GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT OF A RECONNOISSANCE

ON THE PROPOSED LINE OF RAILWAY FROM

LIVINGSTON STATION TO CUMBERLAND GAP.

BY C. J. NORWOOD.

PART VI. VOL. II. SECOND SERIES.

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PRELIMINARY NOTE.

The following report of Mr. C. J. Norwood is published in advance of the completion of the work of which it forms a part. It is the intention of the Survey to complete at least three sections from the Cambrian or Cincinnati axis, continued into the valley of East Tennessee or Virginia, in order to show the internal sections of the rocks of this part of the State and their connection with the lower-lying rocks of the region to the eastward. These sections will, taken together, not only give a basis for the better understanding of this district, but will aid in furnishing data for the study of the dynamic geology of the Appalachian Mountain system, as far as it is displayed in this region.

Mr. Norwood has been compelled to touch upon several of the important questions concerning the structure of the mountains in the neighborhood of Cumberland Gap. These matters are receiving the earnest attention of the Survey, but will require years for their mature consideration. Within a year I hope to extend the section given herewith so as to show the general resources of the country between Cumberland Gap and the railway connection of East Tennessee. This work will, however, be done without cost to the Geological Survey, by the aid of the Harvard Summer School of Geology, which holds its sessions in connection with the parties of the Survey.

A considerable amount of information, especially upon the questions of a theoretical nature, referred to in this report, will be found in the biennial report of the Director of the Survey for 1875, which is now in press, and should appear simultaneously with the volume of which this forms a part. A special report concerning the iron ores of Cumberland Gap

will be found in the fourth volume of reports (second series). Other reports on the timber resources, the soils, &c., of this district, are in preparation.

This report alone is, however, sufficient to show that any transportation route along this line will command a great area of available mineral resources.

N. S. SHALER.

INTRODUCTORY LETTER.

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

DEAR SIR: I herewith submit a report of a reconnoissance made along the path of the survey for a railway, extending from Livingston Station to Cumberland Gap, made, according to your instructions, in August, 1875.

Respectfully,

C. J. NORWOOD.

REPORT OF A RECONNOISSANCE ON THE PROPOSED LINE OF RAILWAY FROM LIVINGSTON STATION TO CUMBERLAND GAP.

I.

For the purpose of obtaining a somewhat better knowledge of the structure and of the general value of part of the region through which the "Knoxville Branch" of the Louisville and Nashville Railroad has been projected, some examinations were made along a line reaching from Cumberland Gap to Livingston, following near the path of the railroad survey. The distance traversed was about 70 miles, and the time occupied in the work was less by a few days than a fortnight; so that, upon the whole, the work should be regarded as only a "detailed reconnoissance;" and the accompanying section for this report is to be accepted only as a preliminary delineation of the relations of the beds in this district.*

The survey for the railroad, beginning at Livingston, crosses the Rockcastle river at a point about half a mile above Fish-trap ford, and thence, whenever possible, passing along valleys, takes its way to London, in Laurel county. From London it was carried to Flat Lick, Knox county. Two available routes were surveyed to Flat Lick. One of them passes within less than a mile of Barbourville, following the State road which leads from London to Barbourville as closely as the topography will allow, and thence up the right bank of the Cumberland river to Flat Lick. The second route follows the State road leading from London to Barbourville to within six miles of the latter town, then, turning to the southeast, it follows up

* It is to be remarked, that a large number of the heights were determined by *uncorrected* barometrical (Aneroid) measurements, and the results are, therefore, subject to future revisions.

—one of the tributaries of Collins' Fork of Goose Creek, to Payne's Cross Roads, whence it follows along the "old State road" to Flat Lick; thence it follows up the Cumberland river, passing through Pine Mountain at the Pineville Gap, to the mouth of Patterson's Branch, about three and a half miles above Pineville, whence the course is turned towards the south, and the survey carried up Patterson's Branch and up Cannon Creek, past Rocky Face, between that mountain and the first Log Mountain, to the valley of Yellow Creek; up which it is carried to Cumberland Gap. It seems unnecessary to discuss the relative merits of the two routes that have been suggested from London to Flat Lick, as the question is one which may be best left to the consideration of the engineers who made the survey. Whether or not the route approaching nearest to Barbourville is to be commended before the other, because of the facilities which will be afforded to the town instead of the country further east, is a matter best left to the judgment of those better informed as to the probable amount and value of the domestic exports of the two regions.

The geological examinations were more particularly made along a line passing through Barbourville; but it is proper to state, that, measured by economic resources, there is little if any difference, between the region along the Barbourville route and the region along the route which carries by the way of Payne's Cross Roads.

II.

The general structure of the region examined is made up of beds belonging to the coal measures. Some of the lower rocks have been brought up by faults.

At Cumberland Gap lower beds are brought to the light on the east side of the Cumberland Mountain by the great uplift that caused the mountain; and at Pineville, beds as low down as the Devonian black shale are brought up in the Pine Mountain fault. The region included between Pine Mountain and

Cumberland Mountain is suggestive of a number of problems that yet await a satisfactory solution.

It has been suggested that the country between the two mountains is virtually a great synclinal valley, with masses of nearly horizontal rocks piled over its greater part;* the two mountains, the Cumberland, with its beds dipping towards the northwest, and the Pine, with its beds inclining towards the southeast, forming two sides of the valley; and that the two uplifts are of nearly the same age.

Another interesting and important matter concerning the region between the Cumberland and Pine mountains, is the apparent change in the physical structure and order of the beds of the coal measures and the number of coal horizons, when it is compared with the region on the north side of the Cumberland river. It seems that the coal horizons decrease in number towards the northwest.

The thickness of the coal measures in mass seems also to be diminished towards the northwest, suggesting that towards the south or southeast the surface was gradually depressed, and that upon this inclined surface the deposits were laid down in approximately horizontal layers.

In other words, there seems to have been a deepening of the floor of deposit towards Cumberland Gap, when the beds were laid down.

Each bed added to the mass in the valley, so to call it, would certainly have entered into the total thickness of the strata, but when extended towards the rising ground, it would have not only lost in thickness as it advanced towards the summit, but gradually encroached on the old surface, and, passing beyond the limits of the immediately preceding deposition, formed of itself the sole covering of the original surface. And thus the thickness of the coal measures would have become less and less as the summit of the rising ground was neared. In fact, there seem to be many things in common, in their position and extent, between the carboniferous

*See the biennial report of N. S. Shaler for 1876, now in press.

beds in this district and deposits that are laid down on the sloping shore of a sea. See the figure in the following plate.

The fact of the increase in the thickness of the carboniferous deposits towards the southeast, and the probability of this being due to the conditions just described, have considerable bearing on the questions concerning the age of the Cincinnati axis, and the relations existing between the eastern and western coal fields of this State. Should the suggestions offered by the condition of the deposits in the region covered by this report be confirmed, there is little room to doubt that the two coal fields are, for the most part, entirely distinct.* The results obtained by examinations made in the vicinity of Manchester, Clay county, and along the road leading from that town to Fish-trap ford, Laurel county, very clearly show an increase in the thickness of the measures towards the southeast. An approximative estimate for the increase towards Manchester, in a distance of 33 miles, gives 700 feet or more as the amount of thickening in that direction alone, there being in that region a thickness of about 1,100 feet or more of beds between the horizon of the visible top of the Wild Cat Mountain conglomerate and the sub-carboniferous series, against 350 feet between the same limits on Wild Cat Mountain.

The accompanying plate of grouped sections exhibits the thickening of the beds towards Cumberland Gap with tolerable clearness.

III.

In consequence of the lateral changes undergone by the deposits, the region examined has been divided into three distinct areas, and a special grouping of the beds made for each area.

The first division includes, with the exception of the Yellow Creek valley, the area included between the Cumberland and

*This should be taken as the individual opinion of the writer. I shall hereafter endeavor to show that the eastern and western coal fields were connected during a part of their history. N. S. S.

Pine mountains, and may, for convenience, be designated as the Log Mountain area. All the knowledge now had concerning the structure of the Yellow Creek valley is largely conjectural, as, so far as I am aware, very few absolute facts concerning the beds underlying its surface were obtained.

My personal study of the valley was so limited that no suggestions of value were obtained concerning its structure; any discussion of the questions concerning it is, therefore, deferred or left to the consideration of those whose explorations may be more thorough.

There is, therefore, a gap of three miles or thereabouts left in the work—it being that space reaching from Log Mountain to Cumberland Gap.

As the structure of Cumberland Mountain was studied in more detail by other officers of the Survey, and under more favorable conditions than were possible for me, only a few general notes are given. The mountain is essentially the remnant of a great fold, which, extending in a northwestwardly course, thrust up the rocks from the southeast. By denudation, the larger part of the eastern slope of the uplifted mass has been removed, leaving the east side of the mountain to front Powell's valley, as a nearly bare face of the basseting edges (in the direction of the strike line) of beds that are tilted towards the northwest, and which make the northwest slope of the mountain.*

On the west side we have deposits of the coal measures only, but on the east the section shows beds from the coal measures to the Silurian, inclusive, as enumerated in the following statement, which represents the order in the beds descending from the pinnacle to Powell's valley:

1. Conglomerate and associated sandstones and shales of the coal measures.
2. Shale, olive green in color, and sandy . . . . . 75 feet.
3. Limestone of the Chester Group, in massive beds. In its upper part it is grey and coarse-grained, changing, however, to a drab, close-grained, rather knotty limestone at the middle and towards the base, having, also, much hornstone scattered through it. The upper beds yield the larger part of the organic remains . . . . . 30 "

*For a fuller discussion of the structure of this mountain, see the biennial report of N. S. Shaler for 1876.

4. Limestone, in dark colored and argillaceous, rather fragile beds. Upon weathering, the rock breaks apart and becomes granular. This bed is the principal deposit of the typical Chester fossils. *Athyris Royissii*, *Spirifer Leidyi*, *Productus elegans*, several *Pentremites*, *Retepora lyra*, and *Archimedes* are found. The lower part of this division forms a distinct bench, having a gently sloping surface, such as is usually characteristic of shale and limestone. This bench marks the junction of the Chester rocks with the St. Louis limestone . . . . . 30 feet.
5. Massive limestone of the St. Louis Group. The lower part of the limestone is grey and oölitic. This is soon succeeded by a greyish to light drab, faintly oölitic to rather dense limestone. At the base of the mass, as it nears the Waverly, the rock becomes silicious; a feature which is also apparent in some of its upper members. Some parts of the limestone are formed of hard calcareous nodules, bound together with a softer calcareous material, and as the weathering of the rock tends to dissolve out the softer material, the face of the limestone often has a pitted appearance. The collection of organic remains from this limestone is very meagre; in it are included *Productus mesialis*, *Prod. cora*, *Spirifer Keokuk*, *Spr. pseudolineatus*, and *Retzia Verneuiliana*. Thickness about . . . . . 400 "
6. Waverly Group, consisting of silicious shale, having hard bands and some beds of nodular chert, about . . . . . 155 "
7. Devonian shale, about . . . . . 100 "
8. Silurian, sometimes forming foot hills, sometimes on the main slope.

