GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT

ON THE

GEOLOGY OF A SECTION

FROM

NEAR CAMPTON, WOLFE COUNTY, TO THE MOUTH OF TROUBLESOME CREEK, BREATHITT COUNTY.

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REPORT ON THE GEOLOGY OF A SECTION FROM NEAR CAMPTON, WOLFE COUNTY, TO THE MOUTH OF TROUBLESOME CREEK, BREATHITT COUNTY.

The examination upon which this report is based was made late in the fall of 1875, for the purpose of determining something of the number and character of the coals which would be reached by a projected line of railroad, from the central part of the State, to the coal fields of the Kentucky river in Breathitt county. Owing to the lateness of the season, and the lack of time, as well as to the fact that there is no map of this region by which observations can be located with any exactness, the examination was only little more than a detailed reconnoissance. It is, therefore, highly probable, when the region comes to be examined in detail, that corrections will have to be made in the following report and the accompanying section, though it is believed that, in their general features, they are essentially correct.

As there are several different routes for the projected railroad under advisement—all, however, crossing the divide between the Red and Kentucky rivers, and subsequently the Kentucky river itself—a section of the rocks was made along this divide, from the head of Chimney Top Branch of Red river to Frozen creek; thence across the Kentucky river, and up on the south side to the mouth of Troublesome creek, which enters from the opposite side.

With the comparative merits of the different lines from an engineering stand-point this report does not deal. They will all encounter more or less difficulty in surmounting the dividing ridges between the streams. They all will reach substantially the same coal-beds, but they differ somewhat as to the

distances at which they will first strike the outcrops of the coals.

Each of the lines encounters the coals below the Conglomerate sandstone, long before those above the Conglomerate are reached. There are several of the Sub-conglomerate coals, usually of excellent quality, but, with the exception of one, not often of workable thickness. This coal is fully described by Mr. A. R. Crandall, in his report on the geology of Menifee county.

It is in quality good, but it varies from twenty-two to forty inches in thickness, with an average of perhaps thirty. The area underlaid by it is very large, and it is capable of producing a large amount of coal; but from its thinness and irregularity, it cannot be mined so cheaply as the thicker coals above the Conglomerate. These Sub-conglomerate coals of the Red river, Slate, and Beaver Creek valleys, having been examined and described in the report of Mr. Crandall, no further mention of them will be made here.

The examination for this report began at the top of the Conglomerate, at the head of Chimney Top creek, and extended in a southeasterly direction to the mouth of Troublesome creek.

TOPOGRAPHY.

The country between the Red and Kentucky rivers has its topography determined for the greater portion of its area—all of it, at least, except that near the head of Red river—by the Conglomerate sandstone.

In its western extension, from the Middle Fork of Red river westward, the dividing ridge is narrow, high, and precipitous, as the sandstone, in its resistance to erosion, forms bold and massive cliffs, often extremely picturesque in outline. The ridge grows higher and narrower to the west as the determining rock, the Conglomerate, rises in conformity with the general rise in the rock formations of the country; while to the east, toward the head of Red river, as the Conglomerate descends, and is covered by an increasing thickness of over-

lying shales and shaly sandstones, the surface of the country becomes more even, the hills lower, and with more gentle slopes, while only that portion of the country bordering closely on the main streams shows the cliff topography.

From the head of Middle Fork of Red river eastward, for several miles, the dividing ridge is narrow, and the thickness of rock above the Conglomerate slight. After passing Chimney Top and Lower Devil creeks, the surface of the country becomes more even, the hills low, not usually extending more than one hundred and fifty or two hundred feet above the branches of the main creek, while the slopes of the hills are so gentle that they can be, and in many cases now are, cultivated clear to the tops. It is one of the best agricultural regions in Eastern Kentucky. In the ridge there are numerous low gaps, leading from one stream to another, offering a comparatively easy passage for a railroad line.

The topography is of this character on both sides of the dividing ridge, at and near the heads of Upper Devil, Swift's Camp, Stillwater, and Holly creeks; but along the Red and Kentucky rivers, as well as on the lower part of the creeks just mentioned, the country is still rocky and broken by the Conglomerate cliffs.

As we proceed southeastward from Holly creek, another change takes place in the topography, which is here determined by the alternated coarse and shaly sandstones which occur above the Conglomerate.

After the Conglomerate passes beneath the drainage, there is no one member of the rock series which alone determines the topography. On the contrary, we have the hills, showing the resultant of the different resistance to erosion of massive sandstones and shales or shaly sandstones. The hills rise from four hundred and fifty to six hundred feet above the river, and present a much steeper slope, extending in about the same degree from top to bottom; but when it comes to be examined in detail, it is seen to be made up of a series of terraces, steep, and often precipitous, where the heavy, coarse standstones occur, and more gently sloping over the

shales and shaly sandstones. The coarse sandstones, from the way they resist erosive agencies, are more often exposed than the shaly beds, and they are seen in proportion to their thickness. The shales and shaly sandstones are usually covered by the talus from the overlying coarse sandstones, and good exposures are more rare.

This character of topography begins above the mouth of Holly creek, and extends as far as the field covered by this report. Above Jackson, in the dividing ridge between the river, or the short branches emptying immediately into the river and Cane creek, a heavy sandstone, about fifty feet in thickness, caps the hills, which there rise to a greater height above the river than at any place before noted.

GEOLOGY.

In the description of the topography, or the surface configuration of the country under discussion, the character of the geology has been roughly outlined, for it is the rock structure which determines the contour of the surface of any region, and no intelligible description of the topography can well be made without reference to the determining rocks.

