

KENTUCKY GEOLOGICAL SURVEY.

JOHN R. PROCTER, DIRECTOR.

REPORT

ON THE

PROGRESS OF THE SURVEY

FOR THE YEARS 1886 AND 1887,

By JOHN R. PROCTER.

FRANKFORT, KY.:
CAPITAL OFFICE, JOHN D. WOODS, PUBLIC PRINTER AND BINDER.
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REPORT OF STATE GEOLOGIST.

To His Excellency, S. B. Buckner, Governor of the Commonwealth of Kentucky:

SIR: In the following report, which I have the honor to make, on the progress of the Geological Survey, I deem it of interest to review briefly the work of the Survey since it came under my direction.

When I took charge of the Survey, the Legislature had just created a Bureau of Immigration, and placed it under the direction of the State Geologist, making no provision for enabling him to execute the mandatory requirements of the law, without trenching upon the appropriation made for the prosecution of the Survey. At the same time the amount appropriated was the smallest that had been made since the inauguration of the Survey.

With the limitations thus imposed, it was difficult to give needed attention to the several sections, and at the same time to conduct the work in a manner to secure the best results to the entire State. In studying how the interests of the State could be best promoted, the following problems were presented to mind:

Kentucky had taken high rank as an agricultural State, but, notwithstanding her great wealth in coals, iron ores, timbers and other natural products, she had fallen behind States less richly endowed in commerce, manufacturing and mining. This is not due, as has been generally supposed, to a lack of enterprise or liberality on the part of the State.

The facts bear out the assertion that few States have been more liberal in promoting public improvement than Kentucky. The second railway constructed in the United States, and the first west of the mountains, was built in Kentucky largely by State aid. A splendid system of macadam roads, unexcelled by any in this country, was begun as early as

1825, and carried to its present perfection mainly by State and county aid. The State early began, and carried forward for a number of years, the improvement of the main rivers within her borders, by an expensive system of locks and dams.* The support given to the Geological Survey, when it is considered that the State had no public lands for sale, has been continued with commendable liberality.

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It was not from lack of a progressive public policy, but from causes without and beyond the control of the State, that she has not taken the rank as a manufacturing State which her vast resources would warrant. A glance at some of these causes is all that can be here attempted. Our pioneer fathers came for hundreds of miles over mountains and through almost impenetrable forests, and settled this fair land long before the advent of railways and steamboats, and the early prosperity of the State was the marvel of those times. Nothing, not even the settlement of the great West, promoted as it was by railways and large donations of public lands, has been so phenomenal. † In

1775 the first path was "marked" by Boone through "The Wilderness," and in 1790 the population amounted to 73,677, notwithstanding constant wars with the Indians, and that, during the period from 1783 to 1790, there were no less than fifteen hundred authenticated instances of death by the Indian's rifle and tomahawk. In 1800 the population was 220,959; in 1810 it had increased to 406,511, and in 1820 to 516,317 souls. And during all this time there was hardly a wagon road connecting this prosperous community with the distant settlements in the Atlantic States.*

The increase in wealth and commercial prosperity was as remarkable as the rapid increase in population. The State soon took rank as one of the leading States in the value and variety of agricultural products, and had developed extensive manufacture of such commodities as could reach the markets by river transportation.+

wilderness, in the strict application of the term, now furnishes proofs, on an increase in the value of property, which are not surpassed in the oldest settlements of Europe." (Seybert's Statistical Annals, 1818.)

In 1810 the population of Kentucky amounted to one-seventeenth of the total population of the United States-exceeding the population of some of the States that had been settled for two hundred years—Georgia being one-twenty-eighth; Connecticut, one-thirty-first; New Jersey, one-twenty-ninth, whilst Massachusetts was onetenth.

*Commissioners were appointed by the State of Virginia in October, 1779, to construct a road over the Cumberland Mountains to the "open country in Kentucky, and to cause such road, with all convenient dispatch, to be opened and cleared in such a manner as to give passage to travelers with pack-horses, for the present." Commissioners were authorized to call upon authorities for guards to protect workmen from Indians. In 1792 Commissioners were instructed to construct a "wagon road from the block-house in Washington county, Va., to the top of the Cumberland Mountain, in the county of Russell, being where the road from the State of Kentucky terminates."

In 1785 Commissioners were appointed to open a road from head of navigation, on James river, to the Falls of the Great Kanawha; and in 1786 Commissioners were appointed to receive subscriptions for the purpose of extending this road from the Falls of the Great Kanawha to Lexington.

† I cite one instance, out of many, as proof of the above statement: In 1795 Joseph Hart began the manufacture of cordage in Lexington, Ky., and in 1801 John W. Hunt erected a factory at the same place for the manufacture, from hemp, of bagging for covering cotton bales. In 1840, there were one hundred and eleven establishments in Kentucky engaged in the manufacture of bale-rope, cordage and bagging, producing one-half of the total product of those articles in the United States.

^{*}In 1837 the State had under pay, engaged in work on internal improvements, two engineers at a salary of \$3,000 per annum each; three engineers at a salary of \$2,500, and one at \$1,600 per annum, and four assistants, aggregating \$4,400 per annum, making in all \$19,500 paid to engineers. In 1839 the amount paid in salaries to the engineers engaged on turnpikes and river improvement amounted to \$31,675. Unfortunately, the records of the many surveys made by these engineers, extending over a long period, were destroyed by fire in Frankfort.

^{†&}quot;Such has been the progress of this country (Kentucky) from dirty stations and forts, and smoky huts, that it has expanded into fertile fields, blushing orchards, pleasant gardens, luxuriant sugar groves, neat and commodious houses, rising villages and trading towns. Ten years have produced a difference in the population and comforts of this country, which, to be portrayed in just colors, would appear marvelous. To have implicit faith or belief that such things have happened, it is first necessary to be (as I have been) a spectator of such events." (Imlay's Letters from Kentucky, printed in London, 1792.)

