GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON THE GEOLOGY

OF THE

NOLIN RIVER DISTRICT,

EMBRACING PORTIONS OF

GRAYSON, EDMONSON, HART, AND BUTLER COUNTIES,

BY P. N. MOORE.

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INTRODUCTORY LETTER.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

I herewith transmit my report upon the geology of that portion of the western coal field between Green river and the Louisville, Paducah and Southwestern Railroad, lying east of Bear Creek. The limits of the work have been determined more by geological and topographical boundaries than by political divisions. It therefore embraces portions of Butler, Grayson, Edmonson, and Hart counties, without including the whole of any of them.

I desire here to acknowledge the valuable assistance rendered to the Survey by Mr. John R. Procter. In addition to his services in the field, Mr. Procter has been of great assistance in preparing the cross-sections which accompany this report. His observations have been extensively used in their construction.

Respectfully submitted,

P. N. MOORE, *Assistant.*

ON THE GEOLOGY OF THE NOLIN RIVER DISTRICT, EMBRACING PORTIONS OF GRAYSON, EDMONSON, HART, AND BUTLER COUNTIES.

The area covered by the present report consists of that portion of the western coal field, and the immediately surrounding country, which lies east of Bear Creek, between Green river and the line of the Louisville, Paducah and Southwestern Railroad.

SURFACE FEATURES.

This region, for one in which the vertical height of the hills is comparatively so small, affords considerable variety in its topographical features, which have been formed solely by erosive agencies slowly acting upon sedimentary rocks of various kinds, which are comparatively undisturbed, and lie nearly horizontally.

A great variety of forms of topography are presented, which offer fine illustrations of the effect of the different rock formations of a country upon its surface features by the different degrees with which the rocks resist erosion. Resistance to erosion has been alone the determining agency in forming the topography; it has not been appreciably affected by distortions, upheavals, or faults in the strata; for, taking the region as a whole, it is very little disturbed, and the rocks usually retain their original position, lying horizontally or dipping slightly to the west.

There are, it is true, in portions of this region, in the limestones and sandstones of the Chester Group, a large number

of small faults, some of which extend up into the overlying coal measures; but they are usually of small vertical extent, rarely measuring more than 50 feet, and they do not seem to have exerted any appreciable effect upon the topography.

There are few prominent hills, but the general surface of the country may be best considered as a plain of considerable elevation, with the variations in height caused by the streams cutting through in different ways. The highest elevations will not exceed 490 feet above low water in Green river, at Brownsville, or 920 feet above tide water, estimating Green river at Brownsville as 430 feet above sea level—a level obtained from the best data at command, which, however, are imperfect. The general level of the country, on the ridges and comparatively flat uplands at the heads of the streams, is from 300 to 400 feet above Green river; while the level of the valleys, which in the lower part of this region are usually quite narrow, is from 200 to 250 feet below the uplands.

The drainage is all into Green river, chiefly through its two principal branches, Nolin river and Bear Creek, although there are a number of small creeks flowing directly into Green river, in the southern part of the region.

To the north, on the ridge which forms the divide between the waters of Rough Creek and those of Nolin river and Bear Creek, and along which the Louisville, Paducah and Southwestern Railroad passes, the surface of the country is level or gently rolling. To the south, it is much more broken, showing high table lands with the streams cut as deep gorges or cañons, with precipitous and often impassable banks, affording remarkably picturesque scenery.

The topography of the northern portion is due to the alternate thin sandstones, limestones, and shales of the Chester Group, which, not offering great resistance to the erosive agencies, are acted upon quite uniformly, giving us even and gentle slopes, except where there is a limestone or sandstone thicker than usual, when the streams cut narrow and gorge-like but shallow valleys, leaving the general surface above the streams still comparatively level and unbroken. On the south,

a series of heavy, coarse sandstones, culminating in the massive conglomerate, which is from 100 to 180 feet thick, are the determining rocks, and give us a characteristic topography.

Where the massive sandstone forms the tops of the hills, and is underlaid by friable shales and shaly sandstones, we have for the uplands a nearly level surface, streams narrow and precipitous at the upper part, where each one heads in the sandstone, and wider below, giving occasional valleys which afford good-sized farms of nearly level land. This is the character of the topography over a large portion of this region—of nearly all of that north of Sycamore and Dismal Creeks to the edge of the coal measures. Here a massive, thick-bedded sandstone, ranging from 40 to 60 feet in thickness, lies near the surface, and gives character to the topography. All the streams head in it, or cut their way through it near their heads, where it shows many exposures of its full thickness, in precipitous cliffs.

Further south, the conglomerate sandstone is of great thickness, and the streams are cut in it and the underlying limestone. The result is, that they are little more than narrow but deep gorges for their entire length, with little or no tillable land even near their mouths. The walls of these gorges are often precipitous cliffs from 75 to 150 feet in height. The country is so cut up by streams of this class, that travel is very difficult or impossible, except by following the main ridges or divides between the streams.

Some of the most romantic and beautiful scenery of the State is to be seen on the streams of this region. The well-known Dismal Rock, on Nolin river, at the mouth of Dismal Creek, is but one instance among many. Piney, Pigeon, Bylew, and the other creeks in the heavy conglomerate, present a series of wild and picturesque cliffs which have been rarely seen by appreciative eyes, but are well worthy the attention of the tourist. Were they more accessible, the region would doubtless become a well known and attractive resort. As it is, some of the finest scenery is but a short ride

from Mammoth Cave, and can readily be visited from that place.

Nolin river, from Dismal Creek to its mouth, cuts its way through the heavy conglomerate. Its valley, which above had been at some places of considerable width, at once narrows, and at many places is little wider than the bed of the stream; and the banks are so steep that it is with difficulty one can make his way along them. In this distance, at almost every turn, abrupt, precipitous cliffs tower above the stream from 150 to 200 feet high, and some even higher. Among the best known of these are Dismal Rock, at the mouth of Dismal Creek, on the very edge of the thickest conglomerate, Bylew Rock and Whistling Mountain, one on each side of the mouth of Bylew Creek. A sketch of Dismal Rock is given by Dr. Owen in the first volume, first series, Kentucky Geological Reports.

To the east we have the topography determined by the heavy, massive, and cavernous limestone called the St. Louis limestone. It is of great thickness, homogeneous, stratified in heavy beds, with few shaly and friable members. Into this Green river is cut deep, with high precipitous banks, but the tributary streams on the surface are generally few and short. The drainage is chiefly underground through the labyrinthine caverns and crevices with which the limestone is honey-combed. The country is full of sink-holes, funnel-shaped depressions, into which the water flows and disappears. There are many valleys which have evidently been cut out by streams when the level of Green river was much higher than at present. As Green river cut deeper and deeper into the limestone, the tributary streams, having perhaps reached a level where the limestone was more subject to the action of water, left their former beds and sought an exit underground, through the seams and fissures which were gradually enlarged by the solvent action of the water until they form the numerous caves which are so characteristic of that region.

These in their turn were abandoned for other channels, as the river cut still deeper, and the most of them remain comparatively dry. The surface of the country thus underdrained,

is fairly pitted with the sink-holes, into which the water runs, and from them gradually drains away through the limestone. Often the sink-holes become filled with clay and earth so that the water remains in them the whole year round. If at any time it is desired to drain them, it is easily accomplished by simply digging down through the clay till the limestone is reached, when the water sinks away at once. By reason of the great abundance of these sink-holes the topography is quite complex and varied, but the chief characteristics have been already stated; they are absence of long streams above ground, and abundance of sink-holes through which underground drainage is facilitated.

GEOLOGY.

We have represented in this region only the rocks of the carboniferous system, in the following divisions:

Carboniferous.	*Coal measures.*
Sub-carboniferous or Mountain Limestone.	*Chester Group.*
	St. Louis Limestone.

The description of these different formations will be given, beginning with the lowest of the region:

THE ST. LOUIS LIMESTONE.

This is the limestone known in the first series Kentucky Geological Reports as the cavernous member of the Sub-carboniferous Group. It is the limestone in which Mammoth Cave and all the similar caverns of that region have been formed. It is usually quite homogeneous in structure, very heavy-bedded, not very fossiliferous, occasionally somewhat earthy in appearance, and shows conchoidal fracture. The cavernous nature of this region is due wholly to the character of this limestone. It is so homogeneous and thick-bedded that such gigantic excavations as Mammoth Cave can be made in it without its crumbling or falling in, and thus filling them up.

The greatest thickness of this limestone which we have exposed within the field under discussion is about 230 feet, which is its height above Green river at Mammoth Cave.

In only a small portion of the field, covered by the accompanying map by Mr. Page, and that on the eastern part, does this limestone come to the surface not covered by other rocks.

The total thickness of this limestone in Kentucky has not been accurately determined. It is, however, much thicker than any exposure in this region, as has been proved by borings made in search of oil some years since. One of these wells, sunk on a branch of Dismal Creek, penetrated to a total depth of 804 feet, of which the last 524 feet is said to have been in solid limestone, and the boring was stopped without reaching the base of it. This gives us a greater thickness of this limestone below the drainage than we have exposed above. It is true that all of this limestone may not belong to the St. Louis Group; the limestone of the lower portion of the well may be a still lower member of the sub-carboniferous system, such as occur in other States, known as the Keokuk or Burlington limestone; but until they have been recognized in this State, it will be accurate enough to consider the whole thickness as belonging to the St. Louis.

THE CHESTER GROUP.

Between the massive St. Louis limestone and the sandstones and shales of the coal measures, there is a series of irregularly and frequently alternated limestones, sandstones, and shales, which mark a period of comparatively rapid and frequent geological changes; a progress toward the conditions which attended the formation of the coal measures, met by frequent returns to those which enable the deposition of a fine-grained crinoidal limestone, such as must have prevailed during the long period of the deposition of the St. Louis limestone.

From paleontological evidence, Mr. C. J. Norwood, Assistant in the Kentucky Survey, has identified this series with the Chester Group of the Illinois geologists. For the evidence upon which the identification is based, see his report.

These rocks immediately underlie the conglomerate at the base of the coal measures, and are exposed in nearly all this region.

Nolin river has its bed in these rocks for the whole distance covered by this report. Bear Creek runs in them from its head

to some distance below the mouth of Sycamore Creek. Rock Creek likewise cuts its channel in them from head to mouth. All of the branches of Nolin river, of any size, in the region covered by Mr. Page's accompanying map, have their channels cut in the Chester rocks for the greater portion of their distances. They usually head in one of the sandstones of the coal measures; but the descent is rapid and steep until the Chester limestone is reached, when it becomes much more gentle and regular, and the fall is comparatively slight. The same is true of all the branches of Bear Creek, except Beaver Dam and Gulf Creeks, which, although touching the limestone once in the course of their descent, run in the conglomerate sandstone most of the way, as after these streams have once cut through to the limestone, a rapid dip to the west again carries it underground, and brings the conglomerate down to the bed of the creek once more.

The ridge forming the divide between the waters of Rough Creek and Nolin river and Bear Creek, and along which the Louisville, Paducah and Southwestern Railroad runs, is formed by Chester rocks, which here extend southward three or four miles before they are overlaid by coal measures.

The total thickness of the rocks of this group, as shown along the line of the Louisville, Paducah and Southwestern Railroad, is given by Mr. Norwood in his report as 262 feet. Mr. Norwood's general section of the Chester rocks, along the line of the railroad, as given in his report, is sufficiently accurate in its details for the northern part of the region covered by this report, but as we go south there is a marked change. The great thickness of marly shales, called the Leitchfield marls, and the numerous thin limestones, give place to heavy-bedded limestones and sandstones. This change will be alluded to more in detail hereafter. The thickness of the series, in the region covered by this report, does not vary much from that given by Mr. Norwood. It may be stated in round numbers at 250 feet.

The base of the Chester series, the equivalent of the Big Clifty sandstone of Mr. Norwood's report, is reached at but

few places, except on the very eastern portion of the field, on Green river and its immediate branches.

Some wells, which have been already referred to, sunk in search of oil in this region a number of years since, penetrated through the entire thickness of this series and deep into the underlying St. Louis limestone. The records of some of these borings have fortunately been obtained for publication. One of these wells was sunk on a branch of Dismal Creek by Wm. C. Dodge, of Bowling Green, to whom we are indebted for the records. This well was started just below the level of the lowest coal of the neighborhood, and close to the top of the conglomerate, which is here only 25 feet thick.

The following is the record:

	No.		Thickness.	Total depth.
Carboniferous 33 feet.	1	Clay	8	8
	2	Black sandstone (conglomerate S. S.)	25	33
Chester series; total thickness 239 ft.	3	Shale	25	58
	4	Limestone	9	67
	5	Shale	15	82
	6	Limestone	34	116
	7	Shale	8	124
	8	Limestone	42	166
	9	"Mud vein" (probably shale)	17	183
	10	Limestone	20	203
	11	Black sandstone	15	218
	12	"Sand and shale"	42	260
	13	Shale	20	280
St. Louis limestone 524 feet	14	Grey limestone (St. Louis limestone)	524	804

The above record is given as it was furnished for publication. The names in parentheses are added by the author of this report.

The horizon at which this well was begun is well ascertained to be the top of the conglomerate.

