of soda, and contains less of bromine and lithium compounds. Moreover, it is almost destitute of hydrogen and sodium sulphides, which give a distinctive character to the salt-sulphur water. On examining Volume IV of the Reports of the Geological Survey of Kentucky, First Series, for the former analysis of this water, the writer finds that a transposition of the labels on the bottles in which the waters were sent to the laboratory by Mr. Gill must have occurred (see pages 71, 72), so that the label 'salt water,' etc., etc., was placed on the bottle which contained the so-called 'cooking water,' and *vice versa*. The analysis No. 803, page 72, agrees pretty well with the present in the principal ingredients and the total saline contents. This now published is of course more complete and accurate.

"THE ALKALINE SALINE WATERS OF THE OLYMPIAN SPRINGS.

"No. 1991—*Water* from the well at the kitchen door of the main house; about eight feet deep; yields about one hundred and thirty-five gallons per minute. The water is raised with a wooden pump.

"It is slightly alkaline in reaction, and deposits a slight ocherous sediment in the bottle. Tastes somewhat chalybeate, and smells and tastes faintly sulphurous. This water is used for all ordinary purposes of the kitchen and household, as well as for drinking.

"No. 1992—*Water*, called 'Tea Water,' from a spring or open shallow well, on the border of Mud Lick creek, about half a mile south of the main house, and above it on the stream.

"The spring is inclosed in two no-headed barrels, placed the one on top of the other, and is about four feet deep. The water was not overflowing. Temperature of the water 62°. Reaction slightly alkaline. As there had been rain shortly before the sample of the water was obtained for analysis, it may possibly be weaker than usual.

COMPOSITION OF THESE WATERS.

In 1,000 parts of the water.

	No. 1991	No. 1992	
Carbonic acid gas	not est.	not est.	
Hydrogen sulphide gas	a trace.	none.	
Lime carbonate	0.0556	0.0241	Held in solution by the carbonic acid.
Magnesia carbonate	.0277	.0059	
Strontia carbonate or sulphate	trace.	trace.	
Iron and manganese carbonates and phosphates	.0054	.0022	
Lime sulphate	.0065	. . . . .	
Soda sulphate	.0208	. . . . .	
Potash sulphate	.0285	. . . . .	
Sodium chloride	.1483	.0377	
Potassium chloride	. . . . .	.0039	
Magnesium chloride	.0047	. . . . .	
Soda carbonate	.5431	.4479	
Sodium sulphide	trace.	. . . . .	
Lithia, boracic acid	trace.	trace.	
Silica and loss	.0280	.0315	
Total saline contents in 1,000 parts	0.8686	0.5532	

"Although these waters do not contain a very large proportion of saline matters, yet their alkaline and slightly chalybeate properties may make them available as diuretic, depurative, tonic and alterative remedial agents. Many celebrated alkaline waters are not stronger in saline and gaseous contents than these."

At Young's Springs Post-office there is a white sulphur spring, issuing from the Black Slate in the side of the hill, that comes down to a narrow valley, which soon opens into the wider one of Salt Lick creek. This water, which is very clear and cool, has a pleasant taste. Formerly this spring was much resorted to by strangers, but it now seldom receives other than local visitors. Several other sulphur springs are known in this part of the county. A number of chalybeate springs have their source in the outcrops of the Corniferous limestone, and obtain their character from the solution of the

recently deposited iron ore of the Black Slate. The Subcarboniferous sandstones and the iron ores associated, give rise to a number of small springs which are slightly impregnated with iron.

West of Owingsville, on Salt Well creek, a well was bored many years ago, to the depth of four hundred and eighty-five feet, and a stream of salt water obtained. Here salt was manufactured, in small quantities, from a weak brine, for some years. Such of the old people as remember back to that time, unite in saying that the water is not near as strong now as it used to be. This is perhaps true of all the salt waters of Central Kentucky; they appear to grow weaker as the saline matters are more and more leached out, within the radius of their action. The Niagara Shale is, in places, more or less impregnated with magnesia, iron, sulphate of lime and other minerals, and water passing slowly through it, and taking up in solution these minerals, gives rise to small seaps in which the taste of epsom salts is detected. Some of the wells excavated into this shale are of the same character. It is highly probable that there are places in the county where salts resembling those made at Crab Orchard could be manufactured. A few springs find their exit from the massive layers of the Upper limestone, and these are of usually good, pure water; and if these beds were of greater extent, they would afford very copious discharges of water. The best potable water in the county, and the boldest, freest springs, come from the fractures in the Corniferous limestone.

WASTE BEDS.

Mention has been made, in this report, of the former extension, north of their present limits, of the higher rocks to be seen in the county at this time. The erosion of the rocks from over the present surface of Central Kentucky has been very great, and this waste is continually going on. The remains of the hard portions of the various groups, far removed from their present outcrops, furnish only one of the many evidences of this fact. It is interesting, therefore, to note the presence of these remains where they occur, as they are elements in the solution of several problems connected with the geology of the State.

In the north-eastern part of the county, along the crest of the disturbance heretofore written of, there are quantities of sand and pebbles of the Conglomerate, fragments of Subcarboniferous sandstone, fossils from the Corniferous and chert from the Clinton limestone These occupy the highest points and, since the clearing of the county, are being removed, by water, down the hillsides and into the branches. Occasional fragments of them can be found all over the county on the highest levels, reaching altitudes of more than four hundred feet above the present streams.

Above the mouth of Slate creek, and on all the hills about the head of Clover creek, sand and pebbles, and fragments of the hard Waverly sandstones are common In the bed of the latter stream is a block of this rock, four feet square, and more than a foot in thickness.

All over the country, drained by the lower Indian creek waters, there is much fine sand mixed with the top of the Niagara Shale; sometimes, with this sand, there are round pebbles, rounded fragments of coal, and pieces of rotten wood. The Niagara Shale, when dissolved into clay, is very tenacious while wet, and east of Salt Lick and Polksville the Licking river has eroded wide bottoms, on this formation, and when it reaches above its banks, its sands and other materials, where caught on this mud, stick tight, if slightly imbedded in it. It is very probable that the river has in time, when at a higher level, extended over these shales, throughout a great part of the Indian creek region, and left this material where it is now found. Coal is so common, in some of these places, that baskets full are gathered, and some search has been made for coal-beds. It seems almost useless to write the fact that these are all rounded fragments, made so by running water, and left here by natural causes, and by the same operations which are still going on in the river, a mile or so away. If the present channel of the Licking were changed, and its bottoms exposed, the same condition of rocks, pebbles, sand, sunken wood, fragments of coal, would be seen. Hawkins' pond is a circular lagoon, a mile in diameter, which has at one time been occupied as the channel of the river, and is now sometimes connected with it as an escape for its waters.

At the head of Bracken's Branch, on the Niagara clay, there are fragments of rounded coal and Black Slate, Waverly sandstone, Clinton chert, and wasted sands and pebbles from the Conglomerate. Near Mr. P. Collins' is a deposit of sand, with fragments of coal and micaceous sandstone from the coal-measures, worn by water and left by the current of the river when it was much higher than now, and worked its way back and forward in a wide valley on the Niagara, as it does now higher up the stream. In all of these places the materials are only such as have been derived from the rocks which are now to be seen in the county, or within a few miles of its southern border. It is remarkable that so much of the *debris* from these higher rocks has been left; the chert from the Clinton being the most persistent, and very easily recognized.

ALTERATIONS IN ROCKS AND MINERALS.

The changes which have resulted in the deposit of the iron ores at Preston ore banks, are only a few of the many which have taken place in the stratified deposits of Kentucky, and some of which may be noticed here. Of the various changes which have been going on during the deposition and consolidation of the strata, we know but little; but since they were uplifted into a portion of a continent, they have a series of passing phases, of which they bear their own record. Some of these would seem to be the result of long-continued action, while others seem to have been more rapid in their effects. Part of them appear to be easily understood, while the remainder are obscure. It is only the facts which we wish to note, and not the causes and the operations.

In all the heavy-bedded limestones of the State, from the Chazy Group up to the St. Louis limestones, there are certain assemblages of fossils, which determine their equivalency as far as they may be followed. The thin beds are usually so marked, but they are not always as continuous as the others. At and near the top of these heavy beds, and sometimes all through them, the fossils have been altered by having their original lime constitution leached away, and its place supplied with silica. This, though not so often, is sometimes the case in the thin-

bedded layers. These conditions are less pronounced as we proceed away from the greater disturbance which crosses the State. Corals, shells, crinoids and trunks of trees have all had their parts perfectly substituted by other substances. At what time these changes were produced it is impossible to say, but one fact would seem to indicate that it must have taken place subsequent to those movements upon which depended the present elevation of the State.

The Black Slate has in it, sometimes, long lines of evident fractures, which are filled with quartz of the same character as that seen in many of the replacements. Its behavior has been the same in its expansion and crystallization. A great number of geodes are found in various counties, throughout the Cornif-erous and the lower Subcarboniferous. These have been formed where fossils existed in the beds. They fill the stem and bodies of crinoids, the interior of various shells and the cups of cya-thophaloid corals, in each of which there were pre-existing cavities, and which are never associated with the single valves of shells, or other forms which had no hollow places in them. The walls of all these geodized fossils have been ruptured, and the silica has extended through the fractures, and, par-tially surrounding the nucleus, produced some very curious and interesting forms. In some cases, this expansion has resulted in an apparent diameter six to ten times the size of the fossil in its original condition, and yet, so well preserved are many of those specimens, that the most delicate details of the shells or crinoids are left in the fragments attached to the walls of the geodes.