There are in this region only the rocks of the Carboniferous formation. West and northwest, beyond the head of Middle Fork of Red river, are found rocks lower down in the geological series; but, for a description of their position, order, thickness, etc., the reader is referred to the report of Mr. A. R. Crandall, before referred to.

As may be inferred from what has already been said, the Conglomerate sandstone is by far the most prominent member of the rock series of this region, and has exerted a greater influence upon the formation of the topography than any other. It forms the rocky wall which fences in Eastern Kentucky from ready communication with other portions of the State, and, with its frowning cliffs, guards its stores of mineral wealth. It has been the most serious obstacle to the development, both material and social, of Eastern Kentucky,

for it has prevented that necessity of modern civilization, quick and cheap transportation.

From whatever point a railroad is projected to enter Eastern Kentucky, it must encounter the serious difficulty of surmounting the Conglomerate sandstone, if it would penetrate to the heart of the coal fields, where the best and thickest coals are found in such abundance that they can furnish an ample supply for generations to come—a supply upon which can be based permanent mining enterprises.

The Conglomerate is often found in two members, with a series of shales containing coal, between. The lower member is uncertain and irregular, both in occurrence and thickness; but the upper member is present all through this region, although varying somewhat in thickness. It is the most important, and is the one referred to as the Conglomerate. In thickness it is here from one hundred and fifty to two hundred feet. In character it is a coarse, massive sandstone, at places full of pebbles, and usually showing prominent cross-stratification lines. The pebbles are most abundant in the lower part of the sandstone, decreasing towards the top; and as we go to the southeast, where the greater portion of it has passed below the drainage line, and the top only is exposed, they disappear almost altogether; so that it becomes difficult to distinguish the Conglomerate from some other coarse sandstones which occur above it.

The thickness of rock above the Conglomerate at the western end of this section is small, ranging from fifty to one hundred feet, and this only in detached knobs at the heads of the small streams, while out on the points the top of the Conglomerate is often bare. This thickness increases rapidly towards the southeast, until, between Swift's Camp and Upper Devil creeks, in the neighborhood of Campton, it ranges from one hundred and twenty-five to one hundred and seventy-five feet.

In the dividing ridge at the heads of Holly and Stillwater creeks this thickness increases to two hundred feet and more; but along the lower portion of these streams it is usually less.

Above Holly creek the hills rise rapidly to twice their former elevation above the Conglomerate, in consequence of a change in the character of the prevalent rock from shaly to coarse sandstone. At the western end of the section, from the head of the Middle Fork of Red river to Swift's Camp creek, the rocks above the Conglomerate are almost entirely shales or shaly sandstones, wherever seen.

In passing above Swift's Camp creek thicker and coarser sandstones begin to be seen, which increase in frequency until they form the greater portion of the rocks.

The Conglomerate passes beneath the drainage near the mouth of Frozen creek. From this point to the mouth of Troublesome creek, coarse, massive sandstones, ranging from ten to fifty feet in thickness, are the most prominent features in the section. These sandstones are frequently exposed in cliffs on the hillsides; but, with few exceptions, they do not hold their character and position over large areas, as they frequently give place to shaly sandstones and others, which before had been shaly, become coarse and massive.

Of bituminous and clay shales, there is not in this region any great thickness. Occasional outcrops are found, but, in comparison with the great mass of shaly and coarse sandstones, they are rare; nor do they hold any great extent in area; on the contrary, they seem to be quite local, and when the attempt is made to trace them for any distance, they are usually found becoming more and more sandy, until they change insensibly to shaly sandstone.

After passing the Sub-carboniferous limestone, which lies below the Conglomerate, there is no pure limestone of any thickness found in this region. Numerous bands of dark, very silicious limestone or calcareous sandstone are found, but they are usually thin; not in any case more than four feet in thickness. In many places they do not form regular strata, but occur in large lenticular or kidney-shaped masses, lying in sandstone or shale. These kidneys are usually more silicious than the beds or strata of impure limestone. In places, some of these bands of limestone become fossiliferous, but

these cases are exceptional. So far as seen, they do not occur at regular, well-marked intervals, nor do they have any great horizonal range.

The limestones, so pure in quality and so persistent in position, which often serve as guides in the identification of coal seams near the Ohio river, seem to be entirely wanting here, and we have in their places these numerous, erratic, and untrustworthy bands of impure limestone, which are of almost no value whatever for use in geological identification.

The absence of these limestones, and the frequency with which the sandstones and shales change character, render the construction of an accurate section, and the identification of coal seams across any great interval, a matter of considerable difficulty. The absence of limestone and fine shales, as well as the character of the prevailing rock, which is a coarse mechanical sediment for the most part, indicates the prevalence throughout this region, during its deposition, of shallow waters much disturbed by currents, accompanied by frequent changes of level. There was no subsidence deep enough or long enough continued to allow the formation of pure limestones, nor were the waters quiet and land-locked lagoons, in which the fine mud could settle undisturbed, to be afterwards compacted into shale beds.

It is worthy of notice, that the Sub-carboniferous limestone, which in Ohio is thin and frequently wanting altogether, thickens from the Ohio river to the southwestward, while the limestones of the coal measures, several of which are found in Ohio, disappear soon after crossing into Kentucky.

SECTION.