We have shown by the above section 239 feet of Chester rocks, reckoning the shale between the conglomerate and limestone, as belonging to this group. There is always a large margin to be allowed for error in measurements, and for mistakes in recognizing the material through which the drill is penetrating, as well as the precise point of change from one rock stratum to another, in considering sections obtained by

drilling. It is a difficult matter, without the most careful study, to tell exactly what is the material being penetrated by the drill, for the reason that it is usually all finely pulverized, and there is a considerable admixture of material broken down from the sides of the well above by the drill-rods. Nevertheless, when these allowances are made, these records are of great value, and should always be kept. In the case of this well, there may be some errors in the record of the frequently changing strata of the Chester Group, but it is not probable there is any error in the total thickness, or in the measurement of the St. Louis limestone.

Other wells were sunk in this region on Rock Creek and on Brier Creek; but as yet we have been unable to obtain the records. Six wells, in all, were sunk in this region during the oil excitement. The following is the record of one of these sunk by the Kentucky Oil Company, on the Nolin Furnace tract, near Bear Creek, above the mouth of Decker Branch. The records were kindly furnished for publication by Col. Chas. E. Smith, of Indianapolis, under whose direction the well was sunk. The records were very carefully kept in detail, but in the following account they have been somewhat condensed and summarized. The exact geological level of the mouth of the well is not known, but it is evidently not far from the top of the Chester:

No.		Thickness.		Total depth.	
		Feet.	Inches.	Feet.	Inches.
1	Earth	9	. . .	9	. . .
2	Alternate bands of shale and limestone, mostly limestone	12	6	21	6
3	Shale, with thin bands of limestone, mostly shale	14	7	31	1
4	Hard limestone	38	6	74	7
5	Sandstone	20	3	94	10
6	Limestone	46	2	141	. . .
7	Black sandstone	9	. . .	150	. . .
8	"Mud" (probably soft clay shale)	6	. . .	156	. . .
9	"Slate" (probably hard shale)	2	6	158	6
10	Fine-grained sandstone	19	6	178	. . .
11	"Black mud" (probably soft black shale)	20	. . .	198	. . .
12	Black sandstone	6	. . .	204	. . .
13	"Slate rock"	10	. . .	214	. . .
14	Hard limestone (St. Louis limestone)	288	. . .	492	. . .

By the above record, which is, of course, subject to the before-mentioned liabilities of error, we have a thickness of 214 feet of Chester rocks, and 288 of St. Louis. We note here the beginning of the change in the upper part of the Chester to frequent thin limestones and shales, which are so characteristic of this formation further north.

The heavy sandstone, which is the base of the Chester series in the eastern part of this region, seems, as we go west, to disappear and give place to alternate thin sandstones and shales, the shales prevailing. This feature is shown quite conclusively by the two borings given above. Mr. Norwood also reports finding the same character to this rock in the western part of the coal field.

Further north and east, the sandstone occupies its proper place, growing thicker toward the east. Where the Louisville, Paducah and Southwestern Railroad crosses Big Clifty Creek, the thickness is stated by Mr. Norwood at 125 feet. At Mammoth Cave it is from 60 to 70 feet thick; but on descending Green river to the west it rapidly decreases to 40 or 50 feet, and even less. Near the head of Rock Creek it is 50 feet in thickness, but lower down it is only from 25 to 30.

In the region around Bee Spring, in Edmonson county, and for some six to ten miles north, the character of the Chester rocks differs materially from what it is in the neighborhood of Grayson Springs and Leitchfield. In the Bee Spring region, the series consists of three, and sometimes four limestones, with shales and sandstones between, the sandstone prevailing. The limestones, with the exception of the upper, are usually massive and homogeneous, ranging from 15 to 45 feet in thickness, and occasionally thicker. The upper is usually only from two to ten feet in thickness, and is often in several thin bands in shale. The section of the well last given shows this feature very characteristically. This limestone is usually more fossiliferous than the others. Where it is split up into several thin bands, the aggregate thickness is usually greater than when it consists of a single layer.

The two wells, the records of which have just been given, show typical sections of the Chester rocks of this region, as just described.

Further north, around Grayson Springs and Leitchfield, in place of the heavy limestones at the upper part of this series, we have a very changeable series of shales, marls, or marly shales, thin shaly sandstones, and limestones. At Cedar Knob, near Grayson Springs, a thickness of 115 feet of these rocks is seen, and the most of the shales and sandstones are calcareous. The limestone here, which is persistent, is probably the lowest one of the series. It occurs on Bear Creek, near Grayson Springs, and below. It is seen, at the Chapel, 40 feet in thickness. It dips, however, rapidly down stream, and is overlaid by the shales already referred to, which take the place, in this region, of the heavy limestones further south. Above Grayson Springs it rises rapidly.

In the northern and eastern portions of this region the Chester rocks are peculiarly subject to faults. There are almost innumerable small faults of from 10 to 50 feet vertical distance. They are most abundant where the Chester rocks are not overlaid by the coal measures, but in many places they are seen reaching up through the conglomerate. They are so numerous and irregular—not, so far as we can at present see, following any general direction, any line of uplift or down-throw—that they are often very perplexing, and render the taking of accurate sections quite difficult. They are usually local, and, in most cases, seem to be down-throws.

The Grayson Springs issue near a fault of this kind which extends through the lower sandstone and limestone of the Chester Group. The line of this fault undoubtedly determines the position of these medicinal springs which are here in so great number: the waters, from a depth, probably following the line of the fault underground, as they find it the channel of easiest ascent. The number of springs here is great, and their value high. For analyses of the waters from these springs, see the report of Dr. Peter.

DIP OF THE CHESTER ROCKS.

The region covered by this report is really a projecting tongue of the coal measures in the form of a basin or trough, in which the rocks have a general dip to the west, while there is also a modified dip from north and south toward the center of the basin or trough. The Chester rocks underlying the coal measures rise to the surface both to the north and south. The northern edge of this basin is the ridge already referred to, along which the Louisville, Paducah and Southwestern Railroad runs. Chester rocks are the only ones exposed for from two to three miles south, when they are overlaid by the coal-measure rocks. They are seen, however, still dipping south and west, on all the streams until Dismal Creek is reached, when the dip begins to change and they gradually rise toward the south, coming to the surface again on the south side of Green river, beyond the field of the map. The rise southward from Dismal Creek cannot be traced accurately in many places, as the upper part of this series is cut away by the heavy conglomerate. We only know that the rise does take place, as we find the rocks much higher to the south, even when the heavy conglomerate overlies them.

By reference to the accompanying cross-section, No. 2, running nearly south from Grayson Springs Station to Green river, the above mentioned facts in regard to the dip will be readily seen. The lower limestone of the series is 30 feet below the railroad at the station, which, by Mr. Page's levels, is 313 feet above low water in Green river, at Brownsville. The rocks descend to the south by a series of small faults until we find the top of the same limestone about 20 feet above Bear Creek, at Grayson Springs, or 150 feet above Green river. This descent is in two and one half miles distance. The top of Cedar Knob, near Grayson Springs, is 330 feet above Green river, with marly shales and limestones of the Chester Group extending to the very top. The descent is quite rapid from this point at first, something near 90 feet per mile, and then more gentle, until at the crossing of one of the branches of Dismal Creek, near Berry's Lick, where the upper Chester

rocks reach the lowest point on this section, 110 feet above Green river. The top of a limestone is seen lower than this on Pigeon Creek; but this is where the upper members are missing, having probably been cut away at the time of the deposition of the heavy conglomerate. Near Brownsville we have the highest Chester limestone exposed, 160 feet above Green river. As already stated, the faults seem most abundant on the northern and eastern borders of the region under discussion. In the central region, between Nolin and Bear Creek, faults seem to be very rare. Irregularities in the upper surface of these rocks are, however, very great, especially where the heavy conglomerate rests upon it. These irregularities are well shown along Green river, above and below the mouth of Bear Creek. One half mile above the mouth of that creek the limestone extends 50 feet above the level of the river. At Bear Creek the conglomerate is seen in the river banks, and the limestone near the level of low water. Below Bear Creek, Mr. J. R. Procter reports the limestone at Indian Fort as seen, 40 feet above Green river, while one fourth mile below, it disappears below the drainage; the top of the conglomerate at the same time descending from 235 feet to 125 feet above the river, thus showing undulations equal to or greater than those in the limestone.

In the northern part of this region there are numerous beds of marly shale, which are quite conspicuous, in their frequent outcrop, on account of their bright colors. They range from a dark red to bright yellowish-green. As yet, they have been only occasionally used, in small quantities, for paints. The colors which can be obtained by the use of these earths are fine, and they are capable of yielding an indefinitely large supply. Analyses of these marly shales, from a number of places, by Dr. Peter and Mr. Talbutt, give between four and five per cent. of potash. They would, therefore, if the potash can be rendered soluble, be of the greatest value as fertilizers, especially for exhausted tobacco lands. For the complete analyses, and further information in regard to the value of this material, see the report of Dr. Peter.

THE CHESTER COAL.

At many points near the edge of this region, on Rock Creek, on Nolin river and some of its branches, as high as Roundstone Creek, on Dog Creek and Cub Run, and on Green river, there is found in the rocks of the Chester series a thin coal. This coal has been already referred to in the report of S. S. Lyon, fourth volume, first series Kentucky Geological Reports, as having been found at the head of Rock Creek. It has been observed at so many points that it may be considered as of more than local occurrence. In fact, it seems to be one of the best marked and most trustworthy members of the series. It occurs at the base of a heavy limestone, which is probably the lowest of the series. It has not been seen by the writer of a greater thickness than three inches, hence it is of no economical importance, as it is not of workable thickness. It has served to delude some persons, in times past, into the belief that they might find coal in quantity to pay for working in places where only the Chester rocks occur; but not much labor has been wasted in the search. It usually has from a few inches to two feet of shale between it and the limestone, and rests upon a thin band of fire-clay. The coal is usually quite pyritous and somewhat slaty. The overlying shale is pyritous also, containing casts of stigmariæ in pyrites. The shale contains abundant impressions of various coal-measure plants, the leaves or spines of *Lepidodendron*, *Sphenophyllum cordiates*, &c. It usually immediately overlies a thin shaly sandstone or marly shale, but is not far from the top of the Big Clifty sandstone. The following section, at Mr. Wise's, on the south bank of Green river, near Brownsville, shows the usual association of the coal:

Limestone, probably 35 feet in all, seen only	25	feet.	
Sandstone (partly covered)	40	"	
Limestone	23	"	
Shale	1½	"	
Coal	¼	"	
Fire-clay			1 inch.
Clay shale	3	"	
Sandy shale	1½	"	
Covered	8	"	

Top of sandstone about 30 feet above Green river.

The base of the limestone above the coal is at high-water mark of Green river. The above section is a typical one of the many which have been obtained in which this coal shows. There is little doubt that this limestone, immediately above the coal, is the lowest one of the series, and that the sandstone, at the base of the section, is one of the top layers of the Big Clifty sandstone.

Although of no economical importance, the occurrence of this coal is of much scientific interest, in that it marks the beginning of true coal formation at a period long anterior to the deposition of the true coal measures. The geological changes which its occurrence indicates are also interesting. After the long period of quiet submersion, during which the great thickness of the St. Louis limestone was formed, an era of disturbed waters and rushing currents was begun, and the coarse, massive sandstone at the base of the Chester series was deposited. This rock bears, at many places, a striking resemblance to the conglomerate at the base of the true coal measures, although it has never been found carrying pebbles. As the waters became less disturbed the sandstone grew finer and more shaly, merging at last into a sandy shale, which, as more silt and less sand were deposited, became a fine clay shale, which formed the soil for the plants afterwards converted into coal. Immediately following the deposition of the slight thickness of shale above the coal, a marked and sudden change occurred; a submersion took place in waters in which the abundant crinoids once more began their work of limestone making. The formation of coal, thus interrupted, was not resumed until a thickness of many feet of alternated limestones, shales, and sandstones had been deposited.

THE COAL MEASURES.

As already stated, this region is in reality a basin or trough, forming a projecting tongue of the coal measures, surrounded on three sides by the sub-carboniferous rocks. On the eastern border, this tongue of coal-measure rocks is split in two by the Nolin river, and we have one part capping the ridge between

Nolin river and the branches of Rock and Sinking Creeks, while the other forms the divide between the waters of Nolin and Green rivers, extending further to the east, although the eastern limit of the coal itself is very nearly the same in both.

The boundary of the coal-measure rocks within the field covered by the accompanying map by Mr. Page, is about as follows: beginning at a point on the Leitchfield and Brownsville road, about three miles from Leitchfield, it crosses to Bear Creek, below the mouth of Cedar Lick Branch. From here it continues in an easterly course close to, and on the south side of, Cedar Lick Branch to its head, on the divide between the waters of Bear and Rock Creeks. It then turns a little to the north, and follows the divide between Bear and Rock Creeks, as far north as Grayson Springs. Turning east until Rock Creek is nearly reached, and then south again, it crosses that stream below the mouth of Grindstone Branch, and turns once more in an easterly direction. It continues this course for several miles, once crossing to the north of Grindstone Branch, but for the most part following the ridge between that branch and the Hunting Fork of Rock Creek, and after it passes the heads of these streams, between Sinking Creek and Barton and Laurel Runs. The very eastern extension of it on this outlier, is on a high hill called the "Devil's Backbone," just east of Laurel Run, which is capped with about 50 feet of coal-measure rocks.