In the interior of these are limpid quartz crystals, arranged around a cavity; in some cases it is chalcedony in mammil-lary forms, and in others it has the form of cubical crystals. In some instances carbonate of lime has been left in the inte-rior of the larger specimens, caught and crystallized within the inclosed quartz. In other cases, in some of the rocks, the whole structure has been perfectly replaced, particle by particle, so as to have the appearance of having been formed from the secondary mineral. No finer illustration of this change can be seen than in selected specimens of the silicified wood from the Black Slate, *Dadoxylon newberryi*. This spe-

cies is so wonderfully and beautifully preserved by this replacement, that it is doubtful if any of our recent woods can be made to show by their structure, in cell and fibre, such perfection of detail. Quartz, like ice, expands during the process of crystallization, and the expansion at times has been so great, that the form of the cavity in which these geodes have been formed has been completely destroyed. There is a class of these, of which thousands of specimens may be seen in a day, five or six inches in diameter, alike in shape, having a pentagonal outline, with apparently curved plates. These have the appearance of having been very much enlarged through the expansion of some forms of *granatocrinus*, yet the remains of this genus found in the horizon are not over two inches in diameter.

In other rocks, and at different places, the whole of the structure of fossil forms has been entirely replaced. This is nearly altogether so in the case of the Corniferous fossils in some counties; and where cavities have been left, as in some favorite corals, the crystallization has followed the line of original cell structure. Removed from these lines of disturbance the same fossils, and in the same beds, have been proportionately less affected, and some are to be seen, where only the cell structure, and not the cells, have been filled with silica, or where no replacement has taken place, or geodes have become thin envelopes of silica, with their interior hollow, or subsequently have been filled with calcite. The chert of the Subcarboniferous, the hornstone of the Birdseye, Clinton, Niagara and Corniferous, all seem to have had the same origin by replacement. These flinty rocks nowhere show any evidence of having been derived from microscopic shells or parts of sponges, for they usually are composed of replaced fossil forms, most frequently of broken columns of crinoids.

A farther change has developed in many of these forms. Corals, shells, crinoidal stems and hornstone have all been altered into jasper of different colors. This kind of change seems to be going on at this time, and even a farther one, the conversion of jaspery rocks into granular quartzite, and these crumble down into grains of sand. The chert from some of the beds undergoes such alteration, on long exposure, that it

becomes white like chalk, and with characteristics rendering it suitable for polishing purposes. It is probable that some of the tripolis have been so produced.

The limestones in many cases have changed their texture, passing from compact to half-crystalline or granular, and in the St. Louis thick beds to oolite. In a remarkable measure the limestones, which have the last-named form, have been derived almost entirely from the remains of many species of crinoids, and it is truly wonderful that whole beds, many feet in thickness, should be so altered in their mechanical arrangement that they are now but microscopic spicules of lime. The various stages of this change can be seen, and there is no doubt but what the transformation is still in progress.

Many lime corals have been so changed that it is difficult, and sometimes impossible, to determine their species. The large forms of *columnaria* and *tetradium*, which were once as perfect and beautiful as the recent corals of the ocean, have had their structure crystallized and obliterated, so that only by the association of better preserved forms in the beds it is possible to class them where they belong. With these facts before us, we can understand how iron, dissolved in the waters which percolate through the rocks, may not only displace lime and other minerals, on its way, but may give up its iron whenever the right chemical condition is reached, and thus fossils and whole beds of limestone be replaced by it. The Preston ore banks were thus replaced, and the Clinton ore has been formed, and, perhaps, is still forming in the same manner.

ARCHÆOLOGICAL NOTES.

Bath county, like perhaps all the counties of Kentucky, contains some records of the former presence, if not occupancy, by a prehistoric people. In the great mounds of earth, overgrown with aged trees; in the graves whose almost decayed skeletons are surrounded with primitive implements of stone, and in the tools and ornaments which are uncovered by the plow in many a field, we have evidence that other people than our own lived and died here.

On a high point between Bethel and Sharpsburg is a circular

mound which, although less than five feet high and twenty-five in diameter, can be seen at a long distance. Near Sharpsburg there is a mound some five feet high and thirty feet in diameter, and, close to it, a pond from which were taken part of the remains of a mammoth. This pond was in existence when the county was first settled, about one hundred years ago, and has every appearance of having been excavated by the removal of the earth to build the mound. If these statements are facts, then we have the presence of the mammoth here, after the raising of this elevation. To the east, and not a great way from this mound, on the farm and near the house of Mr. Rogers, there are said to have been about six acres of land inclosed by an earthen wall. The inclosure is now rather indistinct. On this farm is a large mound, and also one of the so-called fort-rings. A great number of interesting relics have been found around these places, and in the neighborhood of Sharpsburg.

On a hill at Mr. Deatley's there is one of those earthen elevations, twelve feet high and forty feet across. On a farm of Captain W. C. Allen, over Slate creek, a small one has been destroyed by plowing. Lower down Slate creek, on both sides, in the neighborhood of Mr. W. P. Shrout's, were several mounds and graves, some of which have been destroyed.

Two mounds are said to be on Mr. Jas. Crook's farm and two also on that of Mrs. Maria Crook, the last eighty yards apart, fifty feet in circumference, and, respectively, four and eight feet high. At T. J. Botts', and situated near his house, is a good-sized mound, from the edge of which, in digging holes for posts, bones were thrown out. On the hill over Slate creek, near the mouth of Peeled Oak creek, there is a pretty-shaped, small mound which does not seem to have been disturbed. Near Water Dale mill a human skeleton and fragments of steatite kettles were washed out of the bank of Slate creek. Isolated specimens of the various stone implements peculiar to this age are found over every part of the county, but the structures spoken of seem to have been principally on the best lands of the northern part of the county.

APPENDIX A.

Record of the rainfall at Sharpsburg, Bath county, Kentucky, for each month, from January, 1859, to September, 1885; observed and recorded by Jonathan Vanarsdell, Esq. The figures are for inches and eighths:

	1859	1860	1861	1862	1863	1864	1865
January	4.0	4.0	3.1	7.2	4.1	2.1	5.1
February	7.5	3.0	1.7	4.3	7.4	1.0	1.3
March	4.3	1.2	0.7	4.4	6.5	2.1	4.6
April	4.4	4.1	7.4	6.1	1.3	1.7	5.4
May	0.7	1.4	7.4	2.0	2.2	4.2	7.2
June	2.5	2 0	2.0	2.3	2.1	2.4	6.5
July	1.6	5.1	3.1	3.4	3.3	0.6	3.4
August	6.3	7.1	6.3	0.3	1.2	6 4	4.4
September	2.4	2.7	3.0	0.3	1.5	5.6	3.7
October	1.5	2.1	3.5	0.5	4.1	2.0	1.1
November	2.2	4.6	5.4	0.5	2.2	9.4	0.5
December	5.7	2.1	2.0	0.6	2.1	1 0	8.1
Total	44.3	40.0	45.4	38.7	38.6	38.3	52.3

	1866	1867	1868	1869	1870	1871	1872
January	5.1	1.6	3.6	2.4	5.0	1.2	0.7
February	2.1	7.6	1.4	2.1	2.7	4.7	1.1
March	3.0	6.7	1.5	4.5	4.2	1.3	1.1
April	2.6	1.1	3.4	3.5	2.5	2.5	7.2
May	2.1	5.4	5.0	4.0	2.2	5.0	1.3
June	4.7	1.6	3.1	4 1	3.2	3.1	3.7
July	5.4	4.2	1.7	4.7	3.4	1.7	6.0
August	3.2	6.2	2.7	4.2	2.4	0.7	2.5
September	4.2	2.0	6.1	2.2	1.0	2.4	0.7
October	2.1	0.7	0.5	0.5	0.4	0.3	1.0
November	4.4	2.0	1.5	2.4	1.0	2.2	1.1
December	1.0	4.0	3.4	2.2	1.5	2.0	2.1
Total	40.5	44.1	35.1	37.6	30.3	29.1	29.3

	1873	1874	1875	1876	1877	1878	1879.
January	1.1	3.7	2.2	5.0	3.2	2.0	0.6
February	4.0	2.7	2.3	2.0	0.5	1.7	3.0
March	4.4	3.4	5.2	3.2	2.7	3.2	2.3
April	2.4	5.6	0.4	1.7	2.2	1.7	1.1
May	4.7	1.1	1.6	1.1	2.4	4.0	1.5
June	4.6	2.3	7.2	6.2	8.1	2.1	4.5
July	1.2	5.5	14.4	8.3	4.1	2.1	2.3
August	6.4	2.5	1.4	3.4	1.2	4.0	7.0
September	1.2	1.7	1.1	3.0	1.7	2.4	3.6
October	3.1	1.2	2.0	2.3	1.3	3.0	0.5
November	1.2	3.1	5.6	0 0	3.4	3.3	1.4
December	3.6	3.2	5.0	1.1	3.2	3.2	10.7
Total	36.0	37.2	49.2	37.7	35.0	33.3	39.5

	1880	1881	1882	1883	1884	1885	
January	7.7	4.0	9.4	1.7	2.0	7.6	. . .
February	7.3	1.2	5,7	9.0	7.4	0.7	. . .
March	6.5	0.5	4.3	1.7	3.4	0.3	. . .
April	5.6	5.2	0.6	2.2	3.6	2.4	. . .
May	2.1	1.0	8.5	3.3	2.5	1.6	. . .
June	5.4	4.4	6.6	4.5	2.6	2.6	. . .
July	1.7	1.2	6.5	0.3	4.2	1.1	. . .
August	6.0	0.6	2.4	3.7	0.0	1.3	. . .
September	1.2	1.4	3.1	3.3	5.6	0.7	. . .
October	4.0	4.0	3.2	7.8	0.4	. . .	. . .
November	4.3	5.0	2.0	4.5	1.4	. . .	. . .
December	1.2	4.3	1.5	3.5	4.1	. . .	. . .
Total	54.0	33.4	55.0	46.7	38.2	19.3	. . .