[&]quot;In 1794 troops were posted at regular stations to protect travelers against savages on their journeys to and from Kentucky to the Atlantic States. At that time the boats in which passengers were conveyed from Pittsburg on the Ohio river were also armed. In those stations the arts now flourished. Steamboats have been there established, to transport passengers and merchandise, prior to their having been adopted in any part of Europe! In 1770 the country, now named the State of Kentucky, was first explored. No white person had settled in it before 1775. In 1810 that State contained a population of 406,511 souls! That which so lately has been a

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The relative importance of Kentucky as a centre of commercial and manufacturing enterprise was for a time changed by the following causes: The completion of the Erie Canal, in 1825, connecting the Atlantic with the great lakes by way of Hudson river, made New York the great commercial metropolis of the Atlantic seaboard, and started industrial development and population westward on a line north of Kentucky. The introduction of the railway as a means of transportation furthermore altered existing conditions. The great mountain ranges, and the hundreds of miles of almost uninhabited forests, offered insurmountable obstacles to the early construction of railways connecting the State with the seaboard.

It was less expensive to construct roads through the States north of Kentucky. From the great public domain to the north and north-west, enormous grants of land were made by the General Government, and by the States, to promote the construction of railways, often amounting in value to more than the entire cost of the roads to which the grants were made. The General Government yet further promoted this building of roads westward by indorsing the bonds of some of the projected roads, in addition to the land grants, so that by this means this system of roads was carried westward to the Pacific ocean.

These roads, in order to bring population along their lines, and realize from the sale of their lands, instituted the most expensive and effective system of advertising ever before seen. As a result an unprecedented foreign immigration has been carried westward, and large drains have been made upon the population of the older States.* Capital and industrial activity followed this vast influx of population, and a resultant speculative mania made large drains upon the productiveness of Kentucky. To the south of Kentucky, the conditions were somewhat analogous. The great valley extending south-westwardly, from Pennsylvania to Alabama, afforded a cheap route along which railways were constructed. In Alabama, Mississippi, Louisiana and Florida

the public lands were the property of the General Government, and large donations were made to aid in the construction of railways.*

Thus great lines of road, connecting the seaboard with the West, passed by the State on the North and on the South, leaving an area, many thousand square miles in extent, comprising south-east Kentucky, western and south-west Virginia, without transportation facilities; being the largest area east of the Mississippi river unpenetrated by railways. This was the principal problem confronting the Survey when I was called to assume the direction of its work in 1880.

Of the large region on the head waters of the Big Sandy, Licking, Kentucky and Cumberland rivers, comprising the counties of Elliott, Morgan, Johnson, Martin, Floyd, Pike, Magoffin, Wolfe, Powell, Lee, Rockcastle, Jackson, Laurel, Leslie, Clay, Knox, Bell, Whitley, Wayne, Pulaski and Knott, no reports on the geology and resources, save preliminary reconnoissance reports on limited areas, had been made, either by the present Survey or by the former Survey conducted by Dr. Owen. Excellent reports in detail had been made by the present Survey on the geology of Greenup, Carter, Boyd and a part of Lawrence counties, and on Menifee county. Prof. A. R. Crandall had begun work in Morgan and Magoffin counties, but his work was not far enough advanced for publication when he retired from the Survey in 1877. These conditions made it my duty to organize for active work in the Eastern Coal Field, and a corps was organized for geological and topographical work. Prof. Crandall, because of his eminent qualifications and his knowledge of this field, was placed in charge of this work.

The topographical and geological work was carried forward in Morgan and adjoining counties, and a preliminary report with map was published on the geology of Morgan, Magoffin, Johnson and Floyd counties. After the completion of this work, the parties were moved into the extreme south-

^{*} By the census of 1880, it is shown that 454,198 persons born in Kentucky reside in other States, mainly in the West.

^{*}The North and South Railway of Alabama, and the Alabama and Great Southern Railway, were land-grant roads. Where these roads crossed, the present prosperous city of Birmingham was built up.

eastern part of the State—and the work there begun has been continued without interruption until the present year (1887). Increased appropriations enabled the Survey to secure the services of Mr. J. M. Hodge and Mr. R. C. B. Thruston, as assistants to Prof. Crandall, and work was carried on simultaneously in the waters of the Chatterawha, or Big Sandy, the Kentucky and the Upper Cumberland rivers. Prof. Crandall was called to the chair of Geology and Natural History in the State Agricultural and Mechanical College, so that the Survey could only obtain his services for a portion of each year. In addition to the general supervision of the work in South-east Kentucky, he completed the geology of Elliott county and a portion of Martin county. The Elliott county report, with map, was published in 1886.

The reports on the South-eastern Coal Field, with maps and numerous sections, were published this year* (1887). The counties of Pike, Letcher, Floyd, Knott, Leslie, Perry, Breathitt, Wolfe and Clay are included in these reports. The report on Harlan, Bell and Knox is ready for the printer. Work has been carried forward almost to completion in Whitley, Pulaski and Wayne counties. It has been the intention of the Survey, so soon as the reports now ready for the printer are published, to bind all of the reports on South-eastern Kentucky in one volume, accompanied with an introduction in which will be discussed the synchronism of the various coals; the cannel coals; the coking coals, and their relation to the iron ores and transportation routes of the South Appalachian region.

Capitalists will not furnish money to build railways and open mines on generalities, however enticing, but demand accurate statement of facts, and the Survey has aimed at placing the exact facts before the public.