Turning a little west of south, the line pursues the divide between Nolin river and the waters of Rock Creek, crosses Rock Creek near its mouth, and Nolin river near the mouth of Dog Creek. It then follows in a southerly course, on the south side of Dog Creek, for about two miles, when it once more turns to the east, along the divide between the branches of Dog Creek and Nolin river, and continues in that direction until it passes beyond the field of the map. The coal-measure conglomerate forms the ridge continuously on the divide between the waters of Nolin and Green rivers for several miles beyond the field of the map, and then occurs in disconnected outlying patches nearly to Munfordville. The south-

ern boundary of this projection enters the field of the map at the head of Cub Run. Occasional detached outliers extend to the south, between Cub Run and Ugly Creek, even across Green river; but the boundary of the main body runs east, across the head of Ugly Creek from Cub Run, then turns southeast, crosses Buffalo Creek diagonally with its course, and pursues nearly the same direction until it reaches and crosses Green river below the mouth of Buffalo Creek, passing out of the field of the present report.

The limits of, and the area covered by, the coal-measure rocks, will be much more readily understood by referring to the accompanying geological map, in which the different formations are colored so as to show the area covered by each.

Within the above described limits there is a considerable area, which is described as covered by coal-measure rocks, where no coal will be found. The conglomerate, which is here the first of the coal-measure rocks, covers the surface, but the coal which lies above it, and the upper part of the rock itself, have been worn away by long-continued exposure. It is for this reason that the map was not extended to the eastern limits of the area covered by the conglomerate. Coal may possibly be found on the top of some of the conglomerate-capped hills, beyond the edge of the map; but the probabilities are strongly against it, and if found, it will be in extremely small areas—mere patches as it were.

In the outlier north of Nolin river, coal has been found as far east as the head of Barton's Run, and will probably be found still further east, if sought for in the right place, although it probably does not extend as far as the indicated eastern limit of coal-measure rocks. Reports were heard in regard to coal as far east as the mouth of Roundstone Creek, on Nolin river; but on examination, it proved to be the Chester coal already described.

Between Nolin and Green rivers, coal has been found on Dog Creek, on Longfall, between Brier and Bylew Creeks, and between Bylew and Buffalo Creeks; but it has not been found further east than the heads of these streams, nor is it prob-

able it will be. The conglomerate forms the ridge at the head of these streams, and for a long distance east, and it is so near the surface, that it is probable the coal has been all removed. This is also the case toward Green river, although in the main ridges the conglomerate is covered, so that there is a possibility of finding the coal at many places.

Reference has been made, in the discussion of the topographical features of this region, to two heavy sandstones, which are the prominent agents in the determination of the topography of the coal field. These two sandstones are the most prominent features in the geological structure, and where they prevail a very different succession of rocks is found. They are: the conglomerate at the base of the coal measures, and a heavy, massive, rarely conglomeratic sandstone, which has been called by Lyon, in the fourth volume, first series Kentucky Geological Reports, the fifth sandstone of the millstone grit series—a series of rocks beginning with the St. Louis limestone, which he termed "the cavernous member of the sub-carboniferous limestone," and extending up into the coal measures. It includes, therefore, what is now identified by Mr. Norwood as the Chester series, and the lower portion of the coal measures. This sandstone, which he termed the fifth sandstone, is in this vicinity not the fifth sandstone above the St. Louis limestone, but the fourth. The name, therefore, is for this region incorrect, and will be discarded. In its place it will be called the Bee Spring sandstone, from the Bee Spring in Edmonson county, where it is well shown in its characteristic features.

The principal problems in the geology of this region are in connection with the occurrence of these two sandstones; and for this reason, and to lead to a correct understanding of the stratigraphy, a description will be here given of their character and distribution.

THE CONGLOMERATE.

The first of these sandstones, the conglomerate proper, in the northern part of this region, is usually thin, and often

wanting altogether. In the northwestern portion of the field under discussion, on upper Bear Creek and its branches, it is either absent altogether, or present as a coarse, non-conglomeratic sandstone. Where found, it is usually only from 15 to 25 feet thick, though occasionally a little thicker. This is its usual thickness north of Nolin river and east of Rock Creek, and it is well marked by the pebbles it carries. Here, more than in any other part of this region, the conglomerate and the coal-measure rocks above are affected by the faults, which have been referred to as so frequent, in the Chester rocks. South of Nolin river, which is here running nearly west, the conglomerate thickens rapidly. West of Rock Creek, and between Nolin river and Bear Creek, for about fifteen miles south, the conglomerate is not seen, at any place, more than 50 feet in thickness, while it is usually about 25. It is also found of about this thickness east of Nolin river, between Brier, Longfall, and Dog Creeks, not extending, however, near to the heads of any of these streams. The limit of the area, where the conglomerate is of this unimportant thickness, is a line somewhat irregular and broken, extending from Bear Creek, above the mouth of Beaver Dam Creek, in a general east-northeast course, crossing Nolin river at the mouth of Dismal Creek, then across Brier, Longfall, and Dog Creeks, until it passes beyond the field of the map. From this line south to Green river, and beyond, the conglomerate is of great thickness, ranging from 60 to 190 feet. This thickening gives us a very different geological section north and south of the line. It is often very sudden in its occurrence, and seems to be effected by the cutting away of several of the underlying Chester rocks. This is finely shown, in one case, near the mouth of Dismal Creek. Here, upon the west side of Nolin river, is a section exposed, showing two sandstones and two limestones, as follows:

Pebbly iron ore, thickness not seen.	
Covered	3 feet.
Conglomerate sandstone	20 "
Covered	15 "
Sandstone	10 "
Covered	15 "
	100

Limestone	25 feet.
Covered	10 "
Sandstone (not conglomeratic)	25 "
Limestone, not seen at this place, but exposed below	15 "
Covered	20 "
Level of Nolin river.	

On the opposite side of Nolin river, in full view, and not more than one fourth of a mile distant, is exposed the well-known Dismal Rock. This is a vertical cliff of conglomerate sandstone, resting upon the lower limestone of the section just given. The total height, as measured by Mr. Page, is 165 feet, of which the conglomerate forms 130 feet.

The section is as follows:

Conglomerate sandstone	130 feet.
Limestone	35 "
Level of Nolin river.	

The top of this rock, as nearly as can be determined with a hand level, is on a level with the top of the upper sandstone of the section just given. We thus see that the currents which have deposited this rock, have cut away about one hundred feet of the Chester rocks, and deposited in their place the heavy conglomerate sandstone.

This sudden thickening is well shown by cross-section No. 4, from Nolin river to Bear Creek, along Dismal Creek, and down Mill Branch. The thickening at this place, from 25 to 130 feet in one fourth of a mile, is all downwards. At other places it seems to be accompanied by a rise in the top of the conglomerate, as well as by an increase in depth.

A large portion of this region is underlaid by this conglomerate, where it is at its greatest thickness. It forms a great irregular mass, with the line of its greatest thickness extending in a course nearly east-northeast. It forms the divide between the waters of Nolin and Green rivers, on the very eastern border of the region covered by Mr. Page's map. Along this ridge it is very prominent, presenting many bold escarpments, and ranging from 80 to 130 feet in thickness. It does not, however, until within the field of the map, extend in any great width to the north or south. Cane Run, Cub Run, Ugly Creek, and other branches, head in the thick conglomerate, but soon pass through it, and have their valleys altogether in the Ches-

ter and St. Louis rocks. As already stated, it extends to the southwest, and crosses Green river below the mouth of Buffalo Creek. Green river cuts its way through it for some distance west of the mouth of Bear Creek. Its limit to the south of Green river has not yet been accurately determined.

From the north line of the coal measures, where the conglomerate is first seen, to the center of its greatest thickness, there is an increase from north to south from 25 to 180 feet. On the southern edge it disappears abruptly, while from 75 to 130 feet thick. There is some thinning in that direction, but it is slight in comparison with that to the north. The greatest thickness known is on the upper part of Dog Creek and its branches. Here it is found as high as 180 feet in thickness. On Piney Branch of Dog Creek there is a single cliff exposure of this sandstone called the "Buzzard Roost," where 160 feet is seen in one face, and 175 feet is the total thickness. The stream here has cut away the base of the sandstone, and formed a rock house of considerable depth and unusual height. The stream here has not cut to the bottom of the sandstone, although the Chester limestone is seen a short distance below. There is in the valley of this branch either a remarkable and rapid dip to the north, from the head of Buffalo and Ugly Creeks, or there is a total thickness of the conglomerate of nearly 275 feet. In less than two miles, going north from the head of Ugly Creek, the distance from the top of the conglomerate on the ridge to the base in the valley is 275 feet. There is, in this distance, room for considerable dip, which probably accounts for the apparent great thickness. The conglomerate has not been found at any point, where the observation was free from possibility of error, of more than 180 feet thickness. Dog Creek cuts its way through the thick conglomerate for nearly its whole length, only emerging from it within the last two miles.

Of the streams flowing into Nolin river, Pigeon and Pine, Bylew, First and Second Creeks cut through it from head to mouth, Beaver Dam and Gulf Creeks, and all their branches, of the tributaries of Bear Creek, do likewise, as also Indian

Creek and the other streams flowing directly into Green river from the north, between Nolin river and Bear Creek.

Bylew Creek cuts longitudinally through the very thickest of the conglomerate, and the result is, that, in its tremendous cliffs and narrow gorge-like valley, as well as the magnificent views which it presents, it is unequaled in this region.

In all the region covered by this thick sandstone, exposures of from 80 to 125 feet in one face are frequent. Its outline is by no means regular, but varies greatly, being full of indentations and projections, so that the direction already given as the line of the axis of greatest thickness is to be understood as approximate only.

The rock has evidently been deposited by very swift-moving currents of water. This is proved by the character of the rock itself, which, where the thickening is rapid and great, as on Nolin river, is composed chiefly of large quartz pebbles, many of them larger than a hen's egg, with barely enough sand to cement them together.

These masses of pebbles have only been found near the bottom of the sandstone, where it is at nearly its maximum thickness, and near the border. The pebbles gradually diminish in frequency as we approach the top, where they usually are found in thin, irregular layers, with a considerable thickness of sandstone between, which is almost or entirely free from pebbles. There is also a gradual diminution in the number of pebbles from the east toward the west and north. At many places on Bear Creek, where the sandstone is still of great thickness, it is hardly conglomeratic at all. It is also noticeable that where the conglomerate is thin, the pebbles are not nearly so abundant. As we approach the northwestern portion of this region the pebbles disappear almost entirely, and the sandstone itself is erratic, sometimes present and sometimes not, and, where present, is recognzied only by its position. I am informed by Mr. Norwood that still further west, along the line of the Louisville, Paducah and South western Railroad, there is no true conglomerate found at the

base of the coal measures on the eastern border of the coal field.

This coarse, pebbly sandstone can only have been deposited by very swift currents of water, and only such were energetic enough to wear away the rocks which the conglomerate replaces. From the character of the rock these seem to have acted with the greatest force from the east, or, more probably, from the southeast, as we find the conglomerate thinning, and finally disappearing to the north, while it changes character to the west, while still retaining a considerable thickness. West of Bear Creek there are indications, although the region has not been examined in sufficient detail to make the assertion positively, that the sandstone, instead of dipping beneath the surface entirely, gives place to a great thickness of shales, which occupy nearly the same geological position. Should this, on more thorough examination, prove to be the case, it will furnish additional strongly corroborative evidence of the statements just made in regard to the direction of the currents which deposited the sandstone.

Further than this, in the eastern portion of this region, between Nolin and Green rivers, at the heads of Bylew, Brier, and Longfall Creeks, there is a second strongly marked conglomerate, at a distance of about 30 feet above the lower, with a coal bed between. Further south and southeast the two conglomerates seem to unite. To the northwest the upper conglomerate changes character, becomes rarely conglomeratic, is thin-bedded and shaly at places, and considerably thicker. It seems here to be identical with the Bee Spring sandstone. Between Brier and Bylew Creeks it is full of pebbles, but they rapidly disappear towards Nolin river. This apparent identity is shown in cross-section No. 1, from Leitchfield to Mammoth Cave.

The occurrence of this second conglomerate in the eastern part of this region above a coal, indicates a long-continued action of rapid currents from this direction, continued and repeated after the elevation and change of conditions in the other portion of this region, which accompanied the deposi-

tion of the coal. It is worthy of notice that this sandstone changes its character to the northwest much more rapidly than the main conglomerate.

The pebbles of the conglomerate are of quartz, usually white, though occasionally a few are found of rose color or jaspery quartz, but never of any other material.

THE BEE SPRING SANDSTONE.

This sandstone, for all that region north of the line which has been given as the northern limit of the heavy conglomerate, is by far the most prominent member of the geological column. It is most extensively developed between Nolin river and Bear Creek, where it shows abundant exposures of from 50 to 60 feet. It lies near the top of the ridge, and has served to form it into a comparatively even, gently rolling table land. Near the northern edge of the coal-measure rocks this sandstone has changed its position, become thinner, and is difficult of identification. There is also here a change in the position of the coals, as will be shown further on. It is not until about five miles south of the extreme northern border that this sandstone reaches its maximum thickness. It then extends for about seven or eight miles south, varying very little in its thickness until south of Dismal Creek, and on the head streams of the different branches of Sycamore Creek, when it becomes thin, rises rapidly to the south, and finally disappears. The position and character of the sandstone here are somewhat obscure. It is usually covered, and very rarely seen outcropping in position. It is certain that it thins rapidly when it comes to overlie the heavy conglomerate. As the conglomerate thickens this sandstone thins. South of Beaver Dam and Pigeon Creeks it has not been recognized, nor is there any indication of its presence shown by the slopes of the hills.