From an analysis of the recorded depth of rainfall here, we learn that the annual average, extended through twenty-six years, is a fraction more than forty and one-eighth inches.

The greatest depth which fell during this time was in 1882, when it amounted to fifty-five inches, and the least in 1871, when it measured twenty-nine and one-eighth.

The total for each month, extended through the twenty-six years, can be seen by the following table, in which the months

are arranged in order from the least to the highest deposition of moisture:

October	54.7
September	70.3
November	76.4
December	84.0
May	85.5
April	88.1
March	89.3
January	94.4
August	94.5
February	96.7
July	101.6
June	104.1
Total: upwards of 86 feet.	1,040.6

Nearly twice the amount of water falls in June as in October, and only in five years, 1860, 1861, 1863, 1878 and 1883 was an excess deposited in October over June. The greatest amount recorded was for July, 1875, when it amounted to fourteen and a half inches. In November, 1876, and in August, 1884, no rain fell.

For purposes of comparison, a number of stations are now selected: some in the Ohio valley, where the conditions are somewhat similar, and the others where they are very different, and show extreme ranges of rainfall. Taken from Report of Chief Signal Service Officer U. S., 1880:

Sharpsburg, Ky.	Average of years, 26	40.13
Louisville, Ky.	" " " 7	48.36
Cincinnati, O.	" " " 8	42.39
Indianapolis, Ind.	" " " 8	45.22
Nashville, Tenn.	" " " 9	49.72
Cape Lookout, N. C.	" " " 3	81.93
Yankton, Dak.	" " " 6	28.25
San Diego, Cal.	" " " 8	9.97
El Paso, Texas	1879	6.63
Yuma, Arizona	Average of years, 3	2.69

APPENDIX B.

STATISTICS OF BATH COUNTY, COMPILED FROM THE REPORTS OF THE TENTH CENSUS OF THE UNITED STATES (1880) AND OTHER SOURCES.

1880. Total population . . .	11,982
1870. Total population . . .	10,145
1860. Total population . . .	12,113
1880. White population . .	9,965
1870. White population . .	8,443
1860. White population . .	9,472
1880. Colored population . .	2,072
1870. Colored population . .	2,702
1860. Colored population . .	2,641
1880. Native population . .	11,897
1870. Native population . .	10,055
1860. Native population . .	12,032
1880. Foreign population . .	85
1870. Foreign population . .	90
1860. Foreign population . .	81
1880. Owingsville population	1,000
1880. Sharpsburg population	356
1880. Wyoming population	105
Number of farms	1,382
Acres of improved land . .	113,583
Value of farms, including buildings and fences . . .	$3,130,857
Value of farming implements and machinery . . .	$67,336
Value of live stock	$584,447
Cost of building and repairing fences, 1879	$31,698
Cost of fertilizers, 1879 . .	$370
Estimated value of all farm products, 1879	$562,724
Assessed valuation, real estate	$1,699,835
Assessed valuation, personal property	$417,730
*Assessed valuation, total, 1885	$2,179,615
*Total equalized value, 1885	$3,281,472
*Taxation, State, 1885 . . .	$17,226 33
Taxation, county	$38,639
Taxation, town and school district	$314
Taxation, total	$56,179 33
Miles of railroad	14.18
Valuation of railroad in county	$286,600
Miles of turnpikes in county.	86–5
Average cost per mile of turnpike	$2,250
Total cost of turnpikes . . .	$194,625
Number of horses	4,162
Number of mules and asses.	1,213
Number of working oxen .	590
Number of milch cows . . .	3,173
Number of other cattle . .	7,935
Number of sheep	8,085
Number of swine	22,696
Pounds of wool	40,218
Pounds of butter	190,191
Pounds of cheese	3,830
Bushels of Indian corn . . .	830,986
Bushels of wheat	124,603
Bushels of oats	50,257
Bushels of rye	2,160
Bushels of Irish potatoes . .	6,652
Bushels of sweet potatoes . .	2,709
Tons of hay	2,873
Value of orchard products .	15,284
*Pounds of tobacco, 1885 . .	2,658,750
Number of manufacturing establishments	49
Capital invested in same . .	$75,625
Number of hands employed in same	85
Amount paid in wages in same	$20,783
Cost of material used in same	$72,301
Value of products made in same	$132,525
*Bonded debt, 1885	$25,000
*Floating debt, 1885	$10,000
Square miles of land	275–1
Acres of land, estimating roads, etc.	176,064
*Acres reported by assessor for taxation	157,932
*Average value per acre . .	$10 15

*From Auditor's Report, 1885.

GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, DIRECTOR.

REPORT

ON THE

GEOLOGY OF FLEMING COUNTY.

BY W. M. LINNEY.

STEREOTYPED FOR THE SURVEY BY JOHN D. WOODS, PUBLIC PRINTER AND BINDER, FRANKFORT, KY.

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FLEMING COUNTY.

HISTORICAL, TOPOGRAPHICAL, ETC.

Fleming county, Kentucky, named after Col. John Fleming, was created in 1798 out of a part of Mason county. It is situated in the north-eastern part of the State, and is bounded by Robertson, Mason and Lewis on the north, Lewis and Rowan on the east, Rowan and Bath on the south, and Bath, Nicholas and Robertson on the west. Licking river flows entirely along its south-western border; it is also watered by Fox, Fleming, Johnson and other creeks, which empty into the Licking, and on its north-eastern border by the North Fork of the Licking. In 1856 a portion of this county was used in forming the county of Rowan.

Like the other counties which form the rim to the Blue Limestone region, Fleming has a diversified topography. In the north-western corner, drained by Johnson, Elk and the lower part of Fleming creeks, the surface is much broken by a great number of small but deep drains; while the sides of the hills above them are very steep. This condition also exists for some distance along the Licking and a number of its tributaries more to the south-east. The northern and central portions are composed of rolling lands, well drained and highly cultivated as good and very desirable farms. The south-eastern part is made up of isolated hills and a net-work of continuous ridges, which rise several hundred feet above the general surface. Fox creek, with a great number of side branches, drains the larger part of this area, and is deeply set in a moulding of steep hills, through which it has eroded a comparative wide valley. Precipitous cliffs are rare, and only to be seen in a few places on the Licking, while the creeks which head in the county all have a considerable fall, yet there are no rapids on them, and, in places, Fox creek is quite sluggish

in its flow. From some of the higher elevations one may look over the country for a long distance. One of the finest points of view can be had from Sugar Loaf Knob, an isolated hill which, near Mt. Carmel, rises some three hundred feet above the surrounding country. From its top a large part of Fleming and Mason can be seen, while the eye looks over the whole northern part of Lewis, to where the blue hills confine the beautiful Ohio to its valley. The taller mountains of Carter and Greenup are discernible from here. From a number of other high points in the county delightful views are to be obtained, and they should be much resorted to by citizens and tourists, for the pleasure and exercise which it gives to climb and survey such commanding heights.

The Maysville Division of the Kentucky Central Railroad passes through the north-western part of the county, and here has four stations—Johnson, Nepton, Ewing and Cowan. From Johnson's Station, the Cincinnati and South-eastern Railroad extends through Flemingsburg and Poplar Plains to Hillsboro, about sixteen miles. The county has constructed a number of good turnpikes, and others are being built. When all the proposed turnpikes are finished, which will be in a few years, the people will have an admirable system of good roads. At Flemingsburg there is a graded school, and at Nepton a seminary, while the common schools are about in the condition of the average counties of Central Kentucky.

The total area of Fleming county is 338 miles, or 216,320 acres. This includes its streams, roads and waste lands. The amount is less as returned by assessors for taxable lands. The population in 1880 amounted to 15,221. Flemingsburg is the seat of justice, with something over 800 people. It is surrounded by a body of good land, and is a neat, well-drained place. By consulting the map it may be seen that there are a number of villages and post-offices distributed through the county. Manufacturing industries are few. A number of saw-mills furnish the lumber, mostly for home use, only a part of it being shipped to other districts. Several steam mills and a number of water mills grind the grain, mostly for home consumption, partly for shipment. If the Licking river was locked and dammed, there would be almost continuous slack-water for bringing down saw-logs and coal, and the interests of mills, etc., might be largely increased.

A number of the elevations in the county are given below. The first four are from railroad levels, while the others are computed from observations by aneroid barometer, and are subject to some correction. The formations upon which these elevations were made are also given:

Stations.	Geological Formation.	Above sea level.
Johnson's	100 feet above base of Upper Hudson	883
Ewing	Base of Upper Hudson	907.5
Nepton	Base of Upper Hudson	844.5
Cowan	Base of Upper Hudson	913.5
Flemingsburg	Middle of Upper Hudson	933
Hill south of Flemingsburg	Near top of Upper Hudson	993
Mt. Carmel	Clinton	990
Pilot Knob	Base of Subcarboniferous	1300
Licking, at Sherburne	40 feet below top of Lower Hudson	625
Hillsboro	Niagara Shale, near base	1030

The annexed table shows the general section of the rocks, and its divisions as exposed in this county. The base is some one hundred and forty feet lower than the section in Bath, but the top does not extend so high in the formations as in the latter county; otherwise there is much uniformity in them, outside of the beds of iron ore, they being continuations of the same rocks, only cut through by the Licking river. The descriptions of them, as given in the notes on Bath, very well suit for those of Fleming, with some exceptions, which will be here noticed.

GENERAL SECTION IN FLEMING COUNTY.