The bench, caused by the partial disintegration of the lower part of No. 4, forms of itself a well-marked line of junction of the Chester with the St. Louis Group. The more trustworthy means, however, of identifying the top of the St. Louis Group is by the fossil contents of its upper bed. At from one to three feet below the top of the group *Productus mesialis* and *Spirifer Keokuk*(?) are found to be rather abundant, especially the *Productus*, and to extend in a horizontal line with considerable regularity. The highest horizon to which these fossils extend may be considered as about the upward limit of the St. Louis Group.

There is a marked difference in the character of the subcarboniferous rocks in this region and those further west. In the western part of the State, the Chester Group is composed of a series of beds of limestone, shale, and sandstone, while in this region sandstone is entirely absent. The absence of the sandstone is especially noticeable, to one acquainted with the group, in its westward extension. In Western Kentucky there are from two to four beds of it, one of them being of special importance as marking the base of the Chester Group.

It varies from 60 to 250 feet in thickness, and has been designated in volume 1 of the reports of the present Survey (new series) as the Big Clifty sandstone.

Although there are marked variations in their texture, the change in the general physical character of the St. Louis beds is not so great as in the case of the Chester Group. The St. Louis beds further west are easily divisible into two great members, viz: the upper or grey limestone division, in the upper part of which is a bed of sandstone and some shale, and the blue or geodiferous limestone division. Here, however, such vertical divisions are not noticeable. The absence of the mud beds and sandstones in the Chester series here, shows the beds to have been rather deep-water accumulations. Further west, however, there are many evidences, not only of shallow-water depositions, but of frequent local currents in various places, which have rearranged the material already laid down.

Of course the few observations at hand do not justify an attempt at an elaborate comparison of the sub-carboniferous group, as it may occur over any considerable area in this part of the State, with its western equivalents; but the greatest apparent difference is probably in the points already given.

As the study of the structure of Cumberland Mountain, and the various other matters of interest pertaining to it, was made the work of other officers of the Survey, further discussion concerning it is omitted.

A preliminary grouping of the beds is all that can be given at present for the ground between Cumberland Mountain and Pine Mountain that is covered by this report.

Observations made by others in the country lying somewhat to the south and southwest of the line of this section tend to show that quite a considerable thickness of beds, including, perhaps, a dozen more coals, is to be added to the summit of the section to make it complete. In Canada Mountain alone there are about 15 beds of coal; the thickness of the section exceeds the one obtained along the immediate line of the railroad survey by some 1,100 feet. Canada Mountain is one

of the high peaks of the Log Mountains, the summit rising to about 3,075 feet above the sea.

The highest peak, Brysen, reaches to a height of 3,225 feet above the sea level, and holds about the same number of coal beds that are found in Canada Mountain—about seven more than are found along the immediate path of the railroad survey.* The nearest point in Canada and Brysen mountains at which the coals found in them may be reached from the railroad is, in Canada Mountain, about two and a half miles, and in Brysen Mountain, about eight miles from the road. There may, however, be points nearer than these at which coal may be obtained.

Without purposely trespassing on the ground of others further than the exigencies require, it is deemed advisable to present the following analyses, made by Dr. Peter and J. H. Talbutt, of samples of coal collected by other officers of the Survey from some of the beds in Bell county, lying within striking distance of the railroad line. This is especially desirable, as circumstances did not favor the collection of samples from the coals lying along the immediate path of the proposed railroad.

More elaborate descriptions of the coal beds from which the samples were taken will appear in the proper report.

*Two or three coal horizons that were discarded in the general section, because of their limited extent, are not taken into consideration.

COMPOSITION.	Col. J. G. Eve's. Fork Ridge, near Stony Creek. A. R. C.	Higgite Branch, upper bed. A. R. C.	Higgite Branch, middle bed. A. R. C.	Higgite Branch, lower bed. A. R. C.	Little Clear Creek, fifteen feet above bed of creek. A. R. C.	Little Clear Creek, in the bed of the creek. A. R. C.	Fork Ridge, near Stony Creek, four feet above cannel bed. A. R. C.	Barnett's Ridge, average sample. J. H. T.	Barnett's Ridge, from the portion sent to market. J. H. T.
Number	1.	2.	3.	4.	5.*	6.	7.	8.†	9.
Moisture	1.00	1.80	2.04	2.96	1.02	1.76	1.26	1.36	1.50
Volatile combustible matter . . .	43.60	35.50	36.64	35.28	37.76	38.90	33.96	35.80	37.94
Fixed carbon	47.80	52.20	58.02	59.40	48.22	52.54	55.42	59.54	58.40
Ash	7.60	10.50	3.30	2.36	13.00	6.80	9.36	3.30	2.16
Total.	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100 00
Sulphur	.590	.956	.736	.420	1.670	2.027	2.772	.975	1.038
Specific gravity	1.262	1.346	1.290	1.277	1.360	1.325	1.344	1.282	. . . .

* In shales first above the conglomerate?
† On a branch of Clear Creek, where it empties into Big Yellow Creek, six miles north of Cumberland Gap. The bed is 40 inches thick.
All samples marked A. R. C. were collected by Assistant A. R. Crandall. All samples marked J. H. T. were collected by Assistant John H. Talbutt.

The Cannel coal of Col. Eve's property* is somewhat remarkable in having the amount of volatile combustible matter and the amount of fixed carbon in nearly equal proportions.

Viewing the coal in its general character, it is found to be an admirable heating fuel. The amount of ash is small, the amount of water to be expelled is inconsiderable, and the proportion of sulphur is quite small. The amount of volatile combustible matters, however, is less than that contained in the best of gas cannels, although the amount in this case exceeds that contained in the average qualities of bituminous coals by from two to seven per cent., and would make the coal of value as a gas enricher.

The bituminous coals are, most of them, so far as the analyses prove, very good. In two or three of them the amount of ash is quite high, especially in that from Little Clear Creek,† which contains thirteen per cent. of earthy materials; but in the most cases the amount of ash is quite small.

* See analysis No. 1.
† See analysis No. 5.

The small proportion of sulphur in some of the coals is especially worthy of notice. It is to be remarked also, that nearly all of them exceed the *average* of Kentucky coals in the amount of fixed carbon they contain. About the best, in all respects, of the bituminous coals is the "lower bed" on Hignite Branch. The amount of fixed carbon (59.40 per cent.), and the small per centages of ash and sulphur (ash 2.36 per cent.; sulphur .420 per cent.), make it a very desirable coal, should it be found convenient to work it.

Indeed, an impartial comparison of the analyses of these coals with analyses made of those from Pittsburgh gives very favorable results for the Kentucky coals. So far as the analysis proves, the best of Pittsburgh coal is little, if any, superior to the Hignite Branch middle and lower bed, and the Barnett coal.

Following are analyses of samples of Pittsburgh coal:

	No. 1.	No. 2.
Moisture	2.00	1.397
Volatile combustible matter	29.70	30.133
Fixed carbon	65.30	65.050
Ash	3.00	3.260
Total	100.00	100.000
Sulphur	0.055	.1598
Specific gravity	1.291	1.2747
Analyst	R. Peter.	W. R. Johnson.

No. 1 is a selected specimen—a hand specimen. See page 363, volume 1, Kentucky Geological Reports, old series.

No. 2 cannot be considered an average analysis either; the probability is that the sample was better than the average.

IV.

The following statement exhibits the preliminary grouping of the beds in the "Log Mountain area."

It may, for the sake of convenience, be called general section No. 1:

1.	Sandstone	55	feet.	
2.	Sandy shale, mostly	60	"	
3.	Covered, occasional outcrops of sandstone	50	"	
4.	Sandstone	10	"	
5.	Concealed, mostly sandstone?	90	"	
6.	Sandstone	20	"	
7.	Concealed, mostly sandstone?	40	"	
8.	Shale, bluish-drab, and ochreous towards the base	45	"	
9.	Coal VIII, may be called the Buckeye Lick Coal. It varies from three and a half to four feet in thickness, and occasionally has a parting of one inch or more at about twenty-five inches from the bottom	4	"	
10.	Clay and shale	20	"	
11.	Sandstone. The upper and lower parts are usually in thin beds, but the middle is massive	75	"	
12.	Covered, possibly with a coal bed concealed	28	"	
13.	Sandstone	96	"	
14.	Coal VII^b			6 inches
15.	Shale	15	"	
16.	Coal VII^a			8 "
17.	Sandstone, merging into shale below	40	"	
18.	Cannel and bituminous coal overlaid by semi-cannel slate, some of which contains *Lingulæ*. Coal VI	1	"	10 "
19.	Sandstone and shale	35	"	
20.	Coal V. This varies in thickness from one foot to nine inches	1	"	
21.	Sandstone and shale; the lower part is frequently all shale	70	"	
22.	Coal IV	1	"	1 "
23.	Shaly sandstone carrying four horizons of coal, all lying near together and classified as Coal IV^a	65	"	
24.	Coal III; varies in thickness from twelve to sixteen inches	1	"	4 "
25.	Sandstone	20	"	
26.	Coal II^b			8 "
27.	Shale	10	"	
28.	Coal II^a	1	"	
29.	Shale; varies in thickness from twenty to thirty feet	30	"	
30.	Coal I; varies in thickness from two to four feet	4	"	
31.	Shale, dark blue and ochreous	50	"	
32.	Conglomerate. Base of section.			

As remarked hitherto, this section is to be regarded only as a preliminary grouping of the beds, and is put forward with some diffidence. The limited study of the district, for which it has been arranged, left some of the problems, including the question concerning the relative persistency of some of the beds and their lateral changes in thickness, in a not very satisfactory condition. In making up the section certain coal horizons were necessarily discarded in favor of others, although it was not entirely clear which had the greater range.

In such cases the thickest beds were always retained. It was also found necessary to shorten up the distance between one set of beds or to lengthen it out between others to make the average. Hence the general section represents only as nearly an average of the number of beds and their distances apart as it was possible to arrive at with the comparatively few observations taken. To do this it was necessary to reduce the number of coal horizons to which numbers may possibly be applied. There are, without doubt, as many as twelve, perhaps fifteen, coal horizons to be found in the space included in the general section; but of these there are probably not more than eight or ten to which distinctive numbers may be rightfully given, and the question can only be decided by a detailed study of the region, and not by a reconnoissance. What thickness a coal should have to be considered "workable" depends, of course, altogether upon the surrounding circumstances. In some regions a thickness of 18 inches is regarded as not too small, while in other coal districts 3½ feet is considered as the least thickness in which mining may be profitably carried on. The matter is governed by the general thickness of the coal beds in the region, their nearness or remoteness to transportation facilities, and their quality.

