GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

A REPORT OF EXAMINATIONS

MADE ALONG THE PATHS OF THE

NORTH AND SOUTH RUNNING RAILWAYS

IN

WESTERN KENTUCKY.

BY CHARLES J. NORWOOD.

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INTRODUCTORY LETTER.

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

DEAR SIR: I herewith present a report of a reconnoissance made along parts of the lines of the north and south running railways that lie within the western coal field. The report is not so complete as at first might seem desirable; it is believed, however, that it will materially aid future investigations in the regions of which it treats. My acknowledgments are due to Captain R. S. Triplett, of Owensboro', and Hon. John McFarland, of Daviess county; to Mr. W. F. Barclay, of Russellville; Mr. Samuel Gaines, Editor of the Hopkinsville New Era, and Mr. Hunter Wood, of Hopkinsville; Col. Sebree, Mr. J. F. Ford, and Mr. Atkinson, of Earlington; to Mr. William Mills, of Nortonville (who spent a number of days with me), and to Mr. M. H. Crump (now of Paris, Kentucky), for assistance kindly rendered me.

Mr. C. W. Beckham, Aid to the Survey, accompanied me for the purpose of studying the timber and soils adjacent to the railroad lines.

Respectfully,

C. J. NORWOOD.

A REPORT OF EXAMINATIONS MADE ALONG THE PATHS OF THE NORTH AND SOUTH RUNNING RAILWAYS OF WESTERN KENTUCKY.

I.

The results obtained from the examinations conducted along the lines of the north and south running railways of Western Kentucky—namely, the Evansville, Owensboro' and Nashville, and the St. Louis and Southeastern—are, unfortunately, quite imperfect, so far as relates to the details of many parts of the regions through which the roads pass.

The wisdom of having an east and west section constructed as the first work in the field soon became apparent, when work was begun on the north and south running lines. Many points which, by the aid of the east and west section, are now perfectly clear, would have seemed almost hopelessly obscure without the aid of such a section.

Even with the aid of that section, however, there are, as stated above, some parts of the regions in which the succession and conditions of the beds underlying the surface are obscure.

This is largely due to the peculiar geographical features of the regions along the lines of road; the conditions of which are such, that the rock exposures are limited in number, and are frequently far between.

As we recede from the Ohio river we find, in the case of each road, a wide extent of comparatively flat land, which reaches southwardly, from the river, for several miles. On the St. Louis and Southeastern road, this region of comparatively flat land extends southwardly for about seventeen miles—reaching from Henderson nearly to Sebree; on the Evansville, Owensboro' and Nashville road, the larger part

of the distance from Owensboro' to Crow's Station—a distance of nine miles—is comparatively flat land.

Then a succession of low hills and intermediate flat lands—the valleys of nearly all the streams are, for the most part, low flats—are the elements in the topography for several miles towards the south, until we reach what appears to be the great ridge of the coal field. This term, however, is used not so much on account of the actual relative height of the ridge, for this varies considerably in places, but because of its height and linear extent together. It is on this elevation that Madisonville in Hopkins county, and South Carrollton on the Green river, stand; and it seems to be the one which extends through Ohio county, being included between the streams which flow southwardly into the Green river, and those which flow northwardly into Muddy creek. The ridge, as a distinct feature in the geography, seems to be terminated on the east by the waters of Caney creek; but its western termination is not known.

A glance at the map of Kentucky will show that the ridge is cut transversely many times by streams, though not so frequently as shown by the map. Indeed, so far as that alone would show, there does not seem to be any distinct line of elevation extending along the course indicated above, the existence of the ridge only becoming apparent (in the present condition of our maps), upon observations made in the field.*

This ridge, as will become apparent hereafter, is of much importance in both an economic and a scientific point of view, and it is desirable that its form, extent, and structure should be well understood.

After passing over this ridge, we again enter flat land, which seems to be wider in a north and south direction in the west, than in the east; then, within a few miles, we begin to ascend, and soon pass beyond the borders of the coal field.

It will be observed that low lands seem to be the prevailing features in the geography of that part of the coal field crossed by the north and south lines of railroad; and that the courses

*A detailed discussion of this ridge is reserved for a report to be given hereafter.

of the ridges and of the valleys are usually in a west and east direction.

This arrangement of the feature lines is to be referred to two causes; that is, the relative proportions of low and high lands is chiefly dependent on the composition of the underlying beds, while the direction of the ridges is largely due to the condition of the beds.

Along the larger part of the distance traversed by each road, shale beds or very incoherent, easily disintegrated sandstones are the surface beds. As a result, we find extensive "flats" prevailing in those regions that are underlaid by the shales, and the hills low where the sandstones are the first underlying beds. Such hills, besides being low, have another marked characteristic; they are, usually, either flat-topped, set with occasional hillocks (a condition which seems to be due to a mingling of shales and soft sandstones), or their surface is gently undulating, though not infrequently marked with many shallow ravines, which are usually deepest in the sandstones—flattening out in the shale beds.

In no part of the State, perhaps, has the eroding power of water been more effectual in altering the surface features of a region than in the western coal field. No deep gorges are left (though there is no reason to suppose they have not existed for a time), nor are there any high mountains to be seen; but, instead, a great and general leveling has taken place, and is even now in operation, the form of the surface being altered, and the heights lowered rapidly year after year.*

The surface is especially marked by flats towards the Ohio river, along both railroads; so that few or no available rock outcrops are seen in that direction; and even when we come farther south good exposures of the beds are rare. These conditions, taken in connection with the fact that a fault or fold extends across the country in an eastwardly and westwardly direction—the disturbance (although sometimes par-

*The topography of the coal field, and the various details concerning it; the effect of the composition and condition of the beds upon water-courses, etc., is to receive attention in a future report.

tially masked) reaching fully from the east boundary of Ohio county to Sebree, in Webster county, and probably beyond* —show at once the difficulty, if not the impracticability, of constructing a connected geological section from the Ohio river southwardly, without the aid of more complete data than can be obtained by limiting the observations to the narrow strips along these lines of railroad. The most we are able to do is to obtain skeleton sections along these lines, which may be filled in when needed (and any imperfect conclusions modified), as the material is gathered from the more extended surveys that may be made to the east and west of the lines. The plan has accordingly been to delineate, in a simple manner, on the profiles, such outcrops as were found—without attempting to show them continuously connected, except in those places where a perfect familiarity with the relative positions of the beds, or the distinctness of the connection warranted it; and to give a general outline of the economic geology along the lines.

Plates of comparative sections of the beds exposed along the respective roads, and other necessary illustrations, are appended to the report.

II.

THE EVANSVILLE, OWENSBORO', AND NASHVILLE RAILROAD.

At present the rails are laid on this road from Owensboro' only so far as its point of junction with the Elizabethtown and Paducah Railroad (at Owensboro' Junction), a distance of about thirty-six miles.†

The southern extension of the road seems to lie within the limits of the coal measures for the most of its length through Muhlenburg county; and from data obtained from Mr. Barclay, of Russellville, there seem to be outliers on the line in the northern part of Logan county. For the present, only

*This disturbance was more fully studied in Ohio county, and there received the name of the "Rough Creek uplift." I first suspected its existence in 1874, but did not fully determine its general character until the spring of 1876, when the study of Ohio county was undertaken. February, 1877.

†It is understood that arrangements are now in progress for the completion of the road to Nashville. March, 1877.

that part of the line which extends from Owensboro', through Daviess and McLean counties, to Owensboro' Junction, in Muhlenburg county, will be discussed; the intention being to complete the section from Owensboro' Junction to the Logan county line when the survey of Muhlenburg county is completed. At Owensboro' Junction we find what are considered to be the highest workable coals yet found in the western coal field, namely, coals A and B.

One or the other of the coals, usually coal B, is worked in the several mines at the Junction. Coal B has been worked in the Louisville and Stroud City mine, in the Ross mines, and the Galena, formerly known as the St. Louis mine. The coal is reached by shafting at the Galena and the Louisville and Stroud City mine, but at the Ross mines the bed is reached by drifting. These mines were noticed in a former report.*

Following are analyses of averaged samples of coal B collected at the several banks:

Composition.	1	2	3
Moisture	4.16	3.36	5.40
Volatile combustible matter	37.44	37.90	34.20
Fixed carbon	49.80	52.74	54.20
Ash	8.60	6.00	6.20
Total	100.00	100.00	100.00
Sulphur	2.727	2.686	3.136
Specific gravity	1.407	1.309	1.235

No. 1 is from the upper member of the bed at the Ross mines.

No. 2 is an analysis of the bed at the Louisville and Stroud City shaft.

No. 3 is the analysis of samples collected from the Galena mine.

*See report on the geology along the line of the Louisville, Paducah, and Southwestern Railway, part VI, volume I, second series Kentucky Geological Reports, N. S. Shaler, Director.

The upper sixteen inches of the bed at the Junction is known as the "gas coal." Following are analyses of samples collected from (*a*) the Galena shaft and (*b*) the Louisville and Stroud City mines:

Composition.	*a*	*b*
Moisture	4.60	4.60
Volatile combustible matter	37.60	42.60
Fixed carbon	52.64	50.06
Ash	5.16	2.74
Total	100.00	100.00
Sulphur	2.372	1.601
Specific gravity	1.307	1.280

Coal B is about on the level, or a short distance below the level of the railroad at Owensboro Junction, and dips towards the northwest.

As stated in a former report, Owensboro' Junction seems to lie within a geological depression, the beds rising southwardly, westwardly, and somewhat eastwardly; but dipping northwardly. In the cutting just north of the crossing of the Elizabethtown and Paducah Railroad, ten feet of the sandstone which overlies coals A and B is exposed, the base of the bed not being visible. Towards the visible base there is a conglomerated band of ferruginous concretions; and in the parts near this ferruginous band, small quartz pebbles, usually not larger than small shot, are found.

This sandstone, and the beds of shale associated with it, are exposed in the cuts, and in the small elevations near the railroad, for nearly three quarters of a mile, towards the north; there being, however, apparently, a general sinking of the beds in that direction.

About one quarter of a mile northwardly, beyond the Junction, the South Carrollton road crosses the railroad, and mounts a ridge which extends for the larger part of the way to South Carrollton.

At the point where the wagon road crosses, just east of the railroad, sandstone equivalent, in part, to that seen at Owensboro' Junction is exposed. In some of its parts it is extremely coarse-grained and conglomerated—the pebbles being of quartz; they are small, however, and are sparingly distributed through the rock, which is incoherent and ferruginous brown in color. Within a short distance from this exposure, on a higher part of the ridge, at the base of which the sandstone crops out, other beds are exposed, as shown in the following section:

1.	Variegated Sandstone—colors, brown, pink, and yellow. The rock is soft and incoherent	20 feet.
2.	Space	50 "
3.	Coal has been opened, but is now covered; thickness unknown.	
4.	Space	40 "
5.	Brown, disintegrating Sandstone, somewhat of a conglomerate. Full thickness not seen	10 "
	Total	120 "

This is down to the bed of the railroad. Still other beds are exposed in the ridge as it extends towards South Carrollton, and will be noticed on a succeeding page.

Between the fourth and fifth railroad cuts, north of Owensboro' Junction, about three thousand feet northwardly from the wagon road crossing, a shaft was sunk sixty feet in depth, and coal obtained. Some time prior to these examinations the shaft had been abandoned; but some of the material in the heap of debris, near the mouth of the pit, was yet in a fair state for examination: fragments of limestone containing *Martinia* (*lineatus?*) *Athyris subtilita* and Crinoid columns were found. It is stated that coals A and B were both penetrated in the shaft in this order:

1.	Coal A	4½ feet.
2.	Limestone	4½ "
3.	Coal B	5½ "

No opportunity has been found for verifying the thickness given for the beds. This shaft was sunk, it is believed, under the direction of Mr. Throckmorton.