Accompanying this report will be found a horizontal section showing the principal features of the geology, from the dividing ridge west of Campton to the Kentucky river, at the mouth of Troublesome creek. This section is by no means complete, and it is not offered as such. On the contrary, as already stated, it will probably be found to need considerable correction when the country comes to be examined in detail; and it

is not at all impossible that, especially in the southeastern end of the section, some of the connections between the coals may be found to be incorrect. It is believed, however, that the greater portion of the section is correct. The measurements for elevation were made with an aneroid barometer, without any correction from a check barometer, at a time of the year when atmospheric variations are often sudden and great, so that there is a liability to error from this cause. On the other hand, the measurements for level were usually made with the Kentucky river as a base, the level of this being known from actual survey, and the variations were checked as often as possible by returning to the river. The measurements for distance will probably need some correction, as they were not obtained from the most reliable sources, the existing maps of this region being very imperfect. The section is given as the best that could be accomplished with the time and means at command, and it serves very well to show the principal features of the geology of this region.

It will be seen that there is a total thickness of seven hundred and fifty feet of strata above the top of the Conglomerate included in the accompanying section. This, with the three hundred and twenty-five feet of Conglomerate and Sub-conglomerate beds, makes a total thickness of one thousand and seventy-five feet of Carboniferous rocks above the Sub-carboniferous limestone, from the river at the mouth of Troublesome creek to the edge of the coal measures.

COAL.

The coals of this region are numerous and of excellent quality, and, taken as a whole, will bear comparison with those found in any other portion of the State in quality or thickness. They are all classed as bituminous coals; but they show all the varieties of this class, known as dry-burning, caking, and cannel coals. The principal coals are of the dry or free-burning variety, while the caking or fat coals are comparatively rare. Cannel coals are abundant and of excellent quality; certain of them having a reputation second to none in the State.

As yet, this region is almost entirely undeveloped, so that it is difficult or impossible, without the most detailed and careful study, to obtain a complete section, showing the thickness and position of all of the coal seams—a study which has, as yet, not been given to it. There are numerous mines along the Kentucky river, where coal has been mined for shipment in boats down the river; but none of them are extensive, and the majority are now abandoned and have fallen in.

The practice is to open a drift from which a few boat-loads of coal are taken, when, as soon as it is far enough underground to render it a matter of some labor to get the coal to the mouth of the drift, it is abandoned, and another one opened. The so-called mines are, therefore, but a series of shallow pits.

Of late years, owing to the low price of coal in the lower markets, coal mining has not been as profitable as formerly, and but little is now mined in this region, except of the finer grades of cannel coal, which bring a higher price, and can, therefore, yet be mined and transported at a profit.

The cause of this stagnation in the mining industry is the excessive cost of transportation; due entirely to the uncertainty and danger of the river navigation. Coal-boats drawing five feet of water can only be run during high water, which can be expected but for a very small part of the year. This, therefore, necessitates the storage of large quantities of coal, often for months after it is mined, while waiting for a rise in the river sufficient to carry it off. This storage is of great detriment to the coal, as it is injured by exposure to the weather. In addition to the injury and loss by exposure, an extra cost is involved through the loss of capital lying idle for so long a time.

The boats used to carry the coal down the river can never be returned, and they are, therefore, usually sold at a great loss. The river is so difficult of navigation, that from three to five men are required to manage each boat, or one man to about each thousand bushels of coal; the boats usually holding from three to five thousand bushels of coal each.

In addition to these necessary and inevitable expenses, there is great risk involved in the navigation of the river, a large proportion of the boats never reaching their destination.

These combined causes make the cost of coal, at the markets along the lower river, so great, that Pennsylvania coal is brought down the Ohio river, up the Kentucky, and sold at a less price in Frankfort than the coal from this region. Thus, the work which has been done by the State in improving the navigation of the Kentucky river, for a part of its course only, actually operates against the interests of Kentucky coal miners, instead of furthering them, for it enables Pennsylvania coal to compete with them in their own markets, without assisting them in any degree. Were Kentucky river slack-watered to the mines, so that coal could be shipped at nearly all seasons of the year, and the empty barges returned cheaply, this region could supply coal to the whole of that part of the State bordering the river, at prices which would drive all foreign coal from the market; and it could even do a large business on the Ohio river in the fine cannel coals in which it abounds.

Until improved means of transportation are furnished this region, either by slack-water or railroad, there can be no extensive and regularly conducted mining enterprises. The fine-grade cannel coals will probably continue to be mined in a precarious and haphazard way, as they commonly bring a price sufficient to pay a small profit over the risk and expense of transportation; but, with this exception, the great body of coal will remain untouched.

The lowest coal mines on the Kentucky river are near the mouth of the South Fork, at Beattyville and Proctor, where one of the Sub-conglomerate coals of excellent quality is mined. There are few mines above this for about twenty-five to thirty miles along the river, until near the mouth of Holly creek. Between these places the river runs through "the narrows," a gorge or cañon which it has cut through the Conglomerate. For most of this distance the Sub-conglomerate coals are beneath the level of the river, while the hills

do not rise sufficiently high over the Conglomerate, until some distance back from the river, to hold the coals which have been mined further up.

Above Holly creek, banks have been opened every few miles, until the last are reached about five miles above Hazard, in Perry county. Most of these, as already stated, are abandoned, and have fallen in, so that exposures of the coal that can be measured are rare. Back from the river, openings or exposures of the coals are very few, as there has been no inducement to mine coal while wood is still the most common household fuel in use. In studying the geology of this country, therefore, reliance has to be placed mainly on natural exposures or outcrops of coal; so that it is a matter of considerable difficulty to obtain a complete section, showing the position of all the coals.