In this region, taking into consideration the quality of the coal, a thickness of 30 inches may be considered as workable when the bed is near to transportation facilities. Under this arrangement there are about three beds that may be considered as workable. These are Coals I, VI, and VIII. Coal No. VI is, so far as known, only 22 inches thick, but its mixed character (being part bituminous coal and part cannel coal) makes it as valuable as a coal 30 inches thick, and it may with propriety be classified as a workable bed. There may be other beds than these that will prove workable upon further search. With two exceptions, all of the coals were seen only as outcrops, and very frequently they were represented merely by stains or by a soft smutty material, so that there is no reason to suppose that any of them will prove thicker when found under better conditions. The total thick-

ness of the eight coals, so far as the section shows, is from 15 feet 3 inches to 16 feet 1 inch, of which two coals (Nos. I and VIII) form nearly one half. This is a small aggregate thickness for such a number of beds and 900 feet of other materials, although it exceeds that of the coal deposits in some regions by several feet. In 1,317 feet of upper coal measures, in Missouri, there are eight beds of coal aggregating in thickness to only 4 feet.

In the bank, Coal VIII appears to be of first-rate quality. The cannel of Coal VI also bears a good appearance. The cannel is probably equivalent to the cannel bed on Col. J. G. Eve's land, an analysis of which will be found on a preceding page.

As stated in the first part of this report, the path of the work between Pine and Cumberland Mountains lies in part along one flank of the Log Mountains and in part, as it enters the valley of Yellow Creek, along two detached mountains, known as Rocky Face and Dark Ridge. For the sake of convenience, the structure of each mountain, or that part of it which serves our purpose, will be considered separately.

DARK RIDGE.

This seems to be really an irregularly shaped spur or ridge striking out from Cumberland Mountain. Its form is peculiar, the figure being swelled in the middle and the main body connected with Cumberland Mountain by a narrow neck, from which flow down branches of Clear Creek on the north, and of Little Yellow Creek on the south. The ridge seems to have formerly been a connecting link between the Cumberland and Log Mountains; remaining so until it was cut away from Log Mountain by Yellow Creek. Unless it be that the neck which connects it with Cumberland Mountain is an exception, the beds in this ridge are virtually horizontal. It is very probable that in the neck mentioned the beds do have the same inclination, or nearly the same inclination, as the Cumberland Mountain mass, although this is not at all a settled question. It has been suggested that the Cumberland

Mountain is simply a great fold,* and that the beds forming its mass pass under the horizontal strata lying to the northwest without interruption. In such a case we may expect the bedding of the nearest rocks of Dark Ridge to conform with the slope of the Cumberland beds. But for this to be true—that is, for the Cumberland beds to pass without break beneath those of Dark Ridge—necessitates a rather sharper upward bending of them than we see, as horizontal rocks are found as near as three miles of Cumberland Gap, and a considerable less distance from the base of the mountain. Another suggestion has accordingly been made, to the effect that, somewhere in the ground lying between the base of the mountain and the first locality of horizontal rocks, there was a break in the beds when Cumberland Mountain was uplifted, and that the western edge of the disturbed mass was raised some uncertain distance above the undisturbed rocks further west. At present it is difficult to determine which of the two suggestions is true; at the most, they are scarcely more than mere conjectures, being valuable only as *possible* solutions of the problem, and only available, therefore, as suggestions to be proved or disproved.

The first observation of immediate interest on Dark Ridge was on Mr. John Colson's land, three miles west from Cumberland Gap, on the southern slope of Brush Ridge, a spur of Dark Ridge.

A coal stain 12 inches thick was noticed. Near by the outcrop a drift has been opened in the coal bed; but as the mine had been idle for some time the roof had given way and filled up the entry, so that the thickness of the coal seam could not be determined.

Just what bed the coal is, in the general order of numbers used in the General Section, is not clear, but it seems to be, without doubt, one of the lower beds. It is not improbable that it is No. II^a or II^b. A coal estimated to be three feet thick is reported to lie high up in the ridge, on Mr. Colson's

*See the biennial report of N. S. Shaler for 1876, volume III, second series, Kentucky Geological Survey.

land, about one mile and a half from this point. The coal is presumed to be No. VIII, as that coal is known to occupy a place in the surrounding high land, and is the only one of such considerable thickness to be found among the upper strata in this locality.

Figure A in the following plate shows a longitudinal section of the rocks in Dark Ridge and the shape of the surface contour of the ridge line from the north end of the ridge, where Yellow Creek sweeps round to the east (passing between Dark Ridge and Rocky Face), to a point about one quarter of a mile south of the pinnacle.

The point indicated as the pinnacle is the highest point on the ridge, and is 900 feet above the level of Yellow Creek at Esquire Boffman's house, which lies at the foot of the ridge, about half a mile south from the pinnacle. The figure is drawn from a stepped survey, and, taking into consideration the smallness of the scale, serves as a fairly good representation of the influence that the structure of a mountain, under certain conditions, has upon its surface features.

The section of the beds in the ridge, in descending order from the pinnacle to Esquire Boffman's, is as follows:

1.	Partially covered. Sand-tone is seen at the top and outcropping at various levels	55 feet.
2.	Shale	60 "
3.	Partially covered. Sandstone is exposed at various levels	50 "
4.	Sandstone	10 "
5.	Mostly sandstone	150 "
6.	Shale	45 "
7.	Coal VIII	4 "
8.	Sandstone	90 "
9.	Concealed: shale?	35 "
10.	Sandstone	40 "
11.	Shale	10 "
12.	Concealed	45 "
13.	Shale	30 "
14.	Sandstone	25 "
15.	Concealed: shale?	20 "
16.	Mostly shale and soft, thinly-bedded sandstone	220 "
	Total	879 "

This takes to the water line in Yellow Creek. The sandstone No. 8 is the most prominent stratum in the structure of

the ridge. Being, as a whole, harder and more homogeneous in structure than the other beds, it has resisted weather waste more successfully, and now stands out as a distinct band among the rocky layers. For this reason it forms a fairly trustworthy guide in tracing the extension of the coal (No. 7) along the ridge. The coal is indicated by a flat, miry bench upon the top of the sandstone, which is caused by the coal having wasted away upon exposure, while its under-clay, being tough and to a certain extent water-proof, has simply softened somewhat and spread out over the flat surface of the sandstone.

BUCKEYE LICK.

There is only one locality on the western slope of Dark Ridge where, so far as known to the officers of the Survey, Coal VIII has been opened for working.* This is at Buckeye Lick, in the neighborhood of Esquire Boffman's house. The ownership of the land upon which the opening was made was, at the time the examinations were made, the subject of litigation; the names of the parties were not satisfactorily obtained. With so little inducement offered by the surrounding country, very little mining has been done at the place. In fact, using the word in its usually accepted sense, no mining has been done. All the coal used was for domestic purposes, and was wagoned away in small quantities. When the locality was examined the seam was covered by debris, so that no measurements of its thickness could be made at the time of inspection; but, from a trustworthy source, it was learned that the bed, when last measured, showed a thickness of four feet, including a clay parting. The clay band is one inch thick and parts the coal into two members, the lower member being 25 inches thick. As will be noticed hereafter, this is a larger thickness by several inches than the coal shows at another locality lying to the southwest. A somewhat careful examination of the approaches to this coal deposit satisfies me that it may be easily reached from the railroad; and the expense for

*Reference is here had to that part of the ridge which extends from about half a mile south from Esquire Boffman's to the north end, where Yellow Creek cuts through to the east.

mining and preparing ways of carriage to the road will not be so great as at first seems probable.

By following up the little valley of a small stream flowing down from the ridge past Esquire Boffman's house, cars may be carried pretty well up towards the coal, and then, by the usual apparatus used for lowering coal down an inclined plane, the coal may be sent down to the car from the mine at a comparatively small cost. An investment of five or six thousand dollars should give the mine a very fair start.

Dark Ridge is supposed to contain a coal bed at a level below that at Buckeye Lick; its presence, however, was not proved.

ROCKY FACE.

This mountain presents for discussion a number of interesting questions, some of which it seems best to leave for the future.

In form the mountain is a rather irregularly figured line of elevation, extending for about two miles in a northwardly direction. Towards the south end a short blunt spur reaches out to the southeast for a short distance. For about two thirds of its length the course of the ridge line is nearly straight, but towards the south end it makes a curve, first to the east and then to the west, so that the south end is in line with the north end. The course of the main line of the crest is represented by figure 1 in the following plate.

The southern end of the mountain is made by Yellow Creek, which flows round from Dark Ridge and cuts off further southern prolongation of the mountain, and then turns to the north and flows down on the east side of the mountain, between it and the Cumberland range, to the Cumberland river.

Along the west face of the mountain Cannon Creek flows down to the north for about one mile and a half, then, rounding rather sharply to the east, passes in front of the north end and empties into Yellow Creek as it flows past the east face of the mountain.

It will be seen that the mountain is almost completely surrounded by water—that it rises up from the small valleys like a high island.

This curious feature in the flow of the streams—making first to the east for a certain distance and then turning to the north, as they do—is accounted for when the structure of the mountain is examined.

The general course of the mountain is north 60° east. The precise position that it holds relatively to Dark Ridge has not been determined; but if it were prolonged in the direction of that ridge it seems that it would pass to the east of the larger part of it, there being a possibility that it was connected with it towards Cumberland Mountain. It is not at all certain, however, that such was the case. As very little is known concerning the geographical features of the ground lying in that direction, any conjectures—for they are merely conjectures—concerning that question are of little value.

Rocky Face, like Pine Mountain, is a fault mountain, but it is an imitation of that mountain on a comparatively small scale. The amount of throw amounts, perhaps, to not much more than nine hundred or a thousand feet. The main mass of the mountain, so far as known, is a conglomerated sandstone, corresponding to the "Upper(?) Conglomerate" of Cumberland Mountain, which has been thrust up from the west and the beds tilted at various angles of dip towards the east, with shale beds towards the base. The average dip of the mass is about 27°, course north 70° east, the strike bearing south 20° west.

As intimated, the dip is not of the same amount at all places on the mountain, nor is the direction of the strike, although that is more uniform than the amount of dip.

About midway the length of the mountain the beds are found inclining at angles varying from 40° to 45°, and then towards the north and south at angles ranging from 15° and 20° to 32°, the course of the dip varying from south 60° east to nearly due east.

These variations in the amount of dip has, of course, modified the form of the crest line wherever a change occurs. Thus a dip of 45° produces a very sharp and narrow crest, almost impassable, with the sides of the mountain too steep to be ascended. This is well illustrated at one place where the crest is scarcely more than 18 inches wide for quite a distance, and the sides of the mountain merely steep uncovered masses of sandstone. An angle of 32° also gives a sharp ridge and steep sides to the mountain, while an angle of 15° gives an entirely different form to its outline.

Figure 2 of the following plate shows the form of the summit of the mountain at a place where the dip amounts to 15°. This figure having been drawn from careful notes made for this especial purpose, may be considered as a fair sample of the form of mountain crests, like in composition to Rocky Face and formed under like conditions.

Figures 3 and 4 show the shape of the mountain in mass at two other localities; one where the dip is as much as 45°, and the other where the beds have the average dip of 27°.