Passing on to the north from this shaft, the beds are found to continue their downward descent towards the north.

At H. D. Rothrock's mine, about half a mile northwardly from Throckmorton's shaft, the coals A and B are found at a depth of one hundred and five feet below the bed of the railroad, which has descended about seven feet of vertical distance from Throckmorton's shaft. This mine is about midway between Owensboro' Junction and South Carrollton.*

A section of the strata at this mine is quite interesting, as we have here the first plain section of the beds above coal A, in which a higher coal is shown.

The following is the record of the materials penetrated in the shaft, as furnished by the manager:

1. Earth, etc.	15 feet.		
2. Sand rock	3 to 4 "		
3. "Soap-stone" (argillaceous and sandy shales?)	50 "		
4. Coal	1 "	8 inches.	
5. "Soap-stone" (sandy shale?)	35 "		
6. Coal A	5 "	6 "	
7. Under clay	2 "		
8. Limestone	3 feet to 3 "	6 "	
9. Coal B	4 "		

Both of the coal beds were worked, but the lower bed, coal B, was the one most largely wrought. The upper sixteen inches of coal B was known at this mine, as at those at Owensboro' Junction, as the "gas coal," a name which appearances would seem to justify. It is a remarkably fine coal for general purposes; and should it prove useful for gas-making, it may be mined and shipped distinct from the other parts of the bed with profit.

The following is an analysis of averaged samples collected from coal B, the "working bed:"

Moisture	3.80
Volatile combustible matters	36.20
Fixed carbon	51.80
Ash	8.20
Total	100.00
Sulphur	3.194
Specific gravity	1.332

* A fire occurred at this mine subsequent to these examinations, and since then it has not been in operation.

From Rothrock's mine to South Carrollton we find occasional outcrops of the beds which overlie the coals at that mine. In the bluffs facing Green river, at South Carrollton, a fine section of the upper beds is exposed. A thickness of at least one hundred and twenty-five feet of beds is found in the river bluff, which, added to that found in Rothrock's shaft, at the foot of the bluff, gives a thickness of about one hundred and eighty feet of beds which overlie coal A at that point.

The following is the section exposed in the bluff near Rothrock's mine, which is about half a mile below (northwestwardly) South Carrollton:

1.	Space from hill top, about	30 feet.		
2.	Black and chocolate colored Bituminous Slate; the upper two inches is soft and smutty			10 inches.
3.	Dark bluish argillaceous Shale	10 "		
4.	Dark argillaceous Shale and thin laminæ of Coal; may be termed an argillaceous coal—very poor—the earthy matter predominating		6 "	
5.	Clay and Shale; the upper two feet is mostly clay, and the lower part mostly argillo-sandy shale, greenish drab in color. In the clay under the coal (No. 4) irregular pieces of light blue clayey limestone, apparently somewhat pyritiferous, are found. The rock seems to be local in its nature, and is somewhat concretionary	5 "		
6.	Massive Sandstone	30 "		
7.	Black argillaceous, carbonaceous Shale	1 "		
8.	Black bituminous Slate, with thin seams of clay	1 "		
9.	Coal, separated from No. 8 by two inches of clay	1 "	1 "	
10.	Variegated Shales (mostly greenish) and thin sandstones	50 "		
11.	Limestone—the "South Carrollton Limestone"	3 to 10 "		
12.	Space, probably filled with Shale	15 "		
13.	Sandstone. This is usually an admirable building stone, and is quarried for such purposes in the vicinity of South Carrollton; it seems, however, to pass into shaly or thin-bedded sandstone at some places	25 "		
14.	Shale—sandy and bluish-grey in color	10 "		
15.	Coal	1 "	8 "	
16.	Sandstone	20 "		
17.	Argillaceous (?) Shale	11 "		
18.	Shale and thin streaks of Coal. This is known among the miners as the "wild" coal	1 "	2 "	
19.	Coal	from 6½ to 6 "	2 "	
20.	Under clay	4 "		
21.	Limestone; base not seen	1 "	6 "	

The beds from No. 1 to No. 14 are exposed in the bluff facing the river; the underlying beds are to be seen in Rothrock's shaft, at the base of the bluff. The section is a very plain one, the succession of the beds, from the top of the hill to the base of the coal shaft, being quite distinct.

The Sandstone, No. 6 of the section, is peculiar in some of its features. It is much cross-laminated towards the bottom;

and, near the bottom, frequently immediately above the black carbonaceous shale (No. 7), conglomerated bands of sand and ferruginous nodules occur. The exterior of the ferruginous nodules is frequently red (due to oxidation), and where the sandstone is thinly bedded or incoherent, it is much stained from them. Knife edges of coal are also not infrequent in the lower part of the sandstone. The physical character of the sandstone seems to be variable; varying from a massive bed to thin or shaly beds, and from a hard, compact rock to a soft, incoherent one.

The Limestone, No. 11, which, for convenience, has been termed the "South Carrollton Limestone," varies in thickness and character; its average thickness may be about six feet. It is somewhat mottled, having somewhat of a ferruginous exterior, marked with dove, drab, or ashy white splotches; upon its fractured surface the rock seems to be mainly blue or dove-colored, changing at some places to drab or chocolate brown. In the vicinity of South Carrollton the surface of the limestone is usually thickly studded with large *crinoid columns;* other fossils seem to be comparatively rare. *Productus splendens*, *Athyris subtilita*, and an occasional gasteropod, were found. Immediately at the town the limestone undergoes a curious modification in thickness. By the road leading down to the ferry it is found as a massive bed, showing a thickness of about four and one half or five feet; but at the large spring, only a few yards away, the thickness is swelled to nearly thirteen feet. At the spring the lower ten feet seems to be massive; but the upper part is a breccia of sandstone and limestone.

This bed seems to be quite trustworthy as a source of water supply; springs are usually found issuing from beneath it.

This limestone was first noticed on the road to Owensboro' Junction, at a point about two or perhaps two and a half miles (by road) from South Carrollton, its position there being about thirty-seven feet higher than at South Carrollton, and about fifty-seven feet higher than in the river bluff near Roth-

rock's mine; the northwardly dip of the rocks is thus plainly shown.

When the first examinations were made in the locality of South Carrollton, this limestone was referred (although with some doubt) to the one which usually separates coals A and B; but the evidence is now pretty plain that it occupies a position about eighty feet above coal A, there being little doubt that the coal wrought at Rothrock's mine, below the town, is to be referred to that number. The order in the beds at this mine, and in the shaft on the railroad (see page 11), is nearly the same: in each shaft a coal of twenty inches in thickness is found, at from thirty to forty feet above the ones below. It is true that only one coal below the coal of twenty inches thickness has been found in the South Carrollton shaft; but there is no reason, as yet, to believe it will not be found. So far, the shaft has been sunk only four feet below the coal, a limestone being encountered at that depth which has not yet been passed through.

The coal at the South Carrollton mine seems to have a considerable amount of pyrites distributed through it in lumps and bands; these are probably partially cleaned from the coal as it is mined. The upper three feet of the bed is considered the best; no analyses have yet been made of it. The bed is about twenty feet, or perhaps a little more, below the level of the water in the Green river, when at its ordinary stage. The bed worked at Kincheloe's bluff (or Lewisport, as it is on the map) is evidently identical with the "working bed" at the Rothrock mine. Its physical characters seem to be the same, and, so far as shown by long measurements, its position below the South Carrollton limestone agrees with that of the South Carrollton bed. The coal was examined, though rather imperfectly, at two places, as the drifts could not be entered for any considerable distance at that time. The section at the mouth of the drift now working is as follows:

1. Massive Sandstone, about	20 feet.	
2. Coal and fragile Slate, and threads of clay, in alternating layers	1 "	
3. Coal, with thin seams of clay	2 "	
4. Clay seam		½ inch.
5. Coal	3 "	11 "

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At an abandoned drift, a few yards down the river from the above described one, the coal occupies a position about ten feet lower than at the first bank. The same arrangement of the parts of the bed occurs, thus:

1. Sandstone.		
2. Clay shale and coal.		
3. Coal	2 feet.	
4. Clay		½ to ¾ inch.
5. Coal	3(?) "	

The beds below the coal were not seen.

From South Carrollton towards Livermore the northwardly inclination of the strata seems to continue for at least three miles, and then, at some point beyond that, to rise towards the north; the precise limit of the northwardly dip, however, is obscure. The materials exposed in the railroad cuts within that distance consist chiefly of sandstones and shales. In the first few cuts beyond South Carrollton a bituminous shale, underlaid by coal, is occasionally exposed. The last exposures are seen in the tenth and eleventh cuts northwardly from the town—a distance of about five and a quarter miles from the station.

The section in the tenth cut is as follows:

1. Soft, disintegrating Sandstone, about	15 feet.	
2. Jointed blue Shale . . . . . 0 to	2 "	
3. Dark argillo-bituminous Shale; hard and somewhat slabby . . .	1 "	6 inches.
4. Coal . . . . . 1 foot to	1 "	6 "
5. Under clay	1 "	

In the eleventh cut the section is very little modified; the coal, however, is about eight feet above the railroad bed, which is descending towards the north, and argillaceous shale is exposed beneath the under clay.

From this cut northwardly the road descends irregularly, sometimes rising, sometimes descending, and reaches a wide area of flat land at about three miles from South Carrollton. Just before entering the principal "flat," however, the road cuts through a low, rather flat-topped elevation, and exposes limestone; this is at a point about four miles from South Carrollton. The limestone is filled with *Martinia plano-convexus*, and contains *Athyris subtilita* and *Martinia perplexus?* The precise relative position of this bed is conjectural; the expos-

ure is very limited; the base is not exposed, and the outcrop is limited to a horizontal distance of only a few yards. The bed is exposed in the middle of the cut, and is concealed, apparently cut off, by quaternary deposits towards the north and south. It somewhat resembles the limestone which separates coals A and B, but it may be equivalent to the "South Carrollton Limestone."

Beyond this cut we descend towards low ground, and soon enter a swampy, densely-timbered flat, which is about a mile wide. This is known as the "Thoroughfare." There is little doubt that this Thoroughfare was at one time the channel for the Green river, or of some large stream which emptied into the river. About midway across the flat the road cuts through a low gravel ridge.

Beyond the Thoroughfare the ground sweeps gently upward and forms a low irregularly-topped ridge, known as the "Island." Island Station stands about midway across the ridge.

In the first cut made by the railroad as it ascends from the Thoroughfare a coal seam 20 inches thick is exposed, as shown in the following section:

1. Soft Sandstone.				
2. Shale			3 feet.	
3. Coal, divided thus:				
a. Coal	10 inches.			
b. Clay	1 "			
c. Coal	8 "	Coal,	1 "	8 inches.
d. Clay	½ "			
e. Coal	2 "			
4. Under clay and Shale to railroad			6 "	

Northwardly from this cut, at about three quarters of a mile southwardly from Island Station, the road exposes two coal stains, which probably represent coals A and B. They are separated by 18 inches to 3 feet of limestone, and are respectively 12 and 6 inches thick. The following section shows the arrangement of the beds:

1. Clay, etc., mostly quaternary deposits.		
2. Coal stain of Coal A? about	1 foot.	
3. Clay		6 inches.
4. Limestone, filled with *Martinia plano-convexus*, 18 inches to	3 "	
5. Coal stain of Coal B?		6 "
6. Clay and Shale	7 "	

It is possible that one of these coals is equivalent to that seen in the cut to the south; but this is only conjectural. The beds seem to be rising to the north, so that the 20 inches of coal seen in that cut may be above the ones at this place.