		Feet.	Feet.
Subcarboniferous.	Lower Subcarboniferous.		175
Devonian.	Black Slate.	200	
	Corniferous.	5	205
Upper Silurian.	Niagara.	100	
	Clinton.	35	
	Medina.	20	155
Lower Silurian.	Upper Hudson.	350	
	Middle Hudson.	175	
	Lower Hudson.	180	705
Total			1240

Lower Hudson.—Owing to the extension of Licking river, northward and westward, farther along the Fleming than along the Bath line, this group is cut deeper by its channel, and consequently exposes deeper rocks. This is true also of the valleys of the creeks in the north-western portion. As much as one hundred and eighty feet of the Lower Hudson can be seen, and the bottom of them must be near the Trenton strata which lie beneath. The beds, as seen here, are quite uniform with their representatives in Mercer, Washington and other counties, being largely composed of thin blue limestones, with much shaly matter included between them, in the lower part.

The soft shales, being easily acted on by atmospheric forces, where exposed, dissolve down into clay or soil, and, that being removed by the rains, the limestones break down, and, in many instances, cover the slopes very thickly. Often they are carried through the smaller drains into the creeks, in such numbers that roads running along them are so covered with blocks that they are as rough as could well be imagined. Towards the top the limestones are heavier and the amount of shale is very much diminished. Some of the layers here are regular in their bedding, solid in their character, and blue or gray in color. These answer very well for ordinary building purposes, but would not be applicable in the construction of the finer buildings.

Among the thicker beds are two whose bottoms are smooth, but whose tops are corrugated in great curved lines, comparatively even in height, breadth and depth. These are the great wave-marks, of which frequent mention is made in the Central Kentucky county-reports. They are wonderfully persistent, being present wherever the individual layers belong, and are always curious and interesting, besides being familiar guides which infallibly indicate certain heights in the series. These beds are hard and tough; a number of the layers have been used as the best obtainable material in the construction of turnpikes, culverts, fences, foundations, etc. They also afford a strong lime when burned.

Usually not many good springs flow out from these beds, yet the Upper as well as the Lower Blue Lick Springs come from this group. The shales are well suited for the storage of saline

matters, while many of the layers contain iron pyrite, from whence comes the sulphur of these waters.

The soils derived from the rocks and shales of these beds are naturally very fertile, wherever the condition of slope admits of their becoming available. The steep slopes, and the wasted rocks which cover them, often prove objectionable, but the rocks can be removed, and the hillsides put under grass. Careful hands not always being ready to do this, many of them are badly washed and worn. In spite of these disadvantages they can be renewed by putting them in blue-grass, which grows well over them.

The white oak is the usual growth on these soils, but with this are seen a few of nearly all the species that grow on the blue-grass lands. To a very large extent the forests here have been destroyed, and only on the very steepest lands are any woods left, and, even there, nearly all the good trees have fallen by the ax. The map exhibits the outline of this group in the valleys of the Licking river, Fleming, Elk and Johnson's creeks.

Middle Hudson.—In parts of the Centreville, Elizaville and the Sherburne precincts the full thickness of this group is seen, and in the districts of Flemingsburg and Tilton they make a small area of surface. In the Centrefield portion the larger part of the upper surface is based on these beds. Like in Bath county, a heavy concretionery bed of blue, sandy limestone forms the base; all its lamina are curved and contorted, and, when exposed, form, by leaching, heavy, rough stones, yellow and silicious. Very persistent is this layer, and not easily confounded with any other. Above is a succession of sandy shales, and earthy shales, often showing as beds of clay, and usually known as soapstone, with layers of blue, gray and even reddish limestones and sandstones.

While the slopes on this series are remarkably steep, they are beautifully rounded; the heads of the hollows are often cut down at angles of thirty to forty degrees, and slopes, up to near forty-five degrees, are cultivated with hill-side plows. So steep are most of these slopes, that it is difficult to cross from one ridge to another, and the roads must of necessity follow the

ridges or creek bottoms, until a point is reached where nature has made an available place to cross. And with these facts before us, it is not often that an exposure can be found where a good section of the rocks is presented, as the rocks and shales decompose easily, and keep the slopes covered with a deep, good soil, if any care be taken to keep them so. More frequently one or two heavy concretionery layers, much like the lower one, are seen. There is sometimes a wave-marked layer found in these rocks, but it is neither as distinct, nor as general, as the one in the lower beds.

In some places the soft shales occur in such force, that they are as much as sixteen feet thick, in one bed, with only some two feet of hard rocks in them. The soils derived from this series, while not ranking quite so high as the Trenton and Upper Hudson soils in the State, are very fertile, and have some characteristics which make them as valuable as any others. Many of the steep slopes, and some of the ridge lands, have been very much injured, in places, by careless culture, in allowing the soils to wash away, until, sometimes, very little of them is left.

Over part of the Middle Hudson, here, there was a large amount of beech timber, while on other parts much white oak had grown. Areas of sugar maple sometimes formed nearly the whole growth, and these have been in time, and to some extent are now, utilized in making maple sugar. Scattered among these species were very fine black walnuts and magnificent yellow poplars, while linn, redbud, sassafras and black locust, all grew large. To-day, on the worn lands, young trees of many species, among them poplar, locust, walnut, persimmon, ash, mock-hickory and beech, appear to grow more rapidly, than on other soils in the State. The decomposition of the soils extends so far down that the roots of trees can penetrate deeper and find larger stores of moisture, than on other soils. There is a close resemblance in these soils to the same beds in Madison, Garrard and Washington counties; the same features are constantly to be seen. The outlines on the map of the county very closely approximate the extension of these rocks and soils.

Upper Hudson.—To this group belongs nearly one-half of the surface of the county. Over its area the lands are more

level, the soils more dsirable, and the farms more beautiful; composed, like those of other counties, of a base of gray and blue limestones, some of which are good, fair, durable layers, while the larger part are of such a nature, that, even in quarries, they crumble down into fragments and dissolve into soil. It is this character of easy decomposition to which is due the conversion of the rocks into soils, and the rapid renovation of the latter, when they have become, in a manner, exhausted. The heavy layer mentioned in this series, in the report on Bath county, as characterized by a large *Stromatopora*, is quite persistent in this county, and may be seen in hundreds of places, where it resists the usual decomposition, and the ledges stand out bare and rugged, above the surface, or where the wear of roads has left them exposed.

The best soils, here, rank with the richest in the State, though those all over the Upper Hudson are not uniform in fertility. The lower part forms a dark-colored, warm, rich soil, quite friable and calcareous. This is the best soil, other conditions being equal. It was originally covered with a forest, composed so largely of blue ash, that the name of the tree is often applied to the soil, so that it is not unusual, as is the case in other counties, to hear of "blue ash soil." Chinquapin oak (Quercus *acuminata*), hackberry, wild cherry, mulberry, and a few other species, made the forest characteristic. It would seem, that, wherever, in the State, these trees have grown, the soil is less impoverished, than by any other growth, though no reason can be assigned for this peculiarity.

Over the upper portion the soil contained more clay, derived from the greater amount of clay shales in these beds, and from its greater presence in the rocks. These clays carry much lime, and other valuable substances, but are lighter in color, and contain less of organic matters, and what they do hold seems to be removed in cultivation or by leaching, much more rapidly than in the lower part of the beds. They are more liable to erosion from heavy rains, and need more watchful care. They have not been kept at so high a standard of excellence as the others, but many fine and well kept farms are situated upon them. They are good wheat lands, and easily restored, when the proper means are used. These lands were

largely covered with fine white oaks, with a fair mixture of red oak, sugar maple, and numerous other varieties of timber.

All these beds of rocks are very rich in fossil forms. At every exposure of them may be seen numbers of the old corals, shells, and other kinds of bygone life, that have dropped from the rocks inclosing them. Among the number *Orthis lynx*, *Orthis occidentalis*, *Streptorhyncus planum-bonum* and *Streptelasma cornicula* are in the greatest profusion. These remains of former organisms, which lie here in untold millions, were the active agents in storing up the lime, the phosphates, and other elements which to-day give the extreme fertility to the soils based on their tombs. They feed alike the woods and grains and grasses. Tiny lives, they were, in a far away time, but they did not live or die in vain.

Quite a large surface is here worn down to near the same horizon in the rocks; for miles the bull's horn coral (*Streptelasma cornicula*) can be picked up wherever any rocks are to be seen, and even in the soil in many places. It seems to have a greater upward range here than usual. It generally has a narrow vertical range. Near the top of the Upper Hudson, at some points, is seen a beautiful layer of wave-marked stone. The ridges are very uniform and about sixteen inches apart. For nearly a mile in the bed of Blue Bank creek, above Hamburg, this layer is observable, dipping down about with the fall of the creek.

The base of the Lynx bed is much nearer the top of the Middle Hudson, in this county, than in Garrard, Boyle, and other counties. In the counties named, on the Middle Hudson, are some seventy-five feet of rocks marked with *Ptilodictya hilli*, *Retopora angulata*. *Cyrtoceras Vallandinghami*, etc. On this side of the blue-grass region neither this character of beds, nor the same association of fossils, are to be seen. The Lynx beds are more largely developed, and their thickness greater, while their base rests nearly on the Middle Hudson.

Tobacco, corn, wheat, oats, rye, hay and hemp are the principal products, while much interest is also taken in the growing and grazing of stock. Clover is the great renovator of these soils, but it is used to a much smaller extent than it ought to be. Near the Licking river are some red cedars and post oaks

on the outcrops. The first are of rather rare growth in the county, and the last are but seldom seen on this series. Mock-hickory and black oak are inclined to grow near the upper part, in some places, where there is a waste of the soils from the next higher group.