The changes in the amount of the dip of the beds and in its direction are curious, and at first seem inexplicable; but as the mountain is studied as a whole the cause becomes plainer.

In descending the northern slope of the mountain the beds are found to flatten out, and finally to pass under the horizontal rocks of the hills lying immediately to the north, and without any plain evidence of a dislocation. Then, passing towards the southern end, we find the rocks approaching horizontality in that direction, towards Yellow Creek, although they are still tilted at a steep angle—about 10°.

From this we plainly see that the mountain is due to a sharp thrust which fractured the beds for only a comparatively short distance north and south, at the same time raising them some nine hundred or a thousand feet above their original level for the length of the crack. When the ends of the crack are reached, the beds are, of course, found to lie at their true level and to retain their general horizontality. It accordingly follows, as a natural sequence, that the steepest

angle of inclination of the beds is to be found about midway the length of the fracture, while towards the ends it decreases at various rates.*

The descent of the conglomerate at the north end of the mountain, to pass beneath the horizontal beds in the opposite hills, and the gradual flattening out of the mass, are distinct features in the structure of the mountain. A fracture extends across the mountain in the direction of the dip at the point where the commencement of the northward descent of the sandstone is most perceptible. At one time it was thought likely that this crack indicated that the fall of the mass towards the north was of a later date than the general uplift, but later observations tend to show that it occurred at the time of the uplifting, and acted as a relief to the strain on the beds.

Whether or not the beds are entirely unbroken in their extent across the valley, as would seem to be the case, is not quite clear, as, although there is not yet sufficient evidence gathered to lead us to believe in the existence of a fracture in the Cannon Creek valley, it is unsafe to assume that there was not a crack, accompanied by a slight uplifting of the mass, on the southern side.

Figure 3 in the following plate is a rude representation of part of the western face of the north end of the mountain, showing the fracture in the conglomerate and the descent of the rock towards Cannon Creek.

The presumption is that the beds flatten out from the south end also; but this is yet an unsettled question: all we know is, that, as the southern termination of the mountain is approached, there is a considerable lessening in the amount of the dip of the beds.

The causes tending to bring Yellow and Cannon Creeks to the east, at the points where they make the turn, and then to again change their course and direct them towards the north, are interesting.

*These facts are in accordance with the general results obtained by the several officers of the Survey who preceded me in their examinations of the ground.

To a large degree they have been influenced by the position of the beds as well as by the character of the material through which they flow. Yellow Creek, when flowing by Dark Ridge, is resisted by horizontal rocks on all sides, and accordingly cuts its way towards the north (having already an impetus in that direction) rather than towards any other point. Passing on to Rocky Face, however, it found horizontal rocks only on the north and west, those on the east being tilted towards the east. This arrangement of the beds changed the ratio of resistance, making it less on the east; in which direction the stream accordingly cut its way—the position of the beds being such as to greatly favor the work.

The Yellow Creek valley on the east side of the mountain is to a certain extent a synclinal one, coursing northwardly; accordingly, when the stream had eaten through the mountain, and entered what is now the valley, it received another check in its course, and was turned towards the north.

The same influences, with perhaps some small differences of detail, were brought to bear in directing the course of Cannon Creek. We find here, therefore, a fine illustration of the bearing that the composition and position of the hard materials underlying a district have in directing the course of its waterways.

THE LOG MOUNTAINS.

The Log Mountains, or rather those parts that come within range of the path of the reconnoissance, owe the larger part of their interesting features to their economic value. They are, it is true, monuments to the sculpturing power of water, and offer in their various parts instructive lessons in the study of the action of running water on variously composed materials; but beyond that there is, with one exception, but few points of interest attached to their merely stratigraphical conditions.

In their stores of economic materials they are of immense value, and have in that respect far more interest attached to them than any part of the region hitherto discussed.

Unlike the mountains hitherto discussed, these mountains had their origin in the eroding effect of water, and not in any great movement of the rocky masses. In general the beds which enter into their structure—notably sandstones and shales—are comparatively horizontal.

A list of the beds making up that part of the mountain examined has already been given, and is designated as "General Section A."

The total number of coal beds indicated in it are eight; but this does not include all that are to be found beneath the surface.

At some points there are a number of what may be called local beds crowded together that were not included. As stated on a previous page, however, the precise character of these beds has not been determined, hence they are only provisionally excluded.

Of the eight beds enumerated, about three are certainly workable, while others have not been sufficiently exploited to prove their character.

The thickest bed is also the highest one, and the one ranking next to it in thickness is the lowest. This arrangement, upon the whole, is a very convenient one, as it gives greater scope to mining possibilities than when the workable beds are all close together.

Coal VIII has been opened on Saw-mill Ridge, near the first summit, at the head of Jack's Branch, which is one of the many small mountain streams making down to Yellow Creek. The land on which the coal has been opened is the subject of litigation—the respective claimants being Messrs. Boffman and Tinsley.

The coal where tested is 2 feet 8 inches thick; but there seemed to be some reason to presume that, as the bed is followed under a more solid surface, its thickness may increase to at least three feet.

The following statement is a section of the beds in the ridge in descending order from near the level of Coal VIII to Mr. Arthur McTee's house:

1.	Slope covered with fragments of sandstone.				
2.	Sandy shale	10	feet.		
3.	Coal VIII	3	"	8	inches.
4.	Concealed	20	"		
5.	Sandstone; thinly laminated	55	"		
6.	Concealed; a coal horizon reported at the top	173	"		
7.	Sandstone	10	"		
8.	Shale; ochreous	20	"		
9.	Shale; very dark blue	10	"		
10.	Black slate containing *Lingula*			6	"
11.	Coal (VI?)	1	"	10	"
12.	Concealed	85	"		
13.	Sandstone	30	"		
14.	Shale; sandy	25	"		
15.	Coal, reported (IV)	1	"	1	"
16.	Concealed; shaly sandstone?	10	"		
17.	Shaly and bedded sandstone and shale	65	"		
18.	Concealed	3	"		
19.	Shaly sandstone	10	"		
20.	Shale in hard bands; ochreous and blue	7	"		
21.	Coal III	1	"		
22.	Sandy shale; yellow and dark blue	20	"		
23.	Coal II			7	"
24.	Shale and sandstone	10	"		
	Total thickness of beds	570	"	8	"

The coal No. 11 is regarded as No. VI, which, in other localities, is in part a cannel of apparently good quality. It is only 22 inches thick, but the surrounding circumstances are such that it may prove of practical value.

Coal I is probably below drainage in this locality, lying about on a level with the bed of Yellow Creek.

By a properly devised system of inclined planes, the coal towards the summit of the ridge may be worked with comparative ease; and the lower bed, Coal I, reached by shallow shafting.

As previously stated, the beds in this part of the range are nearly all horizontal. But south from Mr. McTee's, at a point where the State road begins to enter the Yellow Creek Valley, a low hill, serving as a sort of foot hill for the mountain, has been formed of beds that are nearly vertical. The place is represented on the profile section as being about 3½ miles from Cumberland Gap. Figure A on the profile is drawn on a natural scale of 200 feet to the inch, and serves as a tolerably fair representation of the position of the beds.

It should be stated, however, that the measurements were not made with as much accuracy as was really desirable, but were mostly estimated. The following is accordingly an approximate statement of their arrangement, beginning on that side of the hill looking towards Cumberland Gap:

A. Thin-bedded sandstone	36	feet.	
B. Sandstone and shale	180	"	
C. Semi-cannel coal, about	1	"	7 inches.
D. Sandy shale	108	"	
E. Coal	?	"	
F. Sandstone shale.			
G. Coal	?4	"	

The thickness of the several coal beds is especially uncertain, as they are naturally in a crushed and powdery condition at their outcrops. They are nearly vertical, and seem, most of them, to be distinct from those seen in the mountain. The causes tending to arrange the beds thus, and the question concerning their original place, are problems not yet satisfactorily solved. From the condition of the rocks exposed in the face of the mountain as the ones in question are approached, however, we are helped to a suggestion, that, as a probability, seems to have some merit.

As may be seen in the graphic section, the strata begin to rise towards the south, at about one mile and a half beyond Mr. McTee's house, and continue to ascend thus for nearly half a mile; then, in less than an eighth of a mile, the dip is reversed, and the beds slant towards the south, thus forming a small anticlinal at about half a mile beyond Esquire Boffman's house.

The point at which the beds are nearly vertical is not quite half a mile beyond where the crest of the anticlinal is presumed to be.

Now, by extending the lines of all the beds towards the south, we find what appears to be some relation between those in the foot hill, so to call it, and those in the main mountain; we find it suggested that the most northwardly coal in the foot hill, the four-feet bed, is the Buckeye Lick seam (Coal VIII), and that the others are higher than any of the coals enumerated in the General Section. It would then follow that the

foot hill is a downthrow from the northwest, and that these displaced beds originally held a position at least 400 feet above their present position. At the best, however, the whole matter resolves itself into a conjecture. Although there are reasons for regarding the suggestions given as the most probable solution of the question—among which may be mentioned the failure to find the same order in the strata towards the north, it is possible that the beds may belong towards the base of the section, the thickest coal being Coal I, and that their position may bear some relation to the Rocky Face fault—the beds having been pushed up in this position at the same time that that mountain was formed.

Near Mr. Frederick Barner's, on the northeast spur of Log Mountain (the "second Log"), which forms the divide between the waters of Yellow Creek and Cannon Creek, there are a number of coal horizons visible. Following is a statement of the number of the beds and their order. The section was obtained along the old Pineville road, beginning at the pinnacle of the mountain on the north, and descending to the valley of Yellow Creek, at the point where the old road coincides with the one now in use:

1.	Mostly covered space. Outcrops of sandstone are occasionally seen	275 feet.	
2.	Sandstone in an indurated mass, which forms a prominent bench	25 "	
3.	Sandstone in rather thin beds; is in alternately hard and soft strata	25 "	
4.	Nearly all soft sandstone; probably merging into sandy shale towards the base	35 "	
5.	Shaly sandstone and sandy shale	5 "	
6.	Indurated sandstone band	3 "	
7.	Areno—argillaceous shale	2 "	
8.	Coal stain having a clay parting, thus: *a*. Coal, 3 inches; *b*. Clay, 2 "; *c*. Coal, 1 "		6 inches.
9.	Under-clay	5 "	
10.	Sandstone; disintegrates in spots; full of hard concretions of sandstone	10 "	
11.	Indurated sandstone, with occasional shaly layers	25 "	
12.	Coal divided by a clay seam, thus:* *a*. Coal, 3 inches; *b*. Clay, 2 "; *c*. Coal, 3 "		8 "

* This may not be precisely in place.