In the cut just north of the depot at Island Station, nodules of limestone, probably equivalent to the limestone described above, are exposed in the upper part of the cut, underlaid by sandy shale and sandstone.

From this point the road descends to the north for about three quarters of a mile to a flat, which is about half a mile wide. Sandstones and sandy shales, which underlie the beds seen at Island Station, are occasionally exposed in the railroad cuts from the station to the flat. This flat is probably a part of the Green river flat, but is partially separated from it by a narrow, somewhat peculiar ridge. The rise of the hill from the low land is rather gentle up to about sixty feet of height; but from that point up the sides are formed by vertical faces of sandstone. The sandstone presents a curious feature towards the base. At the base it is very calcareous, and quite ferruginous, and in some places a conglomerate of sandstone and limestone. The larger part of the lower 5 feet of the rock seems to be a coarse conglomerate, consisting of fragments of limestone, *Crinoid* columns, the coral *Chætetes milleporaceus*, chert pebbles, sandstone, and broken remains of plants.

The ridge courses south 75° east, and probably extends to the Green river.

The Green river flat begins at the base of this ridge and extends along the railroad to Livermore, a distance of about a mile and a half.

Generalizing from the foregoing notes, it may be stated that, from South Carrollton northward for about five miles, the beds seem to fall northwardly or northwestwardly, and belong to the upper part of the section at South Carrollton. They then rise to the north, the upward sweep being sufficient to bring up the beds associated with coals A and B in the vicinity of Island Station, and the underlying beds ap-

proach the surface as far north as the Green river flat, at which point the outcrops are cut off.

At Livermore a shaft was sunk 27 feet in depth in search of coal. A coal bed is said to have been penetrated at 20 feet below the surface. At present the pit is filled with water. The débris found at the mouth of the pit would seem to show the materials which were penetrated to have consisted chiefly of a thin-bedded or shaly grey sandstone. A few concretionary nodules of iron-stone were observed in the heap; but they appeared to be of poor quality.

The mouth of the pit is about level with the railroad bed just north of the Green river bridge. It is probable that the coal which was penetrated in the shaft corresponds to one which is exposed on the bank of the river, just above the bridge. A coal 18 inches thick is exposed there, at about 14 feet above low-water mark, and about 12 feet below high-water mark. The bed is covered by about 20 inches of bituminous slate. Sandy shale and shaly sandstone fill the space from the coal to the water line of the Green river. This coal is evidently below any of the beds exposed between South Carrollton and Livermore; but its precise place in the order of the beds is conjectural. It may possibly be coal E, but the evidence concerning it is not at all plain.

A red, ferruginous material is found below the coal, at some points on the bank of the river, which may possibly serve for paint; it has never been tried. This material seems to be chiefly clay, which is thoroughly impregnated with iron, the source of which is in the coal bed.

From Livermore to Tichenor's Station, a distance of three miles, the surface is mostly flat, varied by a few low hills, near the line of the railroad. Accordingly there are very few rock exposures in that distance. There is little doubt that the westward extension of the Rough Creek uplift of Ohio county crosses the path of the railroad somewhere in the region of Livermore, either north or south of the town. The probabilities seem to be that the point lies somewhere between Tichenor's Station (or near the station) and Livermore;

but so far the facts concerning it are obscure. It is possible that the line of the disturbance is located between Tichenor's Station and Riley's Station.

Several localities were examined between Livermore and Riley's Station, but very little information was gained concerning the structure of the section between those points.

On the old "Moses Iglehart farm," about two miles a little north of east from Livermore, a coal stain makes its appearance on the hillside, near the dwelling. When first visited, this was supposed to be the outcropping of a bed of some importance, but subsequent examinations have not verified the conjecture. A carbonate iron ore, however, which lies about four feet below the coal stain, has a very fair appearance and may prove to be of value. This can only be proved, however, by a more extended digging than has yet been done, to determine its area, and by chemical analysis to test its purity. The bed ranges from 6 to 9 inches in thickness. It is especially desirable, in order to judge of the value of this ore, to become fully acquainted with its horizontal extent and physical changes, as in some places it seems to pass into a ferruginous limestone, which is of no value as an iron ore. Immediately under the iron ore, and sometimes merging into it at the top, a bed of limestone about 9 inches thick occurs. It weathers with a yellowish surface marked with white splotches. The surface is also marked by drab lumps, which are spread over it. The rock seems to be nearly bare of organic remains; a few small fragments of *Crinoid* columns and a small *Martinia plano-convexus?* were found.

On Mr. Timor Howard's farm, near Mr. John Jones' place, which is about four miles northeastwardly from Riley's Station, a deposit of black slate occurs, moderately rich in bituminous elements and cannel coal-like in structure. This deposit is known in the neighborhood as cannel coal; but it approaches more nearly to cannel slate in its physical characters. The following is the section as exposed in the summer of 1875:

1.	Black bituminous Slate, resembling cannel slate	4 feet.	
2.	Feriferous layer	1 "	
3.	Cannel (?) Slate	2 "	
4.	Feriferous layer	1 "	2 inches.

On Mr. John Jones' land, near his dwelling, a limestone holding considerable bitumen (in cavities) is exposed. In appearance the limestone resembles some of the Sub-carboniferous beds, but its identity could not be proved. The presence of bitumen in the rock has caused some to have faith in the existence of a profitable quantity of petroleum on the farm. There does not seem to be, in fact, however, any evidence to justify such a belief. There were some unsuccessful borings made for salt on the place several years ago. Sandy shale was penetrated to some depth (which was not very considerable, however); but, so far as can be gathered, the boring was without important result of any kind.

A few feet above the limestone a coal dirt 2 feet thick is exposed on the hillside, and is overlaid by ochreous sandy shale. This coal has been worked near Mr. Jones', and is reported to measure 3 feet in thickness when well opened.

On Mr. T. B. Bratcher's place, near Mr. Jones', about two and a half miles east of Tichenor's Station, limestone is again found, which may be equivalent to that seen at Mr. Jones', although topographically nearly 130 feet above it. As is the case with the limestone seen at Mr. Jones', fossils are quite rare in the rock, and only a few *Crinoid* columns were found. At about 15 feet above the limestone, at Mr. Bratcher's spring, an inch or two of coal has been found. Fragments of pebbly sandstone are strewn over the slope of the hill.

The outcrop of limestone on Mr. Bratcher's place is about two miles west from the Barrett's Creek salt wells, in Ohio county, at which point the Rough Creek uplift is plainly visible, the Chester beds being brought to the surface there and tilted at high angles.

About one mile eastwardly from Tichenor's Station a coal bed has been opened by Mr. William Atherton. The bed is nearly 3½ feet thick; but, so far as proven in 1875, was not of excellent quality. From the positions of the poorer

portions of the bed, however, it is presumable that, when followed further under the hill, beyond the reach of the atmospheric agencies, the coal may gain considerably in quality.

A few outcrops were seen in other localities between Livermore and Riley's Station, a distance of six miles by the railroad, but very little could be determined concerning them.

From Riley's Station to Lewis' Station there are few outcrops; but the surface is less flat than towards Livermore.

Within a mile of Lewis' Station the cuts begin to show sandstone and shale.

In the cuts just south of the 12th mile-post (numbering from Owensboro') a total thickness of 25 feet of sandstone is exposed. This overlies a coal which has been opened near the road, on land belonging either to Mr. Field or Mr. Vanarsdal. The bed is reported to be 3 feet thick. It is covered by bituminous slate, which appears to be sufficiently dense to form a good roof for mining under.

The position of the coal is about ten feet below the railroad at the 12th mile-post. The ground immediately at the present place of opening is not suitable for mining on a large scale, because of the short depth of the coal below the surface. "Stripping" seems to be the only convenient means by which the coal may be reached. At the hills, however, where the overlying sandstone is present, it is possible for the coal to be worked with more profit.

An outcropping of the western extension of the bed is found on Mr. George N. McKay's land, about west of the 12th mile-post. Mr. McKay did a little digging in the coal, in a small branch. He estimates the thickness of the bed at 3 feet 10 inches to 4 feet 4 inches. The quality and general character of the coal has not been proved, no opening being in a suitable condition for sampling the bed or for studying it sufficiently. From Lewis' Station to Crow's Station—a distance of 3 miles—a few low hills are seen, but the outcrops are few.

At Dr. Hickman's, just south of the 9th mile-post from Owensboro', the cuts expose about 20 feet of sandstone.

Below the sandstone, with shale (?) between, a thin coal is exposed, not exceeding 16 inches in thickness. It is covered by 21 inches of bituminous slate.

A number of springs issue from beneath this coal bed, and have a considerable local reputation, the place serving, in a modest way, as a watering-place for the people of Owensboro'. The waters are chiefly chalybeate. Two or three of them contain alum, however—one of them being somewhat remarkable for the amount of this material it contains.

Following are analyses, made by the chemists of the Survey, of the waters of the springs.*

The following analyses show the composition of the alum waters:

IN 1000. PARTS.

Number of the spring	1	2	6
Basic iron persulphate	0.8756	0.0484	0.1460
Alumina sulphate	1.2468	.3303	.3500
Manganese sulphate	.0032	.0102	.0721
Lime sulphate	.5996	.3947	.3271
Magnesia sulphate	.3330	.3315	.2513
Potash sulphate	.0005	.0068	.0074
Soda sulphate	.0724	.2959	. . . . .
Copper sulphate	.0009	. . . . .	. . . . .
Sodium chloride	.0031	.0127	.0651
Lithia	trace.	trace.	trace.
Silica	.0013	.0014	.0022
Organic matters and loss	. . . . .	.0279	.1877
Total saline matters, dried at 212° F.	3.1364	1.4598	1.4090
Specific gravity	1.00304	1.00164	1.00162

In the water of spring No. 1, it will be noticed, a small amount of copper was found; the amount is so small, however, that it will not seriously affect the influence of the waters.†

*The waters were collected in glass jars and forwarded to the laboratory for examination; but, in spite of all precautions, had lost some of their carbonic acid gas by the time they reached Lexington.

†For further discussion of the properties of these waters, see the chemical report of Dr. Robert Peter in this volume.

The following are analyses of the chalybeate waters:

IN 1000. PARTS.

Number of spring	3	4	5
Iron and manganese oxides	traces.	0.0004	0.0018
Lime carbonate	.1106	.1196	.0256
Magnesia carbonate	.0196	.0331	.0211
Lime sulphate	.1306	.0838	.1379
Magnesia sulphate	.1594	.1057	.0651
Potash sulphate	.0035	.0129	.0103
Soda sulphate	.4567	.5019	.2082
Sodium chloride	.0809	.0213	.0127
Lithia	traces.	traces.	traces.
Copper	. . . . .	. . . . .	trace.
Silica	.0174	.0254	.0293
Organic matters and loss	.0373	. . . . .	.0357
Total saline matters	1.0160	0.9041	0.5482
Specific gravity	1.00115	1.00120	1.00086

No. 3 is the "Sulphur" spring; No. 4, the "Brick" spring, and No. 5, the "Yellow" spring. These springs have been described by the writer in the Owensboro *Shield*, and more extended suggestions made as to the use of the waters.

It seems proper to insert at this place an analysis of the water of the chalybeate spring near Lewis. The spring is but a short ride from Dr. Hickman's, and will doubtlessly prove useful in connection with the springs on his place.

The water from this spring was collected by Captain R. S. Triplett.

COMPOSITION OF 1000. PARTS.

Lime carbonate	0.1155	Held in solution by carbonic acid and precipitated on boiling.
Magnesia carbonate	.0046	
Iron carbonate	.0229	
Alumina	.0027	
Phosphoric acid	.0004	
Silica	.0107	
Lime sulphate	.0204	
Magnesia sulphate	.0768	
Potash sulphate	.0403	
Soda sulphate	.0476	
Sodium chloride	.0146	
Lithium chloride	.0013	
Silica, etc.	.0143	
Total saline matters	0.3720	Dried at 212° F.