The thickening of the conglomerate and the disappearance of the Bee Spring sandstone take place within a comparatively short distance—about two miles. The character of the change in the conglomerate can be determined, as it is frequent in

outcrop; but all is obscure in the change and final disappearance of the Bee Spring sandstone.

This sandstone north of Bee Spring is usually quite coarse, and, in a few instances, contains small pebbles; but these are rare. It is remarkable for the great number of springs which issue from its base. Most of the streams head in this sandstone, and at almost every branch there is found a spring issuing from its base. Many of these springs are strongly chalybeate.

The sandstone is here coarse at the bottom and somewhat shaly at top, so that the top is frequently covered. When pebbles occur, they are usually small, and lie between the layers of the sandstone.

North of Nolin river and east of Rock Creek this sandstone changes character somewhat, becoming thin-bedded and shaly. It is, therefore, not nearly so conspicuous. Exposures of it are comparatively scarce; but its presence is indicated by the topography. It forms the divide between Nolin river and the branches of Rock Creek, where the top of it is from 325 to 400 feet above Nolin river, rising towards the east.

South and east of Nolin river, between that stream and the line of the heavy conglomerate already given, there is a triangular area, including the field crossed by Brier, Longfall, and Dog Creeks, in the lower portion of their descent, where this sandstone is found, sometimes shaly and sometimes conglomeratic. As shown by cross-section No. 1, from Mammoth Cave to Leitchfield, this sandstone here occupies the same position as the upper conglomerate, and is doubtless identical with it, although north of Brier Creek it is much thicker. It is, however, found conglomeratic between Brier Creek and Mt. Vernon Mill, on Nolin river.

GENERAL SECTION.

As shown in the description of these two great sand-rocks, there are sudden and great changes in the order and thickness of the various rocks of this region, so that for the whole region, a general section cannot be given which will be of any

service in accurately indicating the order and thickness of all the rocks. For a large portion of the region, however, in the already described field, where the Bee Spring sandstone has its best and most characteristic development, a general section can be given, which will show with considerable accuracy the order and thickness of the various rocks, as follows:

General section of the coal-measure rocks east of Bear Creek, and north of Beaver Dam and Pigeon Creeks, Edmonson and Grayson counties, Kentucky:

1.	Clay shale, with nodules of iron ore	35	to 35	feet.
2.	Iron ore, reported thickness	1½	to 1½	"
3.	Clay shale	30	to 30	"
4.	Iron ore	2	to 3½	"
5.	Space, probably filled with clay shale	0	to 20	"
6.	Clay shale	15	to 15	"
7.	Coal	⅔	to ⅔	"
8.	Coarse sandstone, "Bee Spring S. S."	20	to 60	"
9.	Sandy clay shale	0	to 20	"
10.	Coal	1	to 2	"
11.	Shaly S. S. changing to shale	15	to 20	"
12.	Space, probably filled with clay shale	15	to 20	"
13.	Main Nolin coal	2	to 3½	"
14.	Fire-clay and shale	3	to 10	"
15.	Conglomerate sandstone	15	to 25	"
16.	Shale	0	to 25	"

Top of Chester limestone.

This section applies very well for most of the region between Nolin river and Bear Creek; also for the region between Bear and Rock Creeks, except at the very edge of the coal-measure rocks, where there is some thinning out. It will also answer for a portion of the country east and south of Nolin river.

For the region of the heavy conglomerate it is difficult to give a general section, for the reason that the rocks above are almost always covered. There is rarely more than 100 feet thickness of material overlying the thick conglomerate, although at a few of the highest points it reaches 150 feet. As evidenced by the slopes, this is mostly shale or shaly sandstone. These are also the most prevalent in wasted outcrops, on the hillsides. A complete section of the rocks above the heavy conglomerate has not been obtained anywhere in this region. The nearest approach to this was at Stevens' coal bank, on the west bank of Bear Creek. This section was partly made from statements of Mr. Stevens in regard to the rock passed through in sinking a trial shaft near his entry.

SECTION AT STEVENS' COAL BANK.

Top of hill.		
Covered slope, probably sandstone	35	feet.
Iron ore	½	"
Shale	3	"
Coal (reported)	1⅙	"
Covered	5	"
Sandstone	20	"
Shale	40	"
Sandstone	4	"
Covered (probably shale)	18	"
Coal	3	"
Fire-clay	2½	"
Sandstone (conglomerate)	50	"
Bed of Bear Creek.		

This section shows more sandstone,than is indicated at most places, above the conglomerate.

Between Nolin river and Rock Creek, and in the corresponding country across Nolin, below Dog Creek, the same trouble is experienced in obtaining a complete section, owing to the scarcity of exposures. The conglomerate, here thin, and the Bee Spring sandstone, usually shaly, are here pretty well defined, as also the Nolin coal, resting immediately upon the conglomerate; but the space up to the Bee Spring sandstone is uniformly covered, and it is still a matter of uncertainty whether the coal, which at other places is just below that sandstone, is present or not.

Near the northern limit of the coal-measure rocks, changes are again so frequent that a general section cannot be given, that will be of any service. The Bee Spring sandstone here is thin and shaly when present; as well as the conglomerate, it is difficult of identification. At places the sandstone, which seems to represent the conglomerate, is close down to the Chester limestone, with not more than two or three feet of marly shale intervening; while at other places, within a short distance, it is fifteen feet above the limestone, and a coal occurs between.

There is a well-marked rise in the rocks, from both north and south, towards the head of Canoloway Creek and Long Branch of Bear Creek. This is well shown by cross-section No. 2, south from Grayson Springs Station, and No. 1, from Mammoth Cave to Leitchfield. From here the rocks dip rapidly north for about two miles, and then rise again rapidly, in

conformity with the rise of the Chester rocks. The changes in the character of the rocks, here, are somewhat obscure, as is also the equivalency of the coals. If the sandstone last described be the conglomerate, the lowest coal is a sub-conglomerate, without doubt. If, on the other hand, the lower conglomerate has disappeared, and the sandstone above is the equivalent of the Bee Spring sandstone, we have a section which does not differ so greatly from that further south.

The following will serve as an instance of the rapid changes in the rocks of this region: On Miller's Fork of Bear Creek, at the Gravelly Lick, a coal is seen which is only eight feet above the limestone; a little above, the sandstone, 40 feet thick, is seen, with a covered space of 15 feet between it and the limestone, in which space the coal will undoubtedly be found. On the next branch below, to the west, the sandstone is found close down to the limestone, with only about three feet thickness of shale between. About one mile further west, just across Bear Creek, in the Leitchfield road, the coal is exposed about 12 feet above the limestone. Above the coal is a space of 40 feet, mostly filled with shale, and then a sandstone 26 feet thick. In this short distance the coal disappears and reappears, while a thickness of 40 feet of shale comes in below the sandstone.

A fine section is here exposed which shows quite characteristically the many shales, marly shales, and shaly sandstones of the upper Chester Group.

The section is as follows:

Coarse friable sandstone	26	feet.
Covered (probably sandstone)	3	"
Clay shale	8	"
Covered (probably shale)	7	"
Clay shale	22	"
Coal	1½	"
Fire-clay	1	"
Covered	12	"
Wasted sandstone	3	"
Limestone	2¼	"
Shale	1	"
Covered (probably marly shale)	6	"
Green and red marly shale	4	"
Covered	7	"
Greenish shale	3	"
Amount carried forward	106¾	

Amount brought forward	106¼	
Shaly sandstone	2	feet.
Whitish shale	1	"
Covered (probably shale)	16½	"
Green marly shale	5½	"
Yellow crumbling limestone	½	"
Green shale	3	"
Greenish shaly sandstone	2	"
Total thickness	137¼	"

COAL.

By reference to the general section for the region between Bear Creek and Nolin river, north of Beaver Dam and Pigeon Creeks, it will be seen that there are here three coals. The first of these rests close upon the lower conglomerate; the second underlies the Bee Spring sandstone; and the third rests immediately upon it. Of these, the first is the only one which has been found of workable thickness over any considerable area. The second is reported as 30 inches thick at some places; but it has not been seen by the writer of this of over 18 inches thickness, and in most places it is not more than 12 inches. The third coal has not been found of workable thickness; it is usually only from 8 to 12 inches. The first of these coals was called by Dr. D. D. Owen, in the first volume, first series, Kentucky Geological Reports, the Main Nolin coal, a name which, until the numbering of the coals in the western coal field is finally determined upon, will be retained here. It is the equivalent of Coal L of Mr. Norwood's section along the line of the Louisville, Paducah and Southwestern Railroad. These three coals are quite persistent over all that area where the Bee Spring sandstone is characteristically developed.

The normal distance of the Nolin coal above the Chester limestone is from 20 to 30 feet. The second coal is 40 feet above this, and the third 70 feet above the second. These distances are subject to some slight variation, but within the above limited area this is not great. This section holds good to within three or four miles of the northern edge of the coal-measure rocks, where the changes in the general stratification, which have been already referred to, affect also the position of the coal beds.

We have not here, in any one section, more than two coals exposed, and as we approach the border of the coal-measure rocks but one is found. The following section, on Long Branch of Bear Creek, near Eli Decker's, will serve to show the position of two coals:

Coal	1	foot.
Covered	5	feet.
Sandstone, hard and solid	4	"
Sandstone, shaly	6	"
Sandstone, hard	4	"
Covered	13	"
Clay shale	5	"
Carbonate iron ore	½	"
Clay shale	7	"
Coal, thickness not seen.		
Covered	5	"
Coarse sandstone	35	"
Covered	15	"
Top of Chester limestone.		

Between the base of the sandstone and the limestone there is found, at another locality on this branch, a marly shale belonging to the Chester Group. On the next branch north, called Miller's Fork, there is a coal between this sandstone and limestone.

The changes which take place in the rocks here are well shown by cross-section No. 2, from Grayson Springs Station to Green river. East of this region, on Rock Creek, and beyond, it is also difficult to give a general section, as good exposures are comparatively rare, and there are frequent changes in the character of the rocks. But one coal is here known near the border of the coal measures. This, between Rock and Bear Creeks, is usually only from 10 to 20 feet above the Chester limestone. It has been opened for local blacksmiths' use at Thomas Higdon's, on Cedar Lick Branch of Bear Creek; at John Skagg's, on Dice Branch of Rock Creek; at Lec. Higdon's, on Pearson's Branch of Rock Creek; and at numerous other places. The coal frequently carries a bed of iron ore resting upon it. The ore is a very fair quality of limonite, changing to carbonate as it is followed into the hill, and is from five to eight inches in thickness. The coal itself is from 20 to 27 inches thick, and of very good quality.

East of Rock Creek, in the corner between that stream and Nolin river, there has been but one coal recognized. This is usually 20 to 30 feet above the limestone, resting almost immediately upon the conglomerate, with only the intervention of a few feet of shale and fire-clay. At one locality, a place was seen where another coal is said to have been formerly exposed, but it is now covered, and there is no evidence of its existence. If there be a coal here, it is about 50 feet above the first. The rocks are so generally covered that it has been seen at no other place.

The coal resting upon the conglomerate has been very much disturbed, in the ridge between Rock Creek and Nolin, by frequent faults, which are upon both sides of the ridge. The faults seem to be a series of down-throws or step faults, which follow around the main ridge. They are usually of small vertical extent, hardly ever over 50 feet; but there are a number of them, so that we find the coal at very different heights, dipping, apparently, very rapidly towards both streams, but really carried down by the faults. The greatest thickness of this coal seen here, at any place, was 28 inches; but it is reported, at other places, as three feet and over. The Bee Spring sandstone caps the ridge here, and it is probable the coal, close below it, will be found, on searching in the proper place.

Across Nolin river but one coal has been found. This is the equivalent of the Main Nolin coal, with the sandstone above changed to a conglomerate, and the distance between considerably lessened. Near Mt. Vernon Mills, the Bee Spring sandstone is developed very characteristically, about 30 feet above the coal, which is here exposed nearly two feet thick, and the bottom of the coal still covered. Resting upon the coal is an eight-inch bed of iron ore of good quality.

On Long Fall Creek, at the Old Thompson bank, the coal is very near the top of the lower conglomerate; but the overlying rocks are so covered that it is impossible to determine them exactly. Higher up on the creek, the upper conglomerate is found above the level of the coal. The coal here was

covered at time of examination, so that its full thickness was not seen, but it is reported to be something over three feet.

As shown by cross-section No. 2, from Mammoth Cave to Leitchfield, the coal rises rapidly toward the southeast. Between Brier and Bylew Creeks, it is found overlying about 70 feet of conglomerate, and close under a second conglomerate 35 feet thick. The coal is near the overlying sandstone, with a covered space of 25 feet between it and the lower. This is the most southern exposure of this coal with the overlying conglomerate. On the head of Bylew Creek, the conglomerate consists of two members, with a covered space between, in which the coal belongs; further south and east, the conglomerate is seen solid from 100 to 180 feet thick, without division. The coal occurs at the head of Mill Branch of Bylew Creek, some distance south of the main stream, resting immediately upon the heavy conglomerate, and with no evidence of the existence of a higher one. There is here an iron ore above the coal, but the thickness of neither ore nor coal was seen. The coal here has risen about 60 feet from where last seen, on the head of Brier Creek. Further west, at the head of Piney Branch of Nolin, the coal is seen, apparently thin, resting close upon the conglomerate, which is 140 feet thick. No coal, except the thin sub-limestone coal, has been found further east, along the main ridge between Nolin and Green rivers, than the head of Brier and Bylew Creeks; nor is it probable that there will be, in any quantity, as the conglomerate is very close to the surface, sometimes not covered at all, and hardly ever with more than 30 feet of overlying material. If the coal is found, it will only be on the isolated hills where there is enough overlying material to protect it.