In the accompanying section the position of the coals shown is well ascertained; but, from the reasons just given, the thickness has not been accurately determined in every case.

The change in the general character of the rocks from that of the region nearer the Ohio river, which has been referred to before, is accompanied, to a certain extent, with a change in the coals; but the region has not yet been examined over a sufficiently large area to enable a generalization as to the number and equivalency of the coal seams. The section bears in its lower part a resemblance to that of the country near the Ohio river; but, after the first two hundred and fifty feet above the Conglomerate is passed, the resemblance is not so great. There seem to be, here, greater changes between coals, within short distances, than are common farther north.

In the section accompanying this report are shown eight coal seams above the Conglomerate. From the detailed vertical sections given in the horizontal section, the evidence upon which this identification is based can be seen. The dotted lines connecting the coals in the section indicate the probable connection between them; but it must be distinctly

understood that this is not positively asserted. It is only the connection which seems the most probable, with our present knowledge.

The first coal of the section, the equivalent of coal No. 1 of the Greenup County section, and of Ohio Geological Reports, occurs from twenty to fifty feet above the top of the Conglomerate. It is first opened near Campton, on Swift's Camp creek, and also on Bear Pen Branch of Upper Devil creek. Its position, here, is about twenty-five feet above the top of the Conglomerate. Its thickness is from twenty-four to thirty inches. It is a fat or caking coal, of very good quality, especially the lower portion of it. In this respect it differs from the No. 1 coal further north, which is there a typical dry-burning or furnace coal. It is the famous Jackson and Briar Hill coal, with which over half of the iron made in Ohio is smelted. The per centage of sulphur present varies considerably, but is usually low. It is seen at a number of places along the river, holding an average thickness of thirty inches. Below the mouth of Frozen creek, near Mr. Nathan Day's, is an old mine, now fallen in, where the coal is said to be thirty-six inches thick in some of the rooms. Below the mouth of Holly creek, on the Holland place, is an exposure where it measured thirty-four inches; but this includes a shale parting of several inches in thickness. On Frozen creek it is seen at a number of places near the mouth, usually about twenty-eight inches thick; but above this stream it has not been seen by the writer. A coal, which is probably this one, is reported on the old Cockrill farm. It probably goes under the river not far above. This coal is an excellent blacksmith fuel, and would doubtless make a firm, hard coke. Coal of this quality is rare in this part of the State, as the majority of the coals are of the soft, free-burning, non-coking character; and although this is thin, it will doubtless eventually become valuable.

The following analyses by Dr. Peter and Mr. Talbutt, show something of the character of this coal in this region:

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	1	2
Moisture	3.74	2.50
Volatile combustible matter	35.52	41.10
Fixed carbon	52.64	49.22
Ash	8.10	7.18
Total	100.00	100.00
Coke	60.74	56.40
Sulphur	2.466	0.818
Specific gravity	1.336	1.300

No. 1 is an average sample by Mr. A. R. Crandall, from C. M. Hanks' bank, at Campton, Wolfe county.

No. 2 is an average sample, by the writer, of coal from an opening above Wm. Day's, on Frozen creek, Breathitt county.

COAL NO. 2.

About seventy-five feet above the coal just described, has been found at a few places, another coal seam, which is probably the equivalent of coal No. 2 of the Greenup section. Like that, it is usually thin, not having been seen more than twenty inches thick. At other places it is less, not more than twelve inches. It is not mined at any place, and, consequently, no samples were procured for analysis. It is best shown on the branches of Swift's Camp creek, above Campton.

COAL NO. 3.

At a distance ranging from one hundred and forty to one hundred and ninety feet above the Conglomerate is found a coal, which, from its character and position, seems to be the equivalent of coal No. 3 of the Greenup section.

It is better known than any other coal of this region, for the reason that it has been most extensively worked. The mines on the Kentucky river, from Holly to Quicksand creek, are all in this coal, with the single exception of the entry in the No. 1 coal already noted. On this account, also, better opportunities for sampling the coal are given.

From our present knowledge, this coal seems to be one of the most regular and trustworthy of any in this region, which characteristics it holds all through Eastern Kentucky, as far as we now know it. Along the ridge, between the Red and Kentucky rivers, it is first opened at the head of one branch of Upper Devil creek, about four and a half miles from Campton, at the Hobbs bank.

The coal here consists of three members or divisions, separated by thin shale partings. The following is the section of the coal at this place:

Coal	2′	
Shale parting		3″
Coal	1′	8″
Shale parting		8″
Coal	1′	3″

Giving us a total thickness of four feet eleven inches of coal. The quality of the coal here is excellent, as will be shown further along. It is somewhat sulphurous in appearance; but the pyrites is in small flakes, which hardly form an appreciable per centage of the whole. This splendid coal is the first of a thickness greater than three feet, which would be reached by a railroad, after crossing Red river.

On the Kentucky river, the first opening of this coal is at the Holland mine, below the mouth of Holly creek. The coal is here about three feet in thickness, or a little less. Along the river, the thickness varies from three to three and one half feet of coal. The thickness, including parting, is usually much more, as there is commonly a slate parting, which varies from three to twelve inches. This is usually measured with the coal; hence it is commonly called four feet thick.