From Crow's Station to Owensboro' flats are the prevailing features, the "Black" and "Panther Creek" flats filling the larger part of the distance.

In the vicinity of Owensboro' several coal mines have been opened, all of which are probably in coal D. Two miles and a half below Owensboro', at the site of the old Coal Haven factory, 18 inches of coal is exposed in the bank of the Ohio river. This is mentioned on page 152, volume I, of the old series of Kentucky Geological Reports.

The following section was made at this place:

1. Thin-bedded Sandstone	5 feet or more.		
2. Sandy thinly-laminated Shale, about	10 "		
3. Earthy, pyritous, somewhat lumpy, and calcareous band. Abounds in *Crinoidal* columns and contains *Spirifer cameratus*, *Athyris subtilita*, *Nautilus decoratus?* long slender univalves, *Bellerophon montfortianus*, and *Lophophyllum proliferum*; about			2 inches.
4. Dark Shale, passing below into dense Black Slate	3 "		
5. Coal; said to be	1 "	8 "	

At the time this place was visited the coal was covered by the water of the Ohio river. In the hills back from the river coal D has been worked.

Near the old Bon Harbor mines (which are no longer in operation) Mace (?), Shafer & Co. were mining at Barrett's (?) new bank. The coal measures 4 feet 4 inches to 4 feet 10 inches in thickness, and is covered by dense, hard slate. The position of the coal is about 120 feet above the one exposed at the river, though it may be somewhat less. The upper 14 inches of the bed is said to be the best. The following is an analysis of averaged samples of the coal:

Moisture	5.80
Volatile combustible matter	35.06
Fixed carbon	50.40
Ash	8.74
Total	100.00
Sulphur	3.985
Specific gravity	1.318

The same bed is worked at Mr. S. M. Dean's mine, which is about one mile and a half below Owensboro'. At this bank

the coal measures 4 feet 4 inches in thickness. The following is an analysis of averaged samples of the coal:

Moisture	5.12
Volatile combustible matter	34.72
Fixed carbon	51.44
Ash	8.72
Total	100.00
Sulphur	3.513
Specific gravity	1.337

At the "Dutch" mine, about one mile and a half above Owensboro', the coal worked varies from 3½ to 3 feet 2 inches in thickness. The following analysis shows the quality of the coal to be quite fair:

Moisture	4.10
Volatile combustible matter	38.50
Fixed carbon	51.00
Ash	6.40
Total	100.00
Sulphur	1.538
Specific gravity	1.340

At the "Montgomery" mine, near the one mentioned above, the same coal is worked, and measures 3 feet 2 inches in thickness. The following is an analysis of the coal:

Moisture	6.20
Volatile combustible matter	36.20
Fixed carbon	50.90
Ash	6.70
Total	100.00
Sulphur	1.323
Specific gravity	1.323

It will be observed that the per centage of sulphur, so far as indicated by the analysis, is comparatively quite low in this bed. It is probable that the coal worked here is an extension

of the bed worked below Owensboro'; but the wide differences to be observed between the analyses of the samples collected at the mines below the town and of those collected here would seem to indicate a possibility of their being distinct beds. The determination of their exact relations is accordingly left for future consideration.

A coal seam 20 inches thick is reported to have been found at 90 feet below the one wrought at these mines.

III.

THE ST. LOUIS AND SOUTHEASTERN RAILROAD.

The path of this road extends through the counties of Henderson, Webster, Hopkins, and Christian. The larger part of its distance lies within the coal measures, but in the southern part of Christian county Sub-carboniferous beds make their appearance.

As stated on preceding pages, a region of comparatively flat land extends from Henderson, on the Ohio river, southwardly nearly to Sebree, a distance of seventeen miles; and few available outcrops are seen.

At Henderson quaternary deposits conceal the other beds.

The following are records of borings made within the vicinity of the town, published in the reports of the former Geological Survey. At present they are the most that can be given concerning the structure of the section about Henderson, and are presented only as extracts from another report:*

SECTION SHOWING THE COALS FOUND IN THE HENDERSON SHAFT.

1. Space from top of the shaft to level of high water in the Ohio river	20	feet.	
2. Space from level of high water	40	"	
3. Coal	1	"	8 inches.
4. Space	20	"	
5. Coal	2	"	4 "
6. Space	111	"	
7. Coal	4	"	
8. Space	88	"	
9. Coal	3	"	6 "
10. Space	184	"	
11. Coal	5	"	

No. 11 of the section was reached, it will be observed, at a total depth of 474 feet below the top of the shaft.

*See volume I, Kentucky Geological Survey, old series, D. D. Owen, Director.

A greater depth was reached, and a larger number of coal beds reported, in a boring made by Mr. Holloway at a point five miles from the Ohio river; but a record of the boring would serve for but little at this place. It is the intention to give, at some future time, the record of this boring, compared with sections obtained elsewhere.

The foregoing section is given merely to show what has been done towards learning the structure of the section at Henderson. At the time the examinations were made along the line of this road no opportunity was had to prove the accuracy of the record. Upon comparing it with well-known records of other shafts, and with the natural sections obtained in the hills, in other parts of the coal field, there would seem to be room for doubts concerning some of the details of the section as given to Dr. Owen; but beyond that nothing can be said concerning it at present. They may be perfectly accurate.

The following is the section of "Schlesinger's shaft" (worked by a miners' coöperative company), on the railroad, about one mile and a half, or two miles south of Henderson:

1. Earth, etc.—"yellow surface earth"	18 feet.			
2. Blue Shale? ("blue mud")	35	"		
3. "Gravel" (?)	7	"		
4. "Limestone; hard and shelly"	1	"	2	inches.
5. Coal			9	"
6. Limestone	1	"	8	"
7. Blue sandy Shale	9 to 10	"		
8. Space ("conglomerated material")	5 to 6	"		
9. Sandstone	39	"		
10. Sandy Shale; colors brown and blue. Probably Black Slate at the bottom. (This was drilled through in part)	34	"	6	"
11. Coal	4	"	10	"
12. Under clay	2	"		

The record was obtained from the sinkers of the shaft, at the time the sinking was in progress. In the main it may be considered as about correct. The top of the shaft is about level with the railroad.

The first plain exposures of the beds are found at Sebree. At this place a peculiar disturbance crosses the path of the railroad and is exposed in the cut just beyond the Sulphur springs. About 300 feet north of the cut, near the springs, masses of Sub-carboniferous limestone are strewn somewhat

irregularly over the surface of a hill which rises to a height of about 30 feet above the level of the road. Masses of calcite are distributed through some parts of the limestone, which is also crossed by veins of that mineral. Some parts of the rock are also studded with concretions of black chert, while others are full of minute cavities containing bitumen. A few specimens of *Bryozoæ* were found. Although the rock is nearly destitute of organic remains, by which to determine its age, there is little doubt, when its general features are considered, that its position is below the coal measures. The type of the *Bryozoæ* would indicate as much.

In the cut just beyond (southwardly), however, beds belonging to the coal measures are exposed, inclining at high angles; and the inclination is *towards* the Sub-carboniferous limestone, instead of away from it. This is shown in figure I, plate I.

So far no explanation has been found for this peculiar condition of the beds. The structure of the region in the immediate vicinity of the fault is nearly entirely masked; indeed, so effectually is it concealed that, had the railroad, by a slight curve, passed round the point of the hill through which it cuts, one might have passed over the ground without suspecting such an arrangement of the beds. As shown in the figure, the beds rise southwardly.

The following is an approximated section of the strata, beginning at the north end of the cut:

1. Sandy Shale, with occasional nodules of Iron-stone, about		60 feet.	
2. Sandstone. This is much shattered. The texture of the rock seems to be quite variable, changing from fine to coarse-grained in its various parts	60 to 70	"	
3. Coal dirt, apparently		3 "	
4. Under clay		3 "	
5. Coal dirt	4 inches to	1 "	
6. Argillaceous Shale, some parts calcareous		10 "	
7. Fine-grained drab limestone. This weathers a mottled ashy-white color splotched with brown, and is rough on the weathered surface. The organic remains found in it are: *Martinia plano-convexus*, an *Archæocidaris spine* (?), *Crinoid* columns, and *Chætetes milleporaceus*		2 "	6 inches.
8. Shale			6 "
9. Coal stain			4 "
10. Dark blue and greenish Shale		9 "	

11. Shaly Sandstone	5	feet.
12. Compact Sandstone—base not seen	10	"
Total thickness, about	174	" 4 inches.

The precise position occupied by these beds in the section of the coal measures, as exposed along the road, is as yet conjectural. About half a mile beyond the cut, towards the south, comparatively horizontal beds are exposed, as shown on the profile section, and there seems to be little chance for these beds to have been brought up from below. First impressions would seem to point to their having occupied a position higher than the comparatively horizontal strata to the south. Until the details of the disturbance become plainer, however—and this end is only to be obtained by detailed examinations made along the course of the fault—any conjectures that may be held concerning the proper position of the beds are of little value.

There is little doubt that this disturbance is connected in some way with the "Rough Creek uplift," of Ohio county, either as a direct continuation of the disturbance or as an "offshoot" of it. The evidence is pretty clear that the "Rough Creek uplift" does extend at least into Webster county, although the matters of detail concerning it may change at various points along the line.

One of the usual phenomena connected with lines of faults is to be observed here; at the base of the hill, upon which the Sub-carboniferous limestone is exposed, several springs of sulphur water break forth.

These springs, in connection with one of chalybeate water, which issues from beneath a sandstone about half a mile further south, have caused Sebree to be known somewhat as a watering-place. A hotel has been erected near them for the comfort of summer visitors, numbers of whom come from Evansville, Henderson, and other places during the proper season.

Following are analyses of water from one of the sulphur springs, and from the chalybeate spring. It is proper to state that the collections were made at an unfavorable time—during

a period of heavy rains—and fresh water had mingled with that of the springs to a considerable extent.

FROM THE "SULPHUR SPRING." IN 1000. PARTS.

Iron and manganese	0.0007	Held in solution in the recent water by free carbonic acid.
Lime carbonate	.2178	
Magnesia carbonate	.0499	
Lime sulphate	.0617	
Magnesia sulphate	.0570	
Potash sulphate	.0042	
Soda sulphate	.1433	
Sodium chloride	.2760	
Silica	.0176	
Organic matters and loss	.0076	
Total saline matters	0.8358	Dried at 212° F.

As stated by Dr. Peter, in the chemical report, this is undoubtedly a good "saline sulphur" water.

FROM THE "CHALYBEATE SPRING." IN 1000. PARTS.

Iron carbonate	0.0297
Manganese carbonate	trace.
Lime carbonate	.0247
Magnesia carbonate	.0179
Lime sulphate	.0218
Potash sulphate	.0042
Soda sulphate	.0205
Sodium chloride	.0026
Silica	0010
Organic matters and loss	.0066
Total saline matters, dried at 212° F.	0.1290

This is very apparently a good chalybeate water.

About half a mile north 13° east from Sebree, on the north side of the disturbance mentioned above, a coal bed barely 2 feet thick crops out on Mr. W. J. Marshall's place, in the bank of McAvoy's creek. The bed dips at an angle of 2°(?), course about north 55° east. Quaternary clays rest upon it, and very little knowledge could be gained concerning it.

Beyond Sebree, towards the south, there is a space of nearly half a mile in which the relative positions of the beds are obscure. At the chalybeate spring, mentioned on a preceding page, a massive sandstone, underlaid by shales, comes to view, the base being about 15 feet above the railroad. This is a marked feature in the structure of the region for a considerable area about the spring.

