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COAL RESOURCES

OF THE

RUSSELL FORK BASIN

IN KENTUCKY AND VIRGINIA

BY

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COAL RESOURCES OF THE RUSSELL FORK BASIN IN KENTUCKY AND VIRGINIA.

By Ralph W. Stone.

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INTRODUCTION.

Reasons for this survey.—For many years it has been known that bituminous coal of good quality occurs in abundance in Pike and Letcher counties, Ky. The region north of Pound Gap on the headwaters of Elkhorn and Shelby creeks and of Boone Fork of Kentucky River has been particularly noted as a possible source of a large amount of fuel. This region has enjoyed a good reputation among investors for the amount and quality of the coal present, the only question as to its immediate value being based on the lack of transportation facilities. A large market is readily accessible from the mouth of Big Sandy River, the natural entrance to the region.

For several years the United States Geological Survey has had under advisement an investigation of the geology and mineral resources of the region as soon as adequate topographic maps on which to base the work should be prepared. As new topographic maps were not immediately forthcoming and as a railroad has recently been built which will probably lead to the early development of the field, it was decided to make a reconnaissance survey of the drainage basin of Russell Fork of Big Sandy River in the summer of 1906. The area of this basin, which is largely in Virginia, is approximately 680 square miles, and, as the writer was working alone during the greater part of the thirteen weeks given to the task, it was not possible to study details of structure and stratigraphy. It was not intended that this should be the final survey of the region, but rather that the whole area should be visited and as much information obtained concerning the number, extent, and character of the coal beds as was possible in the limited time available. The first part of this report deals with the Kentucky portion of the basin of Russell Fork, describes the coal found there, and gives a brief account of the structure and stratigraphy.

Previous investigation.—In 1887 the Kentucky Geological Survey published preliminary reports on the southeastern Kentucky coal fields, by A. R. Crandall and G. M. Hodge, and in 1900 the report of the inspector of mines of Kentucky contained the results of investigations made by Prof. C. Newton Brown, who was detailed by the War Department to investigate the mineral wealth of Big Sandy Valley at the time there was a movement to provide for slack-water navigation on the river. Professor Brown's report was the prinicipal source of information concerning the coal of the region until the Kentucky Geological Survey, in October, 1906, issued, as its Bulletin No. 4, a report by A. R. Crandall, entitled "The Coals of Big Sandy Valley." Ten pages of this report deal with the region here described.

Individuals and companies have made thorough investigations of practically the entire district. The Big Sandy Company and the Northern Coal and Coke Company have made areal and geologic surveys of their extensive holdings, but their reports are private. The Big Sandy Company has a lithograph map of the Elkhorn field lying south of Russell Fork which shows the outcrops of the principal coal beds, the geologic structure, and the location of several hundred prospects. This map was made by E. V. d'Invilliers, of Philadelphia. A copy furnished to the writer by the company, together with a tracing of that portion of the original map representing the country north of Russell Fork, formed the base for the field notes and for a large part of the map which accompanies this report (Pl. I). Private reports by R. N. Dickman, E. V. d'Invilliers, A. M. Miller, Neil Robinson, Joseph Sillyman, and others were seen by the writer.

Method of work.—The field work on which this report is based was done between July 24 and September 10, 1906. G. H. Ashley, geologist in charge of Appalachian coal surveys, spent the first week of the season with the party. C. W. Dodge, jr., assisted the writer after August 24.

The work consisted largely in making road sections to determine the structure, in measuring cliff sections to get the stratigraphic succession, and in measuring coal beds wherever exposures could be found. In a region so heavily timbered as this there are but few natural exposures of the coal beds, and the number of coal sections measured would have been small but for the extensive prospecting done by the companies that have been investing in coal lands. As more than a year had passed since most of the trenches were dug, many of them were filled and the coal made inaccessible except by the expenditure of considerable time and labor. It was not practicable in the present survey to reexcavate, and therefore measurements were necessarily confined to those prospects which were open

and could be located, to the banks which are worked for family use each winter, and to the natural outcrops. One hundred and fifty measurements of coal beds were thus obtained, sufficient to prove the character and extent of the coal throughout the field. All coal sections given in this report, except two of the Flatwoods bed, were measured by the writer or his assistant, Mr. Dodge. The locations of prospects shown on the map of the Big Sandy Company were of great assistance in finding places where sections of coal beds might be measured. Stadia elevations given on the map were accepted as true altitudes, and aneroids were constantly referred to them.

Acknowledgments.—The writer is indebted to the officers of the Big Sandy Company, to the officers of the Northern Coal and Coke Company, and particularly to W. T. Griffith, civil engineer, of Pikeville, Ky., J. C. C. Mayo, of Paintsville, Ky., and James W. Fox, of New York, for maps, information, and photographs. C. W. Dodge, jr., gave efficient assistance in the field, and in the office has prepared the map and the figures which accompany the report. G. H. Ashley, geologist in charge of Appalachian coal surveys, has exercised oversight of the work and offered many valuable suggestions. David White has contributed a section on the correlation of the Elkhorn coals. The residents of the district extended kindness to the writer everywhere he went, and he wishes to state that in every locality, without exception, he found unfailing courtesy and hospitality shown to the stranger.

GEOGRAPHY AND HISTORY.

GEOGRAPHIC POSITION.

The Elkhorn coal field is situated close to the eastern boundary of Kentucky, about midway between Huntington, W. Va., and Bristol, Va. The field lies 75 miles south of Ohio River, in the drainage basin of Russell Fork of Big Sandy River. It is a part of the eastern Kentucky coal field, which extends over several counties and is divided by natural boundaries into smaller districts, of which the Elkhorn coal field is one. The Elkhorn field as here discussed and described is a triangular area having its greatest length along Pine Mountain and the State line. The distance from the head of Grassy Creek to the head of Elkhorn Creek is 25 miles. The greatest width of the field is about 10 miles, which is the distance in a straight line from the northern end of Pine Mountain at the Breaks to the mouth of Russell Fork at Millard. This area is all in Pike County except the extreme head of Elkhorn Creek, which is in Letcher County.

Russell Fork divides the field into two unequal parts. The northern part, from the river to the divide between it and Levisa Fork, contains about 30 square miles and is drained largely by Powell, Ferrell,

Beaver, and Grassy creeks, all of which are from 3 to 4 miles in length. The southern part is much larger, having about 100 square miles, and includes Elkhorn, Pond, and Marrowbone creeks. Elkhorn Creek rises on the north side of Pound Gap and flows northeast 20 miles parallel with Pine Mountain to join Russell Fork at Praise (Elkhorn City). Marrowbone Creek, which is 8 miles long, heads at Ashcamp Gap and empties into Russell Fork at Regina, 8 miles below the mouth of Elkhorn Creek. Pond Creek lies between the two and is scarcely 4 miles long.

TOPOGRAPHY.

The topography of the eastern part of Pike County is rugged, almost mountainous. The elevation of the main streams is between 700 and 900 feet above sea level, while the summits of the ridges are over 1,500 feet above tide. In the Flatwoods area, which exceeds 2,500 feet in general elevation, there is a suggestion of the old Cumberland plateau, of which eastern Kentucky forms a deeply dissected part. This broad, level mountain top corresponds closely with the old plateau, which has an elevation of approximately 2,400 feet at Cumberland Gap and, rising northward, is recognized at 3,500 feet on New River. The Cumberland plateau is the oldest, highest, and easternmost of the Allegheny plateaus, and is so deeply eroded in this region that but little trace, the merest suggestion of it, remains. Its general slope was westward.

The valleys have narrow floors and steep walls that rise abruptly several hundred feet to the narrow ridge tops. Because there is practically no level upland surface and the ridges are difficult of access, settlement was first made on the banks of the main stream, whence it spread gradually up the side ravines.

The elevation of Russell Fork at Millard is 680 feet above tide, at the mouth of Road Creek 720 feet, at the mouth of Ferrell Creek 755 feet, and at the State line in the Breaks about 900 feet. This difference of 220 feet in 14½ miles gives an average fall of a little over 15 feet per mile. Elkhorn Creek falls 760 feet from head to mouth, an average of 38 feet per mile for 20 miles. Marrowbone Creek has a fall of nearly 50 feet per mile in the lower 6 miles of its course.

Pine Mountain, which marks the southern boundary of the Elkhorn field, presents a type of topography found in the Appalachian Valley from New York to Alabama. It is a ridge formed by the upturning of hard strata, the Lee conglomerate, which dips southeast at an angle of 25° and which is bounded on the northwest by a great fault. The crest of Pine Mountain is comparatively straight, but more or less serrate. It has a general altitude of 3,000 feet, with no low gaps between Pineville and the Breaks of Sandy, a distance of

85 miles. The heavy sandstone and conglomerate beds resist erosion, so that the crest has retreated but little from the line of the fault. This fault brings the coal-bearing rocks on the west to an abrupt end on the flank of the mountain and raises lower barren rocks high above them on the east, making a scarp which is difficult to cross.

Because of the deeply dissected character of the region, its narrow valleys and sharp-crested ridges, and because the base of the coal-bearing formation is at or not far below water level, the workable coals, which are in the middle of the formation, occur high in the hills. Within 2 miles of Russell Fork, on both sides, the Elkhorn coals are so high in the hills that they have only a small body and very irregular outlines.

This topography, however, does not hinder coal-mining operations, for by frequent bridging or fording of the stream room may be found on each valley floor for the accommodation of a highway and railroad. Of necessity any considerable settlement must be extended along the valleys.

ACCESSIBILITY OF THE REGION.

Pine Mountain, which forms the State line and cuts off the coal field on the east, has always hindered approach from Virginia. To the east it presents a steep, timbered slope rising 1,500 to 2,000 feet above the surrounding country to a crest in which there are no pronounced gaps for many miles. The Breaks of Sandy, at the northern end of the mountain, through which the drainage of Dickenson County, Va., finds its way westward, is a box canyon a thousand feet deep and a difficult place in which to build either highway or railroad. Its precipitous rocky walls, capped with "chimneys" and towers, with the dashing stream far below, make some of the wildest scenery to be found in this section of the country.

On account of this great natural barrier on the southeast practically all approach to the region is from the north, by way of Big Sandy River. Until 1906 Pike County was accessible only by wagon, except at intervals when a flood stage on the river made it possible for steamers of shallow draft to ascend as far as Pikeville, but this method of transportation was infrequent and precarious.

Highways over which wagons may pass without difficulty are confined to the valleys of the main streams. In many places the valley floor is so narrow that the road and stream bed are coincident or cross each other at intervals. The principal road to this coal field is the highway from Pikeville to Virginia via the Breaks of Sandy. In the region shown on Pl. I it extends up the left side of Russell Fork to the mouth of Grassy Creek, which it ascends to reach the upland and pass around the Breaks. Another much-traveled road runs up Marrowbone Creek, over Ashcamp Gap, to the mouth of

Ashcamp Creek, where it joins the road that extends along Elkhorn Creek. Wagons cross Pine Mountain over Pound Gap at the head of Elkhorn Creek and over Blowing Rock Gap opposite Ashcamp Creek. There is a haul or sled road over the mountain at Osborn Gap, opposite Shelby Gap, which is halfway between the gaps just mentioned and about 15 miles from the mouth of Elkhorn Creek. There are also roads up Beaver, Ferrell, and Road creeks, crossing the divide to Levisa Fork.

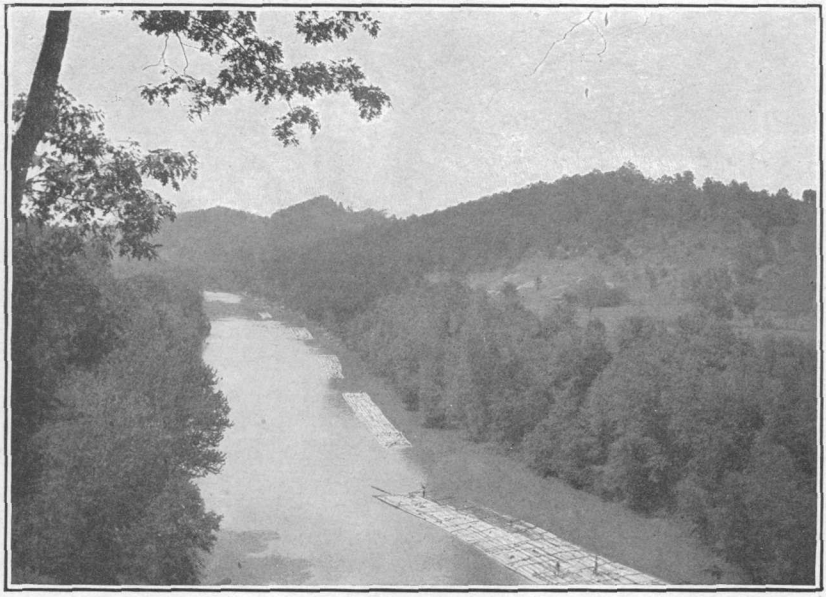
There are no roads on the ridges. Numerous bridle paths make practically all parts of the region accessible to travelers on horseback.

In July, 1906, the Big Sandy branch of the Chesapeake and Ohio Railway was completed from Pikeville to Elkhorn City (Praise post-office), at the mouth of Elkhorn Creek, and to Hellier, near the head of Marrowbone Creek. This railroad makes part of the Elkhorn coal field readily accessible, and affords opportunity for the development of the extensive fuel resources which had not been touched because transportation facilities were lacking. With the coming of the railroad interest in the field has increased and several mines are being opened.

Propositions to tap the field by railroads from the east or south have been frequently promulgated. In 1906 surveyors were working in Dickenson County on the proposed line of the South and Western Railway, which aims at tunneling Sandy Ridge at Trammel Gap, crossing Dickenson County by way of McClure Creek or Cranes Nest River, following down Russell Fork to the Breaks at the north end of Pine Mountain, and connecting at Elkhorn City with the Chesapeake and Ohio Railway. Another proposed route extends up Kentucky River to the head of Boone Fork, down Elkhorn Creek to Shelby Gap, and thence down Shelby Creek. Some grading was done at the head of Shelby Creek and in Shelby Gap to hold the location. In the Breaks of Sandy considerable excavating and grading has been completed, but in the summer of 1906 construction work was not being done on any of the proposed lines.

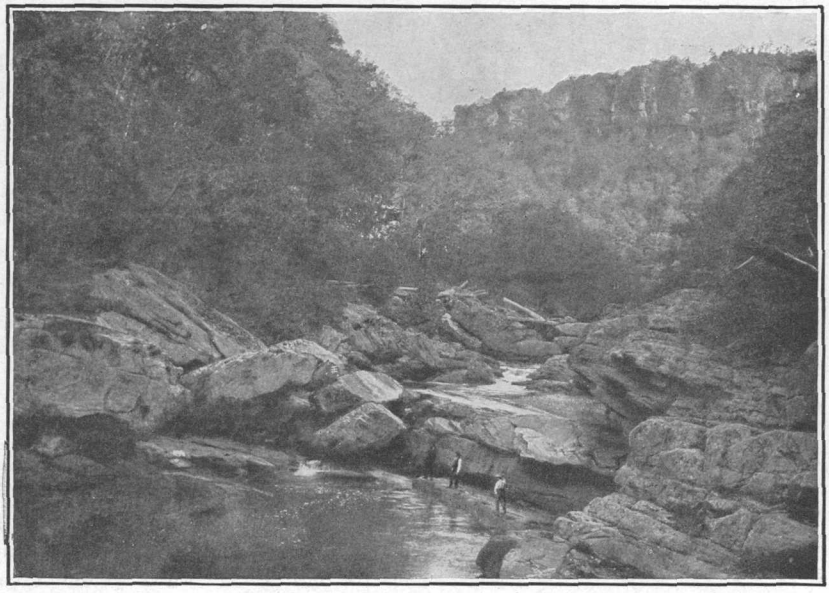
FOREST.

Originally this entire region was covered with a mantle of hardwood forest. The valley floors and the lower portions of the steep mountain slopes are cleared, but the upper slopes and tops of the ridges are as yet heavily covered with timber. Logging has been carried on in the valley for fifty years, the logs being rafted or floated singly down the river at high water to mills on the Ohio. Logs that have been cut and rolled into the river are strewn along the banks and bars waiting for a "mountain tide." Rafts are sent



A. LOG RAFTS ON BIG SANDY RIVER.

Showing river at flood and source of mine timber.



B. CLIFFS OF LEE CONGLOMERATE IN THE BREAKS OF BIG SANDY, NORTH END OF PINE MOUNTAIN.

Photos loaned by Jno. C. C. Mayo.

out with every big stage of the river, but many logs still remain stranded. In the Breaks of Sandy a jam, estimated at 40,000 logs, which failed to come down for four years because the river did not rise enough, went out on a flood in January, 1907.

The most valuable wood native to the region, the black walnut (*Juglans nigra*), is very rare now in trees of any considerable size. In the early days walnut logs were split for rails and firewood, and twenty-five years ago the Singer Sewing Machine Company bought large numbers of walnut trees at 25 cents a piece. Now a black-walnut stump will bring $25 or more.

Chestnut (*Castanea dentata*) and yellow poplar (*Liriodendron tulipifera*) are not so common as formerly. At present white and red oak (*Quercus alba* and *Q. rubra*) are being culled rapidly and made into staves, which are shipped by the railroad. Among the more common trees found in the Elkhorn region and in eastern Kentucky in general are the sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), beech (*Fagus americana*), hickory (*Hicoria alba*), basswood (*Tilia americana*), and sycamore (*Platanus occidentalis*). Less common, but still not infrequent, are the buckeye (*Æsculus octandra*), papaw (*Asimina triloba*), and cucumber tree (*Magnolia acuminata*).

To-day the landscape from any of the highest summits presents a view of low mountains completely clad with timber and with only a few inconspicuous patches cleared for corn. The lumberman, however, is beginning to make rapid inroads, and the day is not far distant when most of the mountains will be stripped of their cover. There is timber in these mountains of quality and in abundance sufficient to meet the demands of extensive coal-mining operations and to warrant the establishment of furniture, spoke, handle, and wagon factories. With the stripping of the forest, however, the soil on the steep hills will be rapidly washed away and the slopes left bare and sterile. Worst of all, with the removal of the forest will come devastating floods that will do incalculable damage to the lands and industries on the banks of Russell Fork. Pl. II, *A*, shows Big Sandy River at flood stage and several rafts of logs, indicating the source of an abundance of timber for mine supports and for outside construction.

EARLY DEVELOPMENT OF MINERAL RESOURCES.

It is probable that small coal banks were opened as early as the civil war, but they must have been few and little more than "gopher holes." One of the oldest known banks, said to have been opened over thirty years ago, is on Harless Creek, 1½ miles above its mouth, on the land of Butler Ratliff. This bank originally supplied fuel for the locomotive of a small steam tramroad which was built up the

creek for logging. The need of fuel for blacksmithing also was an early incentive for digging coal. Some few banks have been open and supplying winter fuel to one or two families for a dozen or fifteen years, but most of the prospecting to locate the coal beds has been done since 1902. Much of it has consisted of simple trenching to face up the coal and measure it, after which the opening has caved. In a few places after the facing up some one has taken the opportunity to drift in and timber the opening so as to keep the coal accessible. The amount of development in this field prior to 1903 was extremely meager and of little or no importance. Even to this day, in spite of the abundance of coal, the principal fuel used in this district is wood.

PRESENT DEVELOPMENT AND PRODUCTION.

Except the few small banks which are kept open for family use and one or two which supply a small custom trade, the development of the field is confined to the upper portion of Marrowbone Creek, where five mines have been opened. The buying of mineral rights was begun by R. M. Broas about July, 1885, and by Wilder and Stratton in 1888. Their purchases were taken over by the Elkhorn Coal and Coke Company about 1893. By the efforts of R. A. Hellier, this company procured a considerable block of coal land and transferred its rights to the Big Sandy Company in 1902.

The Big Sandy Company now owns a large proportion of the mineral rights of the area represented on the accompanying map. John C. C. Mayo commenced buying coal rights in this field in 1892 and continued until he organized the Northern Coal and Coke Company in 1901. Practically all of the coal land between Shelby Gap and the head of Elkhorn Creek is owned by this company, which has made a number of openings to show the character and value of the coal and has built beehive ovens near the head of Elkhorn Creek to test the coking quality of the Upper Elkhorn coal. The Northern Coal and Coke Company exhibited at the Louisiana Purchase Exposition, at St. Louis, specimens of coke made at these ovens, and also a complete section of the 8-foot coal bed. Active development of this company's property is delayed by lack of railroad facilities. The Virginia Iron, Coal and Coke Company owns about 2,000 acres of coal land on Pond Creek, but there is no development of the property other than the opening of a few small banks.

None of this property was of immediate value so long as there was no means of transportation. The construction of the Big Sandy branch of the Chesapeake and Ohio Railway to the mouth of Elkhorn Creek and up Marrowbone Creek to Cassell Fork was completed in June, 1906. Before the completion of the railroad the Big Sandy Company had leased coal-mining rights to five newly formed companies, and preparations for extensive mining were begun at once in as

many different localities on Marrowbone Creek. The companies which began active development work in the spring of 1906 are the Greenough Coal and Coke Company, the Edgewater Coal and Coke Company, the Henry Clay Coal and Coke Company, the Marrowbone Coal and Coke Company, and the Pike Coal and Coke Company.

Outside construction and drifting began in February, and in June the Pike Coal and Coke Company shipped the first car of coal. In July, soon after the completion of the railroad, the Pike and Greenough mines began shipping regularly, the former loading cars from a temporary chute and the latter from a permanent tipple. The Greenough Company is mining the Upper Elkhorn bed, and the Pike Company the Lower Elkhorn. In October, 1906, the Henry Clay Company began loading Lower Elkhorn coal from its permanent tipple. At that date the railroad grade was not completed to the Edgewater mine, which is at the head of Marrowbone Creek, and the tipple for the Marowbone mine was not built. A description of the stage of development of the property of these five companies in October, 1906, will show the prospects of the field.

The Edgewater Coal and Coke Company is developing a lease at the head of Marrowbone Creek one-half mile north of Ashcamp Gap. Main gangways are being driven on both the Upper and Lower Elkhorn beds. In October the gangway on the upper bed was in 140 feet with a course S. 85° E., and on the lower bed 370 feet on a course S. 83° E., with a parallel air course not so long. A tipple and incline were being built. The Edgewater mine is seven-eighths mile from the railroad. A grade for a railroad spur was built to it in the spring of 1906, but was too steep and a longer one with easier grade was built in the fall. Outside construction, including miners' houses, was barely begun.

The Greenough Coal and Coke Company has driven 600-foot gangways on the upper and lower beds, one above the other, at a point about 300 yards above the mouth of Cassell Fork. The upper mine has two right and two left entries started. It is reported that the coal nearly pinched out in the face of the lower mine, but this was not confirmed as the heading was inaccessible on account of water. Coal was being shipped from the upper bed. Miners' houses were built, and the tipple and gravity incline at this mine were the first ones completed on the creek. A roadway has been graded up the mountain side to the upper mine, which is about 350 feet above the stream.

The Henry Clay Coal and Coke Company has a lease on a block of coal which lies on the north side of Marrowbone Creek between Poorbottom Creek and Big Branch. Development was begun by building a group of houses and other necessary buildings along the railroad and by starting a mine on the Lower Elkhorn bed. In October, 1906,

the entry was 550 feet long and was provided with a parallel air course. The course of the main entry is N. 75° W., for 450 feet, where it turns N. 45° W. Cars from this entry are hauled around the face of the hill about 100 yards to the tipple incline, which is located on the point of a spur. An opening had been driven about 70 feet on the upper bed on the opposite side of the spur and was progressing rapidly in a N. 45° W. direction. This mine began shipping coal from the lower bed in October. The tipple is directly on the railroad, so that only a siding is necessary.