At the Hobbs bank, this coal is about four hundred feet above the river. It rapidly descends to the southeast, until, at the Holland bank, it is only a little over three hundred feet above. At Jackson it is only one hundred feet, while above this it descends still more rapidly, until, at the mouth of Quicksand creek, it is at the level of low water in the river. From this point to the end of the section the dip changes, and the rocks are horizontal, or nearly so. From some observations

made above the mouth of Troublesome creek, it seems probable that the coal, there, dips in the opposite direction, and that it rises more rapidly than the rise in the level of the river. This conclusion is based upon an identification of a coal on Wolf creek, which is not as yet supported by sufficient stratigraphical evidence to be by any means certain, as the examinations in that region have not yet been detailed. The coal on Wolf creek resembles the No. 3 very closely in physical character and chemical constitution, as will be seen by the analyses appended. It is thicker here than it is known to be at any other locality below. It is reported, on good authority, to be seven feet in thickness. When visited by the writer, the drift had caved in, so that the whole thickness could not be seen; but satisfactory evidence was obtained, by measuring some of the timbers which had been cut to support the roof of the drift, that the coal is more than six feet thick.

Below Jackson, at Spencer's mine, this coal, with a total thickness of about four feet, including partings, shows a little less than three and one half feet of coal. At Cardwell's bank, near Jackson, it is nearly the same. Along the river, opposite and above Jackson, this coal has been mined at many places, none of which are now open, so that it can be examined. It is stated that the shale parting grows gradually thicker and the coal thinner further up stream. This statement is corroborated by the following section, at a natural exposure of the coal in the bank of the river at the mouth of Stray branch:

Coal	1′	9″
Shale parting	1′	8″
Coal		5″
Shale parting		4″
Coal		2″
Shale parting		2″
Coal		1″
Shale parting	1′	2″
Coal		7″

The total thickness of coal in the above section is thirty-six inches; but the numerous thin bands into which it is divided, and the shale partings between, show that at this point, during the formation of the coal, it was subject to frequent fluctua-

tions of level, probably not of any great extent, but sufficient to check the growth of the coal vegetation, and to allow the deposition of layers of mud, which became afterwards hardened into the clay shale partings.

These frequent old openings in this coal, along the river, identify it beyond doubt, and also show the rate of dip.

In character, it is usually a distinctly laminated and dry-burning coal, with considerable fibrous coal or mineral charcoal between the laminæ. At places portions of it are bituminous enough to coke, but this is not its general character.

The amount of sulphur present varies considerably, but is usually low, as is also the ash, while the per centage of fixed carbon is high. These three qualifications render the coal an excellent fuel for general purposes, and when considered in connection with its dry-burning, non-caking character, render it extremely probable that the coal would make a successful furnace fuel for the manufacture of iron.

The following analyses, by Dr. Peter and Mr. Talbutt, show the composition of this coal at several places:

	1	2	3	4
Moisture	3.50	3.56	4.90	2.76
Volatile combustible matters	35.20	33.56	35.30	36.60
Fixed carbon	56.70	58.38	55.50	56.50
Ash	4.60	4.50	4.30	4.06
Total	100.00	100.00	100.00	100.00
Coke	61.30	62.88	59.80	60.56
Sulphur	1.189	1.381	3.153	0.865
Specific gravity	1.294	1.297	1.290	1.290

No. 1 is from the Hobbs' bank, at the head of Upper Devil creek. Average sample by the writer.

No. 2 is from Wm. Spencer's mine on Kentucky river, below Jackson. Average sample by the writer.

No. 3 is from the Holland mine, below the mouth of Holly creek. Sample taken by the writer from a large pile of coal which had lain exposed to the weather for about one year.

No. 4 is from the South mine, on Wolf creek. Average sample by Mr. J. R. Procter and the writer, from a large pile which had also been exposed to the weather for about a year. As already stated, this coal is not positively identified as the same as the others, but for convenience it is given with them. It will be noted that its chemical composition closely resembles the others.

Above coal No. 3 the remaining coals of the section are not so well known, either as to position or character, for the reason that they have not been so extensively mined, and outcrops are comparatively rare. With our present knowledge, the coals above No. 3 seem to be more irregular and uncertain than that one; although it is possible, when they are better known, and a more complete series of sections obtained, that they will be found to be more uniform than is now supposed. For this reason, the attempt will not be made to number and classify them at present. They will be described in their approximate order.

The first workable cannel coals near the line of this section are found above coal No. 3. Such coals occur, at various levels, all through this region; but the lower ones are usually thin.

On the Kentucky river, at a distance varying from thirty to fifty feet above coal No. 3, is found another coal, usually about two feet thick. It is a rather fat, bituminous coal, of very good quality; but it has not been worked. It is seen of this thickness at the Spencer and Cardwell banks, below Jackson. Still further down the river, it is reported to be more than three feet thick, but it was not seen by the writer. Above Jackson this coal is thinner.

At many localities the proper level for this coal is occupied by a shale or sandstone, while at about seventy to eighty feet above Coal No. 3 we find a cannel coal. This is the cannel coal which is seen in the river hill about one mile below Wm. Spencer's. It is not well exposed here, but it seems to be thin. It is probably also the cannel coal seen at G. W. Johnson's, near the head of Nichols Fork of Frozen creek. It is

here seen in outcrop along the hillsides at many places, but has not yet been opened so as to show its full thickness. Blocks of coal nearly two feet in thickness were seen tumbled out on the hillside; but beyond this there was nothing to determine its thickness.