In the upper part of these beds I found, for the first time in the State, a fossil shell, well-known in Ohio from the same horizon, which was described under the name of *Rhynconella headi.* It is not very common here, is poorly preserved, and appears to be confined to only a few inches in its vertical distribution. In the upper one hundred feet good specimens of *Calymene Senaria* have been found, while at their proper horizon the rocks are literally made up of their fragments. The better preserved of them are confined to thin beds of shale, which here is almost a clay. The great coral bed which occurs in Marion, Nelson and other counties, and which is such a conspicuous feature in many places, did not cover this part of the State. A few specimens of the great coral *Columnaria alveolata* were seen, but the other large corals and the forms of *Beatricea* do not occur here. On the other hand, there is one remarkable form, which is distributed over a large part of these beds in Fleming, and on the hill over Sherburne, in Bath county, and seems, in the west, to be confined to this area. It is a very compact coral, of a remarkably fine, dense structure, varies in size from an inch to sixteen inches in diameter, and wears rather curiously. It is very certain that this is the form from the Black River Group described by Billing as *Stromatopora compacta;* but as it was proven by Dawson to be a coral, and not a sponge, it is known as *Chætetes compactus.* Its interior structure very much resembles the Birds-eye Limestone at times.

For other notes on the foregoing, as well as on the succeeding groups, and on the chemical composition of these soils, the reader is referred to the Bath County Report, under the same heads.

UPPER SILURIAN.

The rocks of the Upper Silurian, so reduced in thickness, in this State, crop out in a rather north and south line, in this

county, and in the valley of Fox creek, from near its mouth up to its sources. Here, about one hundred and fifty feet thick, they exhibit the Medina, the Clinton, and the Niagara divisions. Of these, little need be written more than will be seen in the notes on Bath county.

Medina Group.—These strata, some twenty feet thick, mark an outline around those of the Hudson River, and though of narrow limits, can usually be seen in the very sandy, washing soil. They are alike loose and friable, whether uncovered or only with their edges exposed, and, by their yellow color, are easily distinguished from any others in the county. The rocks, as such, are mostly worthless, and, after breaking into little cubes, melt away. Around Mount Carmel they are better exposed than elsewhere, and marked by very poor, half barren places.

Clinton Group.—The further extension of the Clinton beds from Bath to Fleming has produced very little change in them, beyond the fact that the iron ore is neither so prevalent a feature, nor of as good a character. The heavy beds at the base are marked throughout the county by masses of hornstone, and measure from eight to ten feet in thickness. The waste of this cherty matter, in places, is quite large; this is particularly so in the part of the county about Poplar Plains. The flinty matter there covers the ground in large quantity. To one not acquainted with the origin of these beds, such deposits appear quite singular.

They are the Yellow Magnesian limestones of Dr. Owen's reports, and, while they contain a percentage of that mineral, are far from being dolomites, whose percentages of magnesia amount to nearly one-half of their composition. Some of the layers are frequently marked with indurated particles of clay, blue or olive-colored, which are probably the fossil casts of plants and shells. On the eastern part of the county one layer is better bedded than usual, and has been quarried for building purposes.

The layer of wave-marked stone occurs here with the same persistence as in Bath county. The bed of Clinton ore does not appear at all, in a large part of the outcrops, but around

Hamburg and Wallingford it is exhibited in its usual place, though the amount of iron, in the layers, is very much diminished; and nowhere is it, in quantity or richness, worth any investigation. Near the creek east of Wallingford there is, locally, about two inches of dense ore—a carbonate of iron. Close to this place I found, on the surface, a mass of brecciated chert of the Clinton, cemented with crystallized heavy spar, and several miles to the west of this point I met with several other pieces. These were evidently connected with some disturbance in those rocks.

The soils of the Clinton usually have a reddish tint, from the iron which is contained in the rocks, and when they originate from the more fossiliferous beds about the iron deposit, they are very good soils. The exposures of this description are, however, very small. These soils are sometimes much mixed with the top of the Hudson soils, and the union is productive of fair lands. Near this line there are, at several places, groves of very fine young yellow poplars, which trees promise to make grand specimens if cared for. Sycamores are largely mixed with them. On the Clinton, along part of the Lewis county lines, over the worn soils, groves of young trees have come up and are making rapid growth. They consist chiefly of yellow poplar, white and black walnut, wild cherry, ash, mulberry, and black and honey locusts. Formerly there was much sugar maple on the limestones, and beech on the shales.

Niagara Group.—The beds of the Niagara Group, in Fleming county, are, like those in Bath, almost exclusively composed of shales. There is a typical exposure of them a few miles southeast of Flemingsburg, on the Hamburg pike. The singular feature of this place, called Blue Bank, is that, although in a different formation, its principal characters are very much like the "Licks" of Boyle, Marion and other near counties, which are situated on the lower part of the Subcarboniferous. It is perfectly bare of vegetation, and worn down into hollows and ridges, over which the variegated shales show in bands, where the colors are fresh. Thin flakes of stone and small pieces of iron ore are scattered over them.

These shales are quite heavy around the base of Pilot Knob,

up the valley of the North Fork of the Licking, and trending south-eastward along the foot of the higher lands. They spread out several miles in width, in places, till they reach the Rowan county line near the Licking river. Nearly the whole wide valley of Fox creek is on them. These are equivalent to the shales underlying the limestones of the Niagara Falls, known also in Adams county, Ohio, as the Great Marl Bed. Knob Lick, in Bath county, is in the same beds, which are also finely exposed in Lincoln and Nelson counties. Nearly always, wherever they are seen, on the surface, they only show a stiff, tenacious, blue clay, and in imperfectly drained soils many wet places appear. The thin, curved, laminated plates, included in these shales, have become heavier towards the east, and are here as much as three inches in thickness. The building stone mentioned as occurring in these shales, in Bath, is presented in many places in Fleming, but has seldom been utilized.

Quite a number of farms are situated on these shales in Fleming—not so many in Bath. Nearly the whole valley of Fox creek, with some of the other valleys belonging to its drainage, and a strip along the whole line of knobs, have been cleared, and, although these soils are usually spoken of as poor, they are not always so, but susceptible of being much improved. The following analyses exhibit the composition of these shales, in two samples, collected in Madison county by Mr. John R. Procter, and examined by the State Chemist, Dr. Robt. Peter:

Number.	2186	2187
Silica	42.300	48.780
Alumina, etc.	20 840	17.320
Iron peroxide	4.120	3.240
Lime sulphate (gypsum)	....	19.285
Lime	13.320	....
Magnesia	.461	.496
Potash	2.387	4.768
Soda	.351	.240
Combined water, carbonic acid and loss	16.221	5.871
Total	100,000	100,000

The two following partial analyses of Niagara Shale from Ohio were made by the chemist to the Survey of that State, Dr. Wormley. The first is from Highland county and the second from Green. The Highland county sample would closely resemble those in Bath and Fleming, but for the presence of too much silicious matter:

Number.	1	2
Silicious matter	78.00	12.21
Alumina and iron	3.20	8.48
Lime carbonate	11.40	34.40
Magnesia carbonate	6.50	30.87
Silicate of iron	....	8.40
Water combined	....	5.40
Total	99.10	99.78

It will be seen that these shales vary very much in their composition, when taken from various places. This is what would be expected, when we consider that the materials of which they are composed, largely of sedimentary origin, were distributed by currents of water, and that the conditions which assorted and distributed them, as well as the localities of their origin, were all subject to variation. Yet, with these marked differences there are some characteristics which are constant, and which show, that the general physical conditions were nearly uniform over a large area. Materials arranged like these shales are never found compacted into hard, durable rocks, but, when exposed to the degradation of atmospheric changes, break down into impure clays.

The base of all clays has been demonstrated to be kaolin, that peculiar fine clay of which the finest products of china-ware are so largely composed. With this base are combined, in a mechanical mixture, various elements, which, in their association and percentages, give clays fitted for different purposes. No. 2187 has nearly five per cent. of potash, and more than nineteen per cent. of gypsum. The presence of these ingredients in such large proportions constitutes a variety of marl, which might be advantageously applied to some of the

soils of the county. In No. 2186 there is a high percentage of lime (13.320), enough to make it of intrinsic worth, if applied to soils deficient in that mineral. Its proportion of potash, while not equal to the other, is quite large. In Nos. 1 and 2 the amount of lime is large, in the latter excessive.

Here, then, are elements given to the soils derived from these shales, which in part constitute the wealth of every fertile soil. The Kentucky samples are richer than those from Ohio, and while the areas of Fleming and Bath counties, occupied by this formation, are inferior to the blue-grass lands, they will repay intelligent cultivation. That some of these soils are better than their general reputation, is easily seen. Where holes have been dug in these shales or clays, the excavated material thrown out upon the surrounding surface is soon covered with luxuriant vegetation. Along the railroad to Hillsboro, where it runs over these shales, and where the clay from the cuts has been thrown out over the ground, the improvement in the growth of the grass and other plants is quite manifest. In the valley of Fox creek, where wet places have been drained with trenches, and the earth from them thrown into ridges, the growth of plants on these ridges is greater than at any other place.

These things, trifles in themselves, demonstrate that there is room for improvement in these soils, and indicate the methods by which it can be attained. The soils are stiff and close, they do not allow the air and water to circulate through them, and, when thoroughly wet, are a long time in drying out. If their mechanical composition was better they would be improved. This can be done by good drainage and deep plowing. The use of drain tiles would be preferable, but where this is not practicable, a system of back-furrowing, by which long ridges would be thrown up, with narrow drains between them, would do nearly as well. This system, followed by the turning under of an occasional growth of clover, or other forage plant, would render the soils dry enough for common tillage. As they are, wheat, rye, and the grasses are too apt to freeze out, from the excess of water in the soil. After draining, the application of a small quantity of bone dust,

every two years, would more than double the production of crops of wheat, corn or grass.