At a mile beyond Sebree the sandstone and shale are exposed in the following order:

1. Massive Sandstone; hard and compact, and frequently "honeycombed" on the surface. The bed seems to be dipping somewhat, course about north 15° west . . . . . 25 feet.
2. Sandy Shale, the base not seen. . . . . 15 "
3. Space to the railroad, probably filled with Shale. . . . . 8 "

The total thickness of the sandstone seems to be at least 40 feet.

The shale underlying the sandstone seems to form the substructure of the ground through "McElroy's Gap," nearly if not quite to Deer creek. About half a mile beyond Deer creek 10 feet of sandy shale is exposed, the top of the bed level with the railroad, which may underlie the rocks of McElroy's Gap, as the beds seem to be rising towards the south.

Somewhat less than three quarters of a mile beyond Deer creek, a few yards south of the Dixon road, a limestone is exposed in the field of Mr. G. W. Croly. No perfect exposure of it was found; but the base seemed to be about 35 feet above the railroad at the crossing of the Dixon road (known as the "Dixon Crossing"), and 60 feet above the bed of Deer creek. The limestone has a dark bluish color upon a freshly-fractured surface, and weathers an undecided ferruginous brown. It seems to contain very few fossils. *Productus splendens*, *Spirifer cameratus*, and *Martinia plano-convexus* were found; the specimens were scarce. The place of this limestone has not been determined; it resembles, in some of its features, one or two definitely known limestones; but the exposure of it is so limited that its precise character and position cannot be decided upon at present.

In the Dixon road, about one mile westwardly from the Dixon Crossing, a coal stain makes its appearance, whose position is apparently about 50 feet above the limestone seen at Mr. Croly's. This, however, has not been verified.

From this point to Slaughtersville the region through which the road runs is mostly flat land, and the order of the beds is not well seen.

A short distance north of the 120th mile-post, about one and a half miles northwardly from Slaughtersville, a limited

exposure of sandstone and shale is found. The sandstone is exposed for 5 feet of thickness, and is overlaid by 3 or more feet of shale. It seems probable that these beds contribute most largely to the surface structure of the region near the railroad for the larger part of the distance to Slaughtersville.

About two miles northwestwardly from Slaughtersville a thin coal bed has been discovered, on land belonging to Mr. John Quarles. The bed measures somewhat less than 14 inches at its outcrop. It is overlaid by 18 inches or 2 feet of black bituminous slate, the upper part of which is soft and fragile at the outcrop. The position of this coal is dotted on the profile section at a point about one quarter of a mile northwardly from the 120th mile-post from Nashville, and is placed provisionally at 75 feet (its *apparent* height) above the railroad at that point, and 70 feet above the road-bed at Slaughtersville.

At Slaughtersville we enter the flat lands of the East Fork of Deer creek. Shale forms the sub-structure of the flat around Slaughtersville, as proved by a pit sunk near the railroad depot; but no good exposures of it are to be found. Just back of the station a hill rises to a height of 65 feet above the low land, and even higher towards the northwest; but no available outcrops are found on it.

From Slaughtersville southwardly the ground ascends, and sandstone is occasionally exposed in the hills. No distinct exposures are found, however, much nearer than the large railroad cut, about two and a half miles from Slaughtersville.

At this cut we find an instructive section, the beds of which seem to form the larger part of the surface structure as far south as Madisonville—a distance of eight and a half miles.

As shown on the profile, the section is composed of a massive sandstone and shale beds, arranged in the following order:

1. Massive variegated Sandstone. This is a loose-grained, rather soft sandstone, much cross-bedded, variegated with white, brown, drab, and pink colors . . . . . 40 feet.
2. Greenish Sandstone, alternating with beds of Shale . . . . . 15 "
3. Greenish sandy Shale. This, when comparatively dry, is an olive-green; when damp, it is dark or nearly black; base not seen . . . . . 15 "

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As shown in figure 2, plate I, the massive sandstone No. 1 is fractured in such a manner, towards the north end of the cut, as to allow one part of the bed to sink below the level of the other parts, forming, in this manner, a small fault. There are, indeed, two lines of faulting in the cut, so that, although the underlying shale is apparently cut off by the sandstone a short distance north of the south end of the cut, it is exposed again near the middle, and disappears entirely at the north end, where the sandstone is again let down. In the cut just south of the large cut, which, for convenience, has been called the "Great" Cut, shale beds are exposed which underlie the sandstone of the "Great" Cut.

The following is the section exposed in the cut and a short distance south of it:

1.	Argillaceous Shale, containing ochreous concretions; top not seen . .	5 feet.
2.	Coal stain	⅛ "
3.	Whitish underclay	1½ "
4.	Greenish sandy Shale, in some places merging into thinly-bedded or shaly Sandstone; ochreous nodules are scattered through it	15 "
5.	Coal dirt	½ "
6.	Shale	10 to 15 "

In the cuts southward, to Hanson, sandy, shaly beds are exposed. These seem to be chiefly the underlying beds near the surface, for some distance on either side of the road, between the Great Cut and Hanson. They are probably below the beds exposed at the Great Cut.

At Hanson a shaft was sunk, it is said, to a depth of 40 feet, by Messrs. Sebree & Co., in 1867 or 1868, reaching a level about 45 feet below the railroad. Coal is reported to have been found at the bottom, measuring 4 to 5 feet in thickness; the material passed through before it was reached is reported to have been shale and sandstone. I was unable to verify the report by personal observations; nor could sufficient data be gathered in the neighborhood to indicate, with certainty, what coal should be found at this point at such a depth. Coal is also reported to have been found within a mile of Hanson showing a thickness of 4 feet.

Hanson lies in an extensive flat, on the waters of Otter creek. From the station to the 110th mile-post (from Nash-

ville), a distance of three miles, no exposures of the strata are found, although there is a general upward sweep of the ground in that direction. The topography, however, is that of soft sandstones associated with beds of shale. Beyond the 110th mile-post the upper series of beds begin to show more plainly.

In the second cut south of the 110th mile-post—about half a mile beyond it—15 inches of coal dirt is exposed. This is probably (?) the equivalent of the first coal above the "South Carrollton" Limestone, as seen in the Green river bluff. Very little data could be obtained concerning it, however, so that its general extent and precise relations could not be definitely determined.

The following is the section at the cut:

1. Thickly-laminated sandy Shale	10	feet.
2. Coal dirt	1¼	"
3. Sandy Shale; base not seen, to level of railroad	2	"

There is little doubt that the bed is above the Madisonville Limestone (described on a succeeding page), and is not far below the base of the massive Variegated Sandstone which lies above the limestone.

In the large cut just north of the 109th mile-post a massive, soft, disintegrating sandstone, 20 to 25 feet thick, is exposed. It is much cross-laminated. This is probably the Variegated Sandstone, described at another place.

In the railroad, a short distance south of the 109th mile-post, lower beds come to view.

From this point to Madisonville the southwardly rise of the rocks is apparent. About one mile and a half to two miles northwardly from Madisonville, in the Slaughtersville road, the highest point in the region seems to be found, with an incoherent sandstone capping the summit.

The following is the section of the beds, so far as exposed, from the summit of the hill to the railroad crossing, about half a mile northwardly from Madisonville:

1. Soft, loose-grained, but massive Sandstone, variegated with pink, white, drab, and brownish colors. Upon long exposure the bed disintegrates and forms a bank of sand. This has been called the "Variegated Sandstone"	30	feet.
2. Covered space. This is apparently mostly filled with greenish sandy Shale and thin bands of Sandstone	30	"
3. Greenish Sandstone in thin layers, with shaly partings. To the railroad	20	"

All the cuts from this point to the first cut south of the Madisonville depot, a distance of three quarters of a mile, expose greenish-tinged sandstones and shales, which succeed, in descending order, the beds enumerated in the section given above. On the east side of the railroad, by the spring opposite the water-tank, a thick bed of limestone is exposed, which has been temporarily called the "Madisonville Limestone." The rock resembles that seen at South Carrollton, and it is probably identical with that bed. It will be remembered that the two towns, Madisonville and South Carrollton, are on the same line of elevation. The Variegated Sandstone, which occurs at 60 feet above the limestone at Madisonville, may be identical with the massive bed exposed in the Green river bluff, 50 feet above the "South Carrollton Limestone."

The following is the section of the beds exposed at the spring:

1. Disintegrating very micaceous, variably coarse and fine-grained Sandstone. Some parts are very ferruginous, but the general colors are greenish-grey and brown. Cross-lamination is very frequent in the mass	10	feet.
2. Space, probably filled with Shale, merging into sandstone at the top	5	"
3. Space, apparently all Shale	5	"
4. Massive Limestone. Is drab and dove colored usually; some parts are blue. The rock weathers a dirty ash color, shading into light ferruginous brown. *Martinia lineatus* (*or M. plano-convexus*) is abundant	4	"
5. Nodular Limestone	1	"
6. Shale and nodular Limestone, somewhat resembling marlite. This thickness is variable	½	"
7. Blue Shale	½	"
8. Limestone, covered in many places with mammillary incrustations of *Chætetes milleporaceus*. Varies from 6 inches to	1	"

It is possible that the full thickness of the limestone is not seen here.

In the cut just south of the water-tank, opposite which the foregoing section was made, the limestone is exposed, and shows a greater thickness, or rather a different arrangement, of the beds.

The section is:

1. Soft Sandstone	8	feet.
2. Coal dirt. This disappears towards the south	½	"
3. Massive Limestone; abounds in *Productus splendens* and contains *Spirifer cameratus* and a *Cyathophylloid* coral	4½ to 8	"
4. Greenish-grey sandy Shale	5	"
5. Limestone, rather mottled and somewhat of a brecciated appearance. The upper part, for 6 inches, is nodular and is frequently charged with fossils, viz: *Martinia plano-convexus, Martinia lineatus? Macrocheilus inhabilis, Chonetes mesoloba,* and a *Rhynconella.* The general color of the Limestone seems to be grey mottled with red	3 to 4	"
6. Dark blue Clay, merging into Shale below; somewhat calcareous near the top; base not seen	3	"

The limestone bed No. 3 has quite a limited extent. It is most fully developed near the central part of the cut; towards the southern end it disappears.

Passing southwardly from Madisonville, we find the beds which underlie the "Madisonville Limestone" occasionally making their appearance, though the connection is not unbroken. Two miles and a half from Madisonville coals A and B make their appearance on Mr. Earle's land. Their position is about 80 feet below the Madisonville Limestone. Coal B has been mined to some extent. The following is the section at the bank:

1. Covered space; fragments of Sandstone seen on the slope of the hill	65	feet.
2. Coal "A," showing as a coal dirt	1½	"
3. Limestone; this varies in thickness. It is sometimes represented by worn fragments imbedded in clay	3 to 3½	"
4. Clay Shale, about	½	"
5. Bituminous Slate and Shale, divided thus:		
a. Slabby black Slate 1½ feet.		
b. Friable slaty Shale ½ "	2½	"
c. Slabby black Slate, 5 inches to ½ "		
6. Coal "B." The base of the bed was not seen. The bed is divided by a clay parting, thus:		
a. Coal, the "upper bench" 4 feet 7 inches.		
b. Clay 2 "	6½	"
c. Coal; base not seen 1 " 9 "		

This bank is a "drift" driven in the north end of a ridge which courses southwardly, towards Earlington.

The coal has been opened by Mr. Peyton and others, at points further to the west.

At Earlington a number of coal mines are in operation, namely: the "Hecla," the "Fleming" (formerly known as the "Diamond"), and the "St. Bernard" drifts.

The Hecla mines consist of a drift driven into coal B and a shaft sunk to coal D.

At the Fleming mine coal B alone is wrought, and is reached by drifting.