The Marrowbone Coal and Coke Company undertook the development of their property in May, 1906, and in October had not completed the tipple and siding, although the building of this part of the plant and of houses for the miners was progressing. This company's lease is on the south side of Marrowbone, nearly opposite the mouth of Rockhouse Creek. At this point the Upper Elkhorn coal is about 570 feet above the railroad and stream. Entries on both beds are driven S. 30° E. One on the upper bed had reached 127 feet and two on the lower bed 125 feet.

The Pike Coal and Coke Company began construction of houses and a company store in February and shipped coal early in July, 1906. More work was done on the lower than on the upper bed, and on September 1 the lower mine had a main gangway 720 feet long with a parallel air course, and a left entry 350 feet long, with an air course. Three rooms from 30 to 70 feet long have been cut from this entry. At the same time the entry of the upper mine had advanced 246 feet. Foundation for a permanent tipple was laid in October, cars then being loaded from a temporary chute.

All of these mines are using the room-and-pillar system, and the coal is shot from the solid. Mining machines have not yet been installed. The mines are ventilated by furnace, and the hauling is done by mules. Natural drainage is obtained. Miners are paid $3.75 a yard for driving headings 6 feet high and for mining at the rate of 60 cents for a 1½-ton car. Miners working in the Lower Elkhorn bed are paid 70 cents a car, the higher rate being demanded for throwing out the laminated coal. All of the mines have had difficulty in getting enough miners and were working short-handed. The daily production of the three mines which were shipping in October, 1906, was as follows:

Daily production of mines on Marrowbone Creek, October, 1906.

	Tons.
Greenough mine from Upper Elkhorn bed	60
Henry Clay mine from Lower Elkhorn bed	50
Pike mine from Lower Elkhorn bed	90

A very rapid increase in the amount of coal produced and shipped was possible as soon as outside construction could be completed and a greater number of miners procured.[a]

From the above statements it is apparent that here is a coal field as yet practically untouched which is just entering upon a period of active development. Whether the mines above described are located in the best part of the field so far as thickness and quality of the coal are concerned is a question. Certainly there are areas in which the beds are thicker, or at least one bed has a much greater thickness than either of those mined on Marrowbone Creek, but in one place the body of coal to work upon is small and the cover is slight, being located near the top of narrow-crested ridges, and in another place the desirable district is much less accessible. It is possible that from the beginning here described a considerable mining industry may grow up and the Elkhorn field of Kentucky become known for the excellent quality of its steaming and coking coal.

MARKET.

The natural outlet for the coal and coke of the eastern Kentucky fields is the Ohio Valley. Geographic conditions make the market of the immediate future lie to the north, west, and south. The Appalachian Mountains form a natural barrier which hinders the delivery of coal to the east. There is a possibility, however, that within a few years there may be a railroad from the Atlantic seaboard directly across the mountains to this coal field. The market in the Ohio and Mississippi valleys is of sufficient size to handle all of the coal that will be poured into it. With Chicago receiving 10,000,000 tons of bituminous coal annually, Cleveland 6,000,000, Cincinnati 4,000,000, and Toledo and St. Louis 7,000,000 each, there is an abundant market to which the Elkhorn field is directly accessible.

The Chesapeake and Ohio Railway, as explained in the introduction, extends into the heart of this field. It needs but the construction of a few miles of track to bring any point in the field in direct connection with the main line. Millard, at the mouth of Russell and Levisa forks, is a natural collecting point. The following table shows the distances and routes from Millard, in the heart of the Elkhorn field, to some of the principal markets which the field may supply:

Distances and routes from Millard.

	Miles.
Ashland and Ironton, via Chesapeake and Ohio Railway	121
Cincinnati, via Chesapeake and Ohio Railway	267
Columbus, via Chesapeake and Ohio Railway and Norfolk and Western Railway	255

[a] In April, 1907, the daily capacity of the five mines was about 1,000 tons, but the supply of cars was short and irregular.

	Miles.
Cleveland, via Chesapeake and Ohio Railway, Norfolk and Western Railway, Cleveland, Cincinnati, Chicago and St. Louis Railway	390
Toledo, via Chesapeake and Ohio Railway, Norfolk and Western Railway, and Hocking Valley Railway	379
Chicago, via Chesapeake and Ohio Railway and Cleveland, Cincinnati, Chicago and St. Louis Railway	573
Indianapolis, via Chesapeake and Ohio Railway and Cleveland, Cincinnati, Chicago and St. Louis Railway	377
Lexington, via Chesapeake and Ohio Railway	245
Louisville, via Chesapeake and Ohio Railway	330
St. Louis, via Chesapeake and Ohio Railway and Southern Railway	604
Nashville, via Chesapeake and Ohio Railway and Louisville and Nashville Railroad	517

The relation of the Elkhorn field to these markets is illustrated in the accompanying sketch map (fig. 1).

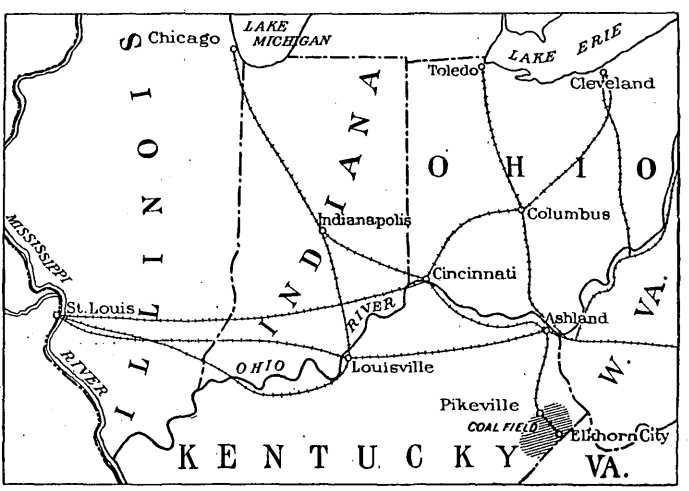


FIG. 1.—Sketch map showing location of Elkhorn coal field with relation to markets.

GENERAL GEOLOGY.

STRATIGRAPHY.

GENERAL DESCRIPTION.

The rocks exposed at the surface in the Elkhorn coal field belong to the lower part of the Carboniferous system. They consist, beginning with the lowest, of the Newman limestone, Pennington shale, Lee conglomerate, and a coal-bearing series which has not been divided into formations. It is possible that the Chattanooga shale, which lies next below the Newman limestone, is above water level on the north side of Pine Mountain, near the head of Elkhorn Creek, but if it is raised above the overturned edges of the coal-bearing rocks in this field it is likely that talus from the fault scarp conceals it.

NEWMAN LIMESTONE.

This formation, which includes all the strongly calcareous rocks in this part of the geologic column, is named from Newman ridge, in northern Tennessee. It varies in thickness from 200 or 300 feet up to 2,600 feet. The formation is not all limestone, but includes calcareous and sandy shales and sandstones. Massive and pure limestone forms at least the lower half and there are some chert nodules at the base. The Newman limestone is well exposed at Big Stone Gap, Wise County, Va., where it has a thickness of 829 feet.[a] The lower 400 feet is solid limestone, and the upper part is composed of dark shales and sandstones with thin beds of impure limestone.

In the Elkhorn field exposures of the Newman limestone are numerous in sheer cliffs on the north side of Pine Mountain, but neither the thickness, limits, nor section of the formation could be obtained with any degree of accuracy on any of the roads that cross the mountain. It is best shown on the Blowing Rock Gap road. Here limestone is found through a vertical distance of 650 feet, the highest outcrop seen in the road being about 400 feet below the gap. No rocks in place were seen within 100 feet above the highest or below the lowest limestone outcrop, so that considering the dip of the beds, there is ample room for 1,000 feet of this formation. Shaly sandstones and red shale are contained in the upper part of the formation as seen on this road. The limestone itself is blue to drab or light gray, and weathers white, so that the outcrops and bowlders of it are conspicuous.

On the road ascending the mountain from Shelby Gap to Osborn Gap almost no limestone is exposed. In a vertical distance of 800 feet between beds of sandstone only one outcrop of limestone was noted. On Pound Gap road about 100 feet of limestone is overlain by a heavy sandstone supposed to be the bottom member of the Pennington and is underlain by 15 feet of shale, below which is sandstone. Whether these rocks belong in the Newman is not certain, but it seems probable that they do. The lowest outcrop of limestone is about 250 feet above the supposed line of the fault. The writer is of the opinion that only 350 feet of this formation, including sandstone, shale, and 100 feet of limestone, is exposed here, and that the lower part of the formation, made up of heavy beds of limestone, was never raised to the surface.

PENNINGTON SHALE.

Above the Newman limestone lies a series of variegated shales and sandstones of variable thickness. Green, blue, olive, red, and purple

[a] Campbell, M. R., Geology of the Big Stone Gap coal field of Virginia and Kentucky: Bull. U. S. Geol. Survey No. 111, 1893, p. 38.

shales are the distinctive features of the formation. On the south slope of Powell Mountain it has an extreme thickness of 1,300 feet. At Pennington Gap, the type locality, and at Big Stone Gap it is 1,025 feet thick; at Hurricane Gap, in Pine Mountain, it is 890 feet thick. At Big Stone Gap there is over 250 feet of fairly heavy sandstone at the bottom of the formation.[a]

On the north side of Pine Mountain at Blowing Rock Gap there is a concealed interval of about 100 feet above the highest outcrop of limestone. Above this there is about 300 feet of sandstone (principally), supposed to be the lower portion of the Pennington. Overlying a very heavy sandstone which makes a strong cliff just below the gap is a mass of strongly colored shale which is exposed in the gap itself. The Lee conglomerate lies only a few feet above. There is then at least 500 or 600 feet of Pennington. Either the variegated shales and thin sandstones which appear farther south to the thickness of several hundred feet were not laid down here or a considerable portion of them was worn away as a land area previous to the deposition of the Lee conglomerate.

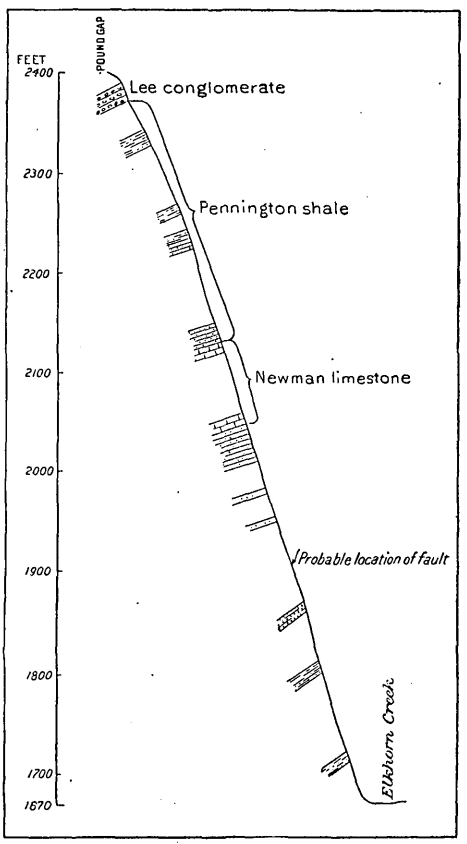


FIG. 2.—Section on road from Pound Gap to Elkhorn Creek.

At Pound Gap from the base of the Lee conglomerate to the base of a heavy sandstone resting on white limestone, which is believed to be the top of the Newman, there is a vertical interval of 250 feet, but the thickness of the Pennington is considerably greater. The dip of the rocks ranges from 18° to 25°, but the actual thickness of the formation was not determined because the horizontal factor was unknown. Typical red and green Pennington shales are exposed in the midst of the interval. The accompanying section (fig. 2) from the north side of the mountain is out of pro-

[a] Campbell, M. R., Geology of the Big Stone Gap coal field of Virginia and Kentucky: Bull. U. S. Geol. Survey No. 111, 1893, p. 37.

portion, the horizontal distance from Elkhorn Creek to the crest of the mountain being approximately three-fourths of a mile.

The thickness of the Pennington formation at Osborn Gap could not be determined. The bottom of the highly colored shale is 300 feet below the base of the Lee, and it is underlain by 50 feet or more of sandstone. From the bottom of the Lee to the first limestone seen in the road is 700 feet vertically. Allowing for the dip of the rocks and grade of the road there may be 1,000 feet or more of the Pennington at this point.

LEE CONGLOMERATE.

Above the Pennington shale and immediately below the coal-bearing rocks there is a great thickness of heavy sandstones and conglomerate which is known in this part of the Appalachian region as the Lee conglomerate. In the Elkhorn field it has a thickness of 1,000 feet or more and is composed of thick beds of fine conglomerate at the top and bottom, with softer sandstone and shale and one or two small coal beds in the middle.

The Lee conglomerate is exposed all along the crest of Pine Mountain at the southeastern edge of this field, and also along Russell Fork from the Breaks to a little below the mouth of Elkhorn Creek. Elkhorn City is located directly on it, and the formation, which rises gradually toward the fault at the mouth of Grassy Creek, makes the walls of the gorge below that point. White, opaque quartz pebbles up to a quarter of an inch in diameter are common in the top and bottom members of the formation and give to it the name of "hailstone rock." The cementing material is not always strong and the quartz pebbles are abundant in the streams that flow off the formation. Along parts of the crest of Pine Mountain where the base of the Lee has been deeply weathered the surface is so covered with pebbles as to resemble the ground after a hailstorm.

The writer did not measure a section of the Lee. The base forms the crest of Pine Mountain, and the rest of the formation, dipping at an angle of 25°, is exposed on the eastern slope of the mountain in Virginia in such a manner that an accurate section can not be obtained. At the Breaks of Sandy the Lee is exposed in cliffs nearly 1,000 feet high (Pl. II, *B*, p. 14) and so nearly vertical as to be difficult of ascent. The formation as shown there appears to be composed very largely of sandstone.

A characteristic feature of the Lee conglomerate as noted in several places is the very strong cross-bedding within 50 feet of the top. This is well exposed at the lower end of the Breaks about 3 miles above Elkhorn City. Here between horizontal beds of coarse sandstone from 5 to 6 feet apart are sandstone strata a foot thick, dipping westward at an angle of 20°.

There are said to be two or three small coal beds in the Lee, but the writer did not see any in this district. It is reported on good authority that a 2-foot bed outcrops at the mouth of Grassy Creek and also in the gorge three-quarters of a mile below, but the former was not found when sought and the latter is said to be exposed at only low stages of the river.

COAL-BEARING ROCKS.

Immediately above the Lee conglomerate there is a series of sandstones and shales about 2,000 feet thick, which will be described in this report as the coal-bearing rocks, because they contain all the workable coals and because data has not been obtained sufficient for dividing them into formations. In the Estillville and Bristol folios of the Geologic Atlas of the United States, which contain descriptions of coal areas south of this in Virginia, rocks 1,200 feet thick overlying the Lee are called the Norton formation and are overlain by the Gladeville sandstone and Wise formation. It is probable that in the Elkhorn region rocks several hundred feet thick above the Lee belong to the Norton formation as described in Virginia, but the upper limit of the Norton was not definitely recognized, and as it is possible that there is considerable thinning of the formations in this direction it seems best in this reconnaissance report to make no attempt at a division of the coal-bearing rocks into formations. The name coal-bearing rocks in this report refers to the series of sandstones, shales, and coals which extend from the top of the Lee conglomerate to the highest rocks outcropping in the Flatwoods area.

The coal-bearing rocks form the surface of the entire region here described except a narrow belt along the north side of Pine Mountain. Short sections may be measured almost anywhere in the field, but sections of 600 or 800 feet can be seen to advantage only in the bluffs along Russell Fork. In the bluff at the mouth of Elkhorn Creek the rocks are exposed from the top of the Lee to the Lower Elkhorn coal, a distance of about 800 feet. Here, as elsewhere in the field, cliffs are formed by the massive sandstones.

A generalized section of these rocks made up from measurements taken in different parts of the field and averaged represents graphically (fig. 3) the sequence of the rocks. It should be understood that the sandstones are massive, thin-bedded, and shaly, and the shales are equally variable. Furthermore, the beds change in character as well as in thickness along their lateral extent. These facts necessarily make a section intended to represent the whole field merely a suggestion of the sequence of rocks which is not to be relied upon as everywhere true. The section shows that the lower 400 feet is more thin-bedded and shaly than the 600 feet lying next above;

and it makes plain that the upper 1,000 feet is more sandy and the beds are more massive than the lower 1,000 feet. Workable coal beds are largely in the lower half of the formation.

The bottom member is a 30- to 50-foot bed of dark shale which rests upon Lee conglomerate. The road from Elkhorn City to the Breaks is cut in this shale much of the way. Above it lies a 20-foot bed of massive, yellowish-gray quartzose sandstone, which is to be seen only on Russell Fork and the lower part of Elkhorn Creek. It makes a strong ledge which passes below water level just below the mouth of Beaver Creek. A coal bed averaging 30 inches thick and known locally as the Elswick bed lies on top of this sandstone.

Next above this is 60 or 70 feet of shale which carries large calcareous nodules. Some of these nodules are 1 to 3 feet in diameter. They occur at certain horizons rather than scattered through the whole shale bed. A section near the mouth of Moores Branch shows over 80 feet of this shale, but a short distance farther down the railroad there is a 10-foot bed of sandstone in the midst of it. The shale between the Elswick coal and this sandstone is almost black, of a somewhat lumpy character, and carries a few marine fossils.

A 40-foot massive sandstone occurs 150 feet above the Lee; then comes 50 feet of thin sandy beds and a 25-foot massive bed of sandstone, above which lies the Auxier coal. This coal is about 3 feet thick and is overlain by 160 feet of thin-bedded shales and sandstones, in the middle of which is sometimes found a 1-foot coal bed. The upper part of this interval may in places be occupied by massive rather than thin sandstones.

A coal which is at many places of workable thickness lies 160 feet above the Auxier coal, or 440 feet above the Lee conglomerate. This bed is opened at several points on the river below Ferrell Creek. For convenience in description, it will be called the Millard coal, for it has been opened at a number of places near Millard, at the junction of Russell and Levisa forks.

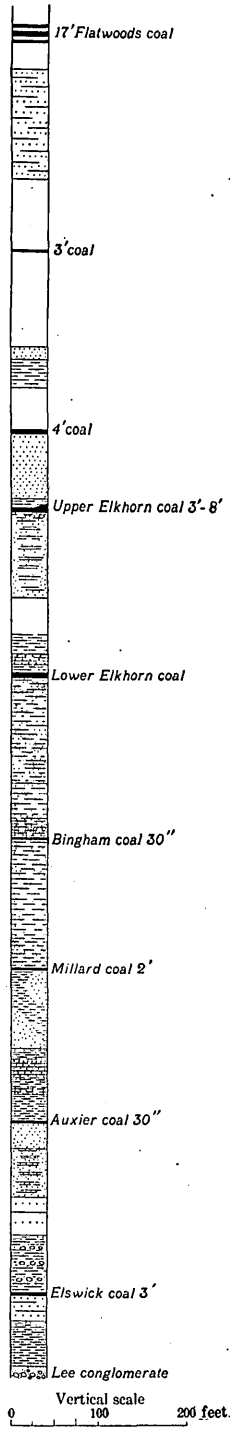


FIG. 3.—Generalized section of rocks above the Lee conglomerate.

Between this coal and the one next above, which will be called the Bingham bed, there is 150 feet of sandstone. The lower portion is thin-bedded and shaly, while the part just under the Bingham coal is massive. The Bingham bed is a little-known coal about 30 inches thick, which has been opened at only a few places. For convenience in description the writer has applied to this coal the name of a man living on the head of Ferrell Creek, who opened a pit on this coal several years ago. Sandstones, massive and shaly, to a thickness of 170 feet lie between it and the Lower Elkhorn coal, which is next above.

The Lower Elkhorn coal is found in this region about 800 feet above the Lee conglomerate. It is a bed of variable thickness, measuring from 3 to 8 feet. An average of 34 sections taken at as many different localities gives a thickness of 4 feet 3½ inches for the bed. The distance between the Lower and Upper Elkhorn beds is 180 feet, more or less. Shale or thin-bedded sandstone makes up the lower part of this interval, while rather massive sandstone occupies the upper half. This makes the Upper Elkhorn coal about 950 feet above the base of the formation.

The Upper Elkhorn coal is from 3 to 9 feet in total thickness. It averages about 4 feet in most of the area. This is the thickest of the workable coals occurring extensively throughout the field. Two beds reported as above the Upper Elkhorn are so high in the hills that they have been prospected but little, and exposures were not seen by the writer. One of these is said to be 80 feet and the other about 230 feet above the Upper Elkhorn coal. Each will yield an average thickness of 3 feet of coal.

Four hundred feet of rocks above the Upper Elkhorn coal are made up about equally of sandstone and shale. Then comes a massive, coarse-grained sandstone about 100 feet thick, which is exposed at the head of Cassell Fork of Marrowbone Creek. Its position is so high that it overtops the hills in a large part of the area here discussed, and is seen principally in the Flatwoods district. Like the Lee, it is very quartzose, has a gray weathered surface, and may possibly carry small quartz pebbles, although none were seen in the exposure on Cassell Fork. This sandstone is about 500 feet below the upland level known as the Flatwoods.

Above this sandstone lies a series of coal-bearing rocks 600 feet thick, which are found in the Elkhorn field only in the elevated region between the heads of Elkhorn and Shelby creeks. The detail of these beds, as measured by David White, is as follows: At the head of Cassell Fork a 17-foot coal bed, known as the Flatwoods coal, has been opened about 30 feet above the massive sandstone just mentioned. Above this coal is 100 feet of thin-bedded and 150 feet of

massive sandstone, some of which is strikingly pink on fresh fracture. The massive sandstone is overlain by 20 feet of shale, above which is a small coal bed. Above the coal is 110 feet of sandy shale with a band of limestone nodules near the top. Next above this, or 380 to 400 feet above the Flatwoods coal, is about 150 feet of massive sandstone, which forms a cliff around the edge of the Flatwoods area. A coal bloom was seen about 40 feet above this massive sandstone, and the highest rocks noted were sandy shale. A 4-foot coal reported [a] about 530 feet above the Flatwoods coal, close to the top of the hill, may be the one last mentioned.

STRUCTURE.

IMPORTANCE OF DETERMINATION OF STRUCTURE.

In the investigation of any coal field one of the principal questions to be answered is, What is the position of the coal beds; are they flat, folded, or strongly inclined from the horizontal? This knowledge is as important as a knowledge of the quality of the coal. In the first place, to the prospector a knowledge of the structure serves as a guide for tracing the outcrops of the beds. If the structure is flat, then the coal should be found at the same elevation on both sides of the hill or valley; if it dips, then the coal may be expected at a lower or higher elevation, according as the dip is with or opposed to the direction of advance. In the location of mines a knowledge of the structure of the field as a whole is invaluable for their successful development and operation. An outcrop entry or a shaft should be so located that there will be natural drainage to it; in other words, entry on a coal bed should begin at the lowest point. This is essential to facilitate drainage and the delivery of loaded cars from the breast to the mouth. Having a knowledge of the structure, an engineer can lay out his mine before breaking ground.

That the rocks do not lie flat in this field is seen readily by noting how the Elswick coal dips below the railroad at Moores Branch; it is shown by the way some coal banks drain in and others drain out.

METHOD OF DETERMINING AND REPRESENTING STRUCTURE.