The frequency of outcrop of this coal in this neighborhood shows it to be quite a persistent seam, and it is to be hoped that, when it is opened, it will be found of workable thickness. Two varieties of cannel coal are seen here, both probably from the same bed or seam. One is hard, of very uniform, rather coarse-grained structure, showing perfect conchoidal fracture, and abounding in brilliantly polished surfaces or slickensides, which have probably been caused by faults or slips in the hill squeezing and pressing the coal upon itself. This coal contains a considerable proportion of earthy matter, as will be seen by the analysis further along; and to this cause may possibly be due the readiness with which it assumes a polish.

Fortunately, this variety of the coal seems to be much less abundant than that other, which shows a partly laminated structure, irregular fracture, is of a less homogeneous nature, and not nearly so handsome; but which proves, on analysis, to be one of the best cannel coals of this whole region. It is sometimes called the "curly cannel," owing to its peculiar structure.

The cannel coal which is found at John Murphy's, on Stillwater creek, is probably the equivalent of this seam.

The cannel coal which is mined on Quicksand creek, about one mile above its mouth, is probably also the same. This coal shows a total thickness of twenty-five to twenty-six inches, of which the upper eight inches is bituminous, leaving only a thickness of seventeen to eighteen inches of pure cannel. It has an excellent reputation in the lower markets, and commands a high price; so that, in spite of its being so thin, it is mined at a profit. The analysis of this coal is given further along in this report.

On George's branch, which empties into the Kentucky river several miles above the mouth of Troublesome creek, a cannel coal of excellent quality is mined, which, if the supposition as to the equivalency of the Wolf Creek coal with the No. 3 be correct, is the same coal as that just described on Quicksand creek. This coal shows a total thickness of thirty-four to thirty-six inches, of which twenty-two to twenty-four inches is cannel coal, the remainder bituminous. Like the Quicksand Creek coal, this has an excellent reputation in market, and brings the highest price. It is much sought after by consumers, for household fuel.

The position of this coal at the various localities corresponds very well with that of coal No. 4 of the Greenup County section.

At a distance ranging from sixty to eighty feet above the last described coal another has been seen in imperfect outcrop at a number of places, but it is not mined at any place; so that very little is known of its thickness or quality. The stain, or the weathered outcrop of it, is frequently seen. On a short branch emptying into the Kentucky river from the opposite side, above the mouth of Quicksand creek, this coal is washed bare by the stream, and shows a thickness of thirty inches. It is a bright, glistening, caking coal, of very good quality, as far as could be judged from the limited exposure.

At the Haddock mines, on the bank of the river above Troublesome creek, this coal has been found as a cannel coal, and is reported to be twenty inches thick. The outcrop was not sufficient, when seen by the writer, to prove anything as to its thickness; but it showed the existence of cannel coal at that point.

From one hundred and ten to one hundred and twenty-five feet above this last coal, at a height, where best known, of two hundred and fifty feet above the Kentucky river, is found the most valuable cannel coal of this region. It is commonly known as the Haddock coal, as it is mined most largely at the Haddock mines, at the mouth of Troublesome creek. This is the thickest cannel coal on the line of this section, and in

quality it is equal to any. It does not contain as much volatile combustible matter as some of the other cannel coals, and will not make quite so brilliant a fire, but it contains less ash than the most of the others. It is mined, for this region, in considerable quantities at the Haddock and Sewell mines, near the mouth of Troublesome creek. Here it usually shows a thickness of thirty-four inches of cannel coal, with ten to twelve inches of bituminous coal above. In one of the drifts of the Sewell mines there was seen thirty-six inches of cannel coal, with ten inches of bituminous above; and the miners report that, in some rooms, the cannel coal reaches a thickness of forty-eight inches. The miners "bear in" on the soft bituminous coal above, and then wedge up the cannel coal in large blocks.

This coal is also found on the same side of the river two or three miles below, on land belonging to Wm. Spencer. It has never been mined here, but it shows at an outcrop, imperfectly seen, thirty-four inches thick, and it is reported to be three inches thicker when the whole thickness is exposed. Of this, all but the upper four or five inches is cannel coal. Below this point this coal has not been mined or even opened so as to show its thickness, at any point known to the writer; but it has been found as a stain at some places. It is said to be opened on the east bank of the river a short distance below the mouth of Troublesome creek, but the place has not yet been visited by any member of the Survey. Whether the coal extends down the river, holding its thickness for any distance, is unknown; but from the well-known uncertain character of cannel coal, it is at least doubtful. However, it has been found at enough places, widely separated from each other, to prove that it underlies a large area, sufficiently large to be able to supply all the demands of an extensive mining industry for a long time to come.

In the hill at the Haddock mines, at a distance of one hundred and ten feet above the main cannel coal, a coal has been found, which is reported to be a semi-cannel coal, four feet in thickness; but it had caved in at the time of examination by

the writer, so that nothing could be seen of it. The "stain" or "sign" of this coal was found at other places, enough to show that it holds its position with considerable persistence.

Fifty feet above this coal is found another, which has been mined on the opposite side of the river from the Haddock mines, by Mr. J. Wells. It here shows the following section:

Coal		11 inches.
Shale parting		2 "
Coal	1 foot	1 "
Shale parting		4 "
Coal	1 "	3 "

A total thickness of three feet three inches coal, excluding shale parting. It is a dry-burning, bituminous coal, quite free from sulphur, but carrying a rather large per centage of ash, as shown by the following analysis, by Dr. Peter and Mr. Talbutt, of an average sample taken by the writer. The coal sampled from was near the outcrop, and hence the analysis may possibly show more ash than properly belongs to it:

Moisture	2.78
Volatile combustible matter	35.52
Fixed carbon	44.94
Ash	16.76
Total	100.00
Coke	61.70
Sulphur	1.423
Specific gravity	1.398

This is the highest coal geologically in this region of which anything is definitely known. At several localities a coal stain is found immediately below the massive, heavy sandstone which caps the hills back from the river, but nothing is known as to its character or thickness.