13. Shale				5 feet.		
14. Sandstone and shale; the shale predominating				5 "		
15. Coal					4 inches.	
16. Shale having sandstone nodules distributed through it.				5 "		
17. Coal stain	1½ inches					
18. Indurated sandy shale	1½ "					
19. Coal stain	½ to 3 "					
20. Indurated clay	6 "			2 "	4 "	
21. Coal stain	2 "					
22. Hard, ochreous sandy shale.	6 "					
23. Coal	6 to 8 "					
24. Sandstone; thin bedded; weathers into thickly laminated shale				10 "		
25. Coal; local?			1 to 1	"	2	"
26. Sandstone; shaly at top				20 "		
27. Coal covered by a thin slate					8	"
28. Bluish and ochreous shale				10 "		
29. Coal stain					1	"
30. Sandstone and sandy shale, the shale somewhat ochreous.				25 "		
31. Concealed				15 "		
32. Coal I, outcrop (said to measure 4 feet)				2 "		

The lowest coal, No. 32 of the section, has been opened at several places on Mr. Frederick Barner's place and in the vicinity.

The coal crops out in the road by Mr. Barner's, showing a thickness of two feet; but Mr. Barner states that he measured the coal with a carpenter's "square" at two of his pits, and in each case the thickness was four feet. At the time the examinations were made, the pits were filled with water. The section was made near Mr. Barner's house, and may be considered as a representative one, for the height that it reaches, of that part of the mountain extending from Mr. Arthur McTee's (just north of Saw-mill Ridge) to the ford of Cannon Creek, opposite the west face of Rocky Face.* There are, perhaps, a number of minor changes in that distance—five miles—but not enough is known of the details to warrant a discussion of them.

Passing from Mr. Barner's towards Cannon Creek ford, beds are sometimes seen that are tilted at small angles, usually towards the west, as the road approaches the line of the Rocky Face fault. The precise nature and extent of these disturbances, however, is not known; although their position

*It must not be forgotten that these sections are to a great extent preliminary.

suggests that they have a limited extent, and are merely the ends of the horizontal beds that were bent upwards somewhat when the great fracture occurred and Rocky Face was elevated. There are many other matters not only of economic value, but of special interest to the geologist, that are left undiscussed for want of sufficient data.

From Cannon Creek ford to Pineville examinations were made along two routes; one lying along the path of the railroad survey, and the other following the common road. The latter route crosses directly over one spur of the mountain known as the "third Log," leading from the valley of Cannon Creek to the valley of Clear Creek; whereas, the former one follows down the valley of Cannon for about one mile from the ford; then over a low gap to Patterson's Branch, and down that to the Cumberland river; passing thence, along the foot of the mountain, to Pineville.

As the horizontality of the beds is preserved well up to Pine Mountain (in the gap of which Pineville is situated), no new points of interest are offered in the structure of the ground passed over. All that section lying between Rocky Face and Clear Creek seems to be one mass of horizontal, or nearly horizontal, rocks. We begin, however, to note a diminution in the number of coals as we travel northwest, the number of beds evidently being less in the district lying towards Pine Mountain than in the section extending towards Cumberland Mountain, in the direction of Tennessee.

The following statement may be accepted as an approximately correct General Section, for the height that it reaches, of the beds in the region under consideration:

1. Sandstone	15 feet.	
2. Covered	85 "	
3. Sandstone	10 "	
4. Concealed	20 "	
5. Sandstone	120 "	
6. Concealed. Coal VIII may be present	13 "	
7. Mostly sandy shale	100 "	
8. Coal VII^c ?	trace.	
9. Sandstone	80 "	
10. Coal VII^b		6 inches.
11. Shale	15 "	

12.	Coal VII[a]				8 inches.
13.	Sandstone		40 feet.		
14.	Coal VI divided thus:				
	a. Cannel coal . . . . 12 inches *b.* Bituminous coal . . 9 "		1 "	9 "	
15.	Sandstone and shale		35 "		
16.	Coal V			9 "	
17.	Sandstone		130 "		
18.	Coal IV?		1 "	4 "	
19.	Shale, about		120 "		
20.	Conglomerate sandstone and shale beds.				

It will be noticed that out of the eight coals held in the mountain lying to the southeast, only five or six are represented here. Coal VIII was not seen, but there is a probability that it will be found in the space indicated by No. 6 in the above statement.

Just where bed 18 of the section belongs, in the order of numbers applied to the coals, is somewhat conjectural still. It is provisionally placed as coal IV, although it may be any of the numbers down to No. I, provided that their associate beds have changed. There are some circumstances, however, which favor the probability of its being No. IV rather than any other number. This being true, we here have our first suggestions as to the manner in which the coal beds decrease, the absence of the beds I, II, and III showing that the diminution is regularly from the bottom upwards, which would be in exact accordance with the idea advanced in the first pages of this report, viz: that there was a *downward* increase in the general thickness of the coal-bearing series towards the southeast, and also in the number of coal beds.

Whether it be true or not, however, that the coals diminish *regularly* from the bottom upwards, it is evident that they do disappear towards the northwest, which still favors the idea just referred to.*

Coal has been opened at a few places within easy reach of the wagon road; but, as in the case of the other districts, the openings are few and in a poor condition for examination—there being no industry in the region whereby constant mining could be sustained.

* This is the general result of the observations made by the officers of the Survey in this district.

On the path of the railroad, as it leaves Cannon Creek ford and makes toward Pineville, there is but one place of opening in any of the coals, so far as was learned.

At Mr. Hugh Browning's, just back from the Cumberland river, about three miles above Pineville, a compound bed of cannel and bituminous coal has been "faced out," and another coal bed discovered below.

Following is a section of the beds seen in the branch flowing down from the cannel bed to the river:

1. Sandy shale and sandstone		20 feet.	
2. Argillaceous sandy slate			10 inches.
3. Bituminous slate			4 "
4. Drab and ochreous argillaceous slate		1 "	
5. Cannel slate			1½ "
6. Cannel coal . . . . 1 foot 7. Bituminous coal . . 9 inches }	VI	1 "	9 "
8. Sandy shale and thin-bedded sandstone		51 "	
9. Thinly laminated sandstone and shale		10 "	
10. Concealed		5 "	
11. Coal stain; slided? Coal V		1 "	
12. Concealed		35 "	
13. Shaly sandstone and sandy shale; mostly the latter		50 "	
14. Concealed		5 "	
15. Shaly sandstone and sandy shale		20 "	
16. Concealed to the Cumberland river, at a low stage of water		30 "	

The coals of No. VI are apparently very good in quality, and are easily accessible from the river. At a cost of perhaps not more than five thousand ($5,000) dollars, the necessary machinery may be purchased, and the ground be prepared for profitable mining on a large scale. These coals may, doubtlessly, be found in the Log Mountains for some distance both up and down the river from Mr. Browning's, wherever the elevation is sufficient to reach their horizons.

PINE MOUNTAIN.

This mountain is a true fault mountain, the slant of the uplifted rocks being towards the southeast, forming as it were one rim of a wide synclinal valley.

The fault, which is a clean fracture, courses about N. 60° E., and forms the northwest face of the mountain.

At Pineville, in the immediate vicinity of which the mountain was examined, the average amount of the dip of the beds

is about 30°, and the course about S. 30° E. Towards the base, on the northwest face, the amount of the dip is of course greater, and towards the southeast it is less than the average.

The amount of throw of the fault has not been determined with perfect accuracy, but it is apparently at least 2,700 feet; more than twice the height of the mountain, which measures 1,100 feet for its average and 1,200 feet for its maximum height, above the river near Pineville.

Upon comparing the heights of the several mountains, it is found that Pine Mountain is one of the lowest in the region. Rocky Face and Pine Mountain, both of them true fault mountains, have about the same altitude.

Following is a table of comparative heights determined by barometrical observations (mercurial), the sea level being used as a datum for measurements:*

Cumberland Mountain; the Pinnacle	2,500 feet.
Brysen Mountain	3,225 "
Canada Mountain, on Log Mountain	3,030 "
Moore's Peak, on Log Mountain	2,413 "
Signal Point, on Log Mountain	2,138 "
Saw-mill Peak, on Log Mountain	2,024 "
Rocky Face	1,900 "
Pine Mountain	1,950 "
Powell's Valley, Tennessee	1,300 "
Yellow Creek Valley	1,100 "
Cannon Creek, at the ford, about	1,000 "

For convenience, a list of comparative heights, with reference to the Cannon Creek ford, has been calculated with approximate accuracy, and is given:

Cumberland Mountain; the Pinnacle	1,500 feet.
Pine Mountain	950 "
Rocky Face	900 "
Yellow Creek Valley	100 "
Powell's Valley	300 "

By these tables we see that Pine Mountain, although more distinctly prominent than some others, mainly because of its form, is really one of the least considerable. For instance, it is only 50 feet, or thereabouts, higher than Rocky Face,

*These heights are not, all of them, free from possible error; if one exists, however, it is inconsiderable. I have to thank Wm. Byrd Page, Esq., Topographical Assistant, for most of the data from which the table was compiled.

while it is several hundred feet lower than a number of the mountain peaks forming the group known as the Log Mountains. Moore's Peak, the highest point in the group, which lies between Pine Mountain and Rocky Face, rises 463 feet above Pine. The mountain is cut by the Cumberland river at Pineville, the river making in a northwestwardly course towards Barbourville, after following down its northwest face for a short distance. The causes tending to affect the river, so that it preserves its bearing towards the northwest after having passed through the mountain, instead of closely following the line of the fault, as the circumstances would lead us to expect it to do, are as yet unexplained.

The sketch on the following plate serves to convey an idea, somewhat vague though it may be, of the geographical conditions in the immediate vicinity of the gap.

Straight Creek, it will be seen, follows the line of the fracture closely, and of itself distinctly marks the break.

Clear Creek also follows its part of the mountain closely, so that on a good map of these streams the trend of the mountain is indicated with close accuracy by the course of the streams.

The fault making this mountain is a very clear one. Immediately on the northwest side of the Cumberland river, only a short distance from the foot of the mountain, the beds are nearly if not quite horizontal, and of themselves show no evidences of a disturbance; on the southeast side of the mountain, the beds overlying those forming its structure slope gradually away and soon regain their horizontality.

The following is a statement of the beds that enter into the structure of the mountain:

1.	Conglomerate sandstones and shales	1,580 feet.
2.	Shale	160 "
3.	Concealed	35 "
4.	Sub-carboniferous limestone	320 "
5.	Covered space	30 "
6.	Waverly beds	150 "
7.	Covered space; may be Waverly in part	55 "
8.	Covered space with a nearly flat slope	110 "
9.	Outcroppings of Devonian slate	70 "
10.	Concealed space to the river	300 "

These measurements were made by angles, and were subjected to several tests; hence, for the kind of work in hand, they may be considered as fairly accurate.