The method usually employed in working out the structure of a coal field where the rocks have not been excessively disturbed is to select some conspicuous member of the formation and obtain its actual or relative elevations by aneroid, hand level, or spirit level at as many points as possible or necessary throughout the area. The relation of the reference stratum to any particular coal bed being known, and the interval between the beds being, presumably, practi-

[a] Crandall, A. R., Coals of the Big Sandy Valley: Kentucky Geol. Survey Bull. No. 4, 1905, p. 116.

cally constant over a limited area, the lay of the coal can be worked out from the elevations on the reference stratum. Structure may be represented by cross sections or by contour lines. The latter method gives the information much more completely than is possible with cross sections and is being commonly used. Contours are lines connecting points of equal elevation on an inclined surface. They show both the direction and rate of dip or inclination of the bed which they are intended to represent. The contours on the map (Pl. I, in pocket) are drawn from data on the map of the Elkhorn field made for the Big Sandy Company by E. V. d'Invilliers. In his survey D'Invilliers prospected for the Lower Elkhorn coal and obtained its elevation above sea level by vertical angles wherever it was found. With the information thus obtained, he represented the structure on his map by 20-foot contour lines. The structure given by D'Invilliers was checked as far as possible by the writer, and the result is much more accurate than any that could have been obtained with an aneroid barometer in the course of a reconnaissance survey. The map accompanying this report is on a smaller scale, and 50-foot contour lines are shown, practically reproducing the structure as determined by D'Invilliers, with some changes based on notes by the author. Elevations are based on a Chesapeake and Ohio Railway bench mark on a stump at the mouth of Marrowbone Creek, 736.99 feet above sea level.

CAUSE OF FOLDING.

Originally laid down flat, the rocks in the Elkhorn coal field are now inclined and slightly folded. This folding was produced by pressure or squeezing of the earth's crust. The position of the rocks where they have broken and one side has overridden the other indicates that the disturbance resulted from a lateral thrust from the east. Forty or more miles to the southeast, in the Great Appalachian Valley, the rocks are strongly folded and faulted, but from Sandy Ridge westward through Pike County the disturbance and crumpling is very gentle, except for the break along Pine Mountain. The effects of the lateral thrust die out westward until they become recognizable only by close leveling.

STRUCTURE OF THE COAL FIELD.

Pine Mountain marks a great break in the rocks forming the earth's surface. Along the north side of the mountain just under the crest there is a fault which raises rocks lying normally far below the coal formation to the surface and thrusts them up over the coal measures. How great the disturbance has been is shown by the position of the Lee formation, which is over 1,000 feet thick. The

top of this formation is just above water at the mouth of Elkhorn Creek, while the bottom of it, on the opposite side of the fault, has been shoved up until it marks the crest of the mountain at Blowing Rock and Pound gaps. In fact, at Blowing Rock the conglomerate, which is the base of the Lee formation and which is more than 1,000 feet below the surface at Elkhorn, is slightly above the gap.

The displacement at Blowing Rock Gap is probably more than 2,000 feet, but it may not exceed 1,000 feet at the Breaks of Sandy and seems to decrease rapidly from there northward, becoming perhaps merely a plunging anticlinal fold near the head of Grassy Creek.

Because of the drag of the overthrust, the rocks on the north side of the fault for a few rods are overturned. This can be seen in the Breaks of Sandy, where a diagrammatic section is shown in the rocky gorge. Rocks approaching the fault in a nearly horizontal attitude are turned up and over, and stand now at an angle of 70°. Farther south along the mountain these rocks seem to be overridden so far that their overturned edge is hidden beneath the mountain.

From the face of the fault scarp on Pine Mountain to Elkhorn Creek the rocks have a strong westward dip. Thence through the eastern Kentucky coal field there is a general decrease in elevation to the west. Although there is a predominant dip in one direction the rocks are slightly waved or folded, and these minor features rather than the general structure of the region are of the greatest importance to mining operations. It will be seen by the structure lines in red on the accompanying map (Pl. I) that the Lower Elkhorn coal, which is the surface represented by the contour lines, is 1,740 feet above sea level on the right fork of Beaver Creek, and is nearly 500 feet lower at the mouth of Russell Fork. Although the dip is very regular along the river there is a small basin or syncline extending from the head of Cassell Fork in a north-northwest direction to Daniels Creek and parallel with it an arch or anticline that can be traced easily from Shelby Gap to the head of Wolfpit Fork. In the western portion of the territory the dip is very regular to the west at 75 feet to the mile. The inclination of the coal beds scarcely exceeds 125 feet per mile in any locality.

The position of the anticline with relation to Marrowbone Creek is such as to facilitate mining operations on both sides of the creek, giving natural drainage and easy grades for haulage in the mines. The determination of structure in advance of actual mining is recognized to be of prime importance in the selection and development of coal properties.

CORRELATION OF ELKHORN COALS.

By David White.

The equivalents of the Elkhorn coals in the region to the northwest of the junction of Levisa and Russell forks of Big Sandy River have not been worked out completely. Owing to the snowy weather incident to the lateness of the season, field work in eastern Kentucky in 1906 was terminated before the geologic section had been carried to the Russell Fork basin so as to tie definitely with the key rocks of that area. The probable economic horizons were traced, both paleobotanically and stratigraphically, from the Kenova quadrangle on the Ohio River to Pikeville. Above Pikeville but little stratigraphic profiling was accomplished and but few fossils were collected for the reasons stated above. Consequently, in view of the incompleteness of the work and the lack of adequate data, I am obliged to propose only tentative and preliminary correlations, leaving the final and absolute determination or verification until the data may be sufficiently amplified through additional paleontologic or stratigraphic information.

Under the conditions prevailing at the close of the season it was possible to give but a portion of a single day to the collection of material from the Elkhorn coals in the Russell Fork region. This material, gathered from the upper and lower beds worked at the Pike mine, at the head of the railroad spur along Marrowbone Creek, leaves much to be desired, for although the material is richly fossiliferous the rock dump of the mine was so deeply covered with snow as to make collecting most difficult and inconclusive.

Although subsequent and more adequate collections may seriously modify these tentative correlations it appears probable from the paleobotanical data in hand that the upper bed at the Pike mine—the Upper Elkhorn—is the same as the coal worked on Ferguson Branch and Lower Chloe Creek near Pikeville. Similarly, the fossils obtained from the Lower Elkhorn coal at the Pike mine seem to represent the flora of the lower or Syck coal, worked for local consumption on Lower Chloe Creek near Pikeville. I expect that further paleobotanical work in the region will confirm these correlations, which must, however, for the present be regarded as provisional.

Assuming the reference of the Elkhorn coals to be correct the following correlations will obtain. The sandstone immediately or but a very short distance above the Elkhorn coal is a fairly well marked stratigraphic member, becoming very distinct in the region of Paintsville, where it overlies the Paintsville (or Prestonburg) coal and is clearly traceable to its point of disappearance near River station. The Ferguson Branch coal, which I believe to be the same

as the Upper Elkhorn coal, lies in the upper part of a thin band of shales carrying locally workable beds all the way from Pikeville to its disappearance below water level at River station. The Paintsville coal lies at the top and the coal worked at Harold and opened at several other points lies at the base of this thin belt of carbonaceous shales, which seldom exceeds 45 feet in thickness. To this horizon belongs the coal opened on Stonecoal Run at Wagner and at Hemlak. The heavy sandstone underlying this thin shale is continuous to its disappearance below Buffalo station, and throughout most of its exposure is characteristically massive, gnarly, and frequently in a very uneven basal contact with underlying blue argillaceous shales. It is finely exposed along Levisa Fork in the vicinity of Dwale, from which it might appropriately receive its name.

The Syck coal, to whose horizon I tentatively refer the Lower Elkhorn coal, lies above another heavy sandstone, well exposed in the banks of the river and along the railroad track at the lower end of Pikeville. To this sandstone, which first rises above the railroad track a short distance below the twenty-fifth milepost, or about 1½ miles below Pikeville, probably belongs a ledge showing in the sides of the valley below the level of the Lower Elkhorn coal near the Pike mine. Like the sandstone described above, it is readily susceptible of mapping to its point of disappearance.

Granting that the above correlation of the Elkhorn coals is correct, it becomes probable that the group of sandstones about 400 feet above the Upper Elkhorn coal in the slopes of the Flatwoods at the head of Marrowbone Creek is continuous with that associated with the Leslie coal near Pikeville and the old Peach Orchard coal in the vicinity of Richardson. I regard it as a member which may be readily mapped along Levisa Fork to its point of entrance into the Kenova quadrangle, where it falls within the Pottsville formation.

It was not practicable to attempt to determine paleobotanically the boundary between the Pottsville and the Allegheny formation in the Flatwoods region. I can only add that within the limited time available on the occasion of a hasty climb to the Flatwoods summit, the few fossil plants gathered from the roof of the great bed of coal known as the Flatwoods coal, which lies about 550 feet above the Upper Elkhorn coal, distinctly show the Pottsville age of the bed, referring it to the Kanawha formation, and leave no room for doubt as to the Pottsville age of the heavy sandstone ledge, 100 feet or more above the coal. No opportunity was offered to search for fossils in beds above this sandstone, but I am inclined to believe, in view of the age of the big coal just mentioned and of the probable expansion of the Kanawha formation to the eastward, that the sandstone forming the floor of the Flatwoods plateau and cropping out as cliffs

around the brow of that area may also be found eventually to fall within the limits of the Pottsville. If so, they will, perhaps, constitute the uppermost member of that formation.

The present state of knowledge does not justify a correlation of the Elkhorn with the coal beds in the Norton or Big Stone Gap region. It may, however, be remarked that the species of fossil plants from the Lower Elkhorn appear to bear a close relation to such material as I have been able to secure from the Banner group at Dorchester, near Norton.

The scanty paleobotanical evidence in hand indicates that the Elkhorn coals belong to the lower portion of the Kanawha formation, the Ferguson Branch (Pikeville) coal being probably at or near the horizon of the Peerless or Cedar Grove coals, on the Kanawha River.

The designation of the Paintsville coal as "Coal No. 1" and the application of numbers, such as "1" or "3," to the Elkhorn coals is both erroneous and misleading. Local names for the coals are far preferable in every way. The application of a numerical nomenclature to the beds is on all accounts to be discouraged locally and should be abandoned in all publications.

ECONOMIC GEOLOGY.

GENERAL CHARACTER AND OCCURRENCE OF THE COAL BEDS.

INTRODUCTION.

In this section the stratigraphic position and extent of each of the coal beds is described in order to give the reader an idea where each coal is to be found and how much of the territory it underlies, and to indicate the general features of its occurrence. In the succeeding section detailed descriptions of the various beds as revealed throughout the field by natural exposure, prospect trenches, pits, and mines will be given.

Correlations of the coal openings in this field have been so successful that it is possible to trace all of the workable beds with considerable certainty throughout the greater part of their extent in the region here discussed. For this reason it would be possible to make each coal bed the subject of a separate chapter, describing and comparing all the occurrences of that particular coal. It seems desirable, however, for the convenience of those who may make use of this report, and especially for those who may visit or live in the field, to describe under one heading all the coals in any one locality. By this method one can find what coals occur on any particular creek without examining several parts of the report. The description by localities has the disadvantage of not giving a continuous view of

any one coal bed, but this may be remedied somewhat by the grouping of sections of the same coal in one illustration.

ELSWICK COAL.

Lying 50 to 75 feet above the top of the Lee conglomerate and resting on a bed of massive sandstone from 20 to 30 feet thick is a workable bed known locally as the Elswick coal. Being stratigraphically the lowest of the coals in this field, the Elswick has the shortest outcrop. It rises above the waters of Russell Fork close to the mouth of Little Creek about 1 mile below Elkhorn City, and keeps above the river to the fault at Grassy Creek, a distance of 4 miles. It falls below the level of Elkhorn Creek between the mouths of Big Branch and Pond Branch, 1 mile above Elkhorn City. The horizon of this coal, therefore, underlies practically the entire field, but whether the coal exists and has a workable thickness elsewhere than in the immediate vicinity of the short outcrop just described is yet to be proved. If this bed is everywhere present beneath the surface of the field, which may be a reasonable supposition, and if it maintains an average thickness of 30 to 36 inches, then the tonnage of the Elswick bed is probably nearly equal to that of any other coal in the field. It may be considered as an available reserve, but will not be mined extensively so long as thicker beds outcrop in the same locality.

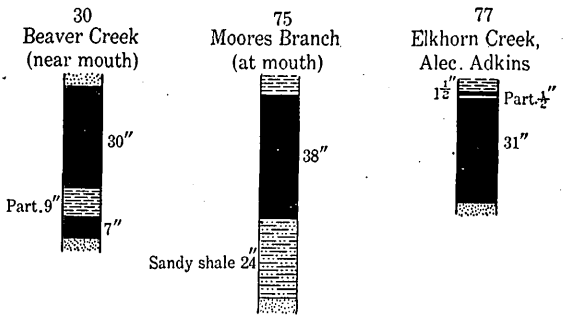


FIG. 4.—Elswick coal sections.

AUXIER COAL.

At a distance of 260 feet above the Lee conglomerate and about 500 feet below the Lower Elkhorn coal is the Auxier coal. It usually rests on a 30-foot sandstone more or less massive in character, and is overlain by shale. This bed has been found at frequent intervals along the creeks in this area and is recognized with some degree of certainty by its size and relative position in the geologic column.

If the correlation is correct, an 18-inch coal bed, said to occur in the bed of Russell Fork at the mouth of Biggs Branch, is the most northern outcrop of this coal in the Elkhorn field. Coal at the mouth of Lower Lick of Harless Creek and at Joe Looney's on Road Creek is believed to be the Auxier, and openings in the hol-

lows on the left of Ferrell Creek as far up as the schoolhouse at the mouth of Sprucepine Fork are tentatively assigned to the same bed. Continuing up Russell Fork prospects are found on Beaver Creek, Little Creek, and three-fourths of a mile up Moores Branch. The outcrop has been traced up Elkhorn Creek to where it goes under water just below Kettlecamp Branch, and although the coal was not seen on Russell Fork above Elkhorn City, the underlying rocks were traced to Grassy Creek and a coal which has been opened on Trace Fork one-fourth of a mile above Riley Cavin's place was recognized as probably being the Auxier. An average of 14 sections gives the bed a thickness of 2 feet 9 inches. The maximum is 4 feet 6 inches and the minimum 1 foot 8 inches.

MILLARD COAL.

This bed has been opened in several places near the confluence of Levisa and Russell forks and is known there as "The Forks" bed. Obviously this is not a desirable name to perpetuate, and the name Millard, which is the name of the post-office at the forks, is adopted for facilitating description and reference. The coal is 450 feet above the base of the formation and 300 to 350 feet below the Lower Elkhorn. It lies usually under a massive sandstone and on top of either sandstone or shale. Although the bed has an average thickness of 3 feet, the amount of available coal is barely 2 feet, on account of the clay partings.

The distribution of this coal in the area here described has not been determined so well as has that of the other beds. This is because it is unimportant, scarcely to be classed as workable, and therefore it has been prospected but little. It is possible that in a detailed survey of the region the outcrop could be traced, but in reconnaissance work of this sort it could not be mapped with thoroughness. The map (Pl. I, in pocket) shows the outcrop of this coal extending from Millard, along the river, up Powell Creek to Lick Fork, over a mile up Biggs Branch, and running up both forks of Daniels Creek. It is seen on Harless and Jimmie creeks, on Road Creek at Isam Fork and the mouth of Middle Fork, and on Ferrell Creek at the mouth of Bingham Fork. On Marrowbone Creek this coal is open in several places, and is best seen at the Marrowbone mine, where there is a pit a few rods east of the tipple. The coal also shows in the railroad cut near Johnson Fork. It was not seen on Elkhorn Creek.

BINGHAM COAL.

This coal was recognized by the writer as one not previously described. Its position is approximately 180 feet below the Lower

Elkhorn coal and in the midst of sandstone. It was first noted at E. B. Bingham's place, on Ferrell Creek, and later seen on Powell Creek and under the incline at the Marrowbone mine. The exposures are so few that a connected line of outcrop can not be shown on the map. The bed varies according to 4 sections from 2 feet 6 inches to 4 feet 5 inches in thickness.

LOWER ELKHORN COAL.

Thorough prospecting for this bed in all parts of the field by both residents and investors has brought to light more information concerning the Lower Elkhorn than any other coal in the region. Prospect trenches have been cut to the crop at short intervals in much of the field, small pits kept open by timbering are plentiful, and five mines show the character of the bed under cover. Under these conditions it can be traced from point to point with considerable certainty. The line on the map representing the outcrop is taken from the map of d'Invilliers and is considered accurate, part of it having been run by stadia. On the map (Pl. I) the boundaries of coal areas where shown by solid lines are regarded as more accurate than where shown by dotted lines.

The Lower Elkhorn coal is between 750 and 800 feet above the Lee conglomerate. As described in the chapter on stratigraphy, it usually crowns a more or less massive sandstone, which may be from 20 to 60 feet thick, and it is overlain by shale or thin-bedded sandstone. The underlying sandstone serves in some places as a guide to the location of the coal, making a ledge on top of which the coal should be found.

This coal is always high above the main drainage and passes below water level only close to the heads of the streams. Its altitude above Russell Fork is from 500 to 800 feet, and as the dips are not strong the outcrop extends up the side valleys to their very heads. As will be seen by the accompanying map, the outcrop of the coal delineates every valley, and is found throughout the field except on the south side of Elkhorn Creek. For this reason no further description of the distribution is deemed necessary. Although the coal is several hundred feet above the river, it is not so high but that the hills rise considerably above it and leave an extensive body of coal with considerable cover. The Lower Elkhorn bed appears to be of workable thickness throughout the field, averaging over 4 feet. There is, however, a feature of this bed, so common in most of the field as to be characteristic, which greatly reduces its value from a mining standpoint and leaves only three-fourths of the bed to be reckoned as available fuel. This unfortunate feature is the so-called laminated coal.

"Laminated" is a term applied to bony coal which is composed of alternating lamellæ of bone and bright coal. The streaks of bone

give strength, so that it mines in hard, flat slabs, but they also make it high in ash. In the Elkhorn field the term is applied also to the soft, flaky, slickensided coal which emits a dull sound when struck and which breaks into small chips when mined. The true laminated and the crushed flaky coal occur commonly in the Lower Elkhorn bed in this field and are found also in the Upper Elkhorn bed.

Bony and flaky coal usually forms the upper part of the Lower Elkhorn bed, but it may be in the middle and overlain by solid block coal. The flaky, crushed material usually exceeds the bony coal in thickness. In this report the term "laminated" coal refers to the bony, flaky portion of the beds, in accordance with the usage in the field described.

The soft and flaky portion of the Elkhorn beds breaks into chips, which have many smooth, polished surfaces; it may have schistosity developed in it parallel or oblique to the normal bedding, and in places is rolled and twisted into a rumpled mass, which is strikingly different in appearance from a normal bed of bituminous coal. It appears to have been subjected to crushing between laterally moving strata, and in that respect resembles the Widow Kennedy coal bed as exposed at Dante and other places in Virginia. The crustal strain which found relief in the Pine Mountain fault probably was partly taken up in the Lower Elkhorn coal. Whether the overthrust at the fault produced a single westward movement of a few inches in the beds down to the Lower Elkhorn coal or whether the movement was a forward-and-back jarring motion is not certain, but it seems plausible that the broken condition of the upper part of this bed was produced by slight lateral movement of the overlying beds.

The laminated coal ignites quickly and burns readily under a strong draft, but it is high in ash, and for that reason and because so much of it breaks down to slack on handling it is undesirable as a steaming coal. The experience of the companies operating on Marrowbone Creek has been that the inclusion of the laminated coal in run-of-mine shipments was objectionable to their customers, as it gave them a fuel with an undesirably large amount of slack and clinker.

The common section of this bed on Marrowbone Creek is 30 to 36 inches of solid coal overlain by 9 to 20 inches of laminated coal. If the lamination is due to movement, it would be natural to expect that it would disappear to the west with increasing distance from Pine Mountain fault. The evidence on this point noted by the writer is that the greatest thickness of laminated coal is on Big Branch of Elkhorn Creek, which is near the fault, and that there is little or no lamination apparent in the few openings seen on Rockhouse and

Wolfpit creeks. A coal, probably corresponding to the Lower Elkhorn, mined in the John Robinson bank on Pompey Creek 2 miles north of Millard, shows no lamination.

UPPER ELKHORN COAL.

The position of this bed is from 160 to 190 feet above the Lower Elkhorn or 900 to 1,000 feet above the Lee conglomerate. It is in a portion of the geologic column that is made up largely of heavy-bedded or massive sandstone. Geographically it is located in the high land, being from 700 to 900 feet above Russell Fork, and therefore near the tops of the ridges along the river. Between Russell and Levisa forks this coal occurs only in long narrow bodies in the crests of the divides, but west of Russell Fork the dip of the rocks brings the coal down so that it underlies broad areas between Shelby, Marrowbone, and Elkhorn creeks. It can be found throughout the entire region by going high enough on the hills.

East of Russell Fork, in the vicinity of Ferrell Creek, the Upper Elkhorn coal ranges from 5 to 7 feet thick, with only 4 to 8 inches of waste. On Marrowbone Creek 9 sections give an average of 3 feet 10 inches for the thickness of the bed, and 3 feet 2 inches of this is the average amount of marketable coal. The range in thickness of the whole bed on this creek is from 2 feet 10 inches to 5 feet and of the solid coal from 2 feet 5 inches to 4 feet 4 inches.

At the head of Elkhorn Creek, where the Upper Elkhorn attains extraordinary development, the thickness of the entire bed at 7 localities ranges from 7 feet 8 inches to 9 feet 4 inches, with an average of 8 feet 7 inches. The amount of marketable coal in this bed around the head of Elkhorn Creek averages 7 feet 9 inches.

Twenty sections from all parts of the field give the Upper Elkhorn an average thickness of 6 feet, but the average amount of marketable coal is only 5 feet 4 inches. It should be borne in mind, however, that 7 of these sections are from a very small part of the field where the bed is exceptionally large. The other 13 sections, which represent more nearly the normal condition through much the greater part of the field, gives an average thickness of 4½ feet for the whole bed.

FLATWOODS COAL.

The Flatwoods coal is approximately 1,500 feet above the Lee conglomerate. Its altitude is so great that it occupies only two small areas of the greatest elevation in the field. The larger area, which has an irregular shape, lies at the head of Marrowbone Creek and the smaller one is at the head of Poorbottom Creek. They contain about 2,300 acres. The thickness of the bed around the head of

Cassell Fork varies from 14 to 18 feet. Only the upper 7 feet of the bed can be mined advantageously, the lower portion being in large part heavy bands of clay.

DETAILED DESCRIPTIONS.

INTRODUCTION.

In this section the occurrence of the coals as they are exposed in natural outcrop, prospect trenches, pits, and mines, is fully described. The description of the coals is arranged by creeks. Each coal bed in a creek basin is discussed separately, beginning with the lowest. As descriptions of the creek areas do not include a few exposures along Russell Fork, these are given under the heading of the nearest main creek on the same side of the river. That part of the field on the east side of the river is described first. It is customary in this region to speak of the branches and sides of a stream as "right" or "left" as they are encountered in going *upstream*, and that usage is followed in this report.

The graphic sections are arranged in groups, so that all sections of any one coal, as far as possible, are in the same figure.