North of the main dividing ridge, between Dog Creek and Nolin river, coal is found further east than on the main ridge, as the conglomerate is somewhat lower, and there is a greater thickness of overlying material. It will not probably be found, however, a great distance east of Dog Creek, as the rocks rise rapidly in that direction, bringing the conglomerate close to the surface, once more. South of Bylew Creek, between Nolin

and Green rivers, there is not a large area where the coal will probably be found, as the conglomerate comes close to the surface, except on the main dividing ridges between Buffalo, Bylew, First, and Second Creeks. Along the ridge which the Houchin's Ferry road follows, there is from 40 to 75 feet thickness of rock above the conglomerate, until within two miles of Green river, so that, here, the coal has probably been protected from erosion. Of the region, therefore, between Nolin and Green rivers, only that part situated between Nolin river, Bylew, and Dog Creeks, from Wolf Branch down, stated approximately, is furnished with a trustworthy deposit of coal. Beyond this, where found, it is only in detached masses.

Between Bear Creek and Nolin river the Main Nolin coal occurs very regularly and of good thickness, from Decker Branch of Bear Creek south to Green river. Until south of Dismal Creek, the rocks preserve nearly the order and thickness shown in the general section. Here the two coals, below the Bee Spring sandstone, are best developed. From Bee Spring Branch of Dismal Creek south, the Bee Spring sandstone begins to grow thin, and gradually disappears; the coal close below it is seen no more, and the main coal rises rapidly to the south with the thickening conglomerate. From here, south to Green river, this coal is seen at many places, resting close to the heavy conglomerate. The character of the overlying rocks has changed, and no further trace of the second coal is seen. At the Stevens coal bank, near the mouth of Bear Creek, on the west side, as shown by the section already given, there is a thin coal 85 feet above the main coal; but this is the first instance where it is clearly shown.

From Decker Branch to Dismal Creek, the main coal is seen exposed in almost every branch of both Nolin river and Bear Creek. South of Dismal Creek, it is seen close to Nolin river, at Watt Merideth's, above the mouth of Pigeon Creek; but it has not yet been seen in the region drained by Pigeon, Pine, or Indian Creeks. If sought for, at its proper place, above the conglomerate, there is no reason why it should not be found on Pigeon and Pine Creeks, as the conglomerate is, at many

places, overlaid by a sufficient thickness of rock to protect the coal. Over a larger portion of the area drained by Indian Creek, as well as the other branches of Green river entering near Brownsville, the conglomerate has been so nearly denuded that it is very doubtful if the coal will be found. If found, it will be only on the highest ridges. In the drainage of Bear Creek, as might be expected from the dip of the rocks, the conglomerate is covered much deeper, and the coal occurs more regularly and over a wider area. It is seen on Sycamore Creek, between Sycamore and Beaver Dam Creeks, on Gulf Creek, at numerous old openings on Bear Creek, near Green river, at the Stevens bank, where the coal is now being mined, and on a short branch entering Green river, just above the mouth of Bear Creek.

At none of these places has it been opened for more than local use, except at the Stevens bank. This is the only locality within the field of the present report where the coal has been mined under ground. It is put into boats on Bear Creek, which is here navigable, and carried down Green river. Throughout the rest of this region the coal is only opened by stripping occasional patches for the blacksmiths of the neighborhood. These openings are usually in the beds of streams, where the coal has been found originally washed bare by the stream. From their position these openings fall in or fill with water almost as soon as they are abandoned, and the coal becomes covered, so that it is impossible to see its full thickness. In many cases, therefore, the thickness of the coal bed has to be taken from the report of those who formerly dug the coal. This is a very untrustworthy way, as the thickness is hardly ever measured accurately by the digger, and in reporting it afterwards, the tendency is almost always to exaggeration. The usual thickness of the coal, reported at these places, is from three to four feet. In some cases it is reported at four feet, with a heavy slate parting; but usually no notice is taken of the partings, and the total thickness is reported, as remembered by the digger.

The average thickness of the Main Nolin coal throughout the region just described, where it has been seen by the writer, is three feet. At many places, where it was reported much thicker, it was found, on examination, that a slate parting or very bituminous slate, which often occurs at the base of the coal, had been measured with the coal, thus greatly increasing its thickness.

It is, however, over most of this field, a trustworthy three-foot coal, and, at many places, it shows free from any parting.

The following section at Knob Lick, near Dismal Creek, is fairly typical of this coal over a large region:

Clay shale, bituminous at bottom	3 feet.	
Coal	3 "	1 inch.
Very bituminous slate		4 inches.
Bituminous slate	1 "	

QUALITY.

Of the quality of the coals of this region nothing is accurately known, except of the lowest or Main Nolin coal. The other coals are thin, and so rarely exposed that it is difficult to get fairly representative samples. Moreover, not being of workable thickness, it was not considered as of sufficient importance to warrant any great expenditure of time in endeavoring to procure samples of them.

Of the Main Nolin coal a number of analyses have been made, both from single specimens and from carefully averaged samples.

The following analyses of this coal, by Dr. Peter and Mr. Talbutt, will serve to show its quality:

	1	2	3	4	5	6	7	8	9	10	11
Specific gravity	...	1.305	1.335	1.282	1.345	1.437	1.350	1.367	1.336	1.395	1.36
Moisture	3.40	4.70	4.06	2.30	2.60	4.06	3.60	3.20	3.66	4.14	6.26
Volatile combustible matter	30.66	31.40	33.24	32.10	33.80	32.00	33.00	33.80	35.14	31.52	32.44
Fixed carbon	54.94	52.20	51.70	56.30	53.14	50.84	54.40	52.60	54.26	56.08	53.80
Ash	11.10	11.70	11.06	9.30	10.46	13.10	9.00	10.40	6.94	15.26	7.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Coke	65.94	63.90	62.70	65.60	63.60	63.94	63.40	63.00	61.20	65.34	61.30
Sulphur	2.544	1.945	1.67	1.059	2.425	4.938	2.101	2.923	2.706	3.565	1.476

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No. 1 is an average sample, taken by myself, of the coal from the Stevens bank, Butler county.

No. 2 is an average sample, taken by myself, of coal from Tar Lick, near Dismal Creek, Edmonson county.

No. 3 is an average sample, by Mr. J. R. Procter, of coal from same locality.

No. 4 is a single specimen from same locality.

No. 5 is an analysis of a single specimen from Knob Lick, Dismal Creek.

No. 6 is an average sample, by myself, from a small outcrop of coal on Mill Branch of Bear Creek. The outcrop from which the sample was taken was so small that it cannot be safely considered as a representative sample.

Nos. 7 and 8 are analyses of single specimens from the same locality.

No. 9 is an analysis of a single specimen from Shoal Branch of Bear Creek.

No. 10 is an analysis of coal from Gravelly Lick, Miller's Fork of Bear Creek. The sample was taken by myself from a very small outcrop, and cannot be considered as an average of the whole bed.

No. 11. Coal from Brushy Branch of Canoloway Creek; average sample by myself.

These analyses, with the exception of Nos. 6 and 10, show a coal of quality which entitles it to rank among the best of Western Kentucky. The superior quality of the lower coals of the western part of the State has been frequently noted, and is well shown by the above analyses of the Nolin coal, the lowest of the series. The coal varies considerably, at different places, in the amount of sulphur present, but is otherwise, usually, a moderately dense coal, which stands exposure remarkably well, and apparently is sufficiently fat to produce a good coke. At some places the coal is so bituminous that the bitumen flows from the base of it, giving rise to "Tar Springs." This is the character of the coal at the Tar Lick, analyses of which have just been given. At some places where the coal shows the most sulphur, the sulphur is present in a layer or

parting of pyrites, which is so thick and persistent that it can easily be rejected when mined, and the remainder of the coal left comparatively free from sulphur.

IRON ORE.

The iron ores of this region are abundant and valuable. It is one of the most richly endowed undeveloped localities in the State.

Iron ores are found in association with the rocks of each geological age in this region, but they are by no means uniformly distributed, nor are they of uniform quality. The region is as yet almost wholly undeveloped, and but little pick and shovel prospecting has been done; so that it is in many cases, impossible to tell of the quantity of ore present when outcrops are found. Doubtless the ores which have been seen will be found, on further investigation, to be more extensive than at first supposed, and ore will be found, at many localities, where it has not been discovered, as yet. It is, therefore, not to be considered as evidence against the continuance of an ore, that it has not been seen at certain localities, unless it has been dug for, or the situation is such that, if present, it must have shown in outcrop.

The ores of this region are mostly in stratified beds, conformable to the rocks with which they are associated. The ores are both limonites and siderites, or earthy carbonates. There is, however, an exception to the rule as to the character of deposit just stated. This is found in the lowest ore of this region, associated with the St. Louis limestone. It is found in the surface clays where the limestone has been much eroded. The ore is thinly scattered, at a great many localities, where the St. Louis limestone is the prevailing rock; but within the field, covered by the present report, it is not apparently in any quantity. The deposits are limited and irregular, and seem to have been formed by the segregation of the ferruginous matter, which was disseminated in small quantities, through the limestone, before its erosion. As the limestone was dissolved away, the iron and the silicious matter in the lime-

stone remained unaffected by the agencies which effected the solution of the limestone; the iron separating to itself formed the deposits just described, and the silicious residue formed the surrounding clays. The ore is a limonite, which, in some cases, seems to be the original mineral, and, in others, is derived from pyrites, as is shown or proved by the pseudomorphs of limonite, after pyrite found and by the presence of pyrites in the center of some of the largest pieces of ore. This ore is the geological equivalent of the Cumberland river limonites of the western part of the State, which are so valuable and so well known; but it is by no means as abundant. There are numerous places where this ore shows in quantity sufficient to justify working on a small scale, if there were any market for it, or means of shipment; but it does not show enough, at any one place, to justify a reliance upon it as a basis of ore supply for a furnace. The ore is usually of excellent quality, except when injured by the presence of sulphur; but these cases are comparatively rare. It is rarely ever mixed with chert or flint, and is not often silicious to an injurious extent. There were, formerly, iron furnaces in Hart county, which are said to have used ore which is the same as this, with charcoal as fuel, but they are not now in operation, and nothing definite has been learned in regard to them.

The other ores of this region, found in both the Chester and the coal-measure rocks, are stratified deposits of earthy siderite or carbonate of iron, and limonite or hydrated peroxide of iron, derived from the carbonate. At most places only the limonite has been seen; but it will doubtless be found to change to siderite on following it underground, where there is a sufficient covering to protect it from oxidizing agencies.

At a number of places, ores have been found associated with the rocks of the Chester Group, usually resting upon limestone. On Napper and Saltsman's branches of Bear Creek, there are several exposures of a lean-looking ore, from two to two and one half feet thick. The ore consists of a silicious matrix, inclosing many small nodules of comparatively pure limonite. The ore here rests close under the conglomerate,

upon a limestone which is probably the upper one of the series. An analysis was made by Dr. Peter and Mr. Talbutt of an average sample, collected by myself, from an exposure of this ore on Stillhouse Branch, with the following results:

Peroxide of iron	40.798
Alumina	1.293
Lime and magnesia	traces.
Phosphoric acid	1.019
Sulphuric acid	.360
Combined water	7.250
Silica and insoluble silicates	50.030
Total	100.750
Metallic iron	28.519
Phosphorus	.445
Sulphur	.207
Silica	46.760

This shows a high per centage of silica, combined with a low per centage of iron—a combination which renders the ore, for the present at least, of little value.

On Caney Branch of Gulf Creek, one of the lowest branches of Bear Creek, on the farm of Jacob Souders, there is found an ore of excellent quality, a limonite, so far as seen, of remarkable purity. It appears to be in a bed or stratum of about two feet thickness, resting under shales, upon or near the top of a limestone, the exact equivalency of which was not determined, as the exposure was small, and the undulations or irregularities of the strata soon carry it below the bed of the creek, both above and below. The heavy conglomerate sandstone, showing cliffs from 50 to 100 feet high, is seen immediately above the ore; but the base of it is covered, so that the exact distance of it from the ore could not be ascertained; but it is probably not over from 10 to 20 feet. This sandstone comes down to the bed of the creek, both above and below the locality where the ore and the limestone are exposed. The distance within which the limestone is exposed above the drainage is from one third to one half mile along the Creek. The limestone is probably not the upper member of the Chester Group, as it is in the region of the heavy

conglomerate, where the upper members of the Chester have probably been carried away at the time of the deposition of the conglomerate. In quality this ore is among the best of this region; and if it can be found to extend over any great area, it will prove one of the most valuable. It has been found outcropping in considerable quantities on the farm of M. Honaker, on Green river, above the mouth of Bear Creek. Enough is here seen to indicate with considerable certainty that this is the same ore, and that it is present in considerable quantity. At numerous other places, traces of this ore have been found, but nowhere else so promising. At other localities, where the Chester are the prevailing rocks, small surface outcrops of ore have been found; but as yet they have not been prospected, and it is impossible to tell anything definite as to the amounts. It is probable that, with careful prospecting, many of these will be found more valuable than now supposed.

The first iron ore of the coal measures rests immediately upon, and, in fact, is often mingled with, the conglomerate. The ore varies largely in its character, but is usually distinguishable by the quartz pebbles which are scattered through it in greater or less quantities.