On the northwest side of the mountain a low sharp spur, so to speak, reaches out from the base, about which centres a considerable amount of interest. The spur is indicated in the profile section by the letters A and B. At about 300 feet from the place where the last outcrop of Devonian shale is seen, and at an altitude of about 275 feet above the river, a large mass of hard, closely-grained, somewhat quartzose sandstone (some 35 or more feet thick) is seen, resting in almost vertical beds, having, however, a slight inclination towards the northwest—a direction directly opposite the course of the dip of the main mass of the mountain. The original position of the rock is quite obscure, so far as any examinations yet made would show. There are two methods by which to account for its position, neither of which, however, are more than mere conjectures. Apparently the most plausible suggestion is, that it is a member of the conglomerate series, which was bent upwards when the mountain was raised: this would indicate the line of fracture as being between this mass and the main mountain. Another suggestion, but against which the northwardly inclination of the rock is opposed, is, that the sandstone has its place in the upper series of beds included in the Niagara period. *

It does not seem desirable, however, to spend further space in conjectural explanations concerning it.

The Pine Mountain fault, as it is usually termed, may prove of considerable money value to the region in which it lies.

In the series of rocks coming next below the black shale of the Devonian group, in this section, are beds of remarkably fine and soft hematite iron ore, known as the "dyestone ore" in Tennessee and Alabama, where, perhaps, it has its best development, or as the Clinton ore in other localities. This ore is brought up by the Cumberland Mountain fold, so that it

* Further study may prove both of the propositions untenable; showing instead that it is merely a large mass that has broken away from some of the sandstones now forming the summit of the mountain.

is easily reached in the ground lying on the opposite side of the mountain from Kentucky. A number of measurements were made at that place by Mr. P. N. Moore, for the purpose of determining the distance between the first ore (there are three beds) and the Devonian shale, and will be found in his report on the iron ore deposits of that region. Unfortunately none of his results are at my command at present; but, from subsequent observations made at another locality, I think it safe to compute the distance at something less than 300 feet. It is not improbable, then, that the lift of the beds in Pine Mountain has also been sufficient to bring the ore, at least the upper bed, within comparatively easy mining distance from the base of the mountain. It, at all events, would be worth searching for by extending a drift into the mountain, starting it a little above drainage. It is a matter certainly of sufficient importance to warrant a judicious outlay of money in prosecuting a close search for the ore. Dr. Safford, State Geologist to Tennessee, records the fact that the ore is brought up by the fault further to the southwest, so that the westward extension of the ore is clearly proved.*

FROM PINE MOUNTAIN TO BARBOURVILLE.

Following the course of the State road, the beds are pretty generally horizontal, and all lie above the conglomerate. The observations made between the two places—over a distance of sixteen miles—were very imperfect, the weather being quite stormy, which so affected the barometrical observations as to render them nearly useless. It is believed best, therefore, to defer any discussion of the region until more accurate observations may be made, and the notes already taken be perfected. Several exposures of coal dirts were seen, some of which may prove valuable. There are also some workable beds that are opened; but, as in other cases, they are not wrought for any but domestic purposes.

Coal is opened on the land of Mr. Ely, Mr. Joseph Smith, and of Mr. John Tuggles. The latter place is about one mile

* For a discussion of the question of the existence of this ore at this point, see the biennial report of N. S. Shaler for 1875, Kentucky Geological Survey, second series, volume III.

and a half beyond Mill Branch. The coal is 26 inches thick, is overlaid by a sand rock, and is about 180 feet above the low part of the road near by. The coal is probably not so high above Barbourville. It is not improbable that there are other coal openings on the route than those mentioned.

FROM BARBOURVILLE TO LONDON.

Beyond Barbourville we seem to get further changes in the rocks, the sandstones giving way to shales or vice versa, and the whole mass becoming thinner.

On Mr. W. F. Costellow's land, up Smoky Creek Fork of Richland Creek, and about two miles from Barbourville, on the London road, a coal has been opened which is probably the equivalent of the coal of Mr. John Tuggles. The coal is quite hard and made up of alternating laminæ of fibrous and hard glossy black coal. Its thickness will average about 24 inches. The proportion of iron pyrites in the coal is apparently small, and altogether its quality seems to be very fair.

This bed is the main coal of the region. It is overlaid by a sandstone and underlaid by sandy shale. At about 50 feet below it darkish shale occurs, and forms a very prominent feature in the order of the beds.

At Mr. Archibald Britton's spring-house, about three miles beyond Barbourville, a coal is found that may prove equivalent to Mr. Costellow's; apparently, however, it is from 20 to 30 feet below that bed. About one quarter of a mile beyond Mr. Britton's another coal is seen, which shows a thickness of 16 inches; it is overlaid by 10 or more feet of shaly sandstone. This is at Smoky Gap, and the coal is about 75 feet above Costellow's. The following preliminary general statement of the section, for the region between Barbourville and Laurel river, will serve to show the relative positions (as they are now understood) of the most prominent coal beds:

1. Shale	25	feet.
2. Sandstone (the Wildcat Mountain conglomerate?)	35	"
3. Coal	½	"
4. Sandstone	75	"
5. Coal stain	1¼	"
	239	

6. Sandstone	90	feet.
7. Coal (V? of the Log Mountain section)	1⅓	"
8. Shale and sandstone; the shale in the upper part	77	"
9. Coal (IV? of the Log Mountain section) 2 feet to	2½	"
10. Shale, dark blue and ochreous	95	"

At Mr. James Britton's a coal equivalent to Mr. Costellow's has been wrought. It is 25½ inches thick, and is covered with 10 or more feet of sandstone, with the dark shale seen near Barbourville underlaying it.

Beyond that fork of Richland Creek which drains the country between Mr. Britton's and Mr. Wm. H. Brafford's is a coal stain probably equivalent to the Smoky Gap coal. The positions of the several coal horizons may be determined from the graphic section accompanying this report, however, and it is not considered necessary to offer further notes on them at present.

Passing on to London, the rocks seem to wedge out, as may be seen in the preliminary horizontal section, and the coal beds decrease in number between the dark blue shale of Barbourville and the Wildcat Mountain conglomerate, if the geolgy has been rightly interpreted.

Following is a statement of the beds at and in the vicinity of London:

1. Sandstone, the conglomerate of Wildcat Mountain	20	feet.
2. Mostly concealed	75	"
3. Sandstone and shale	25	"
4. Coal stain	½	"
5. Shaly sandstone and shale	30	"
6. Coal (IV? of the Log Mountain section), 21 inches to	3	"

The Coal No. 6 is presumed to be, probably, identical with Mr. Costellow's. It is opened in a small valley just west of the town, and has been worked by stripping. The openings, or most of them, have been made on Mr. John C. Brown's land. The land near by, which is hill land, is owned by Messrs. C Pitman, Jarvis Jackson, and W. L. Brown.

The Wildcat Mountain conglomerate covers the hills around London, and extends thence to Wildcat Mountain. The six inches of coal at London (No. 4 of the section) thickens to 15 inches at half a mile beyond the town, and may prove valu-

able in other parts. It is probably identical with the 15 inches of coal at section 34, on the horizontal section.

At two miles beyond London the lower coal seam (No. 6 of the section) has been opened and wrought on Mrs. Evelyn Brown's land. The coal is two feet ten inches thick, and apparently of good quality. The coal dips slightly north 75° west.

The same bed has been opened on Mr. Pitman's land, half a mile beyond Mrs. Brown's, where it measures three feet four inches, and three feet; and at Mr. Allison Woods', about one mile and a quarter beyond Mrs. Brown's, where it is said to measure between three and four feet in thickness.

At about five and a half miles beyond London the pink and drab beds of the Wildcat Mountain conglomerate come to view, and form the most prominent features of the upper part of the section on to Wildcat Mountain.

At a point about six miles from the Rockcastle river ford, a coal stain two inches thick is seen at 35 feet below the base of the sandstone; and at 95 feet below the base of the sandstone a coal bed has been opened which may prove equivalent to that at Mrs. Brown's. A short distance beyond that point three inches of coal, apparently corresponding to the first bed above Mrs. Brown's, is exposed.

At about half a mile further the descent is made into the valley of Hazel Patch Creek, a stream emptying into the Little Rockcastle river. Nearly everything is covered by debris on the hillside, occasional outcroppings of shale and sandstone being all that may be seen.

In the valley, about five miles from the Rockcastle river ford, two (possibly more) openings have been made in coal, but they are now filled up. The coal is one foot or more thick.

Whether this coal is in place or not is still a question. It seems to be undoubtedly equivalent to the Livingston coal; but within a less distance than three miles it is found at a level 120 feet below that of the Livingston bed; and, what is more remarkable, it is topographically 70 feet below the

top of the sub-carboniferous beds which are exposed on the opposite side of Wildcat Mountain, as may be seen in the graphic section. It is a question that merits study, and is one that it is preferred shall be left open for a while, although it would now seem that the coal is not in its true place, but has been lowered either by a great slide or a cave fault.

WILDCAT MOUNTAIN.

With the study of part of this mountain, the work of the reconnoissance was ended.

The structure of the mountain is simple. The mass is virtually a pile of nearly horizontal beds which have been fashioned into its present form by water. The summit of the mountain (that part of it which was examined) is made of a soft disintegrating pink and drab and light colored conglomerated sandstone. It is very questionable whether this rock belongs to the series lying near or at the base of the coal measures as they appear further to the south. There seems to be much reason to presume that it is entirely distinct from the Pine Mountain and Cumberland Mountain conglomerates; that it occupies a higher geological level. The observations made so far tend to give such an impression; and if this should prove true, those conglomerates would be represented by the lower conglomerate of this mountain, which, at most, is not over 30 feet in thickness. Following is a statement of the order in the beds on the northwest side of the mountain, descending to the ford of the Rockcastle river:

1. Conglomerate; massive in its upper members and soft, but becoming harder towards the base and in thin beds	120	feet or more.
2. Mostly concealed, seems to be mostly bluish-drab sandy shale	10	"
3. Hard sandstone	5	"
4. Dark stain, possibly a coal mark?		
5. Dark and drab argillaceous and argillo-sandy shale	25	"
6. Mostly covered	10	"
7. Drab and dark shale	10	"
8. Argillo-sandy shale, bluish and drab in color, 30 to	20	"
9. Sandy shale, merging below into shaly sandstone	10	"
10. Sandstone, massive	10	"
11. Sandy shale	15	"
12. Hard sandstone in three or four beds, the top bed being filled with *Stigmaria*	10	"

13.	Drab to grey sandy shale and shaly sandstone; the top layer is filled with *Stigmaria*	20	feet	or more.	
14.	Coal			9	inches.
15.	Shaly sandstone and sandy shale	5	"		
16.	Coal, slaty			7	"
17.	Hard sandstone, from fire clay, filled with *Stigmaria* rootlets, about,	2	"		
18.	Drab clay	2	"		
19.	Coal: the "Livington Coal"	1	"	6	"
20.	Drab and yellowish shale	5	"		
21.	Dark blue shale, merging into blue and yellowish shale with kidneys of iron ore	5	"		
22.	Covered	5	"		
23.	Sandstone disintegrating in certain parts, particularly towards the base. Ferruginous "boxes" occur in the upper and larger part. The conglomerate	10	"		
24.	Concealed	30	"		
25.	Marly olive green shale of the Chester group	5	"		
26.	Limestone, 6 inches to	1	"		
27.	Calcareous greenish-drab, somewhat marly shale	6	"		
28.	Limestone	1	"	6	"
29.	Shale	4	"		
30.	Massive limestone of the St. Louis group (?) to the river ford	45	"	or more.	