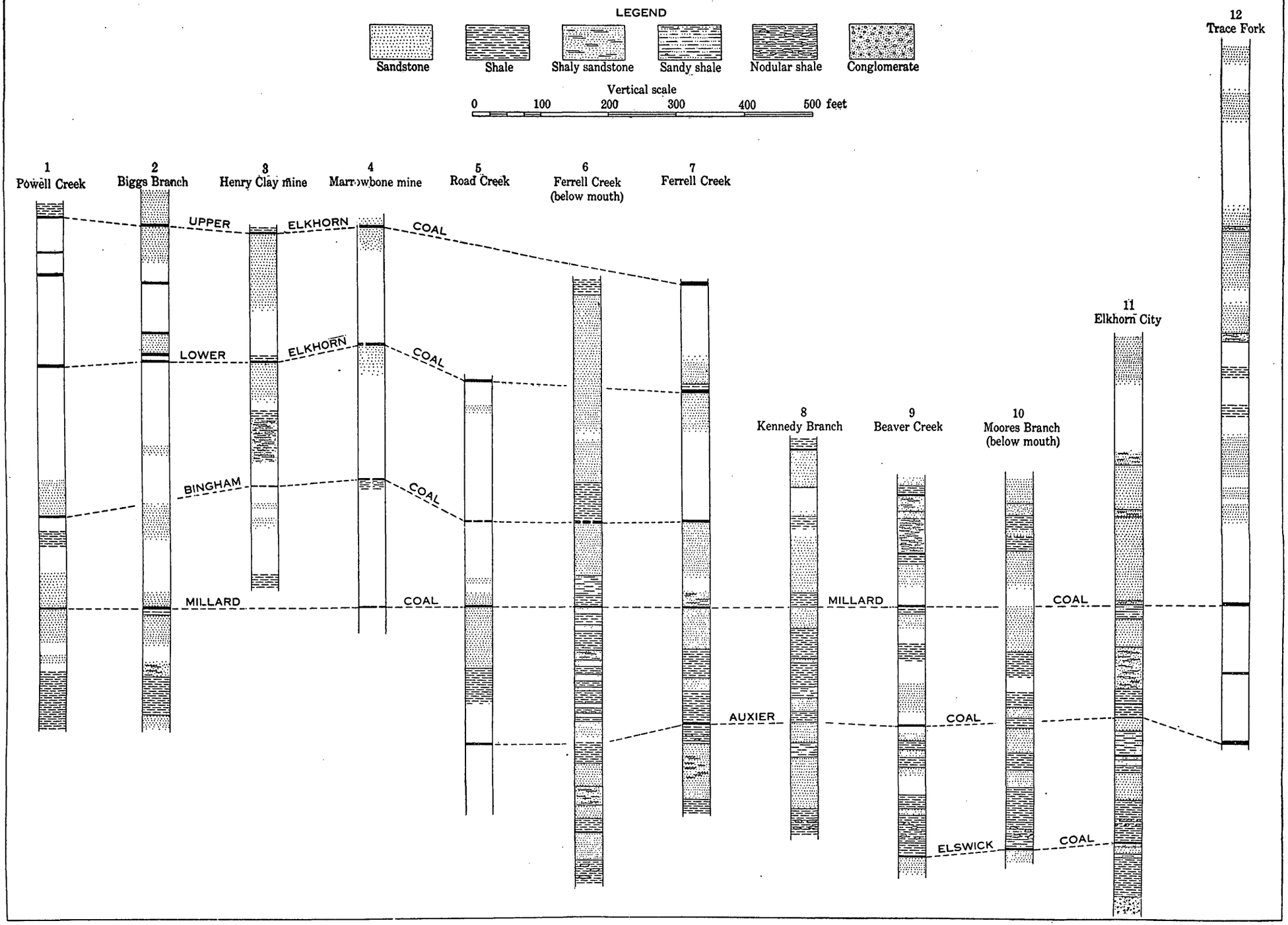
POWELL CREEK AND MILLARD.

Geologic section.—The rock exposed at water level from the mouth of Powell Creek to Millard, or "The Forks," is shale, which is believed to lie close above the Auxier coal. The Millard bed is about 175 feet above the river and is in the midst of 100 feet of sandstone. On Powell Creek a coal bed of which little is known is found 130 feet above the Millard, and the Lower Elkhorn appears to be 340 feet above the Millard. Above the Lower Elkhorn at vertical distances of 125 and 200 feet there are coal beds of workable thickness. A partial section of the succession of rocks in this vicinity is given in the columnar section sheet (Pl. III).

Millard coal.—At the forks of Big Sandy, where this bed is called "The Forks" coal, there is an old pit in the hill above Al. Huffman's house on the northwest side of the river about 175 feet above the water. It was opened many years ago and is still accessible because the overlying sandstone ledge makes an excellent roof. Coal has not been mined here for some years, the supply for the neighborhood being hauled from Pompey Creek. The bed (1)[a] lies between massive sandstones and shows 23 inches of coal with a few inches of shale above and below.

An opening once made on this coal back of J. W. Ford's store, which is also Millard post-office, at an elevation of 175 feet above the river, is caved, but is reported to have shown 2 feet of coal. Three

[a] A number in parenthesis refers to the number of a graphic section in a figure and to the location of the same section on the map.



COLUMNAR SECTIONS IN ELKHORN COAL FIELD.

old openings near the schoolhouse between Millard and the mouth of Powell Creek developed from 26 to 28 inches of clear coal. The Millard bed varies slightly in thickness on Powell Creek. According to report it is 22 inches thick in a small draw on the left, about one-fourth mile from Polley's store, and a little above the mouth of Lick Fork is 18 inches thick (2).

Bingham coal.—Farther up the main creek on the right hillside, just above Mrs. Hunter's, is an entry driven in 40 feet under a sandstone roof which shows (3) a 3-foot bed.

Lower Elkhorn coal.—In the first hollow on the left of Mead Fork, one-fourth mile beyond and 200 feet above Mrs. Mead's house, there is a bank from which coal has been taken recently. It is at an altitude (aneroid reading) of 1,300 feet and is regarded as the Lower Elkhorn. The drift has been driven about 40 feet S. 70° E. and drains out. The roof is sandstone and the floor shale, and the bed is 40 inches thick (4). Laminated coal from 13 to 16 inches thick forms the upper part of the bed and is separated from the block coal, which is from 23 to 26 inches thick, by a one-fourth inch bone parting.

On the right bank of the main fork of Powell Creek about three-fourths mile above the mouth of Mead Fork and at an elevation of 1,300 feet is a pit opposite a cabin. The coal has been dug along the outcrop for 15 feet, showing a sandstone roof, 15 inches of laminated coal (5) and 20 inches of the lower bench. The whole thickness of the bed was not seen. This is a very different section from that in the John Robinson bank on Pompey Creek, where the bed is 4 feet thick and is all solid block coal except 4 inches of bone 10 inches above the floor.

Upper Elkhorn coal.—On the same side of the branch and 135 feet higher in the hill is a prospect which shows 2 feet 8 inches of solid coal with a one-fourth inch clay streak a little above the middle. Thirty feet above it is a 6-inch coal and 50 feet higher a prospect shows a bed over 4 feet thick (6). Whether this bed or the one 80 feet below it is the Upper Elkhorn is not certain. At the head of the main fork an old bank belonging to D. C. Potter is partly caved, but it shows 3 feet 2 inches of solid coal and 4 inches of bone at the base. This bank is said to have been open twelve years and to have two rooms driven east and northeast which drain out. The elevation is the same as that of the 2-foot 8-inch bed farther down the creek, 1,440 feet above tide, and it is supposed to be the Upper Elkhorn.

BIGGS BRANCH.

Millard coal.—Openings on the Millard coal were once made in the hill pasture 180 feet above Jim Goff's blacksmith shop, and also at

Winwright's, on the west side of the river opposite Goff's. Four feet of coal is reported in each of these, but the measurement could not be verified, as the coal is hidden by the caving of the banks. Little more than a mile up Biggs Branch the Millard coal has been dug on both sides of the creek a few feet above the stream. On the left a semi-

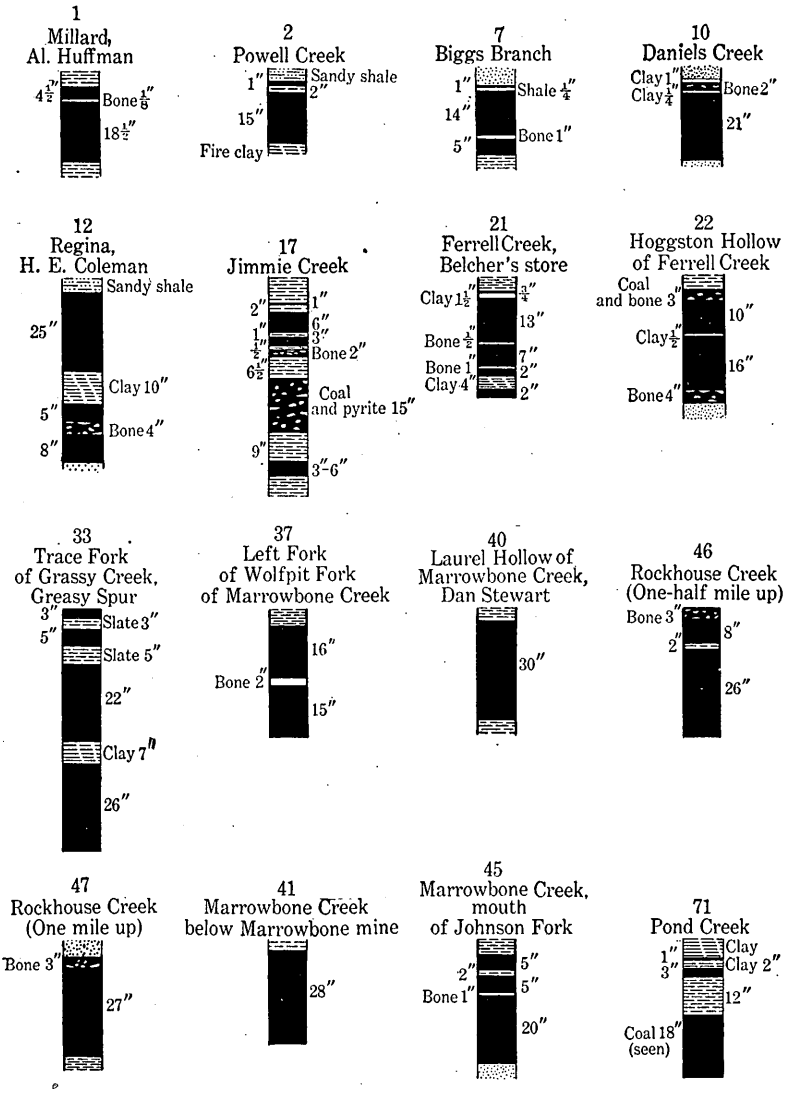


FIG. 5.—Millard coal sections.

circular opening 30 feet long and 20 feet deep shows a 21-inch bed (7) of coal with a shale floor and sandstone roof. In the right bank the bed has the same thickness, and three or four pits within a distance of 50 yards along the crop have been driven in 20 feet.

Elkhorn coals.—Two miles up Biggs Branch, on the right bank behind Isaac Lee's cabin, which is at the forks, and about 150 feet above the cabin, there is an interesting occurrence of a double bed of coal which is at about the horizon of the Lower Elkhorn. The prospect on this coal is driven S. 10° W., is timbered, and drains in. The section of the entire bed (8), beginning at the top, is as follows: Clay, soft and dirty coal, 16 inches; block coal, 2 feet 2 inches; shale, 6 feet; coal, 2 feet; bony coal, 7 inches; shale floor. No similar section was seen anywhere in the field. On the right side of the left fork and 30 feet higher than the double coal just described a trench reveals a bed (9) nearly 5 feet thick and mostly bone. Below the bottom clay is coal and bone of undetermined thickness. This section may improve on driving in.

In the same hollow as the last and 70 feet above it a trench shows 2 feet 6 inches of coal, and on the opposite side of the spur, 80 feet higher than the prospect just mentioned, or at an elevation of about 1,440 feet, there is a 4-foot bed, which is all coal except a 4-inch shale band 8 inches above the floor. The position of this bed corresponds with that of the 50-inch bed (6) in Powell Creek, and the 2-foot 6-inch coal here with the 2-foot 8-inch on Powell Creek. It will be seen by the section of the exposures in this branch given on the columnar section sheet (Pl. III, sec. 2) that the double bed at Lee's is the same distance above the Millard coal as is the Lower Elkhorn on Powell Creek, and that each section has a coal bed not found in the other.

DANIELS CREEK.

Millard coal.—The presence of this coal on the left fork of the creek was reported, but search at that point failed to reveal anything of the pit said to have been dug close to water level. On the right fork at an elevation of 975 feet, or 160 feet higher than the forks, and on a trail along the left hillside, Mose Coleman has a small opening on the Millard coal which lies between beds of sandstone. It has 21 inches of coal with 2 inches of bone for a roof (10).

Lower Elkhorn coal.—The only opening on this coal known on Daniels Creek is a prospect driven by Elijah Anderson in the right bank just above water and close to his house, which is at the head of the left fork. Here over the usual sandstone is a bed of coal more than 4 feet thick (11) and separated from an overlying sandstone by 4 feet of shale. Twelve inches of laminated coal lie above a 2-foot bench of solid coal. Mr. Anderson reported 4 inches of bone and 1 foot of coal occurring below the 2-foot bench. The elevation of this opening, obtained by aneroid, is 1,300 feet, and shows the continuation of the syncline on the north side of the river.

HARLESS CREEK.

Auxier coal.—Probably the oldest coal bank in this vicinity is one opened by Buck Hilton about thirty years ago on land belonging to Butler Ratliff situated on the main fork of Harless Creek between Upper Lick and Lower Lick. It is just above water level on the right bank and 1¾ miles from Regina. A demand for coal for a dinky locomotive which was hauling logs out of Harless Creek was the reason for opening the bank. A chamber about 30 feet wide was excavated and the roof was supported by timbers, but these are giving away and the bank is in danger of caving. The roof and floor are shale. Some coal was taken from this bank in the winter of 1906. The section of the bed (13) resembles more closely the Millard coal opened at Coleman's one-fourth of a mile below Regina than it does any of the sections of the Auxier, but its position as determined by road sections and the interval between it and the Lower Elkhorn on Lower Lick lead to the conclusion that this much-parted bed is the Auxier.

Millard coal.—About 1½ miles below the mouth of Harless Creek, on the left side of Schoolhouse Hollow, perhaps 200 yards from the road, there was once an opening and chute at the Millard coal, which is reported to be 2 feet thick. It is at an elevation of 175 feet above the road, or 980 feet above tide, rests on 60 feet of sandstone, and has a shale roof. The general structure along the river is shown by the gradual rise of this coal bed toward the east.

Probably the largest pit yet opened on the Millard coal is that from which H. E. Coleman has taken fuel for the past ten years. It is situated on the right side of the hollow which opens at his house, opposite Marrowbone station, at an elevation of 250 feet above the river, and is reached by a haul road. The bed lies on 50 feet of heavy sandstone and has a sandy shale floor. It is 4 feet 4 inches thick (12), and the coal is in three benches. A drift has been driven 125 feet S. 25° E. This bed is exposed farther up the hollow at the stable built by David Sanders. An analysis of the Millard coal, made from a sample taken by the writer at the Coleman bank, is given on page 72.

Bingham coal.—An 18-inch bed, which carries considerable iron pyrite and outcrops in the bed of Harless Creek at Will Ward's house, is believed to be at the same horizon as the 3-foot coal at Hunter's, on Powell Creek, and at Bingham's, on Ferrell Creek. Its position is 160 to 180 feet below the Lower Elkhorn coal.

Lower Elkhorn coal.—Four openings on this coal were found on Harless Creek at elevations ranging from 1,320 to 1,400 feet. One at the head of Righthand Fork was opened in the hillside above David Coleman's cabin in 1904. The pit is 20 feet wide and 15

feet deep, timbered, and driven southeast. It shows 15 inches of laminated on top of 4 feet of solid coal (16).

On Lower Lick of left fork a trench shows the bed 5 feet thick. This prospect can be found by going up the bed of the branch about one-fourth mile and climbing the right hillside at a point marked by a tree blazed SR. The upper 18 inches of the bed at this point looks like cannel coal (15). This bed has been prospected on the left side of Corn Hollow at an elevation of 1,320 feet and shows a thickness of 3 feet 3 inches. At the left side of Mose Coleman Hollow, which is the first on the left above Will Ward's, a pit opened thirty years ago also shows the bed 3 feet 3 inches thick and dipping west. The upper 15 inches of the bed is laminated.

Upper Elkhorn coal.—This coal was seen in Mose Coleman Hollow, at the head of Harless Creek, in an old pit on Butler Ratliff's land. It measures 5 feet (14), with only one parting, but that is rather thick.

JIMMIE CREEK.

Millard coal.—On Ratliff heirs' land, about 1¼ miles above the mouth of the creek, there is a coal bed which, from its geologic relations and elevation of 1,050 feet, seems to be the Millard. It lies between the usual beds of sandstone, but it is much thicker here than elsewhere, owing to the presence of shale partings. Section 17, fig. 5, shows the character of the bed.

Sixty feet higher there is a bed in the creek below Thomas Ratliff's cabin showing over 15 inches of coal. It has a shale roof and thin blue clay floor resting on sandstone.

Elkhorn coals.—The Elkhorn coals have not been prospected on this creek, and so nothing was seen of them. The Upper Elkhorn lies well below the summit of the ridge around the head of the creek, but the ridge is so narrow and steep near the top that the remaining portion of the coal bed has only a small area.

ROAD CREEK.

Geologic section.—The meager section obtained on this creek shows the Auxier coal a little over 100 feet above the river, but rising rapidly in the first half mile up the creek. Two hundred feet above it is the Millard, and 320 feet higher is the Lower Elkhorn. The interval between the last two coals is practically the same as in Powell Creek and Biggs Branch. The bloom of the Bingham coal was seen about 120 feet higher than the Millard on Isam Fork. Section 5, Pl. III (p. 38), is a partial representation of rocks on this creek.

Auxier coal.—Several openings, supposed to be on the Auxier coal, have been made at Joe Looney's, 1 mile up the creek. One bank has a 25-foot drift run N. 30° W., which dips into the hill and is full of

water. The bed rests on sandstone and has a shale roof. Only 2 feet of coal could be seen in the flooded opening, but it is reported that at this, as well as other openings close at hand, there are 3 feet of coal. The rocks dip strongly to the west on lower Road Creek.

Millard coal.—Road Creek shows two openings which are presumed to be on the Millard coal. One of these exposures is on Isam Fork by the roadside, a short distance from the mouth of the fork. It shows a sandstone roof, 1 inch of coal, 3 inches of clay, and 22 inches of coal. The other opening reveals the same thickness of bed under a sandstone ledge opposite Marshall Farmer's house, at the mouth of Middle Fork. Its elevation is 1,072 feet.

Lower Elkhorn coal.—As there are several pits on this creek which are timbered and kept open, so that coal can be taken every winter, the character of the bed is easily studied. In every case the roof is shale, and the floor, which could not be seen so readily, probably is bone closely underlain by sandstone. The pit nearest the river is that of Robert Martin, 1,480 feet above sea, at the head of a branch which enters Road Creek on the right less than three-fourths mile above the mouth. This bank has been driven 40 feet N. 45° W., but it drains in. The bed (20) is 15 inches laminated and 4 feet 1 inch solid coal. A sample of the solid coal was taken by the writer, and its analysis is given on page 72.

At the head of Coalbank Hollow Alex Hackney has dug a 20-foot drift N. 75° E., and timbered it. The bed is 1 inch thicker than at Martin's, the increase being in the solid coal. Around the next spur in the head of Cotton Patch Hollow, on John T. Ratliff heirs' land, a drift of about the same size and at the same elevation, 1,465 feet, shows just 5 feet of coal, the top 15 inches of which are laminated. Marshall Farmer has an opening in the left bank at the head of Middle Fork, half a mile above his house, where the bed (19) has the greatest thickness found on the creek. At the face of the drift, which is 30 feet deep and driven N. 15° W., the bed shows a total thickness of 5 feet 10 inches, 14 inches of which are laminated. Its elevation is 1,450 feet. An opening on the left side of Main Fork, one-half mile above Marshall Farmer's, is caved so that the full thickness of the bed could not be determined, but the usual 15 inches of laminated coal was visible. The last bank to be described on this creek is that of H. G. Belcher, at the head of Isam Fork. The coal is at an elevation of 1,420 feet, over 40 feet lower than on the right side of the creek at Hackney's bank, showing a westward dip of the rocks. The Belcher pit is driven east 10 feet and exposes 5 feet 4½ inches of coal. An increase of the laminated to 17 inches is noted here, also the ocurrence of a one-half inch clay parting 2 feet 3 inches above the floor. In the lower bench there are three or four thin partings, not shown in the section (18, fig. 9), which come and go irregularly.

These notes show that the Lower Elkhorn bed on Road Creek, excluding the laminated portion, averages fully 4 feet of available coal.

The Upper Elkhorn coal is so high in the ridge that there is only a very narrow body of it between Road and Jimmie creeks. No openings on it were seen.

FERRELL CREEK.

Geologic section.—The Elswick coal probably is not more than 60 feet below the surface at the mouth of Ferrell Creek, for the Auxier coal is found 130 feet above the river. One hundred and sixty feet higher is a 22-inch coal supposed to be the Millard, and 125 feet above that a 2½-foot bed, here described as the Bingham. The Lower Elkhorn occurs about 300 feet above the Millard, or at elevations ranging from 1,480 to 1,600 feet above tide as the creek is ascended. The dip along this creek in a general way is strongly northwest. The Upper Elkhorn is 150 feet above the Lower and well toward the tops of the hills. On Pl. III (p. 38) is a section compiled from measurements on this creek.

Auxier coal.—On Middlefield Branch, on George Belcher's land, there is an old opening about 80 feet above the mouth of the hollow, in which 2 feet of coal is reported. The rocks rise up Ferrell Creek and at the schoolhouse just below Sprucepine Fork this coal shows 15 feet above the creek. The coal is 22 inches thick and has a blue shale roof. It has been dug along the crop for 100 feet to get fuel for the school.

On Board Fork, one-half mile above Ferrell Creek, there are 3 old openings on John Belcher's land. One of these is an entry driven S. 40° W., down the dip. A small amount of coal has been mined from the bed, which is reported to be 3 feet thick. The same bed was once opened at Marion Spear's on Shop Branch and is said to carry 3 feet of coal. In both of these places the roof is shale and the bed is on top of a considerable thickness of sandstone.

Millard coal.—There is an old bank in the first hollow on the west above George Belcher's store at the mouth of Ferrell Creek at an elevation of about 225 feet above the river. The bed rests on heavy sandstone and has a shale roof. It carries 2 feet of coal, but is broken by shale partings, the thickest of which is 4 inches (21). In Hoggston Hollow, at an elevation of 1,100 feet, or 200 feet above Ferrell Creek, is a little bank on the Millard coal, owned by George Belcher. It shows 2½ feet (22) of coal, and has a shale roof and sandstone floor. A coal at water level in the bank of this creek at the mouth of Bingham Fork, said by L. B. Roe to be 22 inches thick, is also believed to be the Millard.

Bingham coal.—Another and a higher coal, perhaps 125 feet above this last, has been opened back of E. B. Bingham's cabin, one-half

mile up Bingham Fork. It is called a 2½-foot bed, but the bank was caved when the locality was visited, and the report could not be verified. The writer gave the bed its name, because the coal was first recognized and determined here, where the Lower and Upper Elkhorn coals are opened in the same hillside and the intervals between the three coals are easily measured. This coal at Bingham's rests on 40 feet of sandstone and is about 180 feet below the Lower Elkhorn coal.