The St. Bernard drifts are in coals B and D, respectively.

The southwardly rise of the strata is very apparent at Earlington.

Were the bed worked at the Earle bank extended horizontally towards the railroad, it would occupy a position about level with the road-bed, as indicated on the profile. Then at the Fleming mine, about 1,700 feet towards the south, the coal is found showing a rise of ten feet in that direction, while the southwardly rise from the Fleming mine to the upper or "Number Eleven" drift (as it is generally known), is about 53 feet; the total rise is about 63 feet in about 4,600 feet of distance.

THE FLEMING MINE.

This is the most northwardly of the Earlington mines. Coal B is the bed wrought. Its usual thickness, including the clay parting, is 6 feet; the maximum thickness is said to be 8 feet.

The following is a section of the beds at the drift:

1. Coal A. Said to measure		5	feet.
2. Calcareous Shale, with nodules of Limestone distributed through it		2½	"
3. Bituminous Slate	3 inches to	2	"
4. Coal B, divided thus:			
a. Coal	4 feet.		
b. Clay	½ to 2 inches.	6	"
c. Coal, nearly	2 "		
5. Space to railroad, about		10	"

The upper 15 inches of the upper bench is said to be the best part of the coal.

Following are analyses of the upper and lower portions of the bed:

Composition.	1	2
Moisture	2.70	3.04
Volatile combustible matter	40.74	36.90
Fixed carbon	51.64	49.06
Ash	4.92	11.00
Total	100.00	100.00
Sulphur	1.502	5.955
Specific gravity	1.290	1.366

No. 1 is the analysis of the upper portion; No. 2 is of the lower "bench."

THE HECLA MINES.

These mines are located on the westward side of the railroad. Three coals, A, B, and D, have been opened by the company, but only two of them, B and D, are wrought; the larger part of the mining is done in coal D. Coal B is reached by drifting. Its thickness is said to average 6 feet 8 inches.

Following are analyses of the coal. No. 1 is an analysis of averaged samples taken from all parts of the bed—from both the upper and lower member; No. 2 is an analysis of averaged samples taken from the lower member:

Composition.	1	2
Moisture	3.28	3.82
Volatile combustible matter	39.32	36.38
Fixed carbon	49.54	51.10
Ash	7.86	8.70
Total	100.00	100.00
Sulphur	4.710	3.639
Specific gravity	1.323	1.326

Coal D is reached by a shaft of 60 feet in depth.

The following is the section, beginning at the base of coal B, of the materials passed through in the shaft, as reported by Thomas D. Roberts, the underground manager:

1. Coal A	4 feet	10 inches.
2. Fire-clay		11 "
3. Limestone	2 "	
4. Calcareous Shale. Dark colored and filled with specimens of *Martinia plano-convexus*		6 "
5. Bituminous Slate		6 "
6. Coal B	6 "	8 "
7. Sandstone; the upper 18 feet may be shaly, the lower part, however, is compact	38 "	
8. Mostly argillaceous Shale	20 "	
9. Bituminous Slate	2 "	
10. Coal D	4 "	8 "

This mine was opened in May, 1873. In July, 1875, about thirty-five rooms had been turned off.

The coal is raised from the pit by steam power. The mining arrangements seemed to be excellent of their kind. The mine is under the management of Mr. J. F. Ford.

Following is an analysis of averaged samples of coal D:

Moisture	2.32
Volatile combustible matter	37.68
Fixed carbon	51.00
Ash	9.00
Total	100.00
Sulphur	3.606
Specific gravity	1.331

THE ST. BERNARD MINES.

The rise of the rocks to the southward is such that both coals, B and D, are worked at these mines, and are both reached by drifting; the two drifts are about one quarter of a mile apart.

Coal B is worked at the "Upper" drift, or the one furthest north from the railroad depot at Earlington; the coal D drift is a short distance north of the depot, and enters the hill at a level about ten feet above the railroad.

At the coal B drift the thickness of the bed will average about six feet; it is reduced to five and a half feet in places. As is characteristic of the seam, the bed is separated by a clay parting into two divisions; the upper member measures 4 feet, and the lower member 2 feet in thickness.

The upper 15 inches of the bed is admirable coal, and is known as the "gas coal;" this seems to be a general feature

of the bed, not only at the several mines around Earlington, but at various other places where this seam is wrought; its merits will receive attention in another report. From the bottom of the "gas coal" down, towards the bottom of the upper member, the coal seems to deteriorate in quality, the lower parts being more sulphurous than the upper portions.

The lower member (2 feet) is generally quite poor, compared with the better parts of the bed. Bituminous slate occasionally covers the coal; but usually limestone forms its immediate covering.

The following is an analysis of averaged samples collected from the upper member of coal B:*

Moisture	3.20
Volatile combustible matter	38.30
Fixed carbon	48.50
Ash	10.00
Total	100.00
Sulphur	3.345
Specific gravity	1.326

The coal D drift was not in operation the day these mines were visited.

The seam varies from 3 to 4½ feet in thickness, and the quality of the bed seems to improve where the thickness diminishes. The coal dips about 2°, course north 75° east.

The collections made for analysis were obtained along the entries. The following is the analysis of averaged samples:

Moisture	4.30
Volatile combustible matter	37.64
Fixed carbon	50.56
Ash	7.50
Total	100.00
Sulphur	2.892
Specific gravity	1.337

* For the method of sampling coals for analysis, employed in the western coal field, see page 47, part VI, volume I, Geological Reports of Kentucky, second series, N. S. Shaler, Director.

It will be seen that there is comparatively little difference in the quality of the coal worked at the different openings. The market rating of the product of the respective mines probably depends, in a large degree, on the amount of care taken in handling the coal.

The southwardly rise of the beds is continued beyond Earlington, and coal D is brought up still higher at Mr. Arnold's bank, about one mile and a half, or less, beyond Earlington. The bank was not working when visited. At the mouth of the drift the coal measured 4 feet 3 inches. This coal is in a low ridge which comes in between Earlington and Mortonsville.

Coal D (?) has also been opened a short distance beyond Mortonsville, but could not be measured, the excavation having become filled.

From this point to the Diamond mine, about three quarters of a mile beyond Mortonsville, the beds underlying coal D form the structure of the lower land, while sandstones and shale, and other beds associated with coal D, form the upper parts of the hills; the strata rise steadily towards the south.

At the "Diamond" mine coal D is found at a level 30 feet above the railroad, which is 73 feet higher at this point than at Earlington—a southwardly rise of 81 feet in 4½ miles thus being shown.

The following is the section, so far as exposed, at the Diamond mine:

1. Hard Sandstone	10 feet.	
2. Covered space	15 "	
3. Coal (A or B)	1 "	
4. Covered space	75 "	
5. Bituminous Slate	4 "	
6. Pyritous Clay Shale, containing the characteristic fossils of coal D,		6 inches.
7. Coal D	4 "	10 "
8. Covered space to the railroad	30 "	

Beyond the Diamond mine, towards Nortonville, a gap of about a mile occurs in the section, the direct connection between the beds being obscure. At one time this gap was thought to include a line of fracture of the beds. Subsequent observations, however, more perfect in their way than those first taken (though still quite imperfect in many re-

spects), have failed to prove the existence of such a line. But, at the same time, the non-existence of such a fracture has not been proved, and until a better map than we now have of this region may be constructed, and data more detailed in their character be collected, the conditions below the surface will remain problematical.*

At a saw-mill near the railroad, about one mile beyond the Diamond mines, a sandstone is exposed in the hills, and continues to crop out at various points to within somewhat less than half a mile of Nortonville, the Nortonville flat then setting in. In some places the sandstone seems to be at least 30 feet thick.

On the east side of the railroad, somewhat more than a quarter of a mile north of Nortonville, Mr. Wm. Mills has opened a bed of coal said to be 6 feet 8 inches thick. This place was visited for the first time in October, 1874. Since then it has been found necessary to revise some of the conclusions arrived at concerning not only this coal bed, but certain other points relating to the structure of the region about Nortonville.

The reasons for this are simple. Some of the data which entered largely into the foundation of the conclusions were necessarily received from others, since they related to beds which had been laid bare by excavations, but were, at the time, concealed. No opportunity has since occurred to see the beds perfectly, but sufficient evidence has been found to prove the existence of inaccuracies in some of the descriptions furnished me, and, consequently, of errors in the conclusions based upon them.†

When Mr. Mills' bank was visited for the first time the coal was concealed, the roof of the mine having fallen in; but the description given of the bed agreed so closely with that of coal B that, the region to the north not having been studied

*A fracture and fault is plainly visible at Rocky Gap, coursing in an eastwardly and westwardly direction; but until that point is properly located in regard to the surrounding region, it is impossible to determine just where the line crosses this railroad.

† It may be proper to state that such inaccuracies as occurred in the descriptions were doubtlessly unintentional on the part of those who furnished them.

closely, the bed was considered identical with that number, and is so recorded in the report on the geology of the region adjacent to the Louisville, Paducah and Southwestern Railway.* Since that time the outcropping of the coal has been found, and more perfect data have been obtained from Mr. Mills. The results of the subsequent examinations, although not sufficiently definite to determine the precise relative position of the coal, plainly show the bed to be another one than coal B, and seem to indicate its position to be far below the level of that bed.†

When first encountered the bed was divided, by a parting of eighteen inches to two feet of clay, into two members, as may be seen at the outcrop. It is said, however, that the parting either disappeared entirely, when the coal had been followed well under the hill, or became so thin as not to be noticeable.

The coal is covered by argillaceous shale, and seems to underlie the massive sandstone seen in the hills to the north.

Just north of Mr. Mills' coal bank the Nortonville flat sets in and extends southwardly beyond the Elizabethtown and Paducah Railroad.

A short distance beyond the Nortonville depot the railroad mounts a ridge, cutting through beds of sandstone as it ascends.

At the base of the ridge, just west of the railroad, Mr. Mills sunk a well or pit to a depth of about nineteen feet, or somewhat less, reaching coal at twelve feet below the surface. Fragments of the coal were seen in the débris at the mouth of the pit. Efforts were made to see the coal bed, but failed on account of the water in the pit. The coal is said to

* Part VI, volume I, second series Kentucky Geological Survey, N. S. Shaler, Director.

† As may be presumed, these modifications will affect the conclusions drawn concerning the structure of the section between Nortonville and Rocky Gap. That section has been examined once again, and under more satisfactory conditions than existed during the first reconnoissance. A line of fault which has hitherto been concealed was clearly established at Rocky Gap; glazed surfaces of sandstone, slickensides, etc., phenomena common to lines of fracture, besides a distinct downthrow of the beds on one side, were observed. These and other data recently gathered will materially simplify the work of interpreting the structure of the region. The results of these investigations, and the section as modified by them, will be given hereafter, when the more detailed work of the region is undertaken.

measure about seven feet in thickness, having a clay parting near the middle of the bed. The section given for the well is:

a.	Sandstone, about	5 feet.
b.	Argillaceous Shale	7 "
c.	Coal	7 "

This bed is probably equivalent to that opened by Mr. Mills north of the station. The top of the coal is about level with, or a little below, the bed of the railroad by the depot.

In the hill the sandstone passed through in the upper part of the pit is well developed.