At the present valuation of these lands, and in view of their generally level character, and the possibilities, under judicious treatment, which are in store for them, their agricultural value is much underrated. Some of them could be made, as meadows, equal to any grass lands in the State, capable of supporting large dairying interests. As it now stands, some of the small farms on these soils are, to-day, as profitable, in proportion to their cost, as the most valued in the county. They require more work upon them, and really a more practical knowledge to treat them rightly, than the best lands, which so frequently are lazily skimmed. The use of these marly clays as top dressings would often prove of well marked advantage.

Geologists and chemists may point out these things; but it requires watchful experiments of the farmers on their own soils to reap the advantages of their investigations. A few farmers in one neighborhood could, by each spending a little time in experimenting with these clays, pave the way for much knowledge in their community, and live to see grand results accomplished, at but little cost in money, and that largely returned, not to speak of the reward which increased knowledge bestows upon him who seeks it.

Aside from the soil-value, these clays have other economic values, and industries might, in time, spring up which would greatly benefit the county. As these clays lie near a heavily wooded region, the burning of brick, where there are facilities for shipping them, might prove of considerable advantage. The clays are in large quantities, and easy to dig; tests made at several points would probably show them to be very valuable for the purpose indicated.

This same series of clays, while too impure for articles of china and other fine wares, are very suitable for the manufacture of stoneware, drain tiles and pipes, and are largely used, for these purposes, in other States. The wonderful effects produced in draining lands, especially those which are normally wet, by underground drains, and the general use of such in some sections, has built up enormous establishments

for the manufacture of tiles alone; and too often those manufactured of the clays of one State are transported hundreds of miles and laid down in the same clays in another; and this where labor is cheaper, clays as plentiful, and fuel more easily obtainable. There was at one time a small pottery in operation near Poplar Plains, the ware being peddled over the county from wagons. The possibilities for large industries are favorable here.

The fact that epsom salts, of the variety which is produced in so large and paying quantities near Crab Orchard, Lincoln county, are manufactured from these shales, lends them further local importance. Near Ringo's Mill, and here and there in other places, the water which issues from them is impregnated with magnesia, iron, sulphate of lime and various other minerals, which impart to them peculiar properties. The evaporation of this water and the crystallization of the salts form a profitable industry, which it requires but little capital to conduct. Pits are dug, which, when not penetrating to the rock below, hold the water, that, by percolating through the shales and dissolving out the minerals, becomes charged with them. This water is boiled down in kettles or evaporators, is then granulated, and ready for market. It would be worth testing, as the trouble would not be great.

I failed to find a single fossil in these shales. Their deposition must have taken place under such conditions that life could not exist in the muddy waters charged with so many mineral substances. It would seem, from the little remains of the forests over a portion of the Niagara Shales, that beech was the principal growth on the wet flat portions, mixed with a good many sweet gums, and that other portions were covered with Spanish oak, post oak, scarlet oak, white elm, and other species. The first two nearly always mark these shales, if not too wet. Some white oak and red oak of inferior size were occasionally distributed over them.

DEVONIAN.

Corniferous Limestone.—In crossing the Licking from Bath to Fleming county, the layer of Oriskany, which was last seen

about the center of the east and west extent of the former, has disappeared so completely, that no trace of it could be seen. The Corniferous Limestone had become thinner and lost its flinty character, nor was it always in place. This limestone, which has been followed around the blue-grass region from Oldham and Jefferson counties, on the Ohio river, to Fleming, seems to have had a hiatus in its deposition, from Fleming county northward over the Ohio river to Highland county. From that point it extends in an unbroken line through Ohio and Indiana to the Falls of the Ohio at Louisville.

The greatest thickness seen in Fleming was on Fox creek, several miles below Fox Springs, and here it amounts only to about six feet. The layers are heavy-bedded magnesian stone, lying on top of the Niagara Shale, free, as has been stated, from silicious concretions, and with the fossils remaining as casts, of which some of the well known forms were recognized. There is, as usual, a little iron ore associated with these layers, as a comparatively recent deposit. This iron gives rise to the chalybeate waters to be seen at a number of places in the upper branches of Fox creek. Sometimes this iron appears as a yellow ochre, but it is in quantities too small to be valuable as a deposit.

Between the Niagara Shale and the Corniferous there are, in the counties of Carroll, Trimble, Oldham, Jefferson, Bullitt and Nelson, heavy beds of fine building stones. These layers belong to the Niagara Group, and seem to have been formed north-westward of a line which began in Pickaway county, Ohio, and passed south-westward through Kentucky and the western part of Tennessee, and were not deposited in this part of the State. The thickness of the shales here, and the absence of the building stones over them, with the disappearance of the Corniferous Limestone, are very interesting facts; but the causes which led to them are somewhat obscure. The Corniferous thins out gradually from Ohio and Indiana towards the south, and is not to be recognized in its horizon in Tennessee. It is probable that it disappears but little south of its present outcrops in Central Kentucky, and that the presence of the large amount of silica in its beds along

that line was connected with the disturbances which passed through this section.

Black Slate.—This widespread formation, so far as has been investigated, reaches its greatest development in Kentucky in Fleming county. It is thickest to the north-east, and thins out towards the south-west, until it disappears in Middle Tennessee. Thin around its outcrop in Central Kentucky, in Boyle and Marion counties it becomes heavier toward the Ohio river, and beyond it; so that, while it is forty to fifty feet in Boyle, it is one hundred and fifty some miles north of Louisville, and in going east from Boyle county it gradually increases in mass, through Garrard, Madison, Clark, Montgomery and Bath, until, in the eastern part of Fleming, it attains a thickness of two hundred feet.

In this county it makes up the larger part of the isolated knobs, and all the ridges which environ the drainage into Fox creek. In some parts of this series in the State there are some beautiful level lands on which valuable farms are situated; but here it is only to be seen in the sides of the hills, resting on the Corniferous, where this is present, otherwise on the Niagara Shale, and is nearly always capped with the sandstones above. The whole of the bed is very uniformly similar to those seen in other counties; the exception being, that the blue clay shales, related to the Erie shales, seem to have increased from Bath county, in coming north and east.

Some little of the forest on the Black Slate has been cleared on the sides of some of the slopes, both on the main ridges, as well as on the outliers; but these areas are small, and their cultivation lasts but a few years, when the soil is washed away and the decomposing edge of the slate exposed. The clays which are left from the dissolution of these slates are not in any great quantity, nor usually of great value. In Ohio drain pipes have been burned from them, and they are capable of being used for terra-cotta ware. Iron pyrite is so often present in the lower portions, that it gives rise to a number of sulphur springs, and yet its quantity is not sufficient to be of economic value.

Should the stores of the oil regions of the earth ever be exhausted, the time may come when the vast quantities, now

locked up in these shales, will become sources of supply. It has been computed from numerous analyses that the Black Slate contains an average of ten per cent. of petroleum. There should then be, wherever these beds are of maximum thickness in the county (two hundred feet), some twenty feet of this product. This amount can be distilled from them, but at too great a cost for the present market. The slate is dense and unbroken here, and can contain no reservoirs for this fluid. And, as it all lies above the general drainage, it would have escaped, had nature heretofore released it from its present chemical forms, and converted it into oil. That this process is now going on very slowly, is evident from the minute quantities of oil which escape in a few places on the surface of the water that washes through them.

It is probable that, from the continuation of this same Black Slate, and its much greater accumulation in Pennslyvania, have been derived those great stores of oil and gas in that State which have revolutionized many industries, and created vast interests, and whose products have affected the commerce of the world. The conditions are, and have been, so very different, that there are no favorable circumstances which, with our present knowledge, could furnish any sources of petroleum here.

The larger part of the surface is covered with a forest, which, in places, is almost untouched, and, if a wise policy could be enforced, it would forever prevent the clearing of the surface over them, and retain them in perpetuity as lands for the production of valuable trees. White oak, the most valuable of all our timbers, grows to perfection on them, and their renewal, as the aged trees are removed, would be natural. Toward the head of Indian creek there are a number of hemlock, a species which has not heretofore been met with in any of the counties which touch the blue limestone region. Fine poplars and walnuts were distributed over the soils of the Black Slate, but these have been largely culled. There are many beeches to mark the upper limits of the deposit, and its general surface. When the land is cleared here, the wood is given to the flames, and sometimes the fires get beyond control and sweep over greater surfaces, doing much damage to the young growth, if not to the old.

SUBCARBONIFEROUS.

In Fleming county only the lower portion of the Subcarboniferous beds have been left. The limestones, probably, covered it in part, and the upper portion of the sandstones were in place, as they now appear in parts of Bath and Rowan. Time, aided by the complex forces of the atmosphere, has separated the grains of sand, disintegrated the shales and dissolved the limestones, and, together, these have been removed by water, borne towards the ever-swallowing sea, and deposited—who knows where?

The one hundred and seventy-five feet which are left are the sandstones and the shales between them, which, like a protecting shield, lie on top of the Black Slate on nearly all the high places in the south-eastern part of the county, to the Lewis and Rowan boundaries. The sandstones are a vast bed of material which could be drawn upon for building purposes, but they are not quarried, and their quality is not of that kind which would make them very valuable anywhere. There is one layer, containing a large per cent. of iron, a ferriferous sandstone, which is very enduring, and perhaps resists destruction better than any layer in the county, but it does not work easily, and has no beauty to recommend it. There are others, much like some beds of the same series, which have, for a while, obtained some repute in Kentucky, but afterwards proved of little value, if not even worthless.