The Coal No. 19 is the bed wrought at the several mines at Livingston, in Rockcastle county, and is considered to be of very good quality. It is probably also equivalent to the Pine Hill coal, which is much esteemed for general purposes, and is used, it is believed, at Crab Orchard for gas-making.

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KENTUCKY GEOLOGICAL SURVEY.

N. S. SHALER, Director.

PRELIMINARY SECTION FROM

YELLOW CREEK VALLEY to LIVINGSTON STATION.

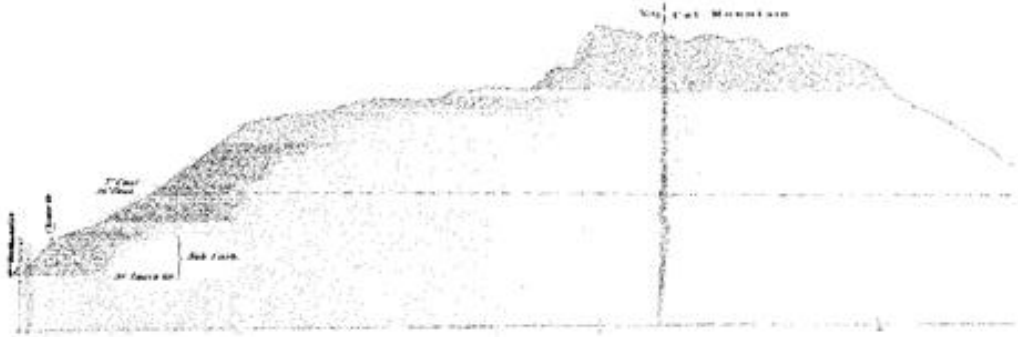
BY

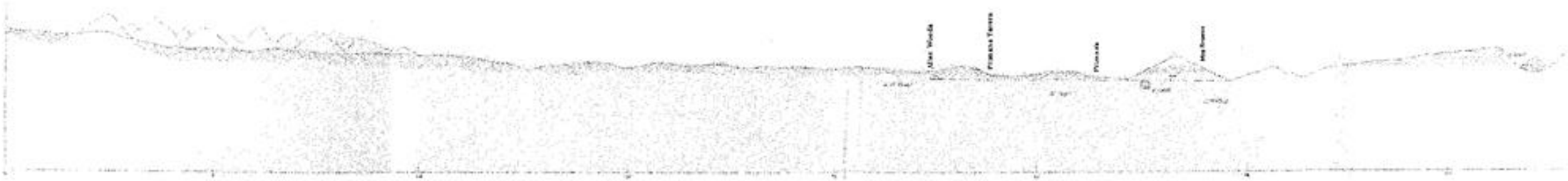
CHARLES J. NORWOOD.

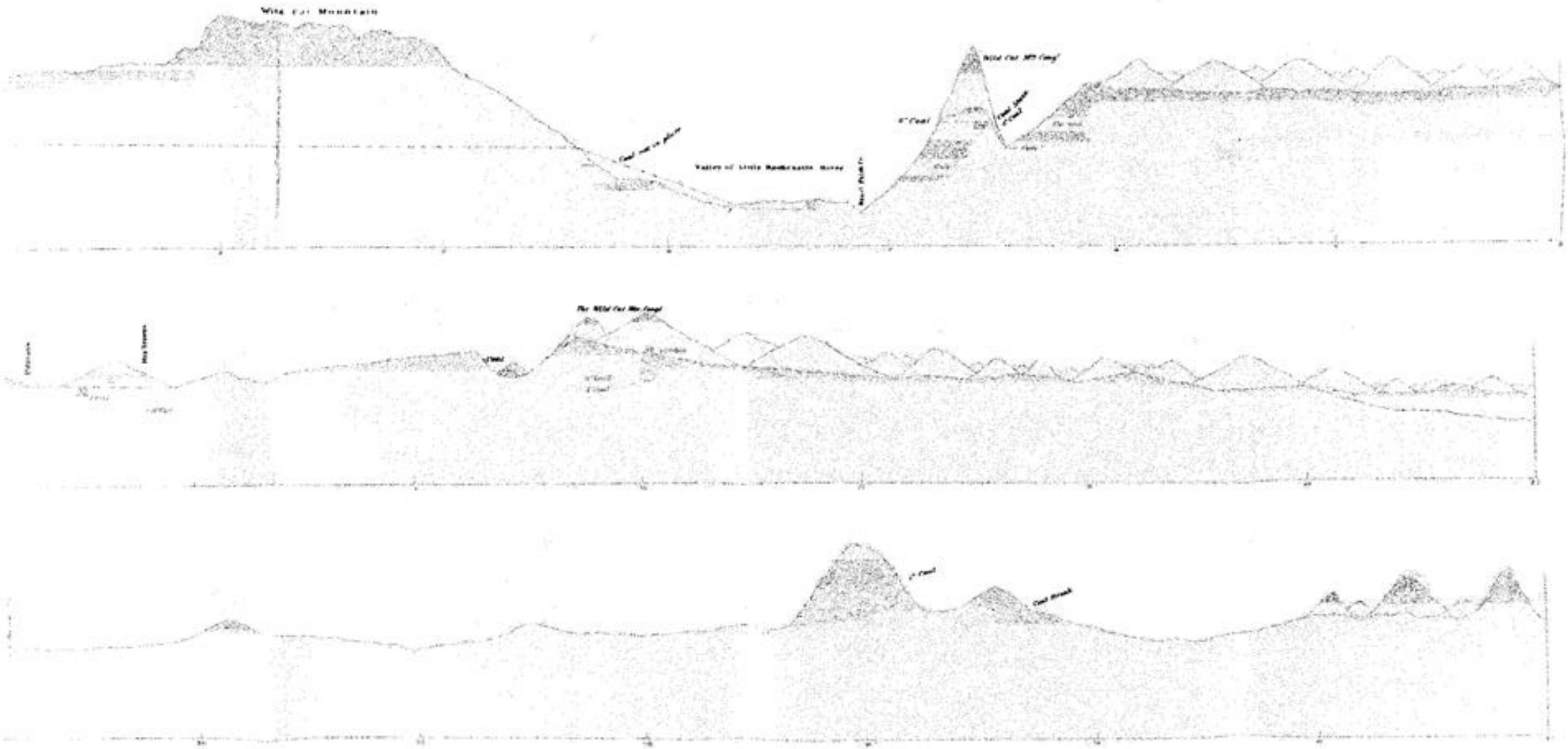
1885.

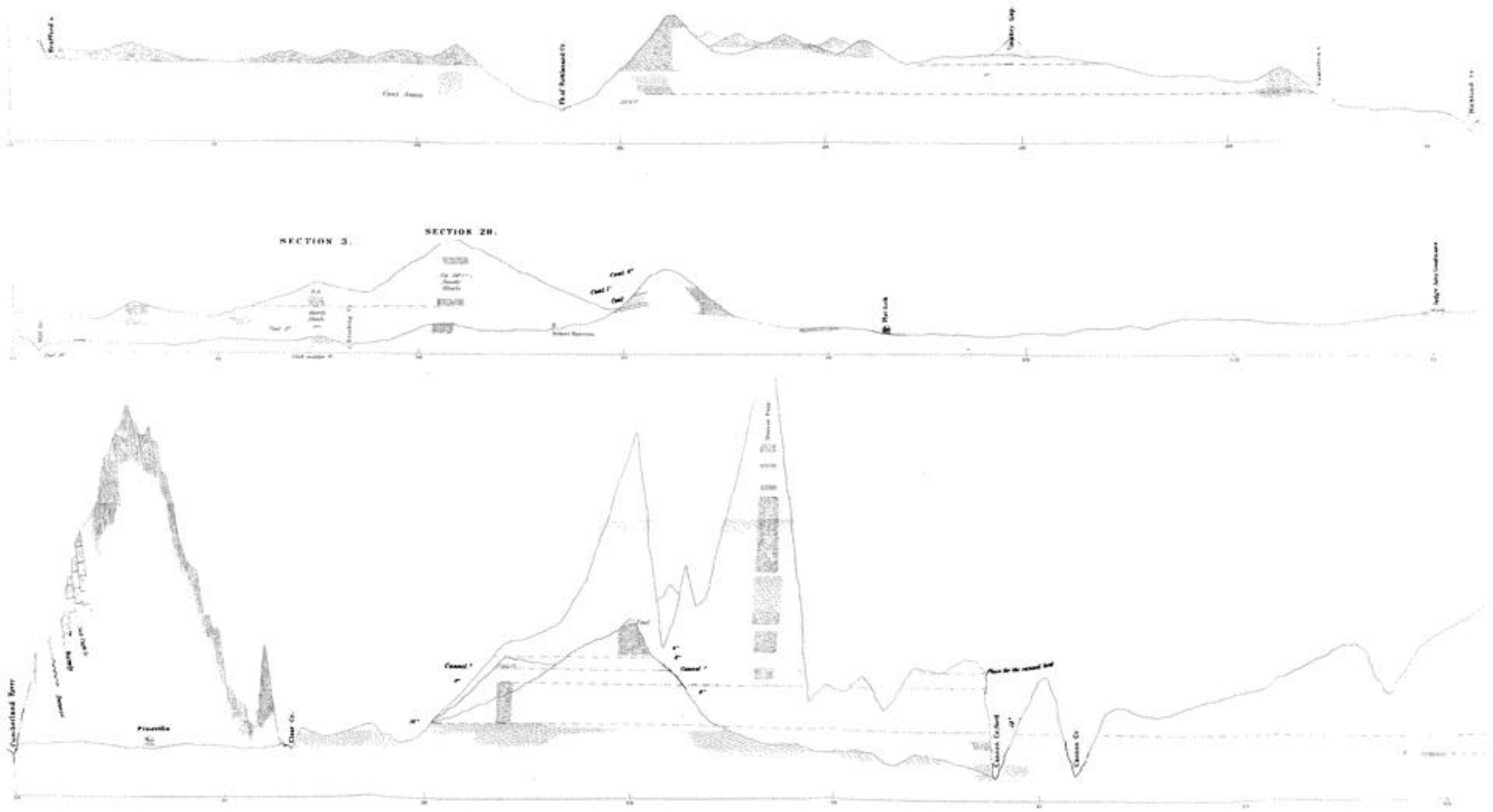
VERT SCALE, 2000 ft. 1 inch.