UNDETERMINED COALS.

As the examination made of this region was so largely of the nature of a reconnoissance, many exposures of coal were seen—especially when at some distance to one side of the line of the section—the geological equivalency of which was not determined, owing to lack of time for detailed examination.

The coals on Wolf creek and George's branch should really be classed here, as they are by no means certainly identified.

On main Frozen creek, above the house of Mr. Green Tolby, a coal is found about one hundred and seventy-five feet above the bed of the creek, in natural outcrop below a sandstone cliff, showing a thickness of three feet nine inches clear coal, without any perceptible parting.

On Stillwater and Gilmore creeks, in Wolfe county, cannel coal is found at a number of places, but its equivalency has not yet been determined. At Mr. James F. Ely's, a cannel coal has been opened; but the drift has now fallen in, so that it is partly covered. This is asserted to be three and one half feet in thickness. A thickness of two and one half feet was seen by the writer at an exposure which evidently did not show the whole thickness of the bed. The exposure was such that an average sample for analysis could not be obtained. A hand specimen was, however, subjected to analysis, with the result of showing an excessive per centage of ash. The per centage is so large that it seems possible the specimen selected may have been worse than the average of the coal, although not intentionally selected as such. The general appearance of the coal does not indicate so large a per centage of ash; and it is but justice that this analysis should not be allowed to go unexplained, to the injury of the coal, before an average sample can be selected and analyzed.

On Stillwater creek, at Mr. John W. Faulkner's, a cannel coal is found, which is commonly reported to be three feet thick. Only about ten inches of the upper part of the bed were seen at time of visit, the rest being covered by mud and water. From this also a hand specimen was taken for analysis, which showed a large per centage of ash, not quite so large as in the last case, however. The same caution should be held in regard to this coal as the last; but against it is the fact that it has the reputation, among those who have burned it, of carrying much ash. At John Murphy's, on Stillwater creek, a cannel coal is found outcropping with considerable regularity in the hills back of his house. It has

never been dug into or opened, and nothing is known as to its thickness. It is the coal before referred to as probably the first coal above No. 3.

On Troublesome creek, about fifteen miles from its mouth, below the mouth of Buckhorn creek, on the Roberts farm, is a coal which shows the following section:

Bituminous coal	1′	10″
Shale parting		3″
Bituminous coal	1′	5″
Shale parting		10″
Cannel coal	1′	10″

A total thickness of five feet one inch coal.

There has been considerable excitement in regard to this coal, and very exaggerated reports were in circulation concerning it. The thickness of the whole bed was commonly stated as being cannel coal, when in reality not more than one third of it is of that kind. It is, however, a valuable seam of coal, as it can be mined very cheaply, owing to its thickness. The quality of the different members of this coal is shown by the following analyses, by Dr. Peter and Mr. Talbutt, from average samples taken by myself:

	1	2	3
Moisture	3.30	2.20	3.40
Volatile combustible matter	31.44	39.20	43.40
Fixed carbon	49.76	51.14	46.96
Ash	15.50	7.46	6.24
Total	100.00	100 00	100.00
Coke	65.26	58.60	53.20
Sulphur	.991	2.525	.630
Specific gravity	1.405	1.290	1.280

No. 1 is the upper seam—bituminous.

No. 2 is the middle seam—bituminous.

No. 3 is the bottom seam—cannel.

There is a salt well on the Kentucky river, opposite the mouth of Troublesome creek, which is reported to have passed through four coals in sinking to its present depth of four hundred and ten feet. Measurements of coals by boring

are always liable to error, especially if, as in this case, the boring was not made for the especial purpose of finding coal, but to obtain salt water, as the borings are very apt to become mixed by the drill. It is also difficult to tell the exact line of passage from one stratum of rock to another. The well was sunk in 1846 by Col. L. C. Bohannan. The records of the well have, unfortunately, been lost; but, from memory, Col. Bohannan states the position and thickness of the coals passed through approximately, as follows:

First, about ten feet below the surface a coal, reported two feet six inches thick.

Second, from forty to fifty feet below the surface another coal, reported three feet thick.

Third, about two hundred feet from the surface a coal, said to be about four feet thick.

Fourth, after passing through a very thick, coarse sandstone, a coal was reached at a depth of three hundred and eighty to three hundred and ninety feet from the surface, which is said to be of the unusual thickness of ten feet.

This is probably one of the Sub-conglomerate coals, which at other places is associated with a great thickness of bituminous shale, often mistaken for coal. This is peculiarly liable to be the case when nothing but the finely comminuted fragments of the material from the well can be had for examination. It is hardly probable that the Sub-conglomerate coal, from what we know of it at other places, would thicken so remarkably in this direction. The heavy sandstone reported as having been passed through before reaching the last coal, is very probably the Conglomerate.

The boring is, therefore, interesting, as showing the salt-bearing rock to be either the Conglomerate or the shales below. Nothing definite could be learned as to the amount of brine yielded by this well, or its strength. The prevalent impression in regard to its strength is, that it requires eighty gallons of brine to produce one bushel of salt.