Lower Elkhorn coal.—Prospect trenches driven to the Lower Elkhorn coal on this creek have in most cases fallen in, and consequently the elevation but not the character of the bed can be obtained. An old prospect at the head of Hoggston Hollow shows that the bed is at an elevation of 1,490 feet, or about 700 feet above the river, while the Clevinger bank, also caved, near the head of the creek, is 100 feet higher, showing the rise of the rocks to the east. A good opening is that of Arch Hoggston, a few hundred yards back of his house, at the right head of Middlefield Branch. The bed is at an elevation of 1,473 feet, has a 3-foot roof of sandy shale overlain by sandstone, and measures 5 feet 2 inches thick. The bed is made up of 14 inches laminated and 3 feet 11 inches of solid coal with a 1-inch clay parting 14 inches above the floor.

On Sprucepine Fork at an elevation of 1,540 feet, on the spur between the main branches, a prospect trench was cut in August, 1906, which shows the bed to be 8 feet 4½ inches thick. This is an unusual thickening, and is due, as is the increase at almost every opening on Ferrell Creek, to the addition of a clay parting and another bench of coal to the bottom of the bed. The section in detail at this opening, which is on George Belcher's land, is: Laminated coal 16 inches, "mother coal" one-fourth inch, coal 17 inches, "mother coal" one-fourth inch, coal 18 inches, clay 20 inches, coal 29 inches. At the right head of a small branch which enters the main stream at Richard Epling's, one-third mile below the gap leading to Road Fork, a bank has been driven 25 feet N. 35° E. The bed is 5 feet 9 inches thick (27) with 1 foot of clay shale separating it from the overlying sandstone. The laminated portion is only 12 inches thick.

Abners Fork is the site of several openings in which the bed has a thickness of over 6 feet. An opening made at the head of the first left fork at an elevation of 1,490 feet is reported by J. W. Church to have revealed 6 feet of coal. L. B. Roe's bank (23) at the head of Abners Fork is driven 75 feet in a southeast direction. Timbering keeps it open so that coal can be mined every winter. The laminated coal 15 inches thick is not mined. Under it is 4 feet of coal, then 6 inches of clay, and a bottom bench of 14 inches of coal. This section differs from that at another opening (24) on Roe's land across the creek from the above and at the same elevation, 1,465 feet, where the

bottom bench of coal is 3 inches thicker and the clay 3 inches thinner. On the right branch of a hollow which enters Bingham Fork at E. B. Bingham's cabin a coal bank has been drifted in about 15 feet. The bed (25) is 6½ feet thick, and has 16 inches of laminated coal at the top.

Upper Elkhorn coal.—A newly faced trench at Bingham's, 150 feet above his bank on the Lower Elkhorn, showed 75 inches of coal in an unbroken bed (26) at an elevation of 1,680 feet. On the right fork of Sprucepine Fork a prospect opened by George Belcher shows the Upper Elkhorn 7 feet thick (28). A prospect at the head of Abners Fork, 160 feet above (24), at an elevation of 1,640 feet, found the Upper Elkhorn coal, but caving had concealed the bed so that it could not be measured. J. W. Church reports that this coal at the head of the hollow back of his house is about 4 feet thick and at the head of Honey Fork is 6 feet thick.

BEAVER CREEK.

Geologic section.—The geologic section on this creek begins with the sandstone under the Elswick coal and extends more than 100 feet above the Upper Elkhorn coal. Nothing was observed of the upper part of the section, so the figures on the columnar section sheet only partially represent the stratigraphy of Beaver Creek. It will be seen that the Auxier coal is about 190 feet above the Elswick and that the correlation and elevation of coals above this is uncertain. This is due partly to the fact that no exposures of the upper coals were found except one at the head of the creek. The rocks rise rapidly up Beaver Creek, but the writer is skeptical about the position of the Lower Elkhorn being so high as is indicated on the Big Sandy Company map.

Elswick coal.—Close beside the schoolhouse at the mouth of Beaver Creek at an elevation of 821 feet above tide there is an exposure of the Elswick coal. The roof is 2 feet of sandstone overlain by shale and the floor is sandstone. There are two benches of coal, the upper 28 to 30 inches and the lower 7 inches, with an 8- to 9-inch shale parting between them (30). On the river a few hundred yards above the mouth of Beaver Creek this coal in a small opening shows 1 foot of clay between it and the underlying 25-foot sandstone and has a shale roof. The bed is a trifle thinner, having 32 inches of coal underlain by 2 inches of bone and 6 inches of coal.

Auxier coal.—In the hollow one-fourth mile below Beaver Creek, Ryus Roberts takes out a little coal every winter from a bank driven about 75 yards S. 45° E. The roof is blue shale and the floor black slaty rock. Solid coal 2 feet 7 inches thick is found in the bank (29), but it increases to 3 feet at the outcrop. There is a prospect above the first left fork of Mud Lick Branch of Beaver Creek on the land of

Enoch Belcher, which shows a shale roof, 4 inches of coal, 5 inches of clay, and 1 foot of coal at the bottom of the prospect. This lower bench is said to be 3 feet thick.

The blossom of the Auxier coal was found in measuring a section at a small branch one-half mile up Beaver Creek at an elevation of 170 feet above the road. An opening made years ago but closed now could readily be reopened back of the house at the mouth of Stonecoal Branch. Two and one-half feet of coal is said to have been found here. The writer is in doubt whether the coal opened on both sides of the creek at Babe Potter's, just above the mouth of Left Fork may not also be Auxier. A hurried tracing of the rocks along the creek seemed to indicate that the coal at the mouth of

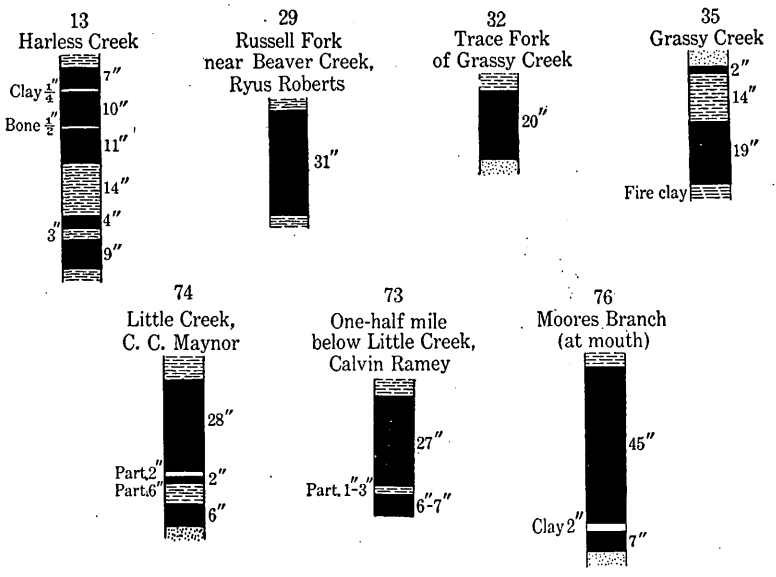


FIG. 6.—Auxier coal sections.

Stonecoal Branch passes below the creek near the mouth of Flat Fork, but it is possible there is sufficient inclination of the rocks to keep it above water for some distance upstream. The opening opposite Babe Potter's is closed, but one back of the cabin shows a shale roof and 2½ feet of coal. The floor was hidden by water, and a lower bench of coal reported by the owner was not seen. The same bed has been dug into on the Left Fork just above the mouth.

On Right Fork, in a hollow back of Mrs. Elizabeth Ramey's place, coal has been dug from a small bed, which is 140 feet above the coal at Babe Potter's, but seemingly not high enough for the Millard coal. At the mouth of Bear Fork, 90 feet above the creek, Enoch Belcher drifted 20 feet into the hill in an easterly direction and took out coal for several years. I. S. Salyer reports that the bed is about 4 feet

thick, with a thin slaty parting 10 inches from the roof and another 8 inches from the floor. This coal is about 340 feet below the lower Elkhorn, and may possibly be the Millard. Bear Fork is a left branch of Left Fork, 1 mile above its mouth.

Elkhorn coals.—At the head of Houselog Branch, near Basil Belcher's cabin, a prospect trench uncovered a coal bed supposed to be the Lower Elkhorn at an elevation of 1,612 feet or 200 feet above the cabin. The coal is reported to be 2 feet 10 inches thick, but can not be seen now on account of caving. Near the top of the ridge, at an elevation of 1,770 feet, directly back of the cabin, the Upper Elkhorn was located, but the trench had been allowed to cave. The bed is said to be 7 feet thick. The Upper Elkhorn at the head of Bear Fork is reported to be 9 feet thick, but this was not verified. The Lower Elkhorn on this fork is reported by I. S. Salyer, who lives at its mouth, to be 5 feet thick with a 6-inch parting in the lower portion.

At the head of Left Fork of Beaver Creek, in the run above the elbow in the road and close under the top of the ridge, Miles Potter has opened the Upper Elkhorn and timbered a drift about 20 feet deep. It shows a bed of coal 6 feet 9 inches thick, with only two thin partings not over an inch thick (31). This bed has an excellent appearance and would be worthy of attention except for the fact that it is so close to the top of the ridge as to have but little body. Even as it is, this bed might be worked in conjunction with the Lower Elkhorn if the latter should be mined on this creek. Several other openings have been made on the Elkhorn coals in the hills around Beaver Creek, but in most cases they were merely prospect trenches, and not being timbered they caved or fell in within a few months and the coal could not be seen.

GRASSY CREEK.

Geologic section.—At the mouth of Grassy Creek the Lee conglomerate rises 150 feet above the water on the west and nearly 1,000 feet on the east. This is because the Pine Mountain fault, but a few rods to the east of the creek, raises the Lee high in the air. A small coal bed in the Lee is said to be exposed at the mouth of the creek, but it was not discovered by the writer. Section 12, on Pl. III (p. 38), is compiled from notes on Trace Fork, and principally from Greasy Spur at the head of the fork. By tracing the rocks up the creek the conclusion was reached that the horizon of the Auxier coal is but little above the stream at the mouths of Trace and Cow forks. This being the case and the dip being gentle to the northwest, the position of a coal found near the head of the fork on Greasy Spur coincides closely with the position of the Lower Elkhorn.

Elswick coal.—Although no openings were seen on the Elswick coal between Elkhorn City and Grassy Creek, the horizon can be traced without difficulty just above the highway, which is for most of the distance near the top of the Lee conglomerate. The bloom of the Elswick coal shows in the road up Grassy Creek just north of Big Hollow.

Auxier coal.—The first opening on the Auxier coal that was seen in going up the creek is on Trace Fork, about one-third of a mile above Riley Cavin's place. Here a prospect shows 20 inches of coal (32) with a fossiliferous shale roof. This opening is 1,113 feet above tide. On the right side of Abes Fork just above Cavin's an opening at 1,153 feet, known as No. 1 of the Yellow Poplar Company, shows 2½ feet of coal, and doubtless is the same bed. As the dip in the vicinity is northwest, it is possible that one of the two small beds found 1 mile farther up Abes Fork may be the Auxier. One is at the mouth of Locust Thicket, 1,140 feet above sea, and has 1 foot or more of coal, the whole thickness of the bed not being visible. The roof is blue fossiliferous clay. On the opposite side of Abes Fork and a few rods farther up, a crop in the creek bank shows a 19-inch coal bed (35), which is 20 feet higher than the one just described. It has a sandstone roof.

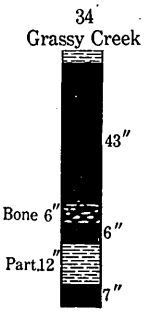


FIG. 7.—Yellow Poplar coal section.

The Yellow Poplar Company made three openings on a bed which lies about 100 feet above the Auxier, the three being 1,265 to 1,270 feet above sea. A clay parting is found near the bottom of each. No. 2 opening shows the bed 4 feet 2 inches thick with a 7-inch clay band. No. 3 is reported 5 feet thick with the same clay seam. This opening is said to have struck a fault 162 feet from the entry, which is quite possible, as this is close to the line of the Pine Mountain fault. No. 4 opening on the left of Old House Branch discovers the same bed over 6 feet thick (34) at the face of the drift, which is 1 foot more than at the mouth of the entry. A small fault having a northeast course at the face of the 15-foot drift displaces the upper bench a few inches, but does not disturb the bottom bench of coal.

Millard coal.—If the correlation of the Auxier is correct, then a coal found 200 feet above it on the left of Trace Fork should be the Millard. Tracing the horizon up the creek it seems to be the coal found at the southern end of Greasy Spur, which W. T. Griffith, a local surveyor, calls the Greasy Spur coal. Two openings on this coal made near water level 1½ miles up Trace Fork show a bed 5 feet 8 inches to 6 feet 1 inch thick, with 3 partings (33). These are at an elevation of 1,220 feet. On Rattlesnake Hollow, 200 feet higher,

a 3-foot bed has been found. This has about the proper position to be the Bingham coal.

Lower Elkhorn coal.—So far as known only one opening has been made on the Lower Elkhorn coal in the valley of Grassy Creek. This is at the extreme head of the main branch of Trace Fork and at an elevation of 1,645 feet. It is on the east side of Greasy Spur and 400 feet lower than the gap leading to the head of Beaver Creek. The opening has been made since the writer left the field and is reported by Mr. Griffith to show a 4-foot 10-inch bed. The Upper Elkhorn should be found higher in the ridge, but can have only a small acreage on account of its position near the top of the hills.

MARROWBONE CREEK.

Geologic section.—The horizon of the Auxier coal is less than 100 feet above water level at the mouth of the creek while the great Flatwoods bed is 600 or 700 feet below the highest point in the area. There is then from the mouth of this creek to the divide at the head a geologic section nearly 2,000 feet thick. The rocks above the Upper Elkhorn coal are shown in the general section (fig. 3) and the lower rocks are partly represented in the Marrowbone and Henry Clay mine sections on the columnar section sheet (Pl. III, p. 38). It is sufficient to state that the Millard coal is found at the mouth of the creek at an elevation of 1,000 feet above tide or 270 feet above the river. The Bingham coal of workable thickness occurs 175 feet and the Lower Elkhorn 370 feet above the Millard. The Upper Elkhorn is 160 to 180 feet higher than the Lower Elkhorn and the Flatwoods bed is at least 500 feet above the former. The rocks between the coals are all shales and sandstones. The shales are in part argillaceous and in part arenaceous, while the sandstones vary from shaly to coarse and massive.

Auxier coal.—By tracing the rocks along the railroad from Moores Branch down the river to Marrowbone Creek, the coal on top of a massive sandstone and level with the roof of Marrowbone station seems to be equivalent to the Auxier. If so, the Auxier is an insignificant coal on this creek, for it is small in the outcrops along the railroad and passes below the level of the creek in a short distance.

Millard coal.—About 240 feet above the railroad, at the mouth of the Marrowbone, on the land of Alec Johnson, on the right of the creek, the Millard coal has been shown by an opening to be 2½ feet thick. On account of the dip to the west this coal is somewhat lower on Wolfpit Fork, where it has been opened (37) on John Coleman's place 1,000 feet up Left Fork. Dan Stewart keeps a small bank open across the run from his house in Laurel Hollow. He has

2½ feet (40) of solid coal between shales. One-half mile up Rockhouse Creek, on the north side and above the sawmill, where this coal has been opened on Henry Ratliff's land, the bed (46) has a bottom bench of 26 inches of solid coal overlain by 13 inches of shale, coal, and bone. One mile up Rockhouse Creek, where the Millard goes under water, it is exposed in the south stream bank for 75 feet and is a 2½-foot bed (47), the top 3 inches of which are bony. The roof is sandstone and the floor shale.

At the mine of the Marrowbone Coal and Coke Company, just above the mouth of Rockhouse Creek, there is an opening on the Millard at an elevation of 953 feet which shows 2 feet 4 inches of coal (41) with a shale roof. This opening is 370 feet below the Lower Elkhorn coal, which is mined directly above. It is known at the mine as the Auxier, but the writer feels certain it is the coal that has been traced from Coleman's at Regina to Huffman's at Millard, and not the coal which has been traced from the mouth of Marrowbone Creek to Elkhorn Creek.

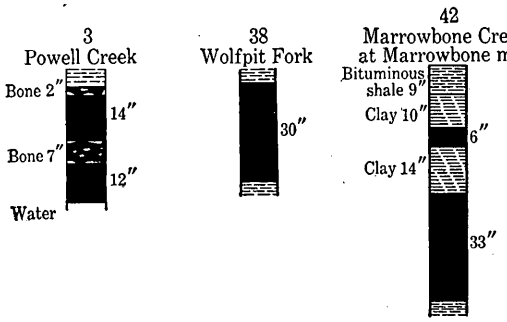


FIG. 8.—Bingham coal sections.

At the end of the railroad cut near the mouth of Johnson Fork there is a partly caved opening (45) in which the dip is 6° W. and which has 20 inches of clear coal in a 2 foot 9 inch bed. This bed, opened under the road below the mouth of Mill Creek, appears about 3 feet thick, but has too many partings to be of value. The sandstone roof is very irregular. These eight openings show an average of about 30 inches of workable coal in the Millard bed on Marrowbone Creek.

Bingham coal.—Two measurements were obtained of the Bingham coal on Marrowbone Creek. One is of the prospect made by the Marrowbone Coal and Coke Company at their mine, where the bloom was discovered 190 feet below the Lower Elkhorn in grading for the incline from the pit mouth to the tipple. The coal was faced close to the surface and the actual character of the bed under cover may not have been revealed. It showed 3 feet 3 inches of coal in two benches separated by 14 inches of clay (42). It is possible that there is some swelling here at the crop and that there may be thin partings in the lower bench which could not be distinguished in the weathered condition of the coal.

Another opening on this coal was seen at Alec Ratliff's, on Left Fork of Wolfpit Fork. It has a good appearance, being 2½ feet thick (38), and lies between shales.

Lower Elkhorn coal.—Besides the pits opened on the Lower Elkhorn coal for family use, many prospect trenches have been cut to prove its extent and character. The outcrop of the coal as shown on the map (Pl. I), which is from D'Invilliers's survey, was run in part by stadia. Many of the prospect trenches have been allowed to cave, so that the writer could not obtain measurements of the coal at so frequent intervals as did Mr. D'Invilliers, but nevertheless more sections of the coal were obtained than are deemed necessary for a thorough description of the bed in this part of the field. The character of the bed at 12 different places on the creek and its branches will be described.

On Wolfpit Fork there is an old pit near the head of the creek on the right above the bend, which shows the full section (36). The roof and floor are shale. The coal is 3 feet 4 inches thick, with 4 inches of bone on top, and without the partings or laminated coal that are found in much of this field.

At the head of the first hollow on the right of Marrowbone above Wolfpit and nearly opposite Bath Hollow there is an opening on Joe Ratliff's land from which coal is taken every winter. It has a shale roof and floor, but the section of the bed (39) differs in all its details from that just described. Here a 15-inch shale is overlain by 2 feet 9 inches of coal and underlain by 2 inches of bone and 9 inches of coal. Still there is no doubt that these two openings are on the same bed. At the head of Deadening Fork of Rockhouse Creek a pit (48) driven in about 15 feet on a dip 5° south shows practically the same character of bed as at the head of Wolfpit Fork.

The next opening on the Lower Elkhorn coal found in going up Marrowbone Creek is that at the Marrowbone mine, just above the mouth of Rockhouse Creek. At this point the bed is over 400 feet above the creek. Two drifts had been driven in 125 feet by September 1, 1906. These were run S. 30° E., and found the rocks dipping in that direction for 100 feet. At 125 feet from the crop the rocks begin to rise. The Lower Elkhorn at this mine has a shale roof and floor, 2 feet 8 inches of solid coal, and a top bench of 16 inches (43) of laminated coal. It is noticeable that the lower 4 inches of the laminated bench is rumpled or contorted, as if it had been rolled under a load. The fact that this 16-inch bench is not marketable, because it breaks down to slack and runs high in ash makes this bed less attractive for mining than it might otherwise be. The same trouble is found in all the mines that have attempted to market run-of-mine coal from this bed on Marrowbone Creek.

One-half mile below the head of Poorbottom Creek James Gibbs has run a drift in 75 feet on the left side on the Lower Elkhorn and

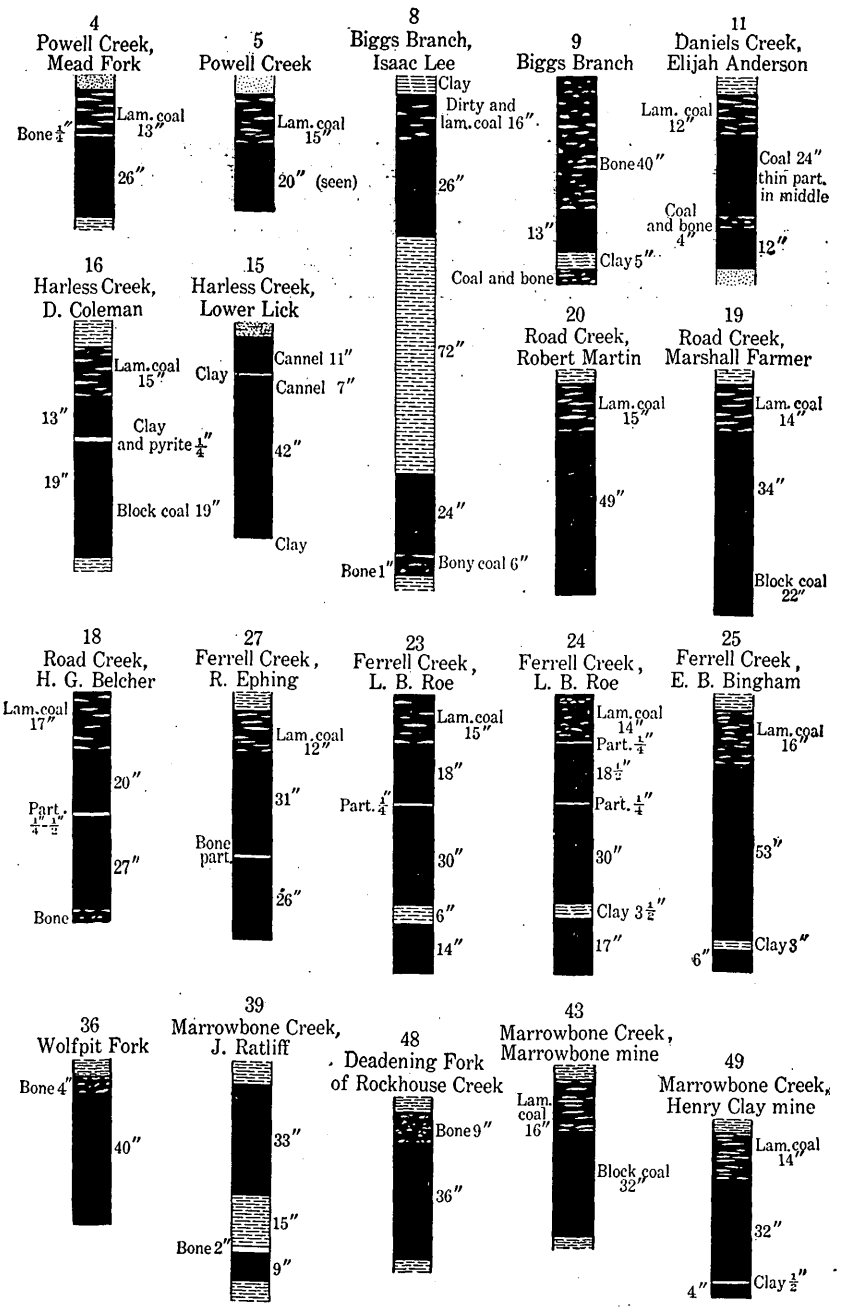


FIG. 9.—Lower Elkhorn coal sections.

found the bed about 3 feet 4 inches thick. At the head of Big Branch, on Levi Coleman's place, the same thickness is found, but the

upper 12 inches is a mixture of shale and coal. It shows 2 feet 6 inches of solid coal (51) with one parting. The floor is shale and the roof sandstone.