That a more intimate knowledge of the coals in this hitherto unexplored region might be obtained, men were employed, under the direction of officers of the Survey, to dig into the coal outcrops, face them up, so that averaged samples could be obtained for analysis; and also that accurate measurement be made of the thickness of the various beds, with the accompanying shale or rock. The large number of detail sections of coals already published, drawn to a scale of five feet to the inch, and the numerous analyses from hitherto unknown coals,* attest the value of such work. It is with pleasure that I am enabled to say, that the several able experts, who have been sent into this region during the past two years, have borne willing testimony respecting the accuracy and reliability of the work of the Survey.

The Geological Survey in South-eastern Kentucky has brought to light the following facts within the past few years:

That, in addition to the coals beneath the conglomerate sandstone forming the base of the coal measures proper, we have above the conglomerate, north of Pine Mountain, 1,650 feet of coal measures, containing nine beds of coal of workable thickness, and between the Pine and Cumberland Mountains there is a greater thickness of the coal measures, containing twelve or more workable coals.

That certainly one, possibly three, of these coals are coking coals of great excellence.

That in places two, and sometimes three, of the coals are found as cannel coals of remarkable richness and purity. The facts brought to light warrant the assertions that the largest known area of rich cannel coals is found in Eastern Kentucky, and that the largest known area of superior coking coal is found in the same section; that this coking coal is more advantageously located, with reference to cheap and high grade iron ores, than any other coking coal. Cannel coals are found in sixteen of the counties in the Eastern Coal Field. Below are recent analyses from some of these cannel coals. The value of a cannel coal is usually determined by relative richness in volatile combustible matter.

^{*}The first publication respecting the discovery of the remarkable coking coal in South-east Kentucky was made in 1882. As the number of reports published by the State is limited, a wider publicity has been given by the publication of articles in various engineering, mining and industrial papers in this country, so that the facts have been brought well before the public.

^{*}Since 1881 Dr. Peter, the Chemist of the Survey, has made analyses from 287 samples, carefully averaged, from undeveloped coals.

CANNEL COAL.

Number in Reports.	Counties.	Vol. Com. Matter, per cent.	Fixed Carbon.	Ash.	Sulphur.
2578	Bell	41.54 51.60 47.40 53.80 41.10 48.22 66.28 50.06 44.16 42.64 50.22 44.40 44.20 44.80 40.56	50.60 40.40 47.70 39.46 46.70 44.24 29.73 40.14 43.74 46.48 40.74 47.00 43.70 37.60 51.24	7.00 7.00 3.30 5.54 11.20 4.76 3.64 8.40 11.80 9.32 7.60 7.88 11.00 16.80 6.70	5.078 .789 .574 .722 1.120 .78 .83 1.65 1.244 .574 .887 .753 .690 .970 2.768

^{*} Analyses by Prof. Thos. Egleston, of Columbia College School of Mines.

For purposes of comparison, analyses from some of the most celebrated cannel coals are given:

Volatile Combustible Matter.	Fixed Carbon.	Ash.
40.30 51.60	56.40 15.70	$\frac{3.30}{32.70}$
49.60 46.00	41.30 41.00	9.10 13.00
	40.30 51.60 49.60	40.30 56.40 51.60 15.70 49.60 41.30

It will be seen that some of the East Kentucky cannel coal excel the most celebrated coals of Great Britain. When the projected roads penetrate this region these cannel coals will find a market all over the country, for domestic use, and for the manufacture and the enriching of gas. They will also bear exportation for the same purposes.

The main Coking Coal of Eastern Kentucky has been named by the Survey the Elkhorn coal, from the stream in Pike county where it was first discovered and proven to be a coking coal. Since its discovery, a few years ago, this bed has been identified as thick coal, and traced by the Survey over an area of more than 1,600 square miles. It has been traced as a thick bed, above drainage, through Pike, Letcher and Harlan counties, and over a large part of Floyd, Knott,

Perry, Leslie and Bell counties. It has also been identified as a workable coal in Wolfe, Breathitt, Clay and Knox counties.

This coal attains its greatest thickness in Letcher, Pike, and Harlan counties, but it is thick enough for profitable mining, when transportation is secured, in all of the counties mentioned above. The following analyses, selected from the many made by the Survey from carefully averaged samples, show the great excellence of this coal over a wide area:

ANALYSES OF ELKHORN BED, KENTUCKY COKING COAL.

AVERAGE OF-	Fixed Carbon.	Vol. Com. Matter.	Ash.	Sulphur.
17 Bell county coals 9 Harlan county coals 6 Letcher county coals 6 Pike county coals Connellsville coal, Penn.*	62.63	37.13	3 83	.760
	60.02	35.46	4.25	.940
	61.09	35.00	3.19	.464
	63.86	31.67	2.86	.686
	60.30	31.38	7.24	1.090

Careful tests, oft repeated, have demonstrated beyond question that a superior coke can be made from this Elkhorn coal. These cokes have been tested for strength and porosity with most satisfactory results. The following analyses, selected from a large number, show that these cokes possess three requisites of a good blast furnace fuel—high carbon, with low sulphur and ash:

ANALYSES OF KENTUCKY COKES.

AVERAGE OF-	Fixed Carbon.	Ash.	Sulphur.
samples of Bell county cokes. I of Harlan county cokes. I of Letcher and Pike co. cokes.	93.68	5.84	.765
	92.20	6 16	.662
	94.27	5.09	.836

^{*}The chemical composition of these Kentucky coals more nearly resembles that of the celebrated Connellsville, than do the coking coals of West Virginia, Tennessee or Alabama.

For comparison, analyses are given from the best cokes now in use in the furnaces:

AVERAGE OF-	Fixed Carbon.	Ash.	Sulphur.
3 samples Connellsville coke . 4 of Chattanooga, Tenn 4 of Birmingham, Ala 3 of Pocahontas, Va 8 of West Virginia	88.962	9.741	.810
	80.513	16.344	1.595
	87.299	10.545	1.195
	92.550	5.749	.597
	92.38	7.21	.552

The importance of the discovery of this coking coal, and its bearing upon the future industrial development of the State, can not be overestimated. It adds to the value of the iron ores in North-eastern Kentucky, and the ores in Bath county, and to the brown ores in the limestone of the Red and Kentucky river valleys. In fact, it adds to the value of the ores of the entire State.