The following is the section of the beds exposed in the ridge:

1.	Covered space, slope from top of hill	35 feet.
2.	Sandstone	30 "
3.	Covered space	10 "
4.	Dark earthy-blue, somewhat pyritiferous Limestone; generally hard and compact, rather tough, fractures irregularly. Fossils scarce and very poorly preserved; *Productus muricatus?* a small *Athyris?* and a few small *Crinoid* columns were found. The rock forms a distinct terrace along the side of the ridge . . . . . 2 feet 9 inches to	4 "
5.	Covered space	15 "
6.	Drab and grey massive Sandstone. This is quite variable in texture, and somewhat in color also. In some places it is quite compact and forms bold escarpments; in others it is brownish to buff colored, coarse-grained, soft and disintegrating, and much cross-laminated. It is usually very micaceous	40 "
7.	Argillaceous Shale	7 "
8.	Coal, reported to be	7 "

The beds from No. 1 down to No. 6 are exposed a short distance west of the railroad. The sandstone No. 6 is partially exposed in the cut immediately south of the depot, and seems to extend for about one mile towards the south, sandstone resembling it being exposed in the cuts as far south as the 94th mile-post (from Nashville). The beds in the cuts nearest the mile-post, however, may partly underlie the massive sandstone, as the strata appear to be rising towards the south. Beyond the 94th mile-post we begin to descend to the waters of Drake's creek, and a gap of nearly two miles occurs in the section—extending from the 94th mile-post to the railroad tank a short distance north of the 92d mile-post. In the fourth cut south of Nortonville shale and sandstone are exposed, which probably underlie the coal found in Mr. Mills' well.

Descending from this cut, we soon reach the "Drake's Creek Flats," which seem to be chiefly underlaid by shales. Sandy shale comes to view in a small branch a short distance beyond mile-post "ninety-three."

It is possible that the Rocky Gap fault crosses somewhere in the space between mile-posts 94 and 92; but the determination of this will have to await the completion of a better map than we now have of this region, and a careful tracing of the line of the fault. The structure of the section is obscure, until we reach the tank north of the 92d mile-post. At this point the railroad cuts a spur of a ridge coming in from the northwest, and exposes a fine section of the beds.

The following is a statement of their order:

1.	Covered space; fragments of Sandstone seen on the surface	25 feet.
2.	Limestone; texture earthy, color blue; shelly towards the top. Fossils are abundant. *Productus splendens* (especially abundant), *Prod. costatus*, *Spirifer cameratus*, *Prod. muricatus*, *Prod. Prattenianus*, *Martinia lineatus?* *Lophophyllum proliferum*, *Crinoid* columns, and a *Fenestella* were found. The bed is divided into two to three layers, and becomes more compact towards the bottom than at the top; the fossils are mostly found towards the top. The rock has the appearance of a "Hydraulic Limestone"	8? to 4 "
3.	Blue and drab Shale, somewhat ochreous; sandy towards the top	25 "
4.	Sandy argillaceous Shale	3 "
5.	Dark blue Shale, with streaks of coal	2 "
6.	Coal, base not seen	2 "

The thickness of the coal is reported at two and five feet, including a clay parting. Colonel Gano Henry, formerly of Hopkinsville, states that he dug into the bed, and found—

a.	Coal	3 feet.
b.	Clay	1 "
c.	Coal	2 "

It is probable, however, that his measurements were estimates, which are not always free from error. This bed is known as coal J in the reports of the present Survey.

About one thousand feet south of mile-post 92, a shaft, reported to be seventy-five feet in depth, was sunk, it is said, for the purpose of mining the coal exposed at the tank. The mouth of the shaft is *below* the level of that bed. Had the shaft been started at about fifteen feet higher up, the venture would have proved more successful. This mistake, however, was productive of considerable good, as those having the work in hand were induced to make a boring. The result was, so

I am informed, to penetrate coal L at a level about one hundred and thirty feet below coal J. The record of the boring assigns four to four and a half feet as the thickness of the coal. It would be unsafe, however, to vouch for the accuracy of the record at this point, as the thickness of the bed does not pass much beyond three feet at other points in the region where the coal is exposed. It is quite possible for some of the dark overlying material to have been mistaken for coal. Borings are valuable aids to the explorer; but when the thickness of a coal bed comes into question, they are far from trustworthy; neither is the reported existence of a coal bed always to be trusted—the degree of confidence to be placed in the record depending very much upon the person selected to determine the character of the materials as they are brought to the surface.

Combining the section made at the tank with the records obtained from Mr. Thomas of the materials passed through in the shaft and the boring, we obtain the following statement of the order of the beds near the tank:

1.	Limestone	4	feet.	
2.	Sandstone and Shale	32	"	
3.	Coal J, reported to be	3	"	
4.	Under clay	3	"	
5.	Sandstone	15	"	
6.	Shale and Coal	1	"	
7.	Shale	12	"	
8.	Coal			2 inches.
9.	Fire-clay	3	"	
10.	"Rash" Coal			½ "
11.	Sandstone	8	"	
12.	Coal	1	"	8 "
13.	Space, probably Shale	13	"	
14.	Bluish Shale and Sandstone	30	"	
15.	Hard Shale and "gritty" beds of Sandstone	30	"	
16.	Shale, "with iron ore"	2	"	
17.	Shale	5	"	
18.	Coal (L?)	4	"	

At the tank coal J rises rapidly north 20° east for a short distance; it seems to be a local disturbance of the bed, and not connected with any extensive movement.

The coal may be traced, either by its outcroppings or associated beds of shale and limestone, from the water tank to Petersburgh Station and beyond.

At Petersburgh a miners' coöperative company have sunk a pit to coal J, which was reached at a depth of about twelve feet below the level of the railroad. It averages four feet in thickness, including a clay parting one inch thick.

The section in the shaft is:

1. Compact bluish Shale			32 feet.
2. Coal, divided thus:			
a. Coal	3 feet 6 inches.		
b. Clay	1 "		
c. Coal	5 "		
		4 "	
3. Under clay			3 "
4. Massive Sandstone; base not seen			4 "

An analysis of fairly averaged samples of the coal shows its composition to be:

Moisture	3.70
Volatile combustible matter	32.56
Fixed carbon	50.04
Ash	13.70
Total	100.00
Sulphur	3.716
Specific gravity	1.398

The analysis of this coal did not prove as favorable as was expected when the samples were collected. The coal is remarkable for the amount of fibrous coal interlaminated with the denser kind, and it is probable that its high per centage of sulphur is in a large degree due to this. It seems to be proven that the larger the proportion of fibrous coal there is in a coal, the larger will be the per centage of sulphur; a fact (if it proves to be a fact) which is well worth remembering when judging of its quality by the appearance of a coal.

The lower five inches of the Petersburgh coal is highly esteemed for smithing, and appears to be much freer from sulphur than the other portions of the bed.

Near the shaft of the miners' coöperative company, the limestone first above the coal is exposed in the road, and in Mr. Williams' field, near the house. In the road it is overlaid by shale (mostly) for forty feet.

Passing southwardly from Petersburgh, the rise of the beds is sufficient to bring coal J up to a level with the railroad at Edmunds, Green, and Norton's old banks, about one quarter of a mile, or somewhat more, southwardly from the town.

From this point southwardly the rise of the beds seems to bring the lower series regularly up to daylight, bringing up coal L at a point about one mile and a half beyond Petersburgh, where it was mined at one time; the banks are known as the Davis (?) banks. The bed worked at this place seems, undoubtedly, to be identical with that worked at the Coaltown banks, which are distant about half a mile from the railroad at this point. Several sections were made in the neighborhood of the Coaltown mines; but, as the region about them is soon to be studied closely, questions concerning the details of its structure are deferred.

Following are two analyses, made by Dr. Robert Peter and Mr. J. H. Talbutt, of average samples of the Coaltown coal collected in the summer of 1875. Analysis No. 1 is of a sample taken from a heap of the coal that had been exposed to the weather for some time. Analysis No. 2 was made of averaged samples collected in one of the drifts. It should be stated that there was considerable water in the mine when the collection was made, and that some of the moisture indicated by the analysis (No. 2) may be due to that circumstance.

By comparing the analyses, it will be noticed that, contrary to the usual conditions, the coal in the stock-piles contained less moisture than did the samples taken from the mine; hence, it is not improbable that neither analysis indicates the true proportion of the moisture, which is probably not greater than 3.5 per cent.

	1	2
Moisture	4.60	5.10
Volatile combustible matter	31.94	32.50
Fixed carbon	54.36	55.70
Ash	9.10	6.70
Total	100.00	100.00
Sulphur	2.469	1.277
Specific gravity	1.307	1.332

These analyses, when compared with those made by the chemists of the Kentucky Survey of coals of other States lying within the Illinois coal field, show very favorably for our coal.*

In the fifth railroad cut from Petersburgh, distant about two miles from the town, a short distance beyond the old Davis banks, the beds are dipping rapidly towards the north—nearly at the rate of ten feet in the hundred.

Passing southwardly from the old Davis banks, the series of beds lying near or at the base of the coal measures come to view, and within a short distance the border of the coal field is passed, though what appear to be outliers of the coal measures are found farther towards the south.

For the reason stated on a preceding page, it is deemed best not to enter into the closer details of the region bordering the limits of the coal field at present; but it may be well to notice some of the beds exposed in the cuts towards Hopkinsville.

In the cut about three hundred and fifty or four hundred feet south of the one mentioned above, the rocks are seen to be much disturbed. At the north end forty feet of sandstone is exposed, dipping northwardly, which is cut out by a fault that crosses the beds about the middle of the cut—the beds lifted by the fault resting nearly vertically against the others. On the south side of the lifted beds sandstone is found, thrown

*The question concerning the comparison of the quality of our coals with those of other States, lying within the same field, will be considered in a report to be given hereafter.

but little out of its horizontal position. A rough diagram of the condition of these beds is given in figure 1, plate V.

In the cut about 2,000 feet south of the foregoing one, the distinct base of the coal measures is seen, Chester limestone showing in the south end. About 1,200 feet farther south, the strata are considerably disturbed. Their order is, beginning at the north end of the cut—

1. Sandstone, dipping northwardly	20	feet.	
2. Shaly Sandstone, nearly vertical	12	"	
3. Coal		3	inches.
4. Shale	10	"	
5. Coal		1½	"
6. Shale, nearly vertical	30 to 35	"	
7. Sandstone	5	"	
8. Shale, vertical	80	"	
9. Shale, dipping northwardly	5	"	
10. Sandstone, dipping northwardly	5	"	
11. Shale, dipping northwardly	65 to 70	"	
12. Sandstone and Shale	10	"	
13. Shale	10	"	
14. Hard sandstone, dipping northwardly at an angle of 50° to 55°	25	"	
15. Olive green marly Shale (Chester ?)	15	"	
16. Chester Limestone		6	"
17. Marlite and Shale	3	"	
18. Dark Shale	1	"	
19. Sandy Shale, passing into Sandstone	20	"	
20. Variegated Sandstone, containing pebbles	50	"	
Total thickness	380	"	

This cut is about four miles and three quarters southwardly from Petersburgh Station, about one mile northwardly from Crofton, and one mile and a half southwardly from the Davis(?) coal banks.

From this cut to a point about half a mile southwardly from Crofton, the beds are imperfectly seen; sandstone seems to be the prevailing rock. At half a mile beyond Crofton, twenty-five feet of sandstone is exposed, which is apparently but little inclined; the exposure was too limited to determine the fact.

About one mile farther towards the south, the beds are again exposed, dipping towards the north. The following is their order, beginning at the north:

1. Dark blue sandy Shale, dipping at an angle of 35°, north 7° east,	15	feet.
2. Thin-bedded ferruginous Sandstone; dips 33°, course north 7° west	5	"
3. Dark drab Shale, dipping as No. 2	4	"
4. Coal	0 to	1 inch.
5. Under clay, containing an occasional *Stigmaria ficoides*	5	"

6.	Shale and soft shaly Sandstone	10 feet.	
7.	Coal, dipping 17°, course north 7° west		½ inch.
8.	Drab Shale, dips 17°	15 "	
9.	Thin-bedded Sandstone, dips 37°	10 "	
10.	Sandy material, probably crushed Sandstone with clay	4 "	
11.	Limestone—Chester Group—dips 57°		6 inches.
12.	Shale and thin plates of Limestone	5 "	
13.	Sandy Shale, with Limestone nodules; dips 7°	12 "	
14.	Irregularly-bedded Limestone, filled with *Bryozoans;* base not seen	7 "	

At the junction of No. 13 with No. 12 the beds are crushed down, as shown in figure 2, plate V.