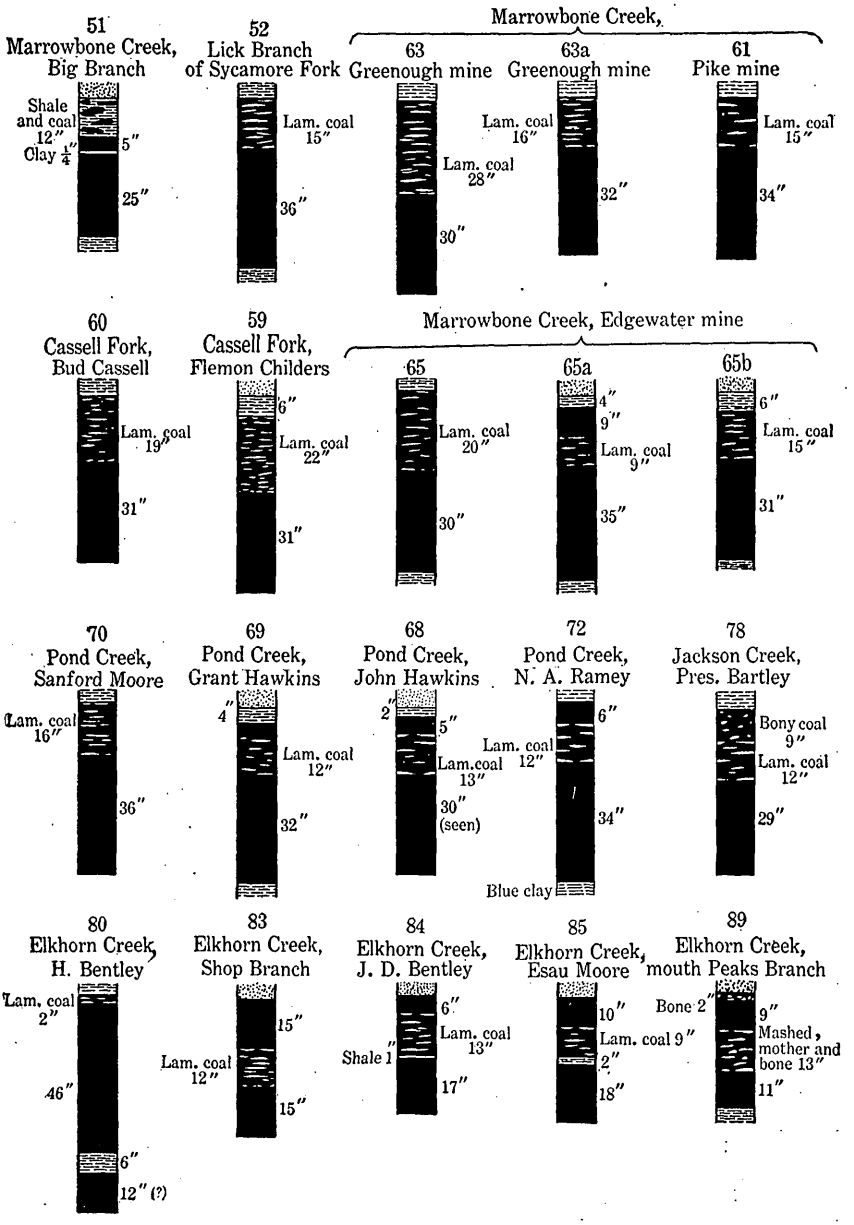


FIG. 10.—Lower Elkhorn coal sections.

The Henry Clay mine is between Poorbottom Creek and Big Branch. In September, 1906, an entry and parallel air course had been driven 550 feet. Two measured sections of the bed were ob-

tained, one near the outcrop (49) and the other at the face. In both places a one-fourth to one-half inch band of clay is found 4 inches above the floor, and the laminated coal is 14 inches thick. The difference between the two sections is the variation in the amount of coal between the clay band and the laminated coal. At the entry the main bench of coal is 2 feet 8 inches and at the face 2 feet 4 inches. The amount of marketable coal in the mine as developed at that time varied from 2 feet 8 inches to 3 feet. The roof is 3 feet of shale, which caves badly.

On Sycamore Fork one section was obtained (52) from an opening on the right of Lick Branch one-half mile above the mouth on the land of J. A. Mullins. Here there is a 60-foot drift showing 3 feet of solid coal and 15 inches of laminated coal. The roof and floor are shale. This is a very characteristic section of the Lower Elkhorn in much of this field.

The Greenough mine is on the left of Cassell Fork just above the mouth. Shale makes the roof and floor. The bed is composed of an upper bench of laminated coal and a lower bench of hard, block coal of fine appearance. At the mouth of the entry the laminated is 1 foot thick; 50 feet inside it has increased to 2 feet 4 inches (63), and at 300 feet from the outcrop it is 16 to 17 inches (63a). The lower bench or block coal at the same points is 2 feet 10 inches, 2 feet 6 inches, and 2 feet 8 inches to 3 feet. The main heading was full of water in September, 1906, and the face 600 feet from the entry was said to show only 6 inches of coal. This is the only instance known to the writer in which the Lower Elkhorn coal falls below 2 feet in thickness, but it suggests the possibility of other considerable variations being found as development progresses. Unless the bed maintains a fairly constant thickness and some use can be found for the laminated coal, the Lower Elkhorn does not promise to be a good mining proposition in this part of the field.

At the Pike mine, on Cassell Fork 1 mile above Hellier, the laminated coal varies from 2 to 22 inches and the solid coal from 2 feet 7 inches to 3 feet 9 inches. The following measurements were obtained in the lower mine:

Sections of Lower Elkhorn coal at Pike mine.

Location.	Laminated.	Solid.	Total.
	Ft. in.	*Ft. in.*	*Ft. in.*
Face of first left entry	1 3	2 10	4 1
Second left heading	1 8	2 7	4 3
Face second left heading	1 5	2 8	4 1
Room 3, second left heading	1 7	3 2	4 9
Room 2, second left heading	1 3	2 8	3 11
Main heading	1 9	2 8	4 5
Main heading	2	2 8	2 10
Main heading	5	3 9	4 2
Face of main heading	1 10	2 8	4 6
Face of air course	1 6	2 9	4 3
Face first right off air course	1 3	3 0	4 3

In the main heading where for a few rods the laminated coal is very thin, a soft clay is found between it and the overlying shale, and there are abundant evidences of movement. The block coal at this point is undisturbed. The mine shows an average of 34 inches (61) of marketable coal. If means could be devised for reducing the amount of ash in the laminated coal, or of using this bench to advantage, the worth of the bed would be greatly increased.

The laminated coal of the Lower Elkhorn bed was sampled at three different points in the Pike mine and mixed to get a fair average. Samples of the solid coal and of the whole bed were taken for comparison, and the analyses are given on page 72. These analyses show only 4.08 per cent of ash in the solid coal, but 22.37 per cent of ash in the upper bench or laminated coal makes the proportion of ash in the whole bed objectionably high. The companies operating on Marrowbone Creek have found that their customers will not accept run-of-mine coal from this bed, and they are obliged to throw the laminated on the waste dump.

The writer's sample of the whole bed is higher in ash than samples taken by others, which are said to represent the entire thickness of the bed. He is confident that the sample taken in the Pike mine is representative of the laminated portion of the Lower Elkhorn coal, and this statement is supported by the following analyses. At the writer's request Mr. Lowry Lewis, manager of the Pike mine, sent 50 pounds of laminated coal in chunks representing the different phases of its occurrence. From these the writer selected three samples which may be described as follows:

Sample 1. Dull, bony coal with numerous paper-thin lamellæ of bright coal. Breaks in flat slabs.

Sample 2. Bony coal, about two-thirds dull and one-third bright, glistening lamellæ. Breaks in flat slabs.

Sample 3. Mixed dull and bright coal, mashed, contorted, and showing many slick faces. Slacks very readily.

Analyses of these samples made in the chemical laboratory of the Survey by George Steiger show the following ash content: Sample No. 1, 35.22 per cent ash; No. 2, 18.81 per cent ash; No. 3, 10.26 per cent ash.

Whether the percentage of ash could be greatly reduced by washing the laminated coal should be determined by testing several tons in a coal washery.

Further evidence of the high content of ash in the laminated portion of the Lower Elkhorn coal bed is shown by the following analyses from samples taken by independent investigators:

Analyses of laminated bench of Lower Elkhorn coal.

	Marrowbone mine.[a]	Edgewater mine.[a]	Peters Creek.[b]
Moisture	2.70	1.52	
Volatile matter	28.24	28.46	31.00
Fixed carbon	42.50	49.18	52.75
Ash	26.56	20.84	16.25

[a] Analysts, Froehling and Robertson. [b] Analyst, J. O. Mathewson.

The sample which represents the Marrowbone mine was taken by S. M. Buck, of Bramwell, W. Va., from a single lump of laminated coal, and does not profess to be an average. The laminated coal in this mine is 15 inches thick and overlain by 2 inches of solid coal. The sample from the Edgewater mine was taken by Mr. Buck from a point where the bed from top to bottom measures: Solid coal 9 inches, laminated coal 8 inches, solid coal 2 feet 6 inches. J. W. Paul, mine inspector of West Virginia, sampled the laminated coal in the Lower Elkhorn bed at Solomon Layne's, on right fork of Peters Creek, a few miles north of the field here described. The laminated coal is 7 inches thick and is overlain by 17 inches of solid coal. These 4 analyses of the laminated, ranging from 16.25 per cent to 26.56 per cent, give an average of 21.50 per cent ash. Two samples of the Lower Elkhorn taken by the writer, from which the laminated was excluded, give an average of 3.08 per cent ash for the solid coal. Considering the proportion of laminated to solid coal, the average amount of ash in the whole bed is on this basis about 10 per cent. An average of 14 analyses by A. S. McCreath and H. J. Williams of the Lower Elkhorn coal on Marrowbone Creek, including the whole bed, gives 8.15 per cent ash. The maximum and minimum amounts of ash in these 14 samples are 13.48 and 1.98 per cent.

The fact that the laminated is overlain in many places by undisturbed solid coal shows that the ash can not be due to a mixture of shale or clay pulled down from the roof during the movement which produced the lamination. The lamination seems to have developed in a portion of the bed which was originally high in ash, and the combination of the coal and its impurity is such that washing would probably not greatly reduce the amount of ash.

On Marrowbone Creek the laminated bench forms so large a portion of the bed that, as long as it has to be thrown out, the Lower Elkhorn is not attractive for mining. Between Russell and Levisa forks the usual 15 inches of laminated coal is present in the top of the bed, but the whole thickness is so much greater that the loss of the laminated is much less important.

The laminated is not a shipping coal, because it breaks down to slack, but probably could be used successfully at the mines for pro-

ducer gas, either for heating or for power. Low-grade coals, high in volatile matter, can be used economically in producer-gas plants.

In an opening at Bud Cassell's, farther up Cassell Fork, the lower bench is normal (60), but the laminated coal has increased in thickness to 19 inches. At Flemon Childers's, in a bank where coal has been taken for two or three years, the block coal is 3 feet 1 inch, and the top bench, bony and laminated, only 8 inches. Still farther up the fork, where the coal approaches water level, the (59) block coal is 2 feet 7 inches and the laminated 1 foot 10 inches.

In the Edgewater mine, at the head of Marrowbone Creek, the Lower Elkhorn maintains a fairly constant thickness. Sections were measured at the mouth (65), 230 feet in (65 a), and at the face of the main entry 370 feet from the crop (65 b). These show a lower bench of 2 feet 6 inches to 2 feet 11 inches, and an upper bench from 15 to 20 inches thick. In one section (65 c) 9 inches of solid coal overlies an equal thickness of laminated.

Upper Elkhorn coal.—The first opening on the upper Elkhorn coal above the mouth of the creek is that at the Marrowbone mine near the mouth of Rockhouse Creek. The Marrowbone Coal and Coke Compay has done development work on both of the Elkhorn beds, one mine being directly above the other and both served by the same incline. On the upper coal an entry (44), driven 125 feet S. 30° E., shows a section of the bed which is different from any other found in the vicinity. At the mouth of the entry it is 3 feet 10 inches thick, but includes a 17-inch clay parting, the bottom of which is 9 inches above the floor. According to R. C. Peacock, manager of the mine, this clay, which contains small streaks of coal, is 12 inches thick at the face of the drift and is two-thirds coal.

When this creek was visited in September, 1906, a drift on the Upper Elkhorn coal had been driven 70 feet northwest at the Henry Clay mine and showed a bed 4 feet 5 inches thick (50). At Cynthia Gibson's, on Lick Branch of Sycamore, a 70-foot drift shows this coal 5 feet thick (53), and on Henry Bowen's land, at the head of Sycamore (54), the bed is 3 feet 6 inches thick.

The first exposure up Cassell Fork is at the Greenough mine, where there is a bed of solid coal (64) nearly 4 feet thick. A sample of the whole bed at this mine was taken by the writer and the resulting analysis will be found on page 72.

At the Pike mine, a mile up the fork (62) the bed is less than 3 feet thick and the upper 5 inches is bony or mashed. Farther up Cassell Fork there are several prospects exposing the Upper Elkhorn. Among these are a pit on Flemon Childers's land (58) and a trench on the Musgrave place which show the bed from 3 feet 3 inches to 3 feet 9 inches thick, the upper 8 inches being bony or laminated.

At the Edgewater mine, on the head of Marrowbone Creek, the Upper Elkhorn coal is nearly 4 feet thick. The main entry shows 2 feet 8 inches of solid coal at the mouth and 2 feet 10½ inches at the face (66), the rest being bony or laminated.

An average of 9 sections measured on this creek gives a fraction over 3 feet for the thickness of the solid or marketable coal.

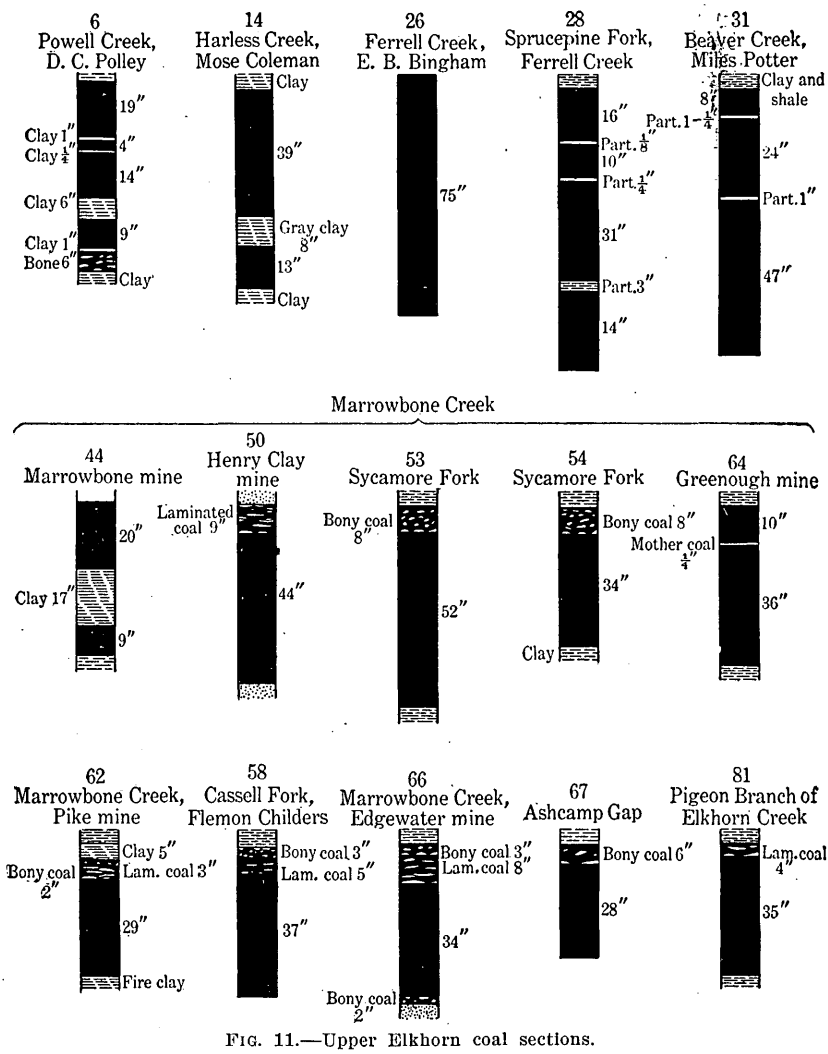


FIG. 11.—Upper Elkhorn coal sections.

Flatwoods coal.—An approximation of the area underlain by the Flatwoods coal is shown on the accompanying map (Pl. I). The stratigraphic position is 500 to 550 feet above the Upper Elkhorn. It has been prospected but little. A measurement of the bed was made at the head of Cassell Fork in a trench cut for the Big Sandy Company and the total thickness (55) found to be 18 feet 9 inches.

Of this the upper 6½ feet is workable coal, and a sample was taken for analysis. The lower 12 feet of the bed is too much broken up by clay partings to be of value. Two other openings in this same locality (56, 57), according to measurements by E. V. d'Invilliers, show 14 feet 2 inches and 16 feet 7 inches, respectively, but much of the bed is worthless.

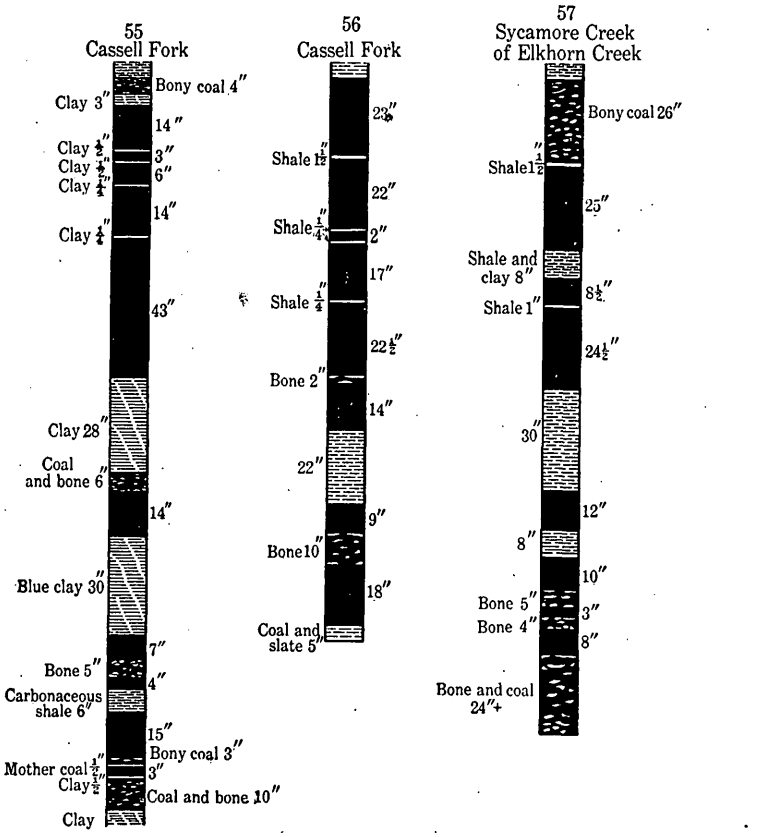


FIG. 12.—Flatwoods coal sections.

On the Flatwoods table-land 500 feet above this coal another bed is reported [a] to have been opened at the head of the right fork of Sycamore Fork of Elkhorn Creek. It was not seen by the writer, but it is reported to be 4 feet thick with only one thin shale parting.

POND AND JESSE CREEKS.

Geologic section.—The geologic section in these creeks begins about 100 feet below the Auxier coal and extends a short distance above the Upper Elkhorn coal. The ridge between the two creeks is too low to

[a] Crandall, A. R., The coals of Big Sandy Valley: Kentucky Geol. Survey, Bull. No. 4, 1905, p. 116.

catch the Upper Elkhorn, but it is present around the head of Pond Creek.

Small coals.—So far as learned the Auxier was not open at any place on Pond or Jesse creeks and no information could be obtained as to its thickness. A coal occurring at a higher horizon was seen in the bank of Pond Creek above an old mill, which is just below Camp Branch, at a point about 200 feet higher than Russell Fork. This is near the horizon of the Millard and is a 3-foot bed (71), with clay partings. Eighteen inches of solid coal was seen at the bottom, resting on sandstone. Between Camp Branch and Laurel Branch, opposite Sanford Moore's house, a facing shows two 6-inch bands of coal, separated by 17 inches of shale. There may be other small, worthless beds in the section exposed along this creek, but their presence was not discovered.

Lower Elkhorn coal.—This coal was opened by Sanford Moore on the left of Pond Creek just below the mouth of Laurel Branch in April, 1906. It is marked by a chute, which brings the coal down to a bin at creek level. The bank furnishes fuel for the dinky locomotive of the Clinch Valley Lumber Company, which is operating on this creek. Normal conditions for this region are found here, the bed having a total thickness of 4 feet 4 inches (70), the upper 16 inches being laminated. Shale forms the roof. An analysis of a sample from the bed at this point, including both laminated and solid coal, is given on page 72.

William Ramey reports that the coal was once opened in the head of the hollow back of his house, and showed a 4-foot 4-inch bed, with 2 inches of slate between the solid coal and the laminated. Mr. Ramey lives at the mouth of the branch on the right, just above Laurel Fork. In a hollow on the right, one-half mile above Ramey's, a bank has been driven about 80 feet N. 75° E., and coal is brought out in a small tram car to a chute for loading on wagons. The westward dip of the rocks makes the drainage good. The section here is the same as at Moore's, 3 feet of solid coal with a 16-inch bench of laminated on top.

An entry on the right branch of Laurel Fork has been driven 35 feet in a southwest direction, according to Sanford Moore, but the water flows in and the pit is now full. The bed is reported to be 4 feet 5 inches thick, with 12 inches of laminated separated from the solid coal by soft "mother coal."

Back of Grant Hawkins's house at the forks at the head of Pond Creek a drift 75 feet long has been run into the hill S. 25° E. on a dip of N. 55° W. The bed is 4 feet thick (69), the lower bench having one or two one-fourth inch partings that are not persistent. At John Hawkins's farther up the creek, a 70-foot drift on the same bed

(68) shows the laminated coal 1 inch thicker and the solid 2 inches thinner than at Grant Hawkins's. The floor in both places is shale, but at the first-mentioned locality only 2 inches of shale lie between the coal and sandstone roof.

The Lower Elkhorn coal has been prospected by N. A. Ramey at the left head of Camp Branch of Pond Creek. His pit shows (72) a shale roof, a bed almost the duplicate of Hawkins's, and a blue-clay floor.

In Jesse Creek the Lower Elkhorn has been opened at the head of a hollow off the left branch. The entry which has been driven 60 feet shows 3 feet of shale between the coal and overlying sandstone, and a bed at least 3 feet 8 inches thick, the upper 14 inches of which is laminated coal. The bottom was not seen. Frank Owens, who lives at the head of this creek, reports an opening on the right side of the right fork, that was driven west 75 feet on a coal bed dipping in the same direction. The roof is weak shale, and the bed 5 feet thick, the upper half of it being worthless. Coal opened back of Owens's house, about 250 feet below the Lower Elkhorn, is said to be 2 feet thick.