It is the nearest coking coal to Cincinnati and Louisville, and also the nearest good coking coal to St. Louis. It is as near Chicago as is the Connellsville coking coal, and nearer to large deposits of Bessemer steel ores than is any other coking coal in this country.

As the south-eastern boundary of the State is for many miles also the south-eastern limit of the Appalachian coal field, and the great deposits of iron ores beyond our border must, in large measure, be smelted with Kentucky coke, a slight reference to some of these ores may prove of interest.

Just beyond, and parallel to the south-eastern border of the State, there is a stratified ore, ranging from two to five feet in thickness, and averaging from 45 per cent. to 54 per cent. of metallic iron. This ore is known by the several names of "Clinton ore," "Dyestone" and "Red Fossil." It extends along the eastern base of the Cumberland and Stone Mountains, and is duplicated along the slope of Powell's Mountain and Wallen's Ridge, giving three parallel lines of this cheap ore, convenient to the South-eastern Kentucky coke, and often most favorably located for cheap mining.

Recently, it has been my good fortune to prove the existence of a reliable horizon of limonite or "brown" ore extending parallel, and near to the above. This ore has been opened in a number of places, showing a thick deposit of excellent ore, averaging as high as 52 per cent. of metallic iron. This ore is in the Oriskany of the Upper Silurian, and knowing that the same formation was brought up above drainage through the Eastern Kentucky Coal Field by the Great Pine Mountain fault, it was hoped that the same ore could be found along the northern slope of Pine Mountain. Investigations made in November of the present year confirmed these expectations. On Straight Creek, about three miles above Pineville, this same Oriskany ore is in place, with indications of a thick deposit, and fragments of the same ore were seen at other places along the mountain. This is a rich ore, and I hope that it will prove a reliable and extensive deposit.*

Prof. Thomas Egleston, of the Columbia College School of Mines, writes of this Low Moor ore, in his report to the C. & O. R. R., as follows:

"An imperfect examination of localities containing such material on the surface has given rise to the impression, announced in some of the most important local works on the Geology of the United States, that the Oriskany deposit contains no iron ores that can be worked. I have made over sixty analyses, from samples collected by myself and others, of these ores, and I find by far the larger part of them valuable for the manufacture of iron, and many of them very rich in iron, and very low in both sulphur and phosphorus. * * * * The ore deposits are not, as they usually are at the north, pockets uncertain in their yield and in their extent, but are regular geological formations, which can be followed for miles, and which, with few exceptions, can be depended on both for quality and quantity of their iron ores."

T. T. Wicks, Engineer and Managing Director of the Low Moor Company, says of the Oriskany ore in his report:

"Thus far, in mining these ores, the rule has been found unvarying that, as the workings deepened, the vein has widened and the quality has improved; in one instance, where the vein of ore was 16 feet wide at the surface, 280 feet down from this surface the vein was 70 feet wide."

Prof. John L. Campbell, in his report to the Buchanan and Clifton Forge Railway Company, says: That of all the ore-bearing formations in that portion of Virginia, 'this (the Oriskany) is the most remarkable for the quantity of the limonite ore that it contains, and the facility with which it is mined."

The industries at Low Moor, based upon this ore, furnished, a few years since, one-eleventh of all the freight hauled on the Chesapeake and Ohio Railway.

^{*} As this is a new discovery, and the ore has never been mined in South-west Virginia nor in Kentucky, we can only form opinion, respecting it, of what is known of the same ore where it has been developed. It is the same as the brown ores so successfully used at the Low Moor, Longdale and other furnaces near Clifton Forge, West Virginia.

In 1882–3 the Geological Survey found an excellent iron ore resting on top of the Subcarboniferous limestone on the northern slope of Pine Mountain, in Pike county, being the same as the ore occupying the same horizon in Estill, Lee and adjoining counties. The hope has also been indulged in that, somewhere along Pine Mountain, the rocks would be lifted up high enough to give the Clinton ore above drainage. The certainty of having two valuable ore horizons, and the possibility of a third (the Clinton), in places along Pine Mountain, opens up wide possibilities for the future development of that region. The Pine Mountain fault extends for many miles immediately through the field containing the coking coal.

Beyond the ores above mentioned, in the great valley, are large deposits of brown ore, resting on the Cambro-Silurian limestones of the several counties of South-west Virginia; and in Carter, Johnson and Unicoi, and other counties in East Tennessee. These ores range from 50 to 60 per cent. in iron, and frequently low enough in phosphorus to make a Bessemer iron. Large deposits of manganese ore, favorably located for cheap mining, are abundant. Yet further east additional brown ores are found in great abundance, in the Potsdam formation, and quite recently an immense deposit of high grade ore has been found at the base of this formation.

Specular ore of great richness, and as low as .003 per cent. of phosphorus, is found in East Tennessee; and along the flanks of the Great Smoky Mountain, having the great Roan Mountain as a center, are deposits of very rich and pure magnetic iron ore. These ores have been found along this range for many miles; the largest development being at the Cranberry mines, in Mitchell county, N. C., where the ore has been uncovered on the face of the hills for a width of near 400 feet, and quite 300 feet high. This ore, now being shipped in large quantities and successfully used in the manufacture of Bessemer steel, is mined by quarrying in open cut, so that it is delivered on the cars at a low cost.