The breaking down and wearing away of the Black Slate, from beneath the edges of this series, has been the chief element of their destruction. The foot-hills and some of the lower ridges are often covered with the broken remains of part of the hard layers. A few of the ridges, which lie along the Rowan county line, are moderately broad, and are covered with magnificent forests of white oak and chestnut (tan-bark) oak. These have hardly been touched, save a few clearings here and there, and some trees cut from the outskirts, for saw-mills in the bottoms. If they could all be protected, and in time have the aged trees judiciously removed, the interests of the State in them would be subserved and a great deal of wealth saved. On the other hand, evidences are growing which show

that, in a few years, this wealth will be ruthlessly destroyed, without advantage to any one but a few lumbermen, while the State will lose in more respects than one.

With all the investigations made by governments, States, societies and individuals; with all the mass of information gathered, written and distributed by forest economists, and with all the advices and enactments, secured by countries and communities, on the criminal destruction of forests and the baneful influences which flow from them, no ear is turned in Kentucky; no arm is stretched forth to stay, and no penalty provided for them, who, over hill-sides, mountain tops and plains, wage such senseless and destructive warfare on the young trees, as well as the old, and often entirely destroy lands whose only return could be a heritage of trees for posterity.

Great evils due to this cause are to be seen to-day in every county in Central Kentucky, and scarcely a score of years will have to pass, ere the last vestiges of a once mighty and universal forest will have rotted down and "left not a rack behind." These lands should never be subjected to a general clearing for any purpose. Where they have been put in the usual routine of cultivation, a few years have seen them exhausted. The sandy soils do not hold much plant food. When opened up they soon lose that, with the removal of crops, and become worthless.

And yet if only the level places were cleared, and a protecting fringe of trees left around them, many fine fruit orchards could be produced. The soil and the elevation are both favorable for this purpose. Peaches, pears, apples, cherries, grapes and the small fruits could find unusual immunity from destructive frosts, while fertilizers could be obtained from the forest leaves and the potash, lime, &c., in the shales below them.

MINERAL SPRINGS.

A number of mineral waters are found in Fleming county. The Upper Blue Licks are just across Licking river; but there is no issue of that variety of water on this side. A well bored at Flemingsburg, which furnishes a very pleasant sulphur water,

is resorted to in the summer. At the head of Fox creek, and on one of its tributaries, near the Lewis line, are situated what are known as Fox Springs. At one time this was a favorite watering-place for this part of the State; but several years ago the main buildings were burned, and since then the visitors are few. The springs are in a beautiful little cove, which juts into Fox Mountain; they consist of a white sulphur and a black sulphur spring, issuing from the Black Slate, about six or eight feet above its base. A chalybeate spring which finds its way out from near the horizon where the Black Slate lies on the Niagara Shale, seems to derive its properties from recent deposits of carbonate of iron in the fractures of the shale; a weak alum water and a sweetish weak chalybeate flow from below a thin layer of ochre which nearly takes the place of the Corniferous Limestone. Two of these waters were collected and sent to the State Chemist for examination, and the following is his report:

"Report of the analyses of two mineral waters from Fox Springs, Fleming county, Ky., collected by W. M. Linney, July, 1885:

COMPOSITION (*in a* 1,000 *parts.*)

NUMBER.	2657. Chalybeate water.	2658. White sulphur water.	
Iron carbonate	0.0130	0.0016	Held in solution by carbonic acid.
Iron sulphate	.0175	....	
Lime carbonate	.....	.0982	
Lime sulphate	.0483	....	
Magnesia carbonate	.....	.0430	
Magnesia sulphate	.0485	....	
Soda carbonate	.....	.0538	
Soda sulphate	.0424	.0460	
Sodium chloride	a trace.	.0427	
Potash sulphate	.0244	.0142	
Silica	.0328	.0238	
Organic matter and loss	.0121	.0802	
Total saline matters in 1,000 parts of water	0.2390	0.4035	

"No. 2657 is a mild saline chalybeate water. In No. 2658

the water had a slight sulphurous odor, but when brought to the laboratory it had lost all but a trace of its hydrogen sulphide.

"ROBT. PETER, *State Chemist.*"

About a mile below the Fox Springs, on the same branch, at Mrs. L. A. Fountain's, are two chalybeate springs and one of sulphur. The latter has a basin cut in the Black Slate which overflows with a clear, beautiful and very pleasant water. Farther down the creek are other springs which afford both iron and sulphur waters. These either come from the Corniferous Limestone or the base of the Black Slate.

On a branch which runs from the west, and into Fox creek, near Plummer's Landing, we find Belle Grove Springs. One of the main roads of former travel from Central Kentucky to Virginia passed up this branch, and, for a long term of years, this was a resort for many people. It is a quiet, lovely place surrounded by mountains and lying in a lovely valley. The waters are both chalybeate and "white sulphur," having the same origin as those mentioned, and being very much like them.

A pleasant chalybeate water is near the residence of J. R. Lumans, and another at the base of Sugar Loaf Knob. Some waters impregnated with iron issue from the rocks about Farmville. Near Ringo's Mills the Niagara Shale has some wells in it that give magnesia water, and such may be also seen in other parts of like formation.

ARCHÆOLOGY.

Judging from the remains found in Fleming county it does not seem to have been very largely inhabited by prehistoric tribes. The evidences of its occupation are comparatively rare. In the north-eastern portion, at Mr. Lukin's, an ancient grave was at one time opened, and in it were found some human bones, fast crumbling to dust, and a number of stone relics. On a ridge, near Mrs. E. O. Wallingford's, is situated a small circular mound. About Mt. Carmel, and north of that point, a number of flint and other stone implements have been gathered from the plowed fields.

On one of the knobs near Hillsboro are a number of stones, which have attracted a great deal of attention. They have been visited by numbers of people, and several newspaper articles were written upon them. They are usually referred to as the work of some people who here made their home, before this portion of the county was known to the white settlers. The stones have the appearance of great kettles, chiseled out of the sandstone, which here lies in place.

These apparent kettles are of several sizes, from four to six feet in diameter, and, while none of them are now unbroken, enough is yet to be seen to give a good idea of their origin and existence. We have in Kentucky, as well as elsewhere, a number of layers of silicious rocks, which are generally termed concretionary. These are masses of material which seem to have aggregated around a center, though this structure is subject to many modifications. Many of these so-called concretionary layers have been formed in currents of water, where the fine particles of matter have been whirled around by eddies, and deposited in such manner as to form pot-holes and other kinds of hollows on the surface. Many of these are so regular, that they appear to have been made with all the nicety of instrumental measurements. Wherever these holes are filled with the same kind of material, deposited by the same concentric forces, all the particles of matter are deposited in this same curve, and when consolidated, the lamination of the rock is on a plane with its deposition.

It was in this manner that the materials of this bed of sandstone were laid down. At times there was some foreign material brought in, which, though but a thin deposit, was sufficient to weaken the stone and make it, under some conditions, open along this line. Some of these bowls are partly beneath an upper layer, where they could not have been reached, to be worked with a chisel. The whole lamination of these interesting forms is in accord with the concavity of the bowl, as well as the cores which have been removed from them. It is possible that some of these have been used as hiding places for food, and there is one fact which makes this supposition probable. It appears that, over one of them,

when found, was a cover of thin sandstone, which had evidently been trimmed into a nearly circular form, to serve as a cover. The origin of these kettles, like that of thousands of less regular ones, which are apparently common, has been a purely natural one.

DISTURBANCES.

There are two lines of disturbance which are marked in Fleming county. The greater one, which has been noticed as traversing a number of counties, crosses the Licking river not far from Sherburne, and continues south of Flemingsburg and north of Hamburg, into Lewis county. In going up the river, the rocks visibly recede beneath the surface and higher ones take their place, until this dip, at the Rowan line, has amounted to nearly five hundred feet. In following Blue Bank and Sand Lick creeks, from the head of the former to the mouth of the latter, the same declension may be seen. At the head of Blue Bank the highest part of the county is on the Niagara Shale, while at Fox creek, where Sand Lick enters, we find the same formation. This dip is finely illustrated in a part of the bed of Blue Bank creek, where a single layer of blue limestone forms the bottom for more than a mile, though the fall is quite rapid. It is through the depression south-east of this disturbance that Slate creek in Bath, and Fox creek in Fleming, have eroded their crooked valleys. From the top of Sugar Loaf Knob the continuance of this line seems to be recognizable through Lewis county, by the north-east trend of the outliers of the members of the upper rocks that make the higher hills. There is some slight evidence of an inconsiderable fault near Polkville, in Bath, and along a line through Fleming, near Grange City and Wallingford ; but neither the fact nor the details could be determined. The first line of uplift mentioned is the one which controlled the drainage lines of the county and led to the planing down of the surface to the present arrangement of hill and valley, and consequently to the distribution of the various belts of soils.

There is another course of fracture connected with the rocks of the county, though its line is rather obscure and in

a large measure hid from direct observation. From what could be seen of this, it begins near the Licking river, above Day's mill, and, extending nearly north through Fleming and Mason counties, is continued into Brown county, Ohio. It is marked by patches of pebbles from the Millstone Grit, with some admixture of other resistant rock fragments from higher series than those now in place; by a line of sinks or natural ponds, which are scattered more or less along its length; and by a bending down of all the country towards the east. This line is most probably a part of the feature as seen by Prof. Edward Orton in Highland county, Ohio, for we learn from him (Ohio Geology 1870, page 262) that they are carried down by a strong eastward dip.