This series seems to correspond in part to the beds exposed in the cut north of Crofton. The upper beds, including the coals, are the last exposures seen of the coal measures, near the railroad, southwardly. From this point on to Hopkinsville the Sub-carboniferous beds have entire sway.

Southwardly to Kelley's Station and beyond, a massive sandstone, underlying the beds exposed in the cut, forms the sub-structure of the ground. About half a mile beyond Kelley's, sandstone and shale, probably belonging near the base of the massive sandstone, come to view; and at half a mile still farther to the south limestone makes its appearance.

Passing a short distance beyond this limestone outcrop, and descending toward Hopkinsville, shaly sandstone makes its appearance, which probably underlies the limestone to the north, and overlies the St. Louis Limestone exposed at Hopkinsville. These lower beds of sandstone and shale are exposed occasionally as far south as the East Fork of Little river, on the banks of which, and beyond, the massive limestone of the St. Louis Group is exposed; the sandstone may be found on some of the hills.

The massive limestone is largely developed at and about Hopkinsville. Beds of admirable oölitic stone are exposed there, and are quarried for domestic purposes. These oölitic beds of the St. Louis Group seem to be the ones most valuable, for all purposes, that are to be found in the series.

The stone at Hopkinsville is easily dressed, firmly cemented, capable of being fashioned after any design, and, apparently, is durable; it also presents a good appearance when

set in a building. Polished specimens of this stone have been seen, and their appearance would seem to indicate that it would serve fairly well as a "marble" for certain indoor purposes. What merit the polished stone may have for outdoor use, however, is, to say the least, conjectural. Of the many limestones that receive a good polish, few are capable of sustaining it when exposed to atmospheric changes.* They become more or less pitted as the softer portions are eaten away. The well known Bowling Green oölite occurs in the same group as does the one in question. Quarries have also been opened in beds of the same description near Glasgow Junction and Princeton. Large shipments of the dressed stone are made from those points. There seems to be no good reason why such an industry may not gain a foothold at Hopkinsville.

One of the interesting points in connection with the beds at Hopkinsville is the bored well of Mr. John B. Trice. The well is one hundred and thirty-four feet deep, with a diameter of five and a half inches. The purpose in view when the boring was commenced was to obtain a trustworthy supply of fresh water. In this, however, the well has so far proved a failure; but it is not altogether a failure when other results are considered. On the contrary, at the depth of one hundred and thirty-four feet, a stream of water was encountered, which analysis proves to be not only valuable as a sulphur water (so far as the value of such waters can be estimated), but somewhat remarkable in its composition.

The following is an analysis made in the laboratory of the Survey of some of the water furnished by Mr. Trice:

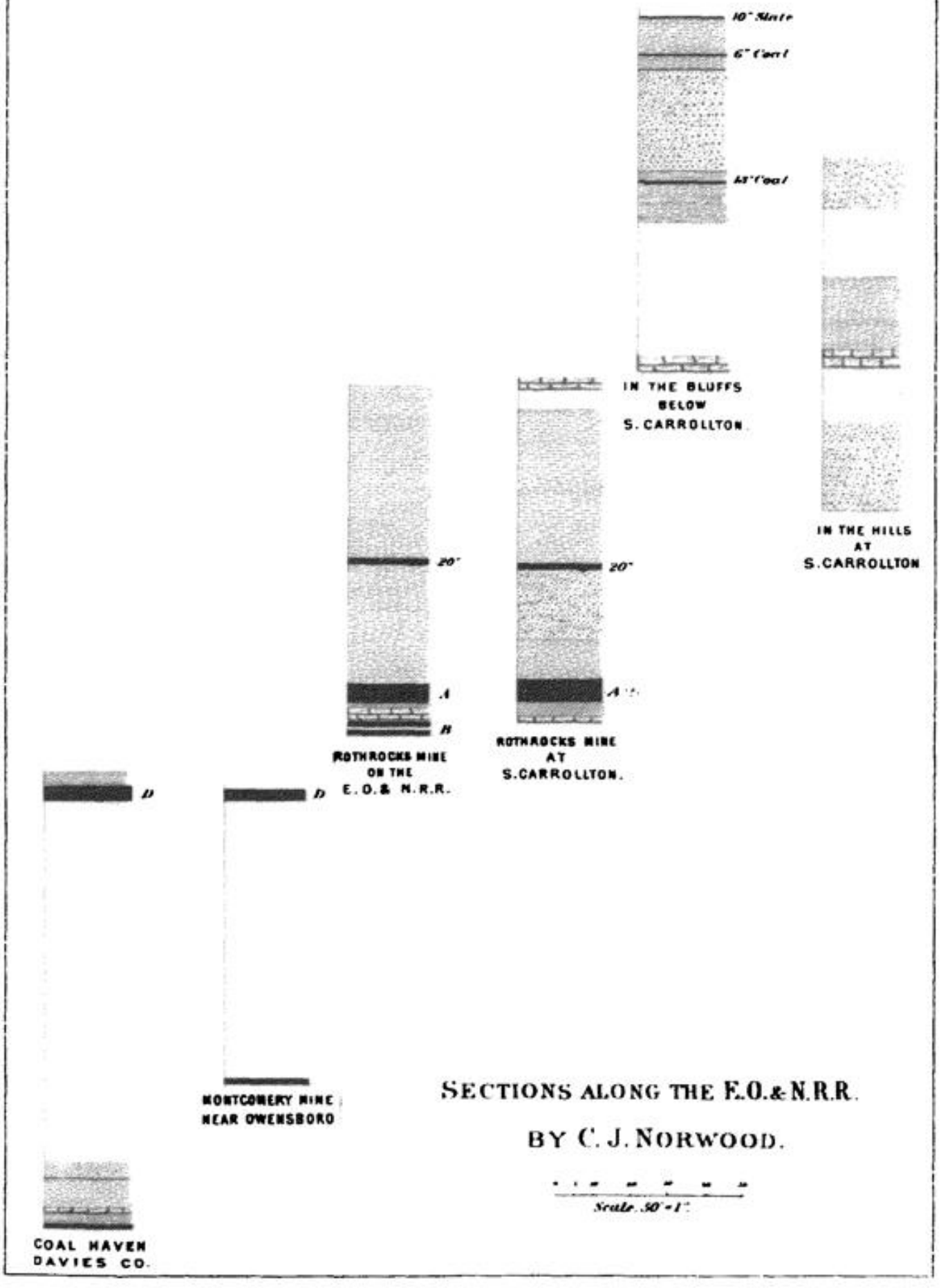
* This stone has not been tested as to its liability to scale; but, judging from the condition of structures already built of it, it does not seem probable that the amount of disintegration will be great.

CONTENTS OF 1000. PARTS OF THE WATER.

Lime carbonate	0.1233	Held in solution by carbonic acid.
Magnesia carbonate	.0253	
Iron and manganese carbonate	.0013	
Silica	.0012	
In sediment formed on boiling	0.1601	
Sodium chloride	3.3647	
*Sodium sulphide	.....	
†Soda carbonate	.2366	
Soda sulphate	.5347	
Potassium chloride	trace.	
Lime sulphate	.1156	
Magnesia sulphate	.4329	
Magnesium iodide	.0018	
Lithia and Bromine	traces.	
Total saline contents	4.8464	

* Not estimated because partly decomposed.
† Representing the sulphide in the recent water.

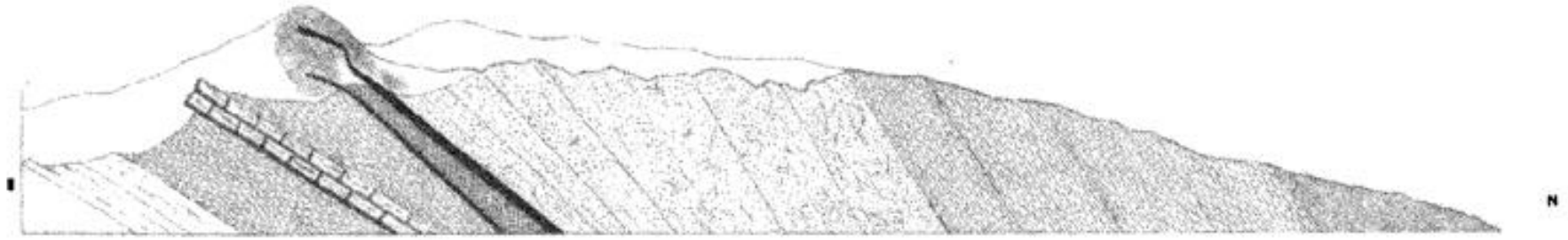
This water was found in a greenish calcareous shale after one hundred and eighteen feet of limestone had been penetrated.



SECTIONS ALONG THE E.O.&N.R.R.

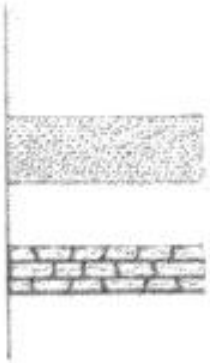
BY C. J. NORWOOD.

Scale. 50' = 1"



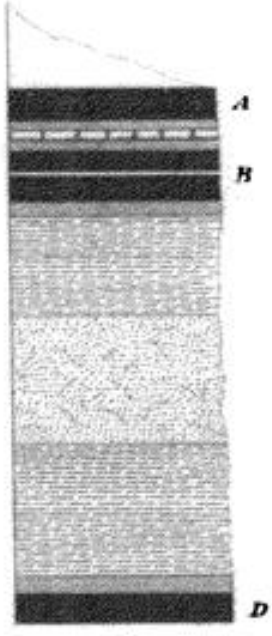
SECTION ON R.R.CUT AT SEBREE WEBSTER COUNTY.

SECTION OF GREAT CUT NORTH OF MADISONVILLE HOPKINS COUNTY



SECTION AT THE
MADISONVILLE
SPRING

SECTION NEAR
R.R. JUST NORTH
OF MADISONVILLE



SECT. OF THE "HECLA" SHAFT.

HOPKINS COUNTY SECTIONS

BY C. J. NORWOOD.

Scale. 60ft.=1in.

Plate. IV.

SECTION AT THE TANK NEAR MILE POST 92.

THE AIR SHAFT NEAR MILE POST 92.

THE PETERSBURGH SHAFT.

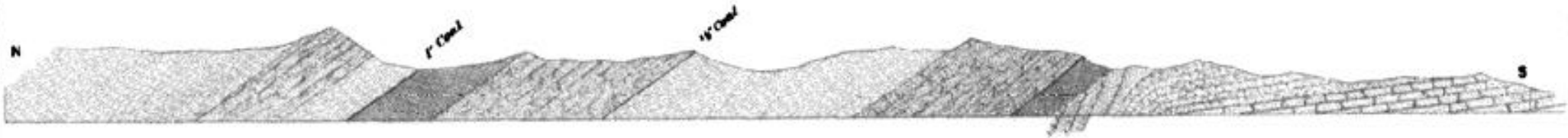
BORING NEAR MILE POST 92.

SECTIONS IN CHRISTIAN COUNTY

BY C. J. NORWOOD.

1877.

Scale, 100 ft.



CUT AT 82 MILEPOST STL & S.E.RWY. CHRISTIAN COUNTY

SIXTH CUT SOUTH OF PETERSBURG CHRISTIAN COUNTY

Plate V