The exact relation which this ore bears to the coal which rests close to the conglomerate is still a matter of some obscurity. At some places the coal has been seen resting immediately on the conglomerate, and at others the pebbly ore occupies exactly the same position; but a satisfactory section, showing the two together in one hill, has not been obtained. At Watt. Merideth's, on Nolin river, above the mouth of Pigeon Creek, the ore was found on the surface, in a position which indicates that its position is below the coal. The coal was found in sinking a well, and no ore was found above it, thus indicating with certainty that the position of the ore is here below the coal, although it cannot be far. Further southwest, on Beaver Dam Creek, the coal is seen resting almost immediately on the conglomerate, with no room for the ore below, and no sign of its presence above. It is by reason

of the uncertainty that attaches to the relative position of ore and coal, that the lines indicating their places have not been carried south of Pigeon Creek, in the cross-section No. 2, from Grayson Springs Station to Green river. Further north, at many places in the region north of the heavy conglomerate, an ore is found resting upon the Main Nolin coal, which, in its turn, rests close to the conglomerate, with no ore between. This ore differs in character from the other; is usually leaner, more porous, thinner, and does not carry any pebbles. Its usual thickness is from six to eight inches, although occasionally thicker. The thickness of the conglomeratic ore is not well shown at many places, but it seems to vary from one to two feet, and occasionally thicker. It is very variable in both quality and thickness, changing suddenly from a nearly pure limonite ore to a ferruginous conglomeratic sandstone, in a very short distance, and making correspondingly great changes in thickness at the same time. The ore, so far as seen, is all limonite. It has not been opened, at any place, far enough to reach the unaltered carbonate.

The following analyses, by Dr. Peter and Mr. Talbutt, will serve to show the quality of this ore:

	1	2	3
Peroxide of iron	55.028	47.724	32.820
Alumina	1.006	2.501	2.356
Brown oxide of manganese	.040	. . . . .	. . . . .
Carbonate of lime	trace.	trace.	trace.
Magnesia	.108	trace.	trace.
Phosphoric acid	.312	.065	.984
Sulphuric acid	.133	.315	.285
Combined water	8.300	8.250	8.330
Silica and insoluble silicates	35.180	41.145	55.180
Total	100.107	100.000	99.955
Metallic iron	35.519	33.407	22.974
Phosphorus	.135	.028	.430
Sulphur	.053	.125	.114
Silica	33.70	39.560	48.960

No. 1 is an analysis of a single specimen of conglomeratic limonite ore from Mrs. Bythe Merideth's, near the mouth of Dismal Creek. Specimen selected by Prof. N. S. Shaler.

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No. 2 is an analysis of an average sample, taken by myself, from an exposure of the conglomeratic ore above Thomas Merideth's, on one of the branches of Dismal Creek, from the south.

No. 3 is an analysis of an average sample, by myself, from the ore resting upon the Main Nolin coal, on Mill Branch of Bear Creek.

Nos. 1 and 2 show the conglomeratic ore at its best. It proves to be better in reality than its looks would indicate; and if it can be relied upon to continue of this quality, it will prove a very valuable ore. Of this there is some doubt; but it will doubtless be found of this quality at many other places.

Analysis No. 3 indicates an ore much poorer than it appears to be. The ore here is porous and sandy, but does not, to the eye, appear nearly so silicious as the analysis proves it to be. it is so poor in iron, and so silicious, that for the present, at least, it is of little value. From its position immediately above the coal, this ore could be mined very cheaply if it were sufficiently rich in iron to justify its use.

Near Old Nolin Furnace, on Davis Branch of Nolin river, there is an ore which occurs between the lower conglomerate and the Bee Spring sandstone. Its place is about 30 feet above the conglomerate. This ore is said to have been used in considerable quantities when the furnace was in operation. It is from three to four feet thick where seen, and very lean. There is evidence of considerable digging at the place where the ore was seen. The analysis shows that the ore is very silicious and poor in iron. The sample analyzed was, however, selected from only a very small surface of the ore, which was uncovered for the purpose, and it may have been worse than the average of the bed. The sample was taken to represent the outcrops exposed, as accurately as possible. The ore is quite fossiliferous, being composed at places almost entirely of the shells of fossils, and it varies in quality. It must be, therefore, that the sample was taken from a place where the ore is more silicious than usual, although it was not known at time of sampling. An ore yielding only 19 per cent. of iron could not be profitably worked in the furnace.

The following is the analysis by Dr. Peter and Mr. Talbutt:

Peroxide of iron	27.340
Alumina	5.930
Carbonate of lime	1.090
Carbonate of magnesia	.447
Phosphoric acid	1.068
Water expelled at red heat	12.380
Silica and insoluble silicates	51.230
Undetermined and loss	.515
Total	100.000
Metallic iron	19.138
Phosphorus	.497
Silica	47.360

This ore has not been recognized at any other locality, but occasional thin bands of clay carbonate are found in the shales, between the conglomerate and the Bee Spring sandstone. These are usually of very good quality; but they have never been mined, and little is known as to their horizontal extent. Many surface outcrops of ore have been found through this region, which could not be traced to their position with the means at command. Many of these promise well, and show ore of very good quality; but little can be learned of their quantity without digging. This is especially the case east of Nolin river. Several promising surface outcrops of very good ore have been seen here. One of them, near Wm. Saunders', on Brier Creek, shows limonite of very good quality, which seems to belong on top of the lower member of the conglomerate; but nothing definite as to position or thickness. At another place, near the Mammoth Cave road, about one mile from Mt. Vernon Mill, surface limonite was found in considerable quantity upon the Bee Spring sandstone, which is here conglomeratic, as is also the ore. There are obscure indications that the sandstone consists of two members here, and that the ore belongs between them. It is certain that the position of the ore is not far above the sandstone.

Above the Bee Spring sandstone is found, apparently, the most regular and promising ore of this region. This is best seen at the old banks, on the Nolin Furnace property, where much ore was formerly obtained for use at the furnace. These

banks are on the ridge at the head of Decker Branch of Bear Creek. The ore is 35 feet above the Bee Spring sandstone, which is here characteristically developed, about 50 feet thick, with the two coals below it.

There are two banks near the Brownsville and Leitchfield road, about two miles apart. At the most southerly of these, the ore is reported to be six feet thick, and it was seen between three and four feet in thickness, of which the upper portion was ore of very good quality; the lower was sandy and ochreous. This bank is between three and four miles north of Bee Spring, between Decker and Davis Branches. A little over two miles north of this is a bank, exactly six miles from Bee Spring, which shows ore of very good quality, two feet in thickness. The ore from this bank is reported to have been the best, in quality, of any ever used at Nolin Furnace. It is, in fact, of excellent quality, as shown by analysis No. 3 of the following table. The same ore is found near McGrew's, on one of the streams of Hart Branch of Bear Creek, showing about two feet thick, although no digging has ever been done, here, to expose its full thickness. Further north, the ore has not been distinctly recognized. It probably thins in that direction, and soon disappears altogether, simultaneously with the change in the character of the Bee Spring sandstone.

South of Bee Spring, on the heads of Sycamore and Beaver Dam Creeks, an ore is found 60 feet above the heavy conglomerate, and from 15 to 20 feet above a sandstone which seems to be the thin edge of the Bee Spring sandstone. This ore is somewhat different in character from that last described, but it is not unlikely the same ore. It has only been seen as a limonite, which is oölitic and rather coarse-grained, appearing more silicious than it really proves to be on analysis. It is a "block" ore, occurring in layers, which cleave into rectangular blocks. It is between three and four feet thick where seen, but in the opinion of the writer will probably average near the lower figure.*

*This ore has been distinctly seen in but two places, and in these it exceeds four feet in thickness, by my measurements. N. S. S.

The quality of this ore, and that of the old Nolin Furnace banks, is shown by the following analyses by Dr. Peter and Mr. Talbutt:

	1	2	3	4
Peroxide of iron	52.926	49.906	57.830	48.913
Carbonate of iron	.....	.....	.....	5.735
Alumina	4.792	3.330	6.719	7.125
Brown oxide of manganese	.210	.....	.....	.....
Carbonate of lime	.180	trace.	.290	9.410
Magnesia	.425	trace.	.122	.144
Phosphoric acid	.355	.694	.921	.489
Sulphuric acid	.143	.395	.....	.199
Combined water	10.400	9.320	12.180	8.905
Silica and insoluble silicates	30.580	39.780	21.040	19.080
Total	100.011	100.425	99.102	100.000
Metallic iron	37.048	34.407	40.481	36.526
Phosphorus	.154	.303	.412	.209
Sulphur	.057	.158	.....	.080
Silica	29.160	33.461	14.360	17.820

No. 1 is an analysis of an average sample, taken by Prof. N. S. Shaler, from a bank called the "Federick bank," at the head of one of the branches of Beaver Dam Creek, near where the Little Mountain road leaves the Leitchfield and Brownsville road, Edmonson county.

No. 2 is an average sample, taken by myself, from an exposure of the same ore, near the head of one of the branches of Sycamore Creek, Edmonson county.

No. 3 is an average sample, by myself, of ore from one of the old Nolin Furnace banks, on the Leitchfield road, six miles from Bee Spring, and nine miles from Grayson Springs, Grayson county.

No. 4 is an average sample, selected by myself, from another of the old banks of the Nolin Furnace, about three and one half miles north of Bee Spring, west of the road, at the head of one of the forks of Decker Branch.

These analyses show a good workable per centage of iron in all of the samples, and not enough of any injurious ingredients to affect their value to any extent. The per centage of

silica is rather high in No. 2, and phosphorus in No. 3, but it is by no means enough to prevent their use.

These ores, whether they be the same geologically or not, are the most valuable in all this region. They alone promise to furnish a sufficiently reliable supply of ore upon which to base a manufacturing industry. There are many square miles of area over which these ores will, probably, be found. As yet, little prospecting has been done, and the opportunities for observing the variations of the ore, as well as for ascertaining the fact of its occurrence at any locality, are very poor. It has been observed, however, at enough localities to obtain its geological position accurately, and at localities far enough separated, to justify the conclusion that it is of more than local occurrence. It is probable that it will be found, at many places, between the outcrops at present known, where it is now not supposed to exist. Its best development is, of course, in the main dividing ridge between Nolin river and Bear Creek; but it will be found out on the spurs of the ridge between the branches, wherever there is a sufficient thickness of rocks above the Bee Spring sandstone to hold and protect the ore. There are, however, many places on the main ridge, even where the Bee Spring sandstone comes so near the surface, that the ore will not be found. It may be stated as a rule, for the benefit of prospectors, that it will be of no use to look for this ore unless there is at least a thickness of from 40 to 50 feet of rock above the Bee Spring sandstone, where it is characteristically developed, or of 65 to 75 feet thickness above the heavy conglomerate, where that is the prevailing rock. When this rule is borne in mind, it will be very easy to tell, at any locality, whether there is a possibility of finding the ore or not.

South of Beaver Dam Creek no prospecting has been done, although there is a considerable area in which the thickness of rock above the conglomerate is sufficient to protect the ore. In the Brownsville road, about three miles from Green river, there is some ore exposed, which is probably the outcrop of the same, although it has not been definitely determined.

South of the Morgantown road, in the drainage of the small streams flowing directly into Green river, the conglomerate is so near the surface that in but few isolated patches can we expect to find the ore.

The region where this ore will be found is, therefore, approximately, bounded on the south by the ridge at the head of the short streams flowing directly into Green river. Its limit to the north has been already given. East of Nolin river, this ore has not been recognized. Near the river, there are numerous hills which are high enough to hold the ore; but these are not found further than three or four miles from the river.

West of Bear Creek, little work has been done, and little or nothing is known of the existence of the ore in this direction. The field of the ore, already known, is sufficiently large to furnish a reliable supply of ore upon which to base an iron industry.

On the Nolin Furnace property, at the head of one of the forks of Davis Branch, 25 feet above the main ore, is another ore bank, where a sandy ore nearly two feet thick is said to have been obtained for use at the furnace. This is the highest ore of the general section, and has been recognized at no other place. The ore was covered so that not enough of it was seen to judge of its quality.

OTHER ORES.

At several other localities in this region, ores have been observed which have not been given a place in the general section, for the reason that they seem to be local. Some of these show ore of as excellent quality as any in this region. The fact, however, that they have not been found elsewhere, in a region where so little prospecting has been done, is not of itself conclusive that they are local. They may, hereafter, be found to be reliable and extensive deposits.