The Bessemer steel ores of the Lake Superior region are over 700 miles from the nearest coking coal, whilst the abundant

Bessemer steel ores of this region are less than 100 miles from the Kentucky coking coal. Assuming Cleveland and Youngstown region as the natural meeting point between the Lake Superior iron ores and the Connellsville coke, the cost of the raw material (coke, limestone and ore) necessary for the manufacture of a ton of Bessemer pig, will be at least \$5 a ton more at those points, than will be the cost of similar materials at favorable localities where the Kentucky coke and the North Carolina magnetic ores may be brought together; and the difference in the cost of materials necessary to make a non-Bessemer pig will be yet greater, and more in favor of the same region.* The facts above stated are at last known and appreciated by ironmasters and railway builders. Four important lines of railway are being pushed to rapid completion, and will penetrate this region during the coming year, viz.: (1) The Clinch Valley extension of the Norfolk and Western. (2) The South Atlantic and Ohio, from Bristol through Big Stone Gap to a connection with the Eastern Kentucky Railway. (3) The Powell's Valley Railway, from Knoxville to Cumberland Gap; and (4) The Cumberland Valley extension of the Louisville and Nashville Railway, through the great water gap in Pine Mountain to a connection with the Powell's Valley Railway at Cumberland Gap, and with the Clinch Valley extension of the Norfolk and Western, at or near Big Stone Gap. An important railway is being located from North Carolina through Eastern Kentucky via the "Breaks" of the Big Sandy. And lines are being located, with prospects of being completed at no distant day, up the valleys of the Big Sandy, the Kentucky, the Licking and Cumberland rivers; so that this region, which a year ago was the largest area east of the Mississippi river unpenetrated by railway, will, within the next two years, have abundant railway facilities.

I have attempted to tell briefly of the early settlement of

^{*} Latest quotations give the price of ore at Cleveland as follows:

Specular and Magnetic Bessemer, per ton, \$7.00 to \$7.50.

Bessemer Hematites, per ton, \$5.75 to \$6.70.

The cost of the ore and coke necessary for the production of a ton of iron in Mahoning Valley district is given in "Iron Trade Review" at \$9.90 for the ore, and \$4.50 for the coke; total, \$14.40.

Kentucky, and the marvelous prosperity of the pioneer State. and how and why great lines of railway, connecting the seaboard with the West, passed by to the North and to the South, carrying industrial development and commercial prosperity beyond our borders. But these conditions exist no longer. Kentucky lies athwart and midway between the east and the west, and between the north and the south, and now great lines of railway traverse the entire length and breadth of the State, and others are being pushed to rapid completion; and from every section comes the information of an industrial awakening, such as the State has never before experienced.

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It is a noteworthy fact that, now railways are being constructed along the routes traversed by our pioneer fathersdown the Ohio river, and others through the great mountain gaps and along the "Wilderness Road," and movements inaugurated within the past year, backed by ample capital and intelligence, will continue until Kentucky is placed in the front rank as a manufacturing State, as she has been in the past as an agricultural State.

SURVEY OF THE CENTRAL REGION.

Dr. D. Owen, in his last report, calls attention to the fact that no reliable geological map of the entire State can be constructed, until detailed surveys are carried through the counties surrounding what is known as the Blue Grass Region. Realizing the truth of this, and also realizing that the numerous analyses of soils, made by the Survey since its first organization under Dr. Owen, were of little practical benefit to the agriculturists, until they could, by reference to geological maps, learn the character of rocks on which their farms are located, and also profit by experiments made by farmers on similar soils in various parts of the State, it was determined to carry forward this work with such dispatch as might be possible, without materially interfering with what might be considered more pressing work in the undeveloped sections of the State. Since 1880 a study has been made. and detailed geological maps published, of the counties of

Mason, Fleming, Bath, Montgomery, Clark, Madison, Garrard, Lincoln, Boyle, Mercer, Washington, Marion, Nelson, Spencer, Shelby, Henry and Oldham.

There remains, to complete this circle of counties surrounding Central Kentucky, Lewis, Bullitt and Jefferson counties. This work can be prosecuted much more rapidly over the central counties located within the above mentioned circle, because of the fewer geological formations present.

For instance, within some of the counties enumerated above are present all of the rocks from the lowest—the Chazy of the Cambro-Silurian—to the coal measures, inclusive; in all, eleven distinct geological divisions, to be traced and colored on the map, whilst in the remaining central counties there are seldom over three geological divisions. The peculiar value of these county maps to the agriculturist will be appreciated by a study of Dr. Robert Peter's report on "Comparative Views of the Composition of Soils, Limestones, Clays, Marls, etc., of the Several Geological Formations of Kentucky."

Until the completion of these county maps it has not been possible to locate the geological horizon of most of the soils previously analyzed and arrange comparisons.

The survey of the counties of Henry, Shelby and Oldham has been made since the date of my last biennial report. The map has been published, and the report is ready for publication.

It is important to complete the geology of the counties comprising the Subcarboniferous region of Western Kentucky. In addition to the iron ores, clays and other resources, it is necessary to determine the dividing line between the Cavernous member of the Subcarboniferous limestone, and the lower groups. The soils produced by these several groups are very different, and require different treatment by the agriculturist. This line meanders irregularly through the counties of Livingston, Trigg, Simpson, Allen, Barren, Metcalfe, Green, Larue, Hart, Hardin and Meade. Also through Casey, Adair and adjoining counties.

The maps of Wayne and Clinton counties have been completed, and a study of the latter county made.

The geological map of Clinton county was published in 1886.

THE SURVEY OF THE WESTERN OR "PURCHASE" * DISTRICT.

The topographical survey of this region had been begun under my predecessor, Prof. Shaler, but was discontinued in the summer of 1878 before the completion of the work in that district.

It was not until 1883 that the Survey was enabled to resume topographical work in that region—when a party was sent there under the direction of Mr. Hugh R. Ayres, and work continued until the survey was completed, and the map made ready for the Geologist.