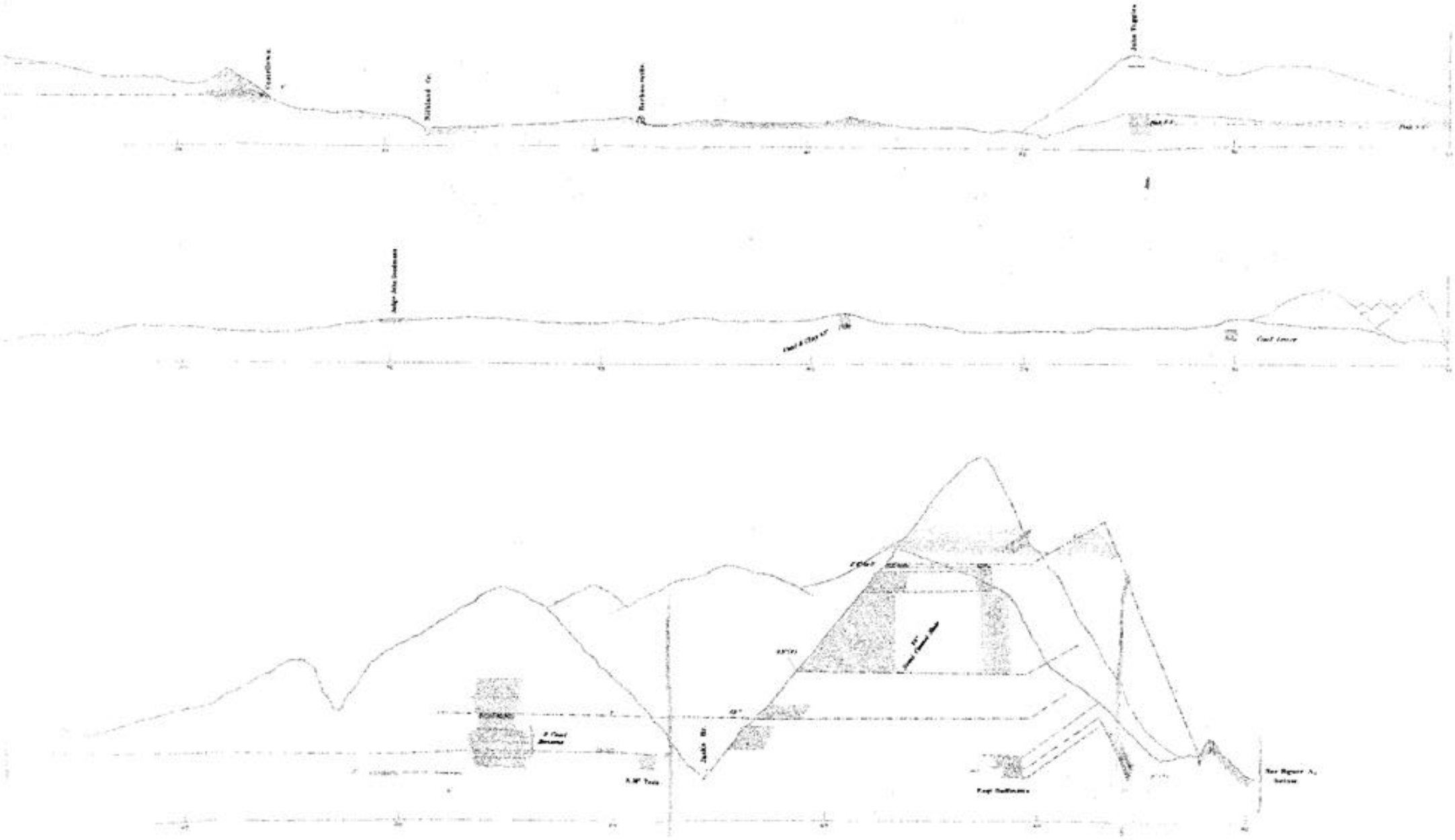
HORIZONTAL SCALE, 2000 ft. = 1 inch.

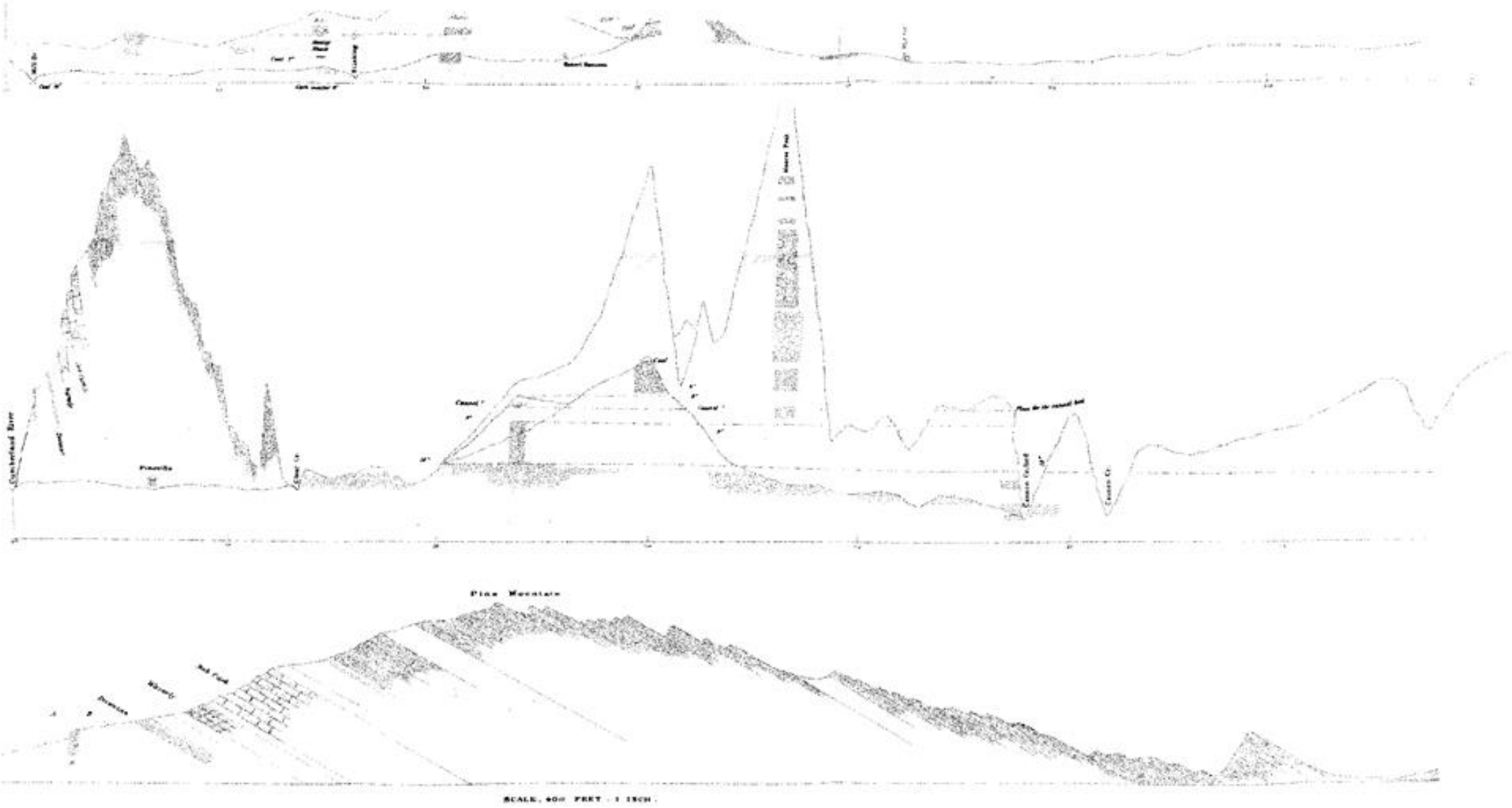







SECTION 3.
SECTION 28.




Pine Mountain
SCALE, 400 FEET - 1 INCH.

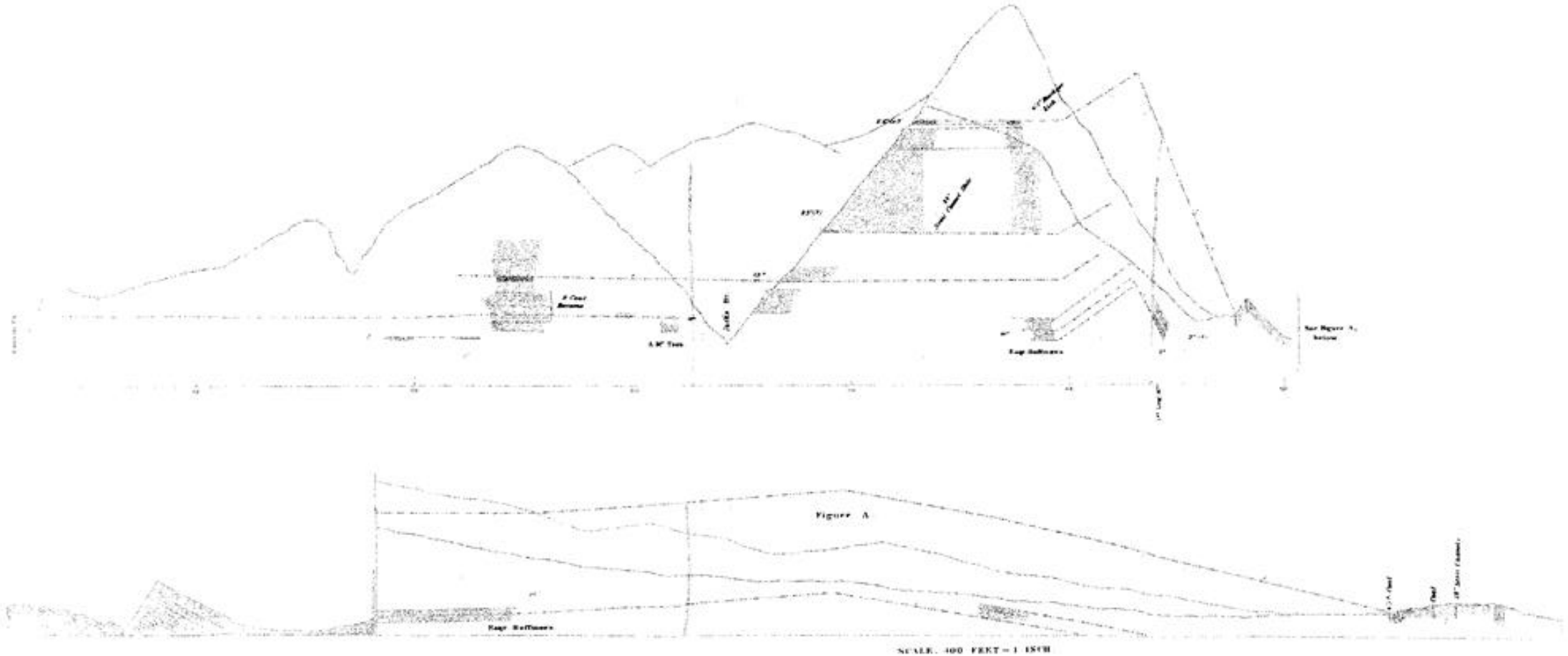


Figure A

SCALE: 400 FEET = 1 INCH