One of the best known of these occurs on a hill between two branches of Sycamore Creek, about two thirds of a mile west of the Brownsville road. It is called the Procter ore

bank. The ore is a limonite, freer from silicious matter than almost any other in this region, but exceedingly fossiliferous. It occurs on the top, and extending some distance down the slope, of an unusually high knob. Some prospecting has been done, but no bed or solid mass of ore has been found; it only occurs in lumps of small size. The character of the ore, and its occurrence in this manner, indicate that it is the remnant of a destroyed stratum or bed of ore, the original position of which was some distance above where it is now found. It was probably a bed of very pure fossiliferous carbonate of iron originally; but the long-continued exposure to oxidizing agencies has converted it into limonite, while the erosive agencies were destroying its identity as a bed. The position of this ore, where found, is considerably above the main bed of ore on Sycamore Creek. The following analysis by Dr. Peter and Mr. Talbutt, from a single specimen, shows the excellent quality of this ore:

Peroxide of iron	76.284
Alumina	2.361
Brown oxide of manganese	.030
Carbonate of lime	.180
Magnesia	.068
Phosphoric acid	1.055
Sulphur	.151
Combined water	12.000
Silica and insoluble silicates	7.951
Total	100.080
Metallic iron	53.399
Phosphorus	.460
Sulphur	.059
Silica	7.660

Another of these ores is shown in the section already given, at Stevens' coal bank. It is the ore above the upper coal, and is about six inches thick. Its quality is shown by the following analysis by Dr. Peter and Mr. Talbutt. The sample analyzed was taken from a very small outcrop of the ore, so that it may not be fairly representative, but it is believed to be as good as the average:

Peroxide of iron	44.974
Alumina	2.391
Carbonate of lime	.643
Magnesia	.234
Phosphoric acid	.535
Sulphuric acid	.158
Combined water	7.700
Silica and insoluble silicates	44.180
Total	100.815
Metallic iron	31.482
Phosphorus	.233
Sulphur	.063
Silica	42.20

On Taylor's Fork of Bear Creek, on a branch entering at M. Ray's, about two miles from Leitchfield, an ore is found, under a heavy sandstone, at a chalybeate spring. The ore is about seven inches thick where seen, and of very good quality, partly limonite and partly the unaltered carbonate. On the opposite side of the branch the same ore is seen, apparently considerably leaner, while the sandstone does not show above. The following analysis by Dr. Peter and Mr. Talbutt, from a sample of this apparently lean ore, shows that it is rich enough in iron to be valuable. The ore on the opposite side of the branch, at the spring, is much richer than this:

Peroxide of iron	44.528
Alumina	1.368
Carbonate of lime	5.590
Carbonate of magnesia	.609
Phosphoric acid	1.074
Sulphuric acid	.151
Combined water	8.940
Silica and insoluble silicates	37.380
Total	99.620
Metallic iron	31.169
Phosphorus	.468
Sulphur	.060

At many other places ores have been found, in greater or less quantities, in surface outcrops; but usually when the quantity was sufficiently great to render them worth attention, the quality has proved to be poor; and *vice versa*, when the quality

was good, the quantity was so small that, without further prospecting to prove the extent greater, they have not been deemed worthy of mention. Beyond the field of the map, west of Bear Creek, near Green river, in Butler county, a number of these ores have been examined. They are mostly bands of clay carbonate, in the heavy shales which overlie or replace the conglomerate. The ores do not seem to be continuous, but are independent beds at various levels. Some of these are of very fair quality, but thin, ranging from three to six inches in thickness. The most promising outcrop was found at John Hudson's, on the Young's Ferry road, about two miles from Green river, where is a bed of carbonate of iron fourteen inches thick, of which the following is an analysis by Dr. Peter and Mr. Talbutt, from an average sample, taken by myself:

Carbonate of iron	29.914
Peroxide of iron	17.945
Alumina	3.583
Carbonate of lime	12.036
Carbonate of magnesia	3.677
Phosphoric acid	.467
Sulphuric acid	.380
Silica and insoluble silicates	28.040
Water and loss	3.957
Total	100.000
Metallic iron	27.041
Phosphorus	.204
Sulphur	.152
Silica	25.260

This ore, by roasting, can be brought to yield over 30 per cent. of iron, while the considerable per centage of lime present will render it an easy working ore.

In the old Brownsville and Leitchfield road, on the first high hill west of Bear Creek, about four miles from Leitchfield, on land belonging to John Higdon, is a bed of ore, partly limonite and partly carbonate, resting on the shales near the top of the hill. The ore is about eight inches thick, and of excellent quality, as the following analysis, by Dr. Peter and Mr. Talbutt, of an average sample, taken by myself, shows:

Carbonate of iron	16.598
Peroxide of iron	42.761
Alumina	4.994
Carbonate of lime	2.840
Carbonate of magnesia	2.904
Phosphoric acid	1.017
Sulphuric acid	trace.
Silica and insoluble silicates	20.830
Water and loss	8.056
Total	100.000
Metallic iron	37.945
Phosphorus	.444

Near the mouth of Hunting Fork of Rock Creek, a small outcrop of excellent ore was found, not far from the top of the Chester limestone; but it was seen in only one locality, and it is not certain if it be a reliable deposit. Its quality is equal to that of any in this region.

On Grindstone branch of Rock Creek, a fossiliferous limonite was found, but proved to be so lean that it is probably of little value.

This closes the list of ores in this region which have been deemed worthy of description. Most of them have been seen at but few outcrops, and may have been judged to be local from insufficient evidence. There is, however, in a large portion of this region a trustworthy supply of ore, sufficient to sustain a number of furnaces. Most of the region is covered with timber suitable for charcoal, which can be obtained at a small cost, and sometimes for the cutting. Of stone-coal there is an abundant supply of good quality, which can be mined cheaply and easily. It will, however, probably be best to coke it, if it is desired to use it for the manufacture of iron. Limestone for flux is also abundant in nearly every stream. The region furnishes, therefore, all the requisites for the manufacture of iron in quantities sufficient, and at prices low enough, to produce cheap iron. The most serious disadvantage which it has, and the one which has prevented its development hitherto, is lack of transportation facilities. The distance from the Louisville, Paducah and Southwestern Railroad to the nearest valuable ores is from ten to twelve miles, while on the south,

it is about six miles from Green river to the ore banks best known at present. This distance is from the river at Brownsville, above the head of slack-water navigation, although, for perhaps half the year, boats of light draught can ascend to Brownsville. The building of a dam across Green river, below the mouth of Bear Creek, would give slack-water navigation to Brownsville, and render Bear Creek navigable to small boats, so that access could be had to the ores.

The necessity of wagoning iron to the railroad, involves so great an expense per ton that it is probable stone-coal iron could not now be made, in this region, at a profit; but a high grade of charcoal iron, either cold or hot blast, as it is a more valuable product, could stand a greater expense per ton for transportation and yet yield a profit.

The Nolin Furnace, which has been frequently referred to, was compelled to suspend operations largely from this cause. It was built in 1844 or 1845, near the mouth of Davis Branch of Nolin river, in Edmonson county. It ran three or four years, and then suspended operations. It has never since been started. The only means of getting out the iron was to run it down Nolin river in keel-boats, at time of high water—a method so uncertain and irregular in its operation that it, in addition to the limited capital of the owners, proved fatal to the enterprise. The furnace used charcoal for fuel, and made only cold blast iron. The iron made was of excellent quality. In the last days of its operation the furnace was run almost exclusively with the ores from the banks above the Bee Spring sandstone, on the ridge between Nolin river and Bear Creek.

A piece of pig iron made at this furnace was obtained, and analyzed by Dr. Peter and Mr. Talbutt. The following is the analysis:

Iron	94.287
Graphitic carbon	3.100
Combined carbon	.700
Silicon	.493
Phosphorus	1.029
Sulphur	.012
Total	99.611

The iron is a fine-grained, cold blast iron of great strength. The noticable feature of the above analysis is the small per centage of silicon and the high per centage of phosphorus. The strength of the iron is due to the low per centage of silicon; for with the ordinary amount of silicon present, added to the phosphorus, the iron would be very brittle. The phosphorus is higher than is usually possible without making a cold-short iron. The amount of phosphorus in this iron shows that nearly all of that ingredient in the ore is reduced, and passes into the pig. This furnishes an additional reason for smelting these ores with charcoal, as with that fuel, silicon and other impurities are not so liable to be reduced, and alloy with the iron, to its great injury.

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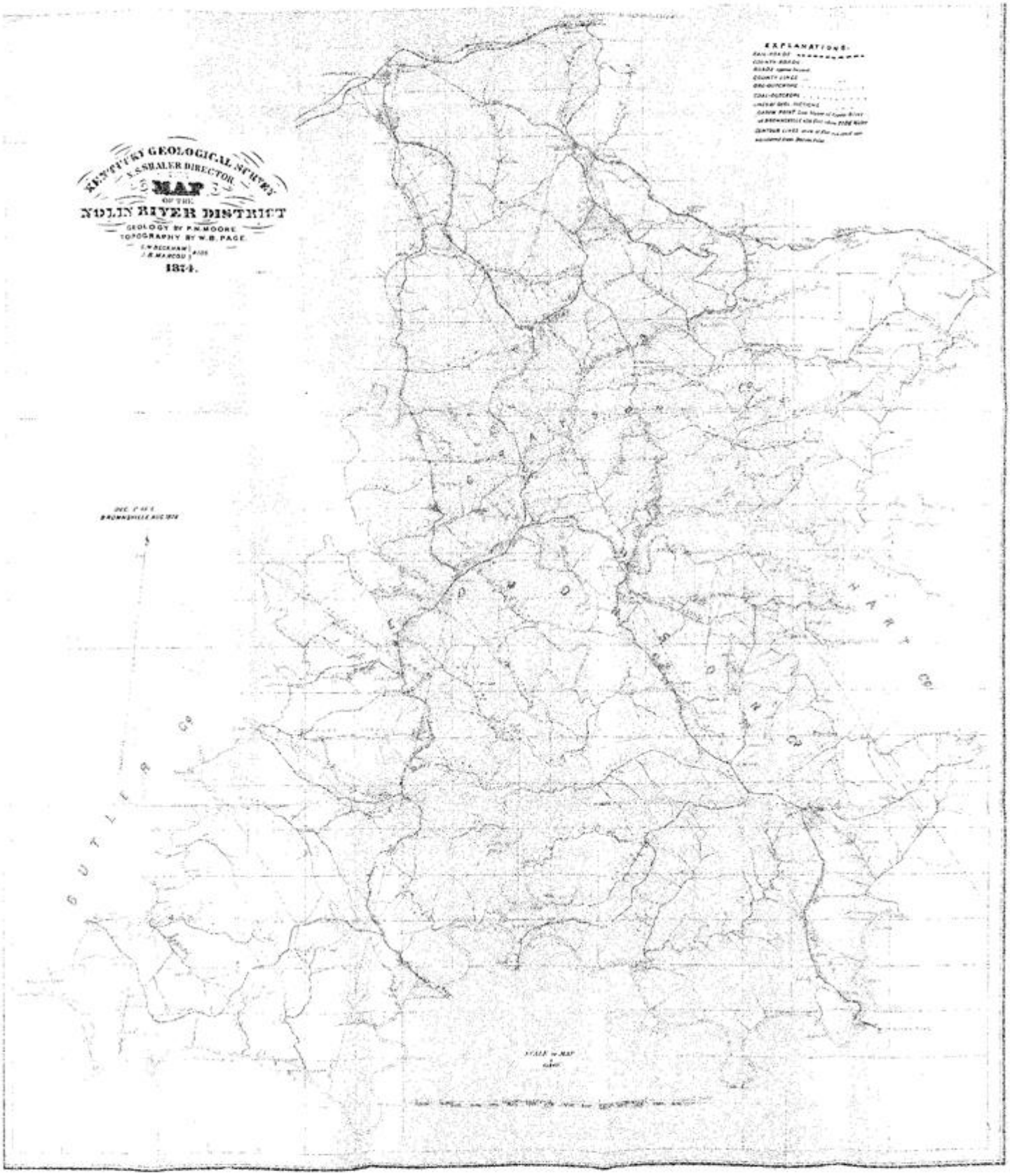
KENTUCKY GEOLOGICAL SURVEY
E.S.SHALER DIRECTOR
MAP
OF THE
NOLIN RIVER DISTRICT
GEOLOGY BY N.S.SHALER AND W.M.DAVIS
TOPOGRAPHY BY W.B.PAGE
1884.
EXPLANATIONS
BUTLER CO
EDMONSON CO
HART CO