Prof. R. H. Loughridge, who was especially qualified for work in this region by a knowledge acquired of similar rocks in other portions of the United States, was placed in charge, and continued without interruption until a most careful and elaborate geological survey of the entire Purchase district was completed. Prof. Loughridge was called to an important chair in the College of South Carolina in the spring of 1886; so that the Survey has only been able to command his services during the college vacation months. The report on the eight counties comprising the Purchase is now in type and ready for the presswork.

It will be accompanied with an elaborate geological map, also a map showing the agricultural features of that region, and another map showing the thickness and distribution of the gravel deposits. It is doubtful if any region of like area in the United States has been more carefully studied, or has a report more accurate or more in detail than this Purchase region.

In my former biennial reports I called attention to the remarkable wealth of fire and pottery clays in the Purchase region. Professor Loughridge's forthcoming report will give minute particulars respecting the location of these clays, and will also contain a valuable chapter on the uses to which they may be applied. It is confidently expected that the publication and distribution of this report will lead to the estab-

lishment of prosperous industries for the manufacture, in that region, of the many articles for which these clays are so admirably suited.*

SURVEY OF THE COUNTIES ON THE LOWER CUMBERLAND AND TENNESSEE RIVERS.

Some topographical work had been carried forward in these counties prior to 1880, but was discontinued before completion. After the parties under Mr. Ayres had completed the

*These clays have not only been subjected to numerous analyses, but many practical tests have been made. The gentleman who kindly superintended the tests of the pottery, terra-cotta and other clays, and who has a wide experience in their practical manufacture, writes to the Survey respecting these Purchase clays:

"You have raw material equal to the finest in England. The articles have a constant and ready sale, and are subjected to heavy freight rates in transportation from New York, Trenton or East Liverpool, so that they should be produced near a market, and Kentucky is known as a good market. The practical experience I have had with clays of this district has taught me their peculiarities, and I can freely say that, from their great plasticity, they are most easily and cheaply worked, and, from their binding qualities, entail less loss in the kiln than any others I have ever met with." One of these clays, he writes, will, with the addition of some flint, make a very beautiful ivory-ware, almost exactly resembling that made by the celebrated firm of Copeland & Sons, England, for table and toilet sets.

Prof. Loughridge says (see forthcoming Report "Jackson's Purchase Region," page 110): "A number of our Kentucky clays compare very favorably in their analytical results with the German glass-pot clays, which are so celebrated for their great refractory character. As will be seen by the table given below, the percentages of iron and potash, the injurious ingredients, are comparatively but little above those of the German clays, and in several it is much less; while in the Calloway county clay, No. 2639, there is only a trace of iron, a small amount of potash, and a very large percentage of silica and alumina, making this a far finer clay than the German. * * * * There is little doubt that these clays can take the place of the German clays in those establishments where they would be required to withstand the most intense heat."

Dr. Peter says of clays in the "Bluffs" bordering on the Mississippi river: "It is evident that these Tertiary bluffs, from which these clays were collected, offer some valuable materials to the industrial arts. Some of these are quite refractory in the fire, especially Nos. 2136, 2138, 2140 and 2141, and would, probably, make good firebricks, etc.; others of them could be employed for terra-cotta work and other forms of pottery, while some of these abundant deposits might, no doubt, be used with advantage in mixture with the more calcareous soft material found in some of these beds, in the manufacture of hydraulic cement of the character of the celebrated Portland cement." Elsewhere Dr. Peter shows that some of these clays are very like, in chemical composition, the celebrated Strobridge clays of England.

^{*}That part of the State situated west of the Tennessee river is known as "Jackson's Purchase," from the fact that General Andrew Jackson was one of the Commissioners to make the purchase of that district from the Creek Indians in the year 1818.

map of the Purchase counties they were moved east of the Cumberland river, and completed the topography of Caldwell and Crittenden counties, and a part of Livingston county. It was intended that Prof. Loughridge should make a geological study of, and report on, these counties; but, finding that the Survey could command only a limited portion of his time each year, and that the delay would be too great, Mr. W. M. Linney was sent there in the summer of 1887 to complete the work. Mr. Linney was compelled to guit the field, after having about completed the study of Caldwell county, by an illness that proved fatal in September of this year.*

REPORT OF PROGRESS

A preliminary report on the iron ores of this region, by Mr. W. B. Caldwell, Jr., was published by the Survey in 1879, but the abundance and excellence of the ores of that region, their nearness to the Western Coal Field, and the peculiar transportation facilities, render them of such importance as to justify a detailed survey. This region is also fortunate in having an abundance of superior building stones, clays, galena and fluor-spar.

SURVEY OF THE WESTERN COAL FIELD.

Much valuable work was done in this field by the Survey under the direction of Dr. Owen. The only county map published by that Survey was the map of Union county. Under the direction of Prof. Shaler, reports were published on "The Nolin Region;" also sections and reports along the various railways traversing that district, and preliminary reports on the region adjacent to the "Eastern Border of the Western Coal Field," and a report on the Airdrie furnace property.

Topographical surveys were carried over portions of Edmonson, Grayson, Hancock and Ohio counties, and the maps published. It has been found advisable to publish the maps on a scale of two miles to the inch, and to publish no maps until the complete survey of the county or counties comprising the map should be completed.*

In the years of 1884-5, the several topographical parties, under the direction of Mr. H. R. Ayres, Mr. J. F. McAdoo and Mr. Fred. H. Bagby, were sent into the Western Coal Field, and the topographical surveys carried over the counties of Warren, Butler, Muhlenberg, Ohio and Hopkins, and a large portion of each of the counties of Webster, McLean, Henderson and Daviess. It was the intention to push this topographical work to completion during the year 1886, and to follow it with a study of, and report on, the geology of the several counties; but the amount appropriated for the Survey was less than the estimates, and the bill was also amended, requiring the engraving of maps and printing of the reports to be paid from the reduced appropriation.