Upper Elkhorn coal.—A bloom of the Upper Elkhorn coal was seen at the head of Pond Creek, above John Hawkins's bank (68). The coal is reported to be 4 feet thick, the lower part peacock coal and the upper a good blacksmith coal. About 100 feet higher in the hill a hole shows another bed 42 inches thick, with a sandstone roof and 5 inches of clay 1 inch from the top. Grant Hawkins is authority for the statement that there is a 1-foot coal 20 feet above this and a 3-foot coal still higher. These were found in plowing and are not now exposed. Sanford Moore reports a bed of solid coal 5 feet 2 inches thick at the head of Laurel Fork, 340 feet above the Lower Elkhorn and too high to be the Upper Elkhorn. An entry was driven in on it 4 feet up the rise, when digging stopped. The pit has caved so that the report could not be verified.

LITTLE CREEK AND MOORES BRANCH.

Geologic section.—A section measured in the river bluff between these two branches and giving the sequence of the rocks from the railroad to the top of the intermediate ridge will be found on Pl. III (sec. 10). Unfortunately none of the coals above the Elswick were seen in climbing the hill, and the positions indicated in the section are only suggestions of their probable location.

Elswick coal.—This coal rises above the river at the mouth of Little Creek and is exposed just below Moores Branch in the rock cut along the railroad a few feet above the track. The cut shows a shale roof, 3 feet to 3 feet 4 inches of coal (75), and a sandy shale floor 2

feet thick resting on a massive gray micaceous sandstone. There is a small pyrite stringer near the bottom of the bed. The Elswick has been opened on Moores Branch, but is now caved.

Auxier coal.—On Little Creek, on the north hillside back of C. C. Maynor's house, there is a 30-foot drift running northwest down the dip of the Auxier coal, which is 3 feet 8 inches thick and has two partings near the bottom (74). A prospect on the point between the forks of the creek, at an elevation of 946 feet, is caved, so that the coal can not be seen. Calvin Ramey has an opening on the Auxier in the hollow one-half mile below Little Creek. It is 150 feet above the railroad, on the left fork of the hollow, one-fourth mile from his house (73). He opened it in the winter of 1905 and drifted S. 70° W. a few feet, then turned S. 20° W. At the time it was visited only 2 feet 3 inches of coal could be seen, but Mr. Ramey reported a thin parting and 7 inches of coal below the floor of his bank. This was confirmed by a prospect in the same hollow, a few rods away, where the thickness of the bed is 3 feet 1 inch with a 2-inch parting 7 inches from the floor.

The outcrop of the Auxier goes below water level about three-quarters of a mile up Moores Branch. It has been prospected in two places near the stream, but the only measurement made on the branch was obtained in the first little sag on the left 200 yards upstream from the railroad and 200 feet above the branch. This is the thickest section of the Auxier seen in the field, being 4 feet 6 inches (76) with a 2-inch clay parting near the bottom. The usual shale roof and sandstone floor were found here.

ELKHORN CREEK.

Geologic section.—A section (Pl. III, sec. 11) measured in the 800-foot bluff opposite Elkhorn City at the mouth of Elkhorn Creek indicates the sequence of rocks exposed in this valley. The top of the Lee conglomerate is a few feet above water at the creek mouth, and the Lower Elkhorn coal is near the top of the ridge. A heavy sandstone 500 feet above the river is correlated with that which makes a conspicuous ledge at Ashcamp, and a 12- to 15-inch bed of coal found near the mouth of Jackson Branch is thought to be near the horizon of the Millard coal. At Joes Branch and in the vicinity of Pound Gap the Upper Elkhorn is barely 100 feet above the creek.

Elswick coal.—The eastward rise of the rocks puts the Elswick coal 870 feet above tide at Elkhorn City. Openings near the mouth of Elkhorn Creek have caved in, but the Elswick coal is seen on the left 80 feet above the creek at the ford a half mile from Elkhorn City. The old coal bank is full of water, but at least 2 feet of coal is visible. At the other end of the same field, opposite the mouth of

Cane Branch, close to Alexander Adkins's house, there is an entry 20 feet deep. It has a sandstone floor and a good shale roof. The bed (77) is 2 feet 9 inches thick, with a half-inch band of sandstone close to the top. On the right side of the creek above the mouth of Cane Branch a bank is kept open to supply a small local trade and shows 2 feet 6 inches of coal. Roof and floor are the same as at Adkins's, and the dip is to the west. This dip makes drainage on the right side of the creek difficult. The Elswick coal bed goes below creek level near the mouth of Pond Branch on the land of Alec Roberts.

Auxier coal.—Although the outcrop was traced up the west side of Elkhorn Creek for more than 2 miles, no measurements were obtained on the Auxier bed. In the bluff opposite the store at Elkhorn City coal was found about 275 feet above the Lee conglomerate, or 300 feet above the river, on top of a 30-foot massive sandstone and overlain by shale. This seems to be at the horizon of the Auxier, but the section is so different from any seen elsewhere that it is questioned and was not considered in determining the average thickness of the Auxier bed. At this place there are two benches of coal, the upper 18 inches and the lower 12 inches thick, separated by 6 feet of shale. The Auxier falls below the creek in the bend below the mouth of Kettlecamp Branch.

Lower Elkhorn coal.—Few openings have been made on the Lower Elkhorn coal bed on the lower part of the creek. The first observed is in Jackson Branch, where William and Caleb Wood have a pit on the left of the stream a little over a mile above the mouth. This pit shows a 4-foot 2-inch bed, the upper 15 inches being laminated. In a hollow on the right, one-half mile below Wood's, Pres. Bartley opened the same bed (78) in the winter of 1905, one-fourth mile up the hollow and 325 feet above Jackson Branch. The bed has the same thickness as at Wood's, but only 2 feet 5 inches of it is solid block coal.

On Ashcamp Branch, back of G. W. Bartley's store, a bank opened on the Lower Elkhorn reveals 10 inches of solid coal underlain by 9 inches of laminated coal and a bottom bench at least 2 feet 6 inches thick. The drift is driven about 30 feet S. 20° E. on a northward dip.

In the head of a hollow on the right of Sycamore Creek there is an opening in which 30 inches of solid coal was seen, with an upper bench of 15 inches laminated and 5 inches bony coal. The bed is said to be 6 feet thick in the face of the drift, which is 42 feet long. On the west side of the same hollow a drift was once driven 35 feet on the coal by Joel Ratliff, who says he found 8 feet of solid coal at the base and nearly 10 feet of laminated coal above. The drift caved, burying tools, car, etc., and has never been reopened.

An opening on Harry Bentley's place, below the mouth of Pigeon Branch, shows a 4-foot bed, only the upper 2 inches being laminated (80).

On the right side of Big Branch an opening on A. W. Childers's property shows the Lower Elkhorn, which is there (82) composed of 30 inches laminated coal and only 13 inches solid coal. This is hardly representative of the bed, however, for it seems to be close to a local fault which may have affected the proportions of laminated and block coal. On Shop Branch a pit opened by Don Ratliff reveals this bed 3 feet 6 inches thick with 1 foot of laminated coal (83) in the middle, and on the head of Shelby Creek at Blackhead Vanover's a 40-foot drift shows 10 inches of solid coal at top and 15 inches at the bottom, but with 20 inches of laminated coal in the midst of the bed. This coal shows a bloom in the road just below Shelby Gap.

Along the road one-fourth mile above Shelby Gap, where the creek has cut a rock cliff, there is exposed a 21-inch bed of coal and bone which can be traced to Marshall Branch. This bed lies over 40 feet below the Lower Elkhorn coal. In the hollow back of J. D. Bentley's house the Lower Elkhorn has been developed by an entry driven N. 70° E. 25 feet under a sandstone roof. The bed is 3 feet thick and has a 1-inch shale band between the solid and laminated coal (84). At Esau Moore's, a little farther up the creek, the small bed mentioned above is at water level 18 inches thick, and a 15-inch bed is about 20 feet above it. In the hollow opposite Moore's house, 50 feet above the creek, there is a pit on the Lower Elkhorn which shows much the same characters (85) as are seen at Bentley's. In the bed of Marshall Branch, below the forks, at William Isom's, the Lower Elkhorn appears again with the same sandstone roof, 7 inches of solid coal and 7 inches of laminated, separated from the 18-inch block coal by 2 inches of shale. At the forks, a few rods farther up the branch, a pit discloses a coal bed 2 feet 8 inches thick, which can be but little above the Lower Elkhorn.

Just above water level in the bank of Elkhorn Creek at Alec Isom's, below Peaks Branch, an opening on the Lower Elkhorn coal shows the bed to be nearly 3 feet thick, but with over a foot of laminated and bony coal in the middle (89).

Upper Elkhorn coal.—This coal is so high in the hills along the lower part of the creek that little prospecting has been done on it below Shelby Gap. A pit at Ashcamp Gap, 1,577 feet above tide, reveals a 2-foot 10-inch bed (67), the upper 6 inches of which is bony. On the longest fork of Pigeon Branch a 100-foot drift made by L. J. Vanover shows 4 inches laminated and 35 inches solid coal at the face (81).

On Marshall Branch the Upper Elkhorn begins to assume the proportions that have become famous in this region. At the head

of the right fork William Johnson takes coal from a prospect pit (86) at creek level, in which there is a top bench of coal 31 inches thick and a lower one at least 20 inches thick. The whole bed was not exposed, so the floor could not be seen, but the roof is fossiliferous shale. At the head of the left fork of Marshall Branch there are two openings in which the bed is 8 feet thick. At Caleb

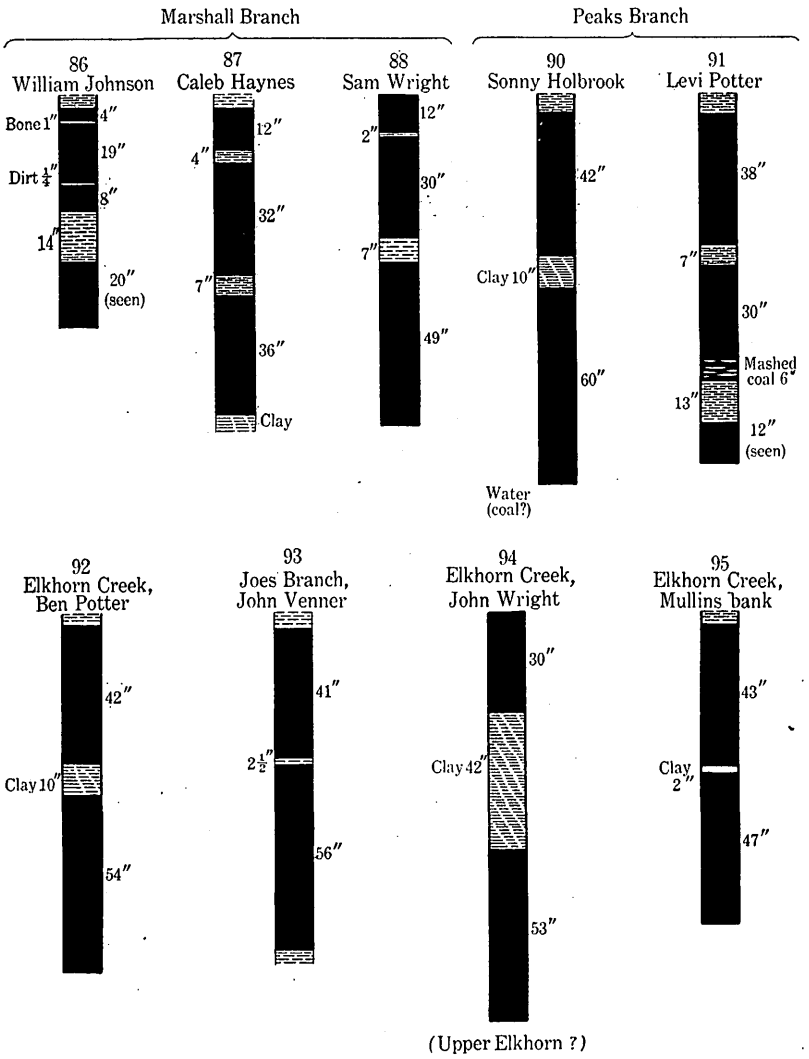


FIG. 13.—Upper Elkhorn coal sections.

Haynes's place (87) there are two partings from 4 to 8 inches thick, while at Sam Wright's, where a trench cut in the hillside (88) shows a bed 8 feet 9 inches thick, only 9 inches in all is parting.

On Peaks Branch, a quarter of a mile from the mouth and in the hill back of a cabin, there is a pit known as the Sonny Holbrook

opening, which shows the bed at least 10 feet thick (90) with only one 10-inch parting. The entire bed was not measured because of water in the pit. On the right fork of Peaks Branch, opposite Levi Potter's house, a trench shows the bed (91) to be at least 9 feet thick and the bottom was not seen. Twenty inches of shale in two partings are included.

On Bens Branch near Ben Potter's house, about 100 feet above Elkhorn Creek, this coal is finely shown in a drift 20 feet long. The bed is 8 feet 10 inches thick and has only one parting, which is near the middle (92). The analysis of this coal from the writer's sample given on page 72 shows that it is of very high grade.

The bed is equally good on Joes Branch, where the Blevens opening, on John Venner's land (93), shows a section of 8 feet 3½ inches with only 2½ inches of parting instead of 10.

At the mouth of Little Elkhorn, less than 40 feet above the creek and close to the ford, a prospect on John Wright's land shows a bed which was not recognized. Whether it is the Upper Elkhorn or not is an unsettled question. The dips in the vicinity suggest that it is a lower coal than the one seen at Mullins's near the head of the creek. This bed at Wright's is nearly 9 feet thick, but it carries 42 inches of clay (94) in the middle.

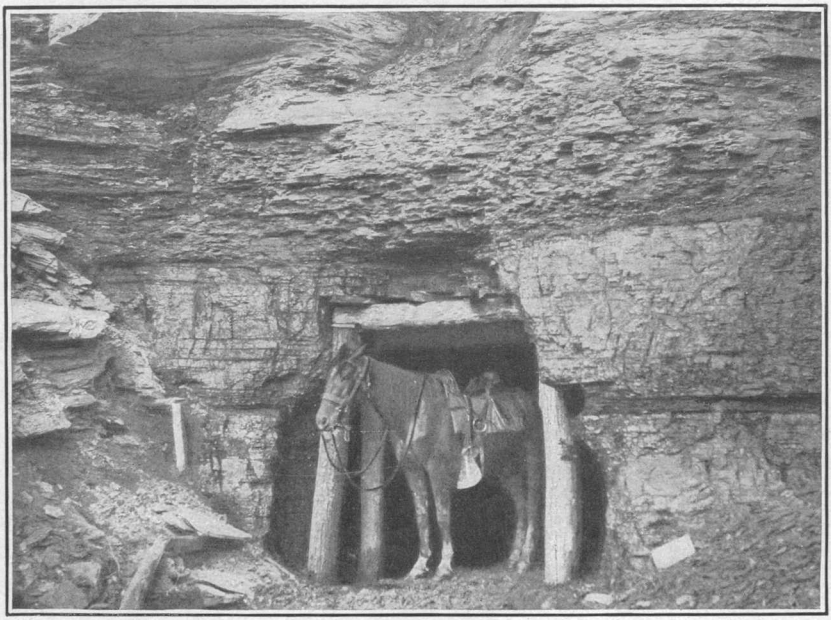
At the main head of Elkhorn Creek, the fork flowing from the north toward Pound Gap, there is an opening commonly known as the Mullins bank (95), which shows the Upper Elkhorn 7 feet 7 inches thick separated near the middle into two benches by 3 inches of clay. The lowest bench has several 2-inch bands of lusterless splint coal. An analysis of a single chip of this dull coal showed 6 per cent ash. A sample of the splint coal in the lower bench of the Upper Elkhorn taken by J. J. Hillsman, presumably at the Mullins opening, had, according to J. W. Fox, the following composition:

Analysis of Upper Elkhorn splint coal.

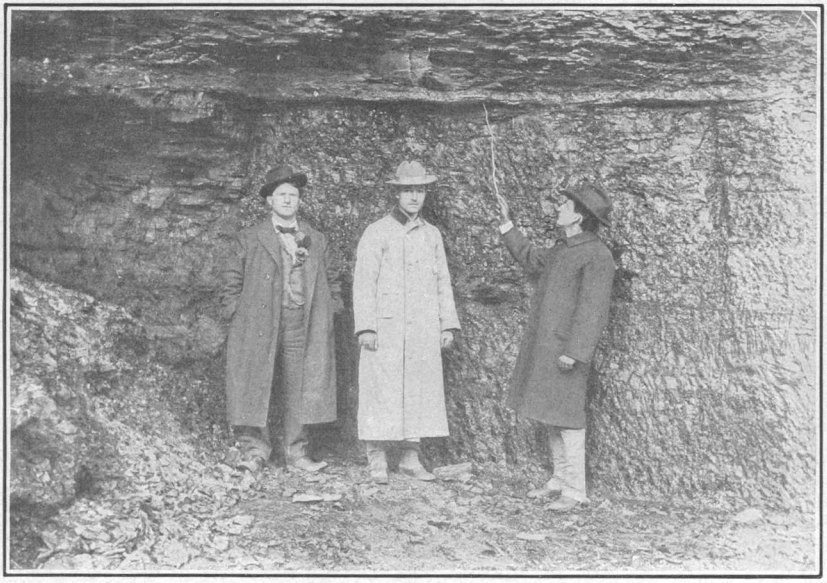
[Otto Wuth, analyst.]

	Per cent.
Moisture	0.96
Volatile matter	34.56
Fixed carbon	62.369
Ash	1.60
Sulphur	.519
Phosphorus	.002

This is surprisingly low in ash, for the splint coals in the southern part of West Virginia average between 3 and 4 per cent ash. This sample represents 14 inches of splint coal found 23 inches above the floor. The entry to the Mullins bank (Pl. IV, *A*) has been driven about 50 feet S. 15° E.



A. MULLINS OPENING ON UPPER ELKHORN COAL, HEAD OF ELKHORN CREEK.



B. UPPER ELKHORN COAL ON WRIGHTS FORK OF BOONE FORK OF KENTUCKY RIVER.

B from photo loaned by Jno. C. C. Mayo.

Coal was taken from the Mullins bank for testing the coking qualities of the Upper Elkhorn in beehive ovens built by the Northern Coal and Coke Company on John Wright's farm. The character of the coke is described in a later chapter. An analysis of the coal in the Mullins bank, given repeatedly in the reports of the Kentucky Geological Survey and of the inspector of mines, will be found on page 73.

Reports by A. R. Crandall, of the Kentucky Geological Survey; Neil Robinson, of Charleston, W. Va.; H. Hardaway, of Georgel, Va.; Arthur M. Miller, of Lexington, Ky., and others, all agree that the Upper Elkhorn maintains the same thickness and characteristics as here described throughout a large area around the heads of Boone Fork of Kentucky River and of Shelby Creek (Pl. IV, *B*). This average thickness of 8 feet is not confined by any means to the head of Elkhorn Creek. The thickness of the bed, its extent, and its steaming and coking qualities all point to the conclusion that it is the best mining bed in the field here discussed. It is not at present within easy reach of a railroad. Mr. Crandall calls this the Lower rather than the Upper Elkhorn coal.

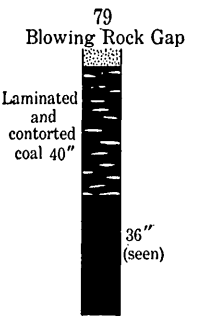


FIG 14.—Coal on Blowing Rock Gap road.

Coals on the flank of Pine Mountain.—Coal has been found in several places on the flank of Pine Mountain, east of Elkhorn Creek, but because of the steep dip it is not known just what beds are exposed here. A coal reported to be 9 feet 6 inches thick, on William Potter's land, between Joes Branch and Pound Gap, has a section similar to that of the Upper Elkhorn on the other side of the creek. Although a bed over 8 feet thick was seen, the bottom of the coal was not reached, and it is possible that the reported thickness is correct. The bed reported by the Kentucky Geological Survey, 1 mile up Pigeonroost Creek, at water level, is said to be 10 feet of clean, solid coal. An analysis of this coal given in the table (p. 73) shows that it is of high grade.

Several other openings were reported on the mountain side, but they are caved so that the coal can not be measured. A coal has been found in a hollow on the north side of the road from Ashcamp to Blowing Rock Gap near George Bartley's house. An opening made ten years ago is so caved now that only a portion of the bed, reported from 9 to 11 feet thick, is visible. The writer saw under a massive sandstone 40 inches of mashed and contorted coal which rested on 3 feet of solid coal (79). It was evident that only a portion of the block coal was exposed. The statement of the neighbors is that a tall man could stand under the slaty or laminated coal and not rub his

hat. This being so, the bed is at least 9 feet thick at this point, but it is possible that this may be a pocket, and that any coal on the mountain side close to the fault is badly crushed and possibly broken by small faults. An analysis of this coal by the Kentucky Geological Survey is given on page 73. It hardly seems possible that the laminated coal or the whole thickness of the bed was included in the sample from which this analysis was made, for it shows only 2.16 per cent ash.

SUMMARY.

It will be seen from the foregoing description of the field that it contains six coals of workable thickness. Two or three other beds have a problematic value. The following table shows the range in thickness of the workable beds:

Summary of coal beds.

Name of coal bed.	Maximum.	Minimum.	Average.	Number of sections.
	Ft. in.	*Ft. in.*	*Ft. in.*	
Elswick	3 10	2 6	3 1	5
Auxier	4 11	1 8	3 1	8
Millard	4 4	1 6	2 5	20
Bingham	4 5	2 6	3 1	4
Lower Elkhorn	6 11	2 9	4 3	34
Upper Elkhorn	9 4	2 10	5 8	19

It should be borne in mind that this table is based on total thickness of bed, and does not represent the amount of marketable coal contained in each bed, nor indicate which are and which are not good mining beds. For instance, although 5 sections of the Elswick bed give an average of 3 feet 1 inch for the whole, the average amount of workable coal in the sections is only 2 feet 7 inches.

The Auxier coal is shown to be about 3 feet thick, and as it usually has but one parting it can be counted on to yield at least 2½ feet of coal in part of the field. Present conditions do not as yet demand the development of beds of this size, but they constitute a reserve which may at some future day, when the thicker beds have been exhausted, yield a large tonnage of good bituminous coal.

It appears from the above table that the Millard coal bed ranges from 1 foot 6 inches to 4 feet 4 inches thick, averaging 2 feet 5 inches. Lest this be misleading, it should be stated that the thickest known occurrence of the bed is on Jimmie Creek (17), where it is unworkable because it contains too much shale and pyrite. There is only 15 inches of solid coal in the thinnest section, and this is too little to mine. The Millard is a mining bed, therefore, in only a portion of its extent, and several decades will pass before it becomes necessary to touch a bed of this character in the great coal field of eastern Kentucky.

The Bingham coal was seen at so few points that little is known of its extent or character.

Of the Lower Elkhorn coal it should be noted that the average thickness of the bed as given in the above table is too great for the entire field included in the accompanying map. On Beaver and Ferrell creeks the amount of coal that could be mined is over 5 feet, while on Marrowbone Creek it is not over 4 feet, and nearly one-third of this is not marketable. Elsewhere in the field the bed is even thinner.