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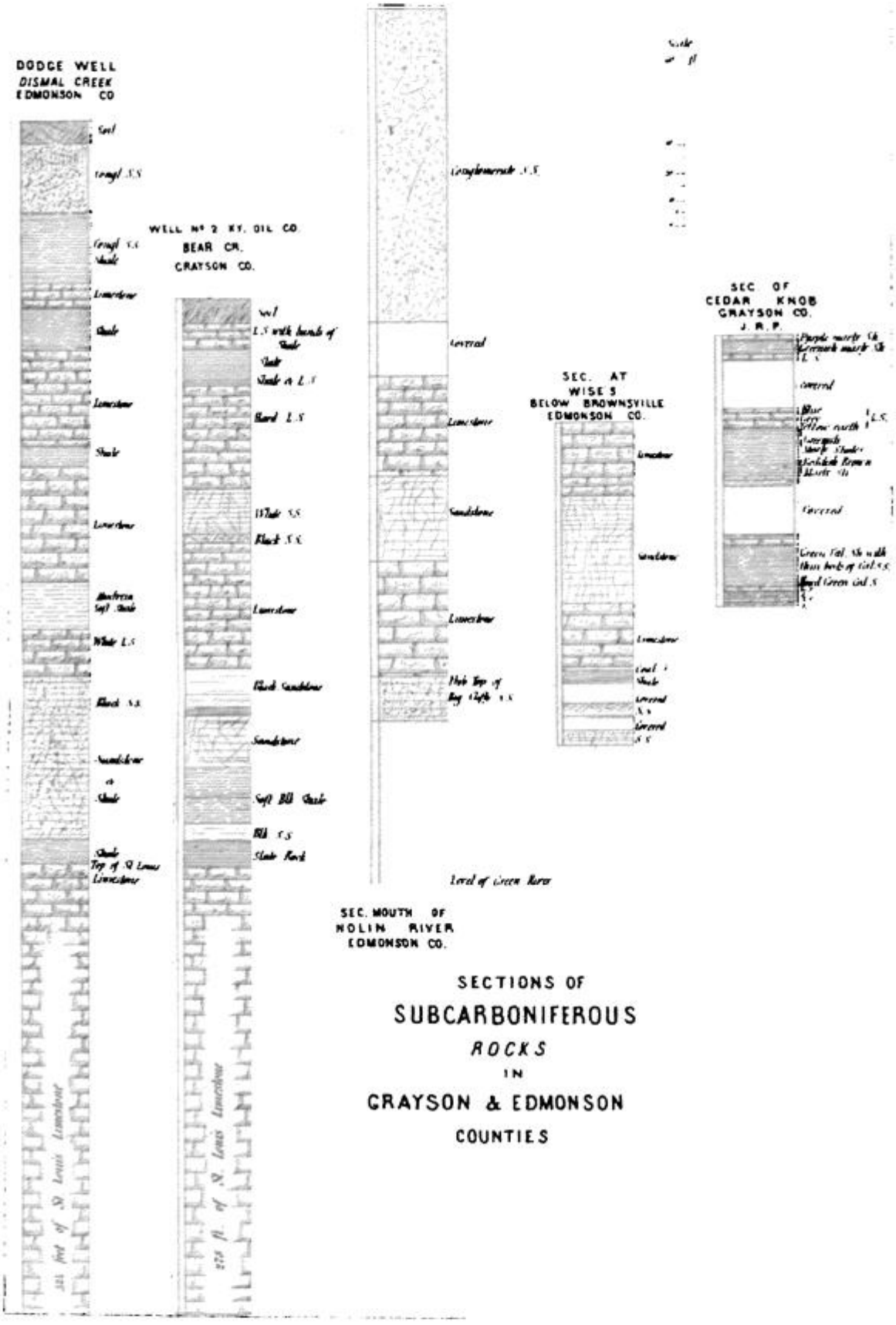

SECTIONS OF SUBCARBONIFEROUS *ROCKS* IN GRAYSON & EDMONSON COUNTIES

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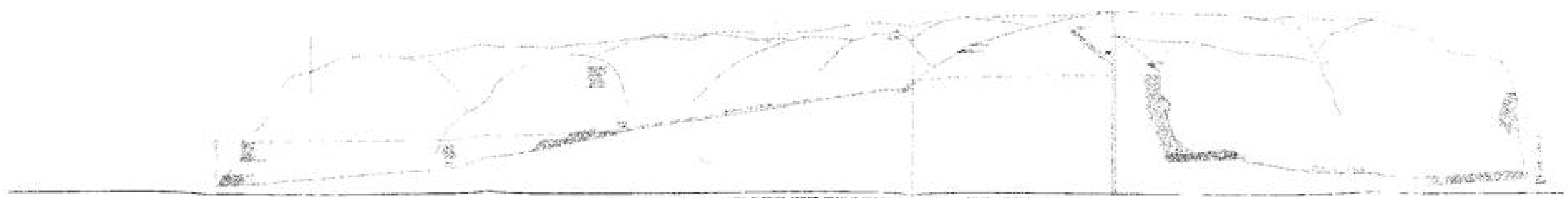
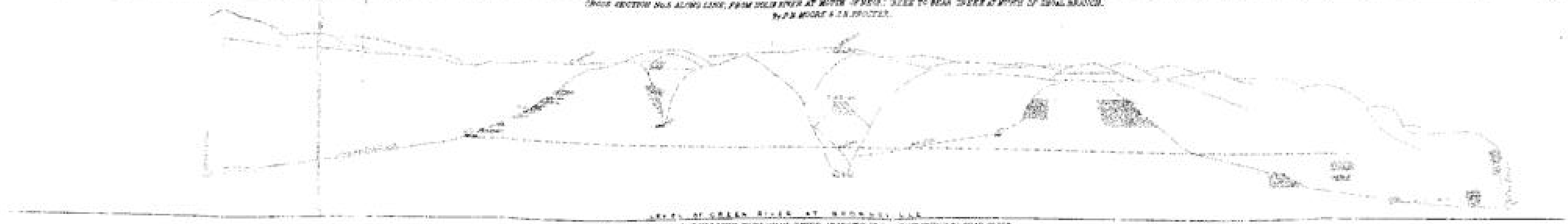


Cross Section No. 3 Along Line of ... Creek from ... River ... Creek to Bear Creek.
By P. N. Moore & J. R. Procter.

Level of Green River at Brownsville.
Cross Section No. 4. By P. N. Moore & J. R. Procter.

Level of Green River at Brownsville.
Cross Section No. 5 Along Line, from Nolin River at Mouth of ... Creek to Bear Creek at Mouth of ... Branch.
By P. N. Moore & J. R. Procter.



Level of Green River at Brownsville.
Cross Section No. 6 Along Line from Nolin River at Mouth of ... Creek to Bear Creek.
By P. N. Moore & J. R. Procter.

CROSS SECTIONS TO ACCOMPANY
THE
REPORT OF P. N. MOORE
on the
EDMONSON COAL AND IRON DISTRICT.

Scale: 100 ft. 1 inch Vertical. 1000 ft. 1 inch Horizontal.

Cross Section No. 7 ... Line from Nolin River ... to Bear Creek.
By P. N. Moore & J. R. Procter.

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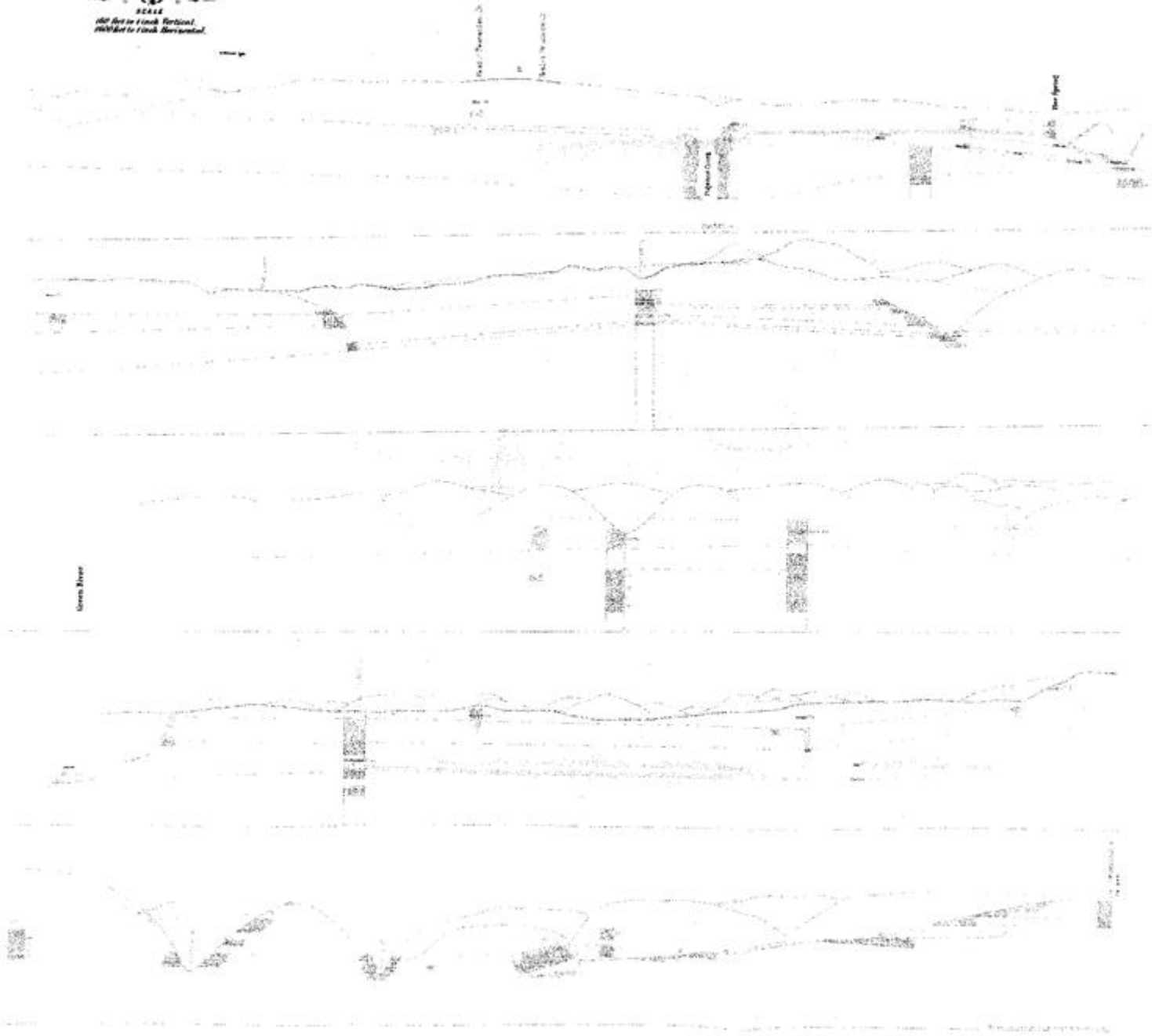
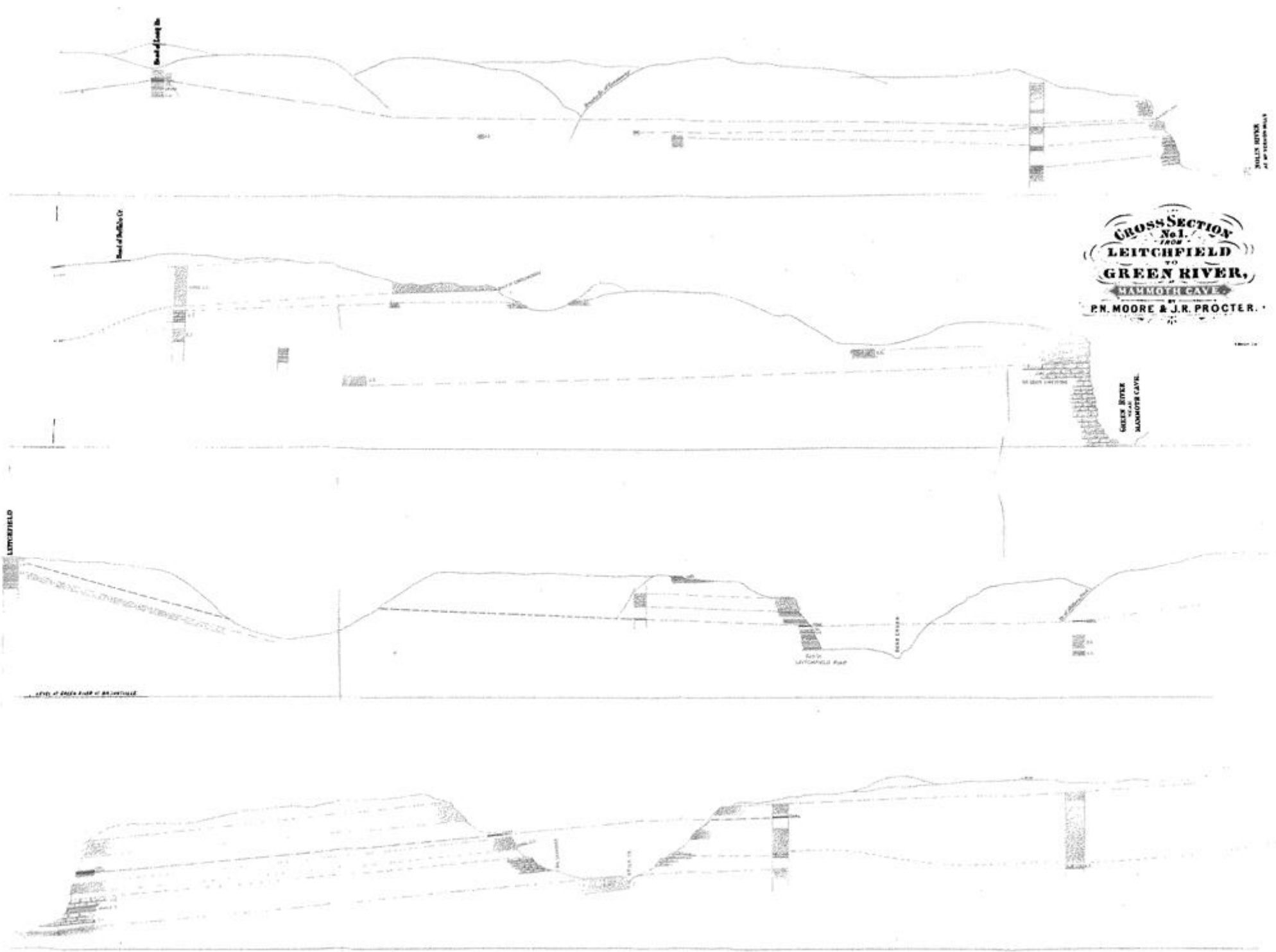
CROSS SECTION No. 2 FROM Grayson Springs Station TO GREEN RIVER,

BY P.N. MOORE & J.R. PROCTER.

SCALE
100 feet to 1 inch Vertical.
1000 feet to 1 inch Horizontal.




CROSS SECTION
No 1.
FROM
LEITCHFIELD
TO
GREEN RIVER,
MAMMOTH CAVE
BY
P.N. MOORE & J.R. PROCTER.
LEITCHFIELD
GREEN RIVER
NEAR
MAMMOTH CAVE.