^{*}The loss sustained by the Survey, and the State, in the death of W. M. Linney cannot be overestimated. He had been continuously connected with the Survey since 1880, and had, by diligent and constant application, attained a knowledge of the paleozoic rocks of the Ohio valley excelled by few. He had endeared himself to his associate workers on the Survey by his unvarying gentle, unselfish and upright conduct, never, under any circumstances, being other than the Gentleman in the true and noble meaning of that term.

^{*}In this connection, I append an extract from my biennial report, January 1st, 1884:

[&]quot;In the four volumes published before the war, as the results of the Geological Survey under the able direction of Dr. D. D. Owen, there is a mass of valuable information, unavailable to the general reader, for the reason that the information gathered respecting one county may be scattered through the four volumes, and only the special student will take the trouble to dissect and combine this information. It was my intention to codify the chemical and agricultural data contained in these volumes (long since out of print) in a small volume, but I have concluded that it would be more valuable if this was elaborated in the various county reports, combining the same with the information gathered by the present Survey, giving credit by marginal references to the several volumes from which such information may be extracted. I am of the opinion that enough preliminary or reconnoissance work has been done by the Survey, and the work of the past few years has been directed with a view of securing complete (so far as the means will permit) final reports on the various regions studied. This, whilst it will lessen the number of reports published, will be a saving in time and money, as the special information contained in a preliminary report on a district must be duplicated in the final report, which should contain all that is known of the geology, soils, timber, etc. In the first stages of the Survey this preliminary or special work was necessary in order to obtain needed information on the general Geology of the State. Besides, the impression prevailed that the Survey might be discontinued before attention was given to the several localities. The method which this involved, whilst it was sufficient to meet pressing demands for special information, and has been productive of good, has not been so advantageous or economical as a plan based on the conviction that the Survey would be conducted to completion, and that when work was begun in a locality it should be only with a view of obtaining a final report, and should be prosecuted without interruption until that should be accomplished."

The Western Coal Field has excellent transportation facilities. Green river traverses the entire field from south to north, affording reliable slack-water navigation from Bowling Green to the Ohio river. One railway traverses the field from east to west and two from north to south, and two important roads are now being constructed, and others projected.

REPORT OF PROGRESS

There is an abundant supply of cheap iron ores convenient to the coals of Western Kentucky. Associated with the coals of the lower measures, in the counties of Grayson, Edmonson, Butler and Muhlenberg, are stratified carbonates and limonites, ranging from two to five feet and more in thickness --and persistent over wide areas.

The following are some of the analyses from thick deposits, one from each of the above-mentioned counties:

		Per C	ent.———	
Metallic Iron Silica Alumina Phosphorus	14.36	42.31 22.40 4.83 0.28	45.10 14.20 6.98 .0.39	48.88 12.73 3.91

Pure limestone is convenient. This region, and the region on the lower Cumberland and Tennessee, certainly offers a most inviting field to the iron manufacturer.

CHEMICAL WORK.

The chemical department has always been a prominent feature in the Geological Survey of this State since its first organization, under the distinguished chemist, Dr. Robert Peter, whose frequent contributions have been most valuable additions to chemical and agricultural science. Since the organization of the present Survey he has been ably assisted by his son, A. M. Peter. Dr. Peter has, in the eleven chemical reports made by him, since the inauguration of the Survey, built for himself an enduring monument, bearing testimony, for all time, to his high attainments as a chemist, his unfaltering zeal and untiring industry, through long years, to his professional duties, and to his patriotic devotion to the best interests of Kentucky.

This department has made 2,862 analyses of substances, coals, ores, clays, etc., with few exceptions from samples carefully collected and averaged by officers of the Survey. The last chemical report, now ready for publication, will in some respects be the most important of the entire series, representing, as it does, a larger number of coals from hitherto unexplored sections, destined to play a most important part in the early development of the State. These chemical reports afford a fair index of the work of the Survey. I give below a table of some of the principal materials analyzed since the reorganization of the Survey.

Year in which Chemical Report was made.	1875.	1877.	1878.	1881.	† 1883.	1884.	1886.
Coals from developed mines Coals undeveloped Cokes Iron Ores Clays Limestones Pig Iron Mineral Waters Soils	* 58 34 	86 62 29 4 22 12 83	5 4 4 17 5 74	5 6 25 13 8 90	29 86 19 15 2 19 4 26 16	1 39 9 	11 162 39 3 31 1 7 51

^{*} The large number of coals analyzed from developed mines may mislead as to the number of coal mines. Frequently several samples were taken from the same mine. and from the various entries and "rooms" of a single mine.

TOPOGRAPHICAL WORK.

This Department has, since 1882, been in charge of Mr. J. B. Hoeing, a gentleman well qualified for the position, having received an excellent training in one of the best engineering schools in this country, and who had been connected with the State Survey for the several years preceding the year 1878. It was decided to make the county maps on a uniform scale of two miles to the inch; and to construct a map of the State on a scale of 1-300,000 (the nearest decimal scale to one of five miles to the inch). In order to collect obtainable reliable data to supplement the work of the

[†] There was also made, in 1883, a valuable report on the comparative composition of the limestones, clays, marls, etc., of the several geological formations of Kentucky.