At Mr. Marcum's, above the Haddock mines, two coals have been mined near the river, one of them about seventy-

five feet above the river, and the other about twenty. The upper coal is three feet thick, and is reported to be one of the very best coals mined on the river. The lower was not seen, as it was covered at the time of visit. There is another coal two feet thick above it, separated by about seven feet of space. The upper coal was seen.

At Mr. McIntosh's, about two miles above, a coal about forty feet above the river has been considerably mined, but has now fallen in. This coal was not seen, but was reported to be four feet four inches thick by the former owner.

In addition to the above, numerous exposures of coals too thin for working have been seen, ranging from a few inches in thickness up to two feet. The positions of some of these are known to be in the regular series of the coals, while others seem to be erratic and intercalated seams of no great horizontal range.

QUALITY OF THE CANNEL COALS.

The cannel coals of this region are, for the present, and probably will be for some time to come, more valuable than any other. They will always command a higher price per ton than other coals, on account of their excellent qualities as household fuels and for steam-making. They are also valuable for the manufacture of gas; but their use is limited in this respect, owing to the poor quality of the coke resulting after the volatile portions of the coal have been driven off. The greater thickness and regularity of some of the other coals may eventually, when facilities for transportation become adequate, render them the most valuable, as they can be more cheaply mined than the cannel coals; but the latter, when of good quality and reasonably free from ash, will always be in demand.

As has been already indicated in the descriptions of individual seams, these cannel coals vary greatly in quality as well as thickness, and the same seam often changes thickness and quality very suddenly.

The following analyses, by Dr. Peter and Mr. Talbutt, will serve to show very fairly the different qualities of these coals:

	1	2	3	4	5	6	7
Moisture	1.30	0.94	2.10	1.60	1.20	1.16	1.30
Volatile combustible matter	47.00	52.38	43.10	43.20	58.80	44.58	41.40
Fixed carbon	44.40	35.54	43.36	33.80	35.30	32.76	28.20
Ash	7.30	11.14	11.44	21.40	4.70	21.50	29.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Coke	51.70	46.68	54.80	55.20	40.00	54.26	57.30
Sulphur	1.574	1.423	6.119	2.549	. . . . .	0.530	0.846
Specific gravity	1.265	1.280	1.328	1.360	1.180	1.383	1.434

No. 1 is an average sample from the Haddock mine. Sampled from the seam in the mine.

No. 2 from George's branch. Average sample from the stock pile at mouth of pit.

No. 3 from the Quicksand Creek mines. Average sample from the stock pile of coal at the mouth of the pit, taken by Mr. J. R. Procter.

No. 4 is from Frozen creek, near G. W. Johnson's. Sample averaged from a small pile of coal, not more than one or two tons. This is the coal which shows the brilliantly polished faces.

No. 5 from near the same locality. Analysis from a single specimen only. This specimen was not originally selected for analysis, and may, therefore, possibly represent the coal at this place as better than the average.

No. 6 from John W. Faulkner's, Stillwater creek. Analysis from single specimen.

No. 7 from James F. Ely's, Gilmore creek. Analysis from single specimen.

It will be noted that the last three analyses from single specimens show a very small per centage of sulphur, probably considerably less than the average of the coal would show if representative samples were selected. This is liable to be the case when single specimens are used for analysis, as it is very difficult to obtain one which is exactly representative in every respect.

With the exception of Nos. 4, 6, and 7, of which No. 4 is the only average sample, and consequently the only one which should be regarded as good evidence of the quality of the coal, the above analyses show coals of excellent quality, which will compare favorably with the best cannel coals of other localities.

For the purpose of such comparison, the following table of analyses of cannel coals is appended:

	1	2	3	4
Moisture	1.30	1.50	.....	.....
Volatile combustible matter	59.60	52.20	43.37	50.18
Fixed carbon	27.00	40.60	46.50	46.42
Ash	12.10	5.70	10.10	3.40
Total	100.00	100.00	.....	100.00
Coke	39.10	46.30	.....	.....
Sulphur	1.896	0.782	.....	.....
Specific gravity	1.213	1.306	1.27	.....

No. 1 is the well-known Breckinridge cannel coal, Breckinridge county, Kentucky. Analysis by Dr. Peter and Mr. Talbutt. Average sample by Mr. C. J. Norwood.

No. 2 the Hunnewell cannel coal, Greenup county, Kentucky. Analysis by Dr. Peter and Mr. Talbutt.

No. 3 Kanawha cannel coal, below falls of Kanawha Falls, West Virginia. Analysis by U. R. Johnson; copied from his work on coals.

No. 4 the celebrated Wigan cannel coal, from Lancashire, England. Analysis by Heddle.

CONCLUSIONS.

A brief summary of the principal points of economical importance in the foregoing report may not be out of place here.

Of the eight coals above the Conglomerate shown in the accompanying section, five are of workable thickness, considering a coal of two and one half feet as workable. These five coals range in thickness from two and one half to six feet.

Of the three remaining coals: of one nothing is yet known as to its thickness or quality; one is probably too thin to pay for working; while a third has been mined, although only a little over two feet thick. It is reported considerably thicker at other places, and very probably is so; but it cannot be stated positively as such, as it has not been seen by the writer.

Three of these coals are at places cannel coal, two of them workable, both ordinarily of excellent quality. In addition to the coals above the Conglomerate, there is at least one workable coal below, which is of excellent quality and covers a large area.

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PRELIMINARY SECTION FROM THE HEAD OF

CHIMNEY TOP CREEK WOLFE CO.

TO THE

MOUTH OF TROUBLESOME CREEK BREATHITT CO.

BY P. N. MOORE.

SCALE