There is some reason to believe that this disturbance occurred after the surface of the county had been elevated and the present drainage lines formed, yet early enough afterwards to leave the Conglomerate yet in position when it took place; otherwise it is impossible to see why the flow of the Licking, as well as of other streams, was not carried more to the eastward. This dip is shown by the difference of the elevation between Cowan and Johnson's, and the bending down of all the series on the Ohio river, along the Mason county line.

The natural ponds have been formed by water dissolving the materials which made up their basins, and carrying them, in suspension or solution, down through the fractures created in the rocks. Perhaps, in every case, some of the hard pebbles of quartz have been left in the clay that forms their sides and bottoms. In almost every field over the county a careful search leads to the finding of these hard parts of higher rocks, which have remained unaltered, while hundreds of feet of other materials were removed. Among all these there are no fragments of foreign origin, but all belonged to the series which now lie in place, south and east of the county.

FOSSILS.

The following fossils may be found, some of them in large numbers, in the Upper Hudson beds:

Calymene senaria,
Chætetes compactus,
Chætetes frondosus,
Chætetes mammalatus,
Chætetes alter,
Streptelasma cornicula,
Orthis occidentalis,
Orthis testudinaria,
Strophomena alternata,
Streptorhyncus planumbonum,
Cyclonema bilix,
Bellerophon bilobatus,
Asaphus gigas,
Chætetes delicatulus,
Chætetes dalei,
Chætetes gracilis,
Stellipora antheloidea,
Orthis lynx,
Orthis subquadrata,
Leptæna sericea,
Strophomena rhomboidalis,
Rhynconella capax,
Pterinea demissa,
Zygospira modesta.

There are, in the Subcarboniferous sandstones, splendid specimens of Canda Galli, but as mere impressions it is impossible to collect them, unless large masses of stone are taken.

CONCLUSION.

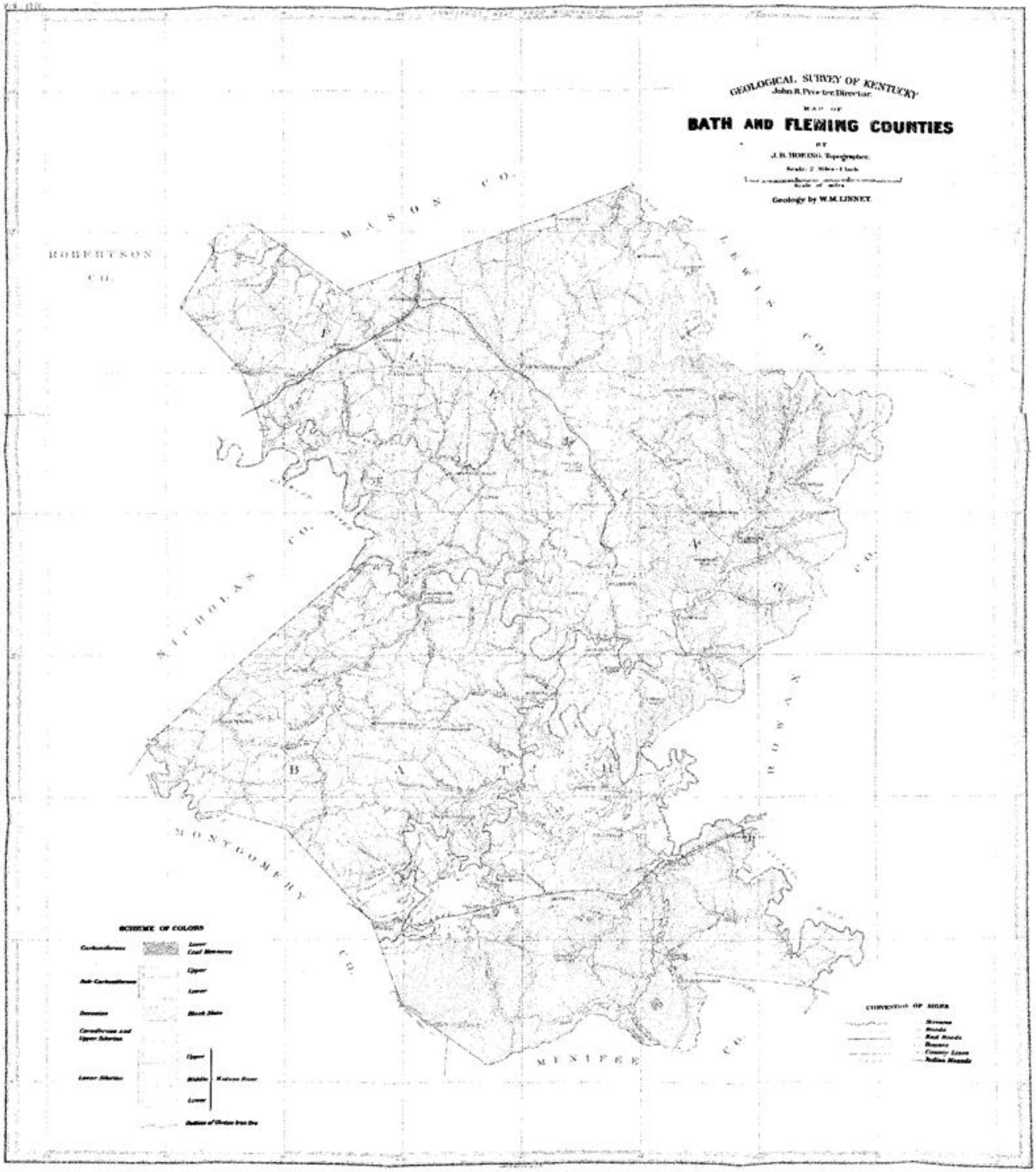
While Fleming county has neither coal beds, nor workable deposits of iron ore, and is without veins of other minerals, and its layers of building stones may never be drawn upon for more than local uses, it yet has a real wealth, greater than these could give: a large breadth of good soils adapted to the cultivation of all the valuable plants of this latitude and climate; lands where vast numbers of stock can be grazed and fattened; soils where fruits can be raised to perfection, and hillsides which should ever produce a wealth of trees for all the needs of its citizens. Some of the soils have been much impaired; but intelligent treatment can, in time, fully restore them to their pristine fertility. Others have not, originally, been very fertile; but labor and care can largely improve them. A number of places near the streams, and on the steep hillsides, should be clothed in timber trees, or in orchards. There is plenty of room for judicious work, and work that will pay.

APPENDIX A.

STATISTICS OF FLEMING COUNTY, COMPILED FROM THE REPORTS OF THE TENTH UNITED STATES CENSUS (1880) AND OTHER SOURCES.

1880. Total population	15,221
1870. Total population	13,398
1860. Total population	12,489
1880. White population	18,646
1870. White population	11,842
1860. White population	10,359
1880. Colored population	1,575
1870. Colored population	1,556
1860. Colored population	2,130
1880. Native population	15,063
1870. Native population	13,147
1860. Native population	12,250
1880. Foreign population	158
1870. Foreign population	251
1860. Foreign population	239
1880. Population of Flemingsburg	811
1880. Population of Poplar Plains	278
1880. Population of Mt. Carmel	185
1880. Population of Sherburne,	177
1880. Population of Hillsboro,	194
Number of farms	1,549
Acres of improved land	139,581
Value of farms, including buildings and fences	$3,728,109
Value of farming implements and machinery	$101,682
Value of live stock	$622,458
Cost of building and repairing fences, 1879	$24,641
Cost of fertilizers, 1879	$1,076
Estimated value of all farm products, 1879	$821,892
Assessed valuation, real estate,	$2,694,996
Assessed valuation, personal property	$981,811
Assessed valuation, total	$3,676,807
Taxation, State	$16,730
Taxation, county	$20,373
Taxation, town and school district	$2,004
Taxation, total	$39,107
Miles of railroad	26
Valuation of railroads in the county	$232,250
Miles of turnpikes and graveled roads	150
Total cost of turnpikes and graveled roads	$300,000
Number of horses	5,031
Number of mules and asses	1,026
Number of working oxen	143
Number of milch cows	3,101
Number of other cattle	6,596
Number of sheep	9,530
Number of swine	20,274
Pounds of wool	49,338
Pounds of butter	220,098
Bushels of Indian corn	717,669
Bushels of wheat	207,625
Bushels of oats	60,433
Bushels of rye	6,223
Bushels of Irish potatoes	16,080
Bushels of sweet potatoes	5,730
Tons of hay	4,094
Value of orchard products	$27,623
*Pounds of tobacco, 1883	2,965,188
Pounds of hemp	5,700
Manufacturing establishments,	65
Capital invested in manufacturing establishments	$112,316
Hands employed in manufacturing establishments	83
Amount paid in wages in manufacturing establishments	$15,355
Cost of material in manufacturing establishments	$208,849
Value of products in manufacturing establishments	$270,708
*Total acres of land assessed in 1885	204,259
*Average value of land in 1885	$11.70
*Pupil children, white	4,996
*Pupil children, colored	579

*From Auditor's Report.


GEOLOGICAL SURVEY OF KENTUCKY
John R. Procter, Director
MAP OF
BATH AND FLEMING COUNTIES
BY
J. B. HOEING, Topographer.
Scale: 2 Miles = 1 Inch
Geology by W. M. LINNEY.
ROBERTSON CO.
MASON CO.
LEWIS CO.
NICHOLAS CO.
MONTGOMERY CO.
MENIFEE CO.
BATH
SCHEME OF COLORS
Carboniferous
Lower Coal Measures
Upper
Sub-Carboniferous
Lower
Devonian
Black Slate
Corniferous and Upper Silurian
Upper
Lower Silurian
Middle
Niagara Group
Lower
Outlier of Clinton Iron Ore
CONVENTION OF SIGNS
Streams
Roads
Rail Roads
Houses
County Lines
Indian Mounds