Survey, three young men were employed in April, 1882, to begin the work of tracing and reducing to an uniform scale the many railway and river surveys. All of the railway surveys that could be found—many rescued from dark vaults and dusty lumber-rooms-were traced and reduced to the scale of the State map. Often, no maps had been made, and it was necessary to plat from the field notes. It is estimated that in this way surveys of over 6,000 miles in length were traced and platted. As it was not possible to put many of these surveys on the map with the necessary accuracy without having latitude and longitude determination of certain points, application was made to the Superintendent of the U. S. Coast and Geodetic Survey, as the result of which an astronomical party was sent into the State in 1882, that made determinations at intervals, during several years; establishing points on the boundry lines of the State, and important points in the interior. After the collection of much data, Mr. Hoeing began the work of platting his final map of the State, and gave such time as could be spared from work on the various county maps, sent in from time to time by the field parties. Lithographic stones were purchased for this map several years since, and such surveys as were known to be accurate, together with the accumulated work by the State survey, have been engraved on the stones, from time to time. This map will be on a scale large enough to admit of the coloring in detail of the Geology, and, at the same time, to show prominently the topography, down to public roads. For the want of checks, or latitude and longiitude determinations, much of the data collected cannot yet be placed upon the map with that degree of accuracy required by this map. The numerous railway surveys made during the past two years will, when traced and reduced to the scale of the State map, greatly advance the map toward completion, and furnish checks and corrections to much of the material already on hand, thus enabling the topographer to utilize it.

The boundary of the entire State was completed in 1885, making it possible, for the first time, to calculate with any degree of accuracy the area of the State. Hitherto the area

had been variously estimated at from 37,000 to 40,000 square miles. The area, as computed by Mr. Hoeing from actual measurements, is 42,283 square miles. As there was no reliable map of the State,* it was found necessary to prepare a smaller map in advance of the completion of the larger map. This map, drawn to a scale of twenty miles to the inch, was published in the spring of 1887, and, together with the various county maps published by the Survey, has received high praise from persons competent to judge of the merits of such work.

The first map of a county, on which the Geology was colored, was published in 1883, and since that time the county geological maps have been published as fast as they could be completed and engraved, until the change made by the last Legislature in the law regulating printing and engraving rendered it necessary to discontinue work on the large State map, and postpone the publication of some of the county maps now ready for the engraver.

The United States Geological Survey, under authority given by Congress, has begun topographical work in the South Appalachian region, and is extending the work into eastern Kentucky. This will enable the State Survey, should it be continued, to concentrate topographical work on other parts of the State, and greatly expedite the completion of the final map of the State, and the enlarged maps of the counties yet to be surveyed.

NATURAL GAS.

The recent discoveries of this cheap and valuable heat and light producer in adjoining States have led to hopes of finding valuable stores by boring into the rocks of this State. These efforts have been measurably successful, and at the same time have been the cause of greatly increasing the knowledge of the rock formation beneath the surface of the

^{*}In 1874-5 a reduction was made of what was known as the "Military map," prepared by the United States engineers during the late war; and it was engraved and published, but when taken in the field was found to be so inaccurate as to be misleading, and its publication has been discontinued.

State. Enough has been learned to establish the fact that there are reliable gas horizons in the State, and at the same time to enable the Survey to advise against the putting down of wells in unpromising localities. The results of all the borings made in the State are being collected by the Survey, and it is hoped to have enough data collected to justify the early publication of a report on this subject, giving a map of the State on which will be located the principal anticlinals and lines of disturbance.

BUREAU OF IMMIGRATION.

By an act of the Legislature, passed April, 1880, the State Geologist was made ex officio a Commissioner of Immigration, and required to "publish and circulate, in such manner, and by such agencies, and in such places as he may deem proper and advisable in the United States and in foreign countries, pamphlets and other publications descriptive of the resources and advantages of the State, and other facts and information having a tendency to attract and promote immigration, &c." This law has remained in force until the present time, and appropriations were made in 1882 and in 1884 to enable the Geologist to carry out the requirements of the law. In the several biennial reports, I have dwelt at some length on the question of immigration, and described the operations of the Bureau, and the methods employed in bringing into the State many desirable immigrants. Efforts have been directed to inducing the immigration of only the better class of agriculturists and home-seekers. The working of this department, during the past two years, has been well described in a paper prepared at the request of the Commercial Club, by Mr. E. A. Fellmer, the Secretary of the Bureau of Immigration, and read before the State Industrial Convention, held at Louisville in October of the present year.

As this paper has been published in the report of the Commissioner of Agriculture, it is only necessary here to say, that information can be there obtained of the present flourishing condition of the colonies of industrious agriculturists located in the State. In the report of the Commissioner of Agri-

culture for the year 1885, page 330, will be found a communication in which I give my opinions on "Immigration and its Effect upon the General Welfare of Kentucky." This Bureau has, by the numerous publications issued, and by a very extensive correspondence, made the State favorably known among the many seekers for information. Although the law was left in force, no appropriation was made by the last Legislature to carry its provisions into effect, so that the work has mainly consisted in answering numerous inquiries and sending out such printed material as might be accessible. Mr. Fellmer has, by his faithful and efficient labors, done much to neutralize the disadvantages resulting from want of funds and printed matter, and the cause of immigration has been advanced steadily during the past two years.

THE STATE CABINET.

A mass of very valuable material has been collected by the Survey in the large, unfinished room of the new wing of the public building. During part of the present year Mr. Moritz Fischer has been engaged in classifying this collection, writing labels, etc., and it is now so arranged that the resources of the State are shown to better advantage, and can be studied more intelligently than ever before. This collection of ores, coals, clays, pottery, fossils, building stones, Indian relics, etc., etc., could not be duplicated without the expenditure of many thousands of dollars.

During the present year the Cabinet received, as a gift from the United States National Museum, a valuable collection of American birds, over three hundred in number. A very valuable Scientific and Economic Library has been collected by exchange.

I believe that a comparison of the work accomplished with the cost of the Survey, will show that it has been prosecuted with due regard to economy. Since I have had the direction of this Department, the total amount available for geological, topographical and chemical work has amounted to near \$8,500 per annum. The maps and reports to be seen in the office of the Survey speak for the character and magnitude of the work. In this connection I desire to express my sincere thanks to each and all of the gentlemen who have been my associate workers on the Survey. The large amount of work accomplished is due to their efficient co-operation and unselfish devotion to their professional duties.

Respectfully yours,

JOHN R. PROCTER, State Geologist.