The thickness of over 5 feet as given for the Upper Elkhorn bed is due to a number of sections of great thickness from a small portion of the field. At the head of Elkhorn Creek the amount of marketable coal in this bed is close to 8 feet, while on Marrowbone Creek it is little over 3 feet. A closer approximation of the thickness of the bed throughtout the field would be about 5 feet.

ANALYSES OF COAL.

All of the coals in this part of the great Appalachian coal field are bituminous, but few are of higher grade than those found in the Elkhorn field of eastern Kentucky. They will probably rank among the best steam generators, and their coking qualities are practically assured. Chemical analysis shows that the sulphur content is uniformly low and that the amount of ash is moderate.

The following table shows the results of analyses made of some of these coals by F. M. Stanton at the United States Geological Survey fuel-testing plant at St. Louis. The samples analyzed were collected by the writer according to Survey regulations, which require that mine samples be taken by cutting a channel across a clean face of the coal bed, including everything except partings and binders over one-fourth inch in thickness. Channels are of such size as to furnish about 5 pounds of coal per foot of bed, and the material is caught on oilcloth to keep out dirt and excess moisture. The gross sample is pulverized and quartered in the mine until reduced to about one quart, which is sealed in an air-tight galvanized-iron can. The original moisture content of the coal is thus preserved until the sample is opened for analysis.

Laboratory analyses of coal samples from Elkhorn field, Kentucky.

[F. M. Stanton, analyst; sampled by R. W. Stone.]

	Name and location of coal.								
	Millard.	Lower Elkhorn.					Upper Elkhorn.		Flatwoods.
		Pike mine.			Robert Martin, Road Creek, excluding laminated coal.	Sanford Moore, Pond Creek.			
	H. E. Coleman, Regina.	Whole bed.	Excluding laminated coal.	Laminated coal only.			Greenough mine, whole bed.	Ben Potter, Elkhorn Creek.	Cassell Fork, 7-foot top bench.
Laboratory number	3662	3705	3706	3702	3663	3661	3708	3828	3829
Sample as received:									
Moisture[a]	3.00	2.90	3.35	3.19	4.73	5.27	4.03	3.96	3.45
Volatile matter[a]	32.22	28.59	31.76	25.83	31.62	27.74	32.46	32.37	33.69
Fixed carbon[a]	56.59	53.70	60.81	48.61	61.57	59.75	58.73	61.10	54.61
Ash	8.19	14.81	4.08	22.37	2.08	7.24	4.78	2.57	8.25
Sulphur	1.06	.49	.54	.40	.71	.50	.74	.56	.82
Loss of moisture on air drying	1.40	1.30	1.70	1.80	3.20	3.40	2.80	1.90	1.70
Air-dried sample:									
Moisture[a]	1.62	1.62	1.68	1.42	1.58	1.93	1.26	2.10	1.78
Volatile matter[a]	32.68	28.97	32.31	26.30	32.66	28.72	33.40	33.00	34.27
Fixed carbon[a]	57.39	54.41	61.86	49.50	63.61	61.85	60.42	62.28	55.55
Ash	8.31	15.00	4.15	22.78	2.15	7.50	4.92	2.62	8.40
Sulphur	1.07	.50	.55	.41	.73	.52	.76	.57	.83
Fuel ratio	1.76	1.88	1.92	1.88	1.95	2.15	1.81	1.89	1.62

[a] Proximate.

The analyses in the preceding table indicate a good grade of coal in each of the beds from which samples were taken. They show that the Millard and Flatwoods coals have the highest percentage of ash and lowest fuel ratios, and that the Lower Elkhorn coal on Pond Creek has a higher fuel ratio than any other coal from the localities represented by the analyses. The high percentage of ash in the samples of Lower Elkhorn coal from the Pike mine has been discussed on page 57. Moisture and sulphur are low in each of these.

Analyses made by A. S. McCreath of samples taken by E. V. d'Invilliers, Joseph Sillyman, and others are given in the following table. They have been assembled from reports of the Kentucky Geological Survey, reports of the Kentucky Inspector of Mines, and private reports. The writer does not know what method of sampling was used or what care was taken of the samples, but from the results obtained it is suspected that they dried before being analyzed and that in some samples the whole of the bed was not represented. It makes a difference with the Lower Elkhorn coal whether the laminated coal is included or not, as shown in the preceding table.

Analyses of miscellaneous coal samples from Elkhorn field, Kentucky.

Constituents.	Name and location of coal.									
	Elswick.	Auxier.	Lower Elkhorn.					Upper Elkhorn.		
	Mouth of Moores Branch	Mouth of Elkhorn Creek.	Average of 22 samples.	Ferrell Creek.	Ferrell Creek.	Head of Marrowbone Creek.	Average of 9 samples.	Average of 19 samples.	Abners Fork, Ferrell Creek.	Pigeon Branch Elkhorn Creek.
	(a)	(a)	(b)	(a)	(a)	(a)	(c)	(b)	(a)	(c)
Moisture	0.65	0.65	1.425	2.89	7.70	0.92	1.441	1.538	7.54	1.420
Volatile matter	30.55	29.96	32.105	32.21	23.30	36.78	31.804	34.985	25.14	32.960
Fixed carbon	59.239	58.98	58.435	59.90	61.46	58.08	56.837	58.367	60.60	59.317
Ash	8.180	9.72	7.459	4.33	7.48	4.22	9.538	4.499	6.72	5.620
Sulphur	1.381	.69	.574	.67	.567	.47	.558	.587	.428	.683
Phosphorus	.....	.....	.0039	.003	.....	.006	.0028	.0022	.....	.001
Fuel ratio	1.94	1.97	1.82	1.86	2.64	1.58	1.79	1.67	2.41	1.80

Constituents.	Name and location of coal.									
	Upper Elkhorn.						Flatwoods.	(?)		
	Marrowbone Creek.		Marshall Branch.		Mullins bank, Elkhorn Creek.	Bens Branch Elkhorn Creek.	Cassell Fork.	Pigeon-roost Creek.	Blowing Rock Gap road.	
	(c)	(c)	(c)	(d)	(d)	(c)	(c)	(c)	(d)	(d)
Moisture	1.97	1.114	1.242	1.24	2.60	1.930	1.930	3.594	1.06	0.60
Volatile matter	33.41	34.916	35.598	38.84	34.20	36.950	36.170	35.156	37.91	39.22
Fixed carbon	56.54	57.068	60.014	58.65	60.80	58.247	57.423	52.792	58.79	58.00
Ash	7.57	6.230	2.610	1.26	2.40	2.380	3.880	7.750	2.23	2.16
Sulphur	.51	.642	.536	.64	.412	.593	.597	.708	.76	.90
Phosphorus	.006	.004	.002	.004	.....	.....	.....	.....	.004	.005
Fuel ratio	1.69	1.63	1.69	1.51	1.78	1.58	1.59	1.50	1.55	1.48

[a] Crandall, A. R., The coals of Big Sandy Valley: Kentucky Geol. Survey, Bull. No. 4, 1905, pp. 108–113.
[b] Manufacturers' Record, vol. 45, No. 23, supplement. 1904.
[c] Private reports.
[d] Annual reports of inspector of mines, Kentucky, 1901–1902, pp. 417–421.

Crandall explains that the high percentage of moisture and ash in the analyses of samples from Ferrell Creek is due to their being taken from weathered surfaces and possibly containing infiltered dirt. It is possible that the same explanation may apply to others of these analyses, for it is noticeable that the sample of coal from Bens Branch of Elkhorn Creek, which was probably taken from Ben Potter's opening at the outcrop, is of lower grade than that from Ben Potter's, which is shown in the first table, and which the writer cut from the heading, 20 feet from the outcrop, where the coal is unweathered.

These miscellaneous analyses show that the fuel ratio of the Upper Elkhorn coal is generally lower than that of the Lower Elkhorn, but, on the other hand, the average percentage of ash in the Lower Elkhorn coal is nearly double that in the higher bed. The sulphur and phosphorus content is uniformly low in all these analyses.

The following table is given for the purpose of comparing the Elkhorn coals with well-known eastern bituminous coals:

Average analyses of eastern bituminous coals.

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.
Pocahontas, semibituminous (average of 38)[a]	0.73	17.43	77.71	4.63	0.62	4.458
New River (Quinnimont), semibituminous (average of 17)[b]	.60	19.93	75.20	4.27	.67	3.773
Pittsburg coking (average of 20)[c]	1.130	29.812	60.420	7.949	.689	2.027
Lower Elkhorn (average of 22)[d]	1.425	32.105	58.435	7.459	.574	1.820
Upper Elkhorn (average of 19)[d]	1.538	34.985	58.367	4.499	.587	1.668
Clinch Valley gas coal[e]	1.180	37.398	56.732	5.602	.619	1.517
Westmoreland gas coal[e]	1.427	37.521	54.921	5.418	.713	1.464
Pennsylvania gas coal[e]	1.280	38.105	54.383	5.440	.792	1.427

[a] White, I. C., Geol. Survey West Virginia, vol. 2, pp. 695, 696, 700.
[b] Ibid, p. 670.
[c] H. C. Frick Coke Company.
[d] Manufacturers' Record, vol. 45, No. 23, supplement. 1904.
[e] McCreath and d'Invilliers, Mineral Resources of Upper Cumberland Valley, p. 145, 1888.

COKE.

How many of the coals in this region are good coking coals has not been determined, but it has been shown by tests that the Upper Elkhorn bed at the head of Elkhorn Creek, where it has a thickness of over 8 feet, makes a high grade of coke. The Northern Coal and Coke Company built beehive ovens near the head of Elkhorn Creek, coked coal taken from banks opened on the Upper Elkhorn bed in the neighborhood, and exhibited the product at the Louisiana Purchase Exposition. The following information on this subject is from the article cited above in a supplement of Manufacturers Record:

Representative samples of coke made from coal from the Elkhorn seams show the following composition, with which are given, for purposes of comparison, the compositions of cokes from other well-known regions:

Analyses of cokes from Elkhorn and other well-known coals.

District.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.	Phosphorus.
Upper Elkhorn, Ky	0.580	1.445	90.451	0.474	7.050	0.004
Do	.860	.914	88.679	.506	9.815	.007
Do	.142	1.033	92.744	.451	5.630	.003
Lower Elkhorn, Ky	.210	.710	90.210	.692	8.870	.009
Pocahontas, W. Va	.350	1.008	93.059	.611	4.972	----------
Pocahontas, Va	.348	.900	92.840	.605	5.307	----------
Connellsville, Pa	.790	1.310	86.880	.695	11.540	.015
Do	----------	1.700	91.000	.470	7.300	.012
Do	----------	1.200	87.900	.550	10.900	.015

Physical tests of Elkhorn cokes represented by the second and third samples in the preceding table were made by Mr. John Fulton, Johnstown, Pa., the well-known coke specialist, from whose report the following extract is taken:

The hardness of the Kentucky coke is so nearly equal to that of Connellsville that no serious practical difference should be mentioned. Both of these cokes (samples 2 and 3) will sustain the highest blast-furnace charges in use to-day, and in chemical purity exceed the average of the standard Connellsville coke. * * * Under these conditions of the physical and chemical properties, especially with very low volumes of sulphur and phosphorus, they are admirably adapted for use in blast furnaces producing Bessemer pig iron.

The following analyses and tests made for the Northern Coal and Coke Company at several different laboratories and plants were kindly furnished by John C. C. Mayo, an officer of the company.

Analyses of five samples of 48-hour coke and four samples of 72-hour coke made in beehive ovens of the Northern Coal and Coke Company on Elkhorn Creek with coal taken from the Ben Potter and William Mullins and banks average as follows:

Analyses of Elkhorn coke.

[A. S. McCreath, analyst.]

Constituents.	48-hour.	72-hour.
Moisture	0.187	0.151
Volatile matter	1.265	1.147
Fixed carbon	90.140	91.072
Ash	7.891	7.082
Sulphur	.517	.546

Phosphorus to the amount of 0.003 per cent was found in two of the samples.

A sample of 48-hour coke from the coal at Ben Potter's gave the following results in a physical test by John Fulton, of Johnstown, Pa.:

Physical test of Elkhorn coke.

Percentage by volume of coke	59.84
Percentage by volume of cells	40.26
Compressive strength of cubic inch, one fourth ultimate strength, pounds	279
Height of furnace charge without crushing, feet	111
Order in cellular space	1.25
Hardness	2.95
Specific gravity	1.75

A test of the coking qualities of the Upper Elkhorn coal, made by the United Coke and Gas Company, of Camden, N. J., from a 200-pound sample taken from 30 sacks, gave a coke of good furnace and foundry quality. The coal was crushed to pieces one-fourth to one-eighth inch in size, thoroughly mixed, and carbonized in an iron box. Analyses of dry coal and coke are shown in the following table. An analysis of by-product coke made by the Illinois Steel Company is given in the last column for the purpose of comparison.

Analyses of Upper Elkhorn dry coal and coke.

Constituents.	Coal.	Coke.[a]	By-product coke.
Volatile matter	38.72	1.20	1.02
Fixed carbon	56.71	93.01	95.55
Ash	3.94	5.32	3.43
Sulphur	.62	.47	----------
	99.99	100.00	100.00
Sulphur	----------	----------	.46
Phosphorus	.0034	.0047	.004

[a] Yield of coke on box test, 71 per cent.

Another test for the Northern Coal and Coke Company was made by the Pittsburg Testing Laboratory (Limited), with the result shown in column 3 of the next table. The Semet-Solvay Company, of Syracuse, N. Y., report as follows on a trial of the Upper Elkhorn coal, the analyses of coal and coke being given in columns 1 and 2 of the table.

A sample of Upper Elkhorn coal from the William Mullins opening was coked by the Hamilton Otto Coke Company at Duluth and gave the results shown in column 4 of the table.

Analyses of Upper Elkhorn coal and coke.

Constituents.	1. Coal.	2. Coke.	3. Coke.[a]	4. Coke.[b]
Moisture	1.12	0.26	0.17	
Volatile matter	37.95	1.68	0.00	1.72
Fixed carbon	55.70	89.67	90.84	94.80
Ash	5.23	8.39	8.99	3.48
	100.00	100.00	100.00	100.00
Sulphur	.55	.64	.49	.48
Phosphorus	.0055	.0118	.16	.003

[a] J. O. Handy, analyst. [b] W. H. Wright, analyst. Sample dried at 105° C.

Total wet coal, 35,335 pounds; moisture, 2.42 per cent; total dry coal, 34,480 pounds; toal wet coke, 23,446 pounds; moisture, 1.3 per cent; total dry coke, 23,141 pounds; yield dry coke, 67.11 per cent; total wet breeze, 1,206 pounds; moisture in breeze, 12 per cent; total dry breeze, 1,061 pounds; yield breeze, 3.07 per cent; total yield, 70.18 per cent.

By-products per 2,000 pounds of dry coal: Ammonium sulphate, 27.607 pounds; tar, 106.3 pounds; total gas, 10,000 cubic feet.

These tests, made by men thoroughly experienced in that work, show that the Upper Elkhorn coal in this part of the field produces a coke which is the equal of the standard cokes made in this country, and is superior to Connellsville coke in its very low percentage of the two impurities, sulphur and phosphorus. It is the belief of some who have experimented with it that the strength of coke made from Elkhorn coal is increased by the addition of a small amount of laminated coal in the charge.

TONNAGE.

Any estimate of the amount of coal in this field must necessarily be only approximate. It is not absolutely known how far the beds extend beneath the surface or whether the average thicknesses shown in prospects and mines are maintained for any great distance back from the outcrops. It may be assumed that a bed 2 feet thick is workable, because beds carrying less than 2 feet of bituminous coal are being mined in the United States to-day.

The following estimate of the coal now in the ground does not include the 3- or 4-foot bed said to be above the Upper Elkhorn coal or the 4-foot bed 500 feet above the Flatwoods coal, both of which underlie only small areas because they are so close to the ridge tops.

The tonnage of the Elswick and Bingham coals is estimated on an area only one-fourth that of the field, because so little is known of the character of these beds. The Auxier and Millard beds are better known and are assumed to be of workable thickness under at least 50 square miles of the 130 which constitute the field. The acreage of the Elkhorn and Flatwoods coals was obtained by planimeter from the accompanying map (Pl. I), the divide at the head of Russell Fork drainage being taken as the boundary of the field.

Estimated gross tonnage in the Elkhorn coal field.

Bed and locality.	Area.	Thickness.	Amount.
	Acres.	*Feet.*	*Short tons.*
Elswick	19,200	2½	86,400,000
Auxier	32,000	2½	144,000,000
Millard	32,000	2	115,200,000
Bingham	19,200	3	103,680,000
Lower Elkhorn:			
East of Russell Fork	12,140	5	109,260,000
Russell Fork to Shelby Gap	33,825	4	243,540,000
Shelby Gap to head of Elkhorn Creek	9,150	3	49,410,000
Upper Elkhorn:			
East of Russell Fork	4,000	6	43,200,000
Russell Fork to Shelby Gap	20,720	3½	130,536,000
Shelby Gap to head of Elkhorn Creek	6,425	8	92,520,000
Flatwoods	2,300	7	28,980,000
Total			1,146,726,000

This estimate is on the basis of a specific gravity of 1.3, or 1,800 tons per acre for every foot of coal.

These figures are so inconceivable that the idea of the amount of coal estimated to be in this field can be grasped only when expressed in other terms than millions of tons. The total amount of coal in the Elkhorn field is nearly three times as much as all the coal mined in the United States in 1905, it is nearly ten times the amount of bituminous coal mined in Pennsylvania in 1906, and is equivalent to all the bituminous coal mined in Pennsylvania previous to 1902. It would make a solid bed of coal 8 feet thick over the area represented by the accompanying map or 1 foot thick over 1,000 square miles. The 92,500,000 tons of coal in the Upper Elkhorn bed between Shelby Gap and the head of Elkhorn Creek lacks only 1,000,000 tons of being equal to all the coal mined in Kentucky between 1828 and 1905; if loaded in 40-foot coal cars carrying 40 tons each, it would make a train 17,522 miles long. The total amount of coal in this field, over 1,000,000,000 tons, if loaded in the same way, would make a train 217,183 miles long, or eight trains extending around the world with enough left over to make more than five solid trains reaching from New York to San Francisco.

With improved mining methods and utilization of the slack 80 or even 90 per cent of this coal may be marketed. Assuming, however, that 30 per cent—the average of present practice—will be wasted in mining, there remains a possible output of 800,000,000 tons.

MINERAL RESOURCES OTHER THAN COAL.

Sandstone.—In the coal-bearing rocks there is usually an abundance of stone at one horizon or another suitable at least for rough construction work. In this field medium to coarse grained sandstone of fair quality is to be found at many places conveniently located for quarrying. A sandstone that outcrops at the mouth of Marrowbone Creek and a little above the water on Jesse Creek was quarried at these two places by the Chesapeake and Ohio Railway, and the blocks were used in bridge and culvert construction. The sandstone is rather massive, blue-gray when fresh, and weathers to brown. Its texture varies from medium to fine. Some of the bedding is marked by black lines of carbonaceous matter, and bed surfaces often are black with carbonized vegetable fragments, including even lamellæ of coal. Mica is abundant in the rock, and brown stains extend along lines of fracture.

Shale.—Little attention has been given to the clays and shales in this part of the State. So far as known, there are no heavy beds of fire clay in this field, and most of the shales are sandy or slightly bituminous and not well adapted for brickmaking. Fine-textured, moderately fusible, and fairly plastic clay shale is required for such purposes.

Limestone.—The Newman limestone outcrops in great abundance on the north side of Pine Mountain. Its outward appearance suggests that it is a pure, high-grade limestone which, in conjunction with suitable shale, might be a source of raw material for the manufacture of Portland cement. No analyses of this stone are at hand.

PART II.—THE RUSSELL FORK COAL DISTRICT, VIRGINIA.

INTRODUCTION.

Purpose of this report.—Even at the present day there are considerable areas in the Appalachian coal region concerning which no one has very definite information. They have escaped examination because of their inaccessibility, their heavily forested condition, or their remoteness from lines of transportation. A combination of these conditions has retarded the prospecting and development of the field of bituminous coal here described, which lies in southwestern Virginia.

The extension of the Chesapeake and Ohio Railway up Big Sandy River into Pike County, Ky., drew attention to the coal field thus made accessible, and the contemplated construction of a railroad from Dante, Va., through Dickenson County made it desirable that information should be obtained as to the extent and character of the coal field in that section. This information would be valuable both to people who live in the field and to outside investors. Most of the residents of the district have very little idea of the extent of the coal or of its value, and hence are wholly ignorant of what they are selling when they dispose of their coal rights. They do not realize that a 4-foot coal bed yields 6,000 tons per acre. To them the information accumulated by this survey and imparted in this report should suggest the desirability of reserving their coal rights or of getting a fair price for their lands rather than, as formerly, selling coal rights by the acre for a merely nominal sum, in no way representing the value of the right disposed of. To outsiders interested in the discovery and development of coal resources this report should be of some value in giving the information at present available as to the character and thickness of the coal seams and their probable extent.

With this purpose in view the task of making a reconnaissance examination of the coal resources of Russell Fork of Big Sandy River in the summer of 1906 was assigned to the writer. The report on the part of the field lying in Kentucky forms the first part of this bulletin. The second part—this report—discusses the Virginia portion of the Russell Fork field.

Literature.—Published information relative to this field is exceedingly scarce. C. Newton Brown made a hasty tour through the northern part of Dickenson County and the western part of Bu-

chanan County in 1897 and says, in his report on the mineral resources of Big Sandy Valley,[a] that as a rule the people have given no thought to the matter and know very little as to the thickness, number, and extent of the coal beds. He states that the beds range in thickness from 3 to 6 feet and some of them are fine bituminous coal. He reports no facts other than these, but predicts that large areas of workable coal will be found here.

M. R. Campbell has described the geology of regions not far to the east and south in the Tazewell and Bristol folios of the Geologic Atlas of the United States and in Bulletin No. 111 of the United States Geological Survey, on the geology of the Big Stone Gap coal field. Brief reports on the coal in scattered corners of this field have been written by various men, but they have not been published.

Field work.—This report is based on six weeks' field work in the fall of 1906. The writer entered the region from Pound Gap on September 10 and made a circuit through Clintwood, across Cranes Nest River, and up McClure Creek to Flint Gap, thence along Sandy Ridge to Carrie post-office and down Fryingpan Creek and Russell Fork to Jane post-office and the Breaks of Sandy. The greater part of the field was reached by side trips from camps along this route.

The work took the form of a rapid reconnaissance with the purpose of covering the whole field described and learning as much as possible about the number and character of the coal beds and something of their occurrence, distribution, and extent. Time did not permit the working out the details of the structure or of the stratigraphy. The basis of the map (Pl. V, in pocket) accompanying this report is a drainage map made for the Clinchfield Coal Corporation by Henry Keel, of Clintwood, Va. To it the writer has added the main roads and trails, so far as he knows them. They are admittedly incomplete. Some of the roads shown are hardly passable for wagons. On this map also is shown the location of over one hundred coal openings. Most of them were visited and their locations on the map are accurately shown, but a few openings were not seen, and their location is based on descriptions by others. The openings whose locations are only approximate are numbered 5, 13, 14, 45, 46, 49, 58, 59, 61, 76, 77, 85, 86, 87, 88, 89, 90.

The field work consisted largely in running road traverses and plotting the geology on road sections. Coal banks and prospects were visited and measured wherever they could be found. All elevations were obtained by aneroid with no bench mark to check the readings. Coal outcrops are not shown on the accompanying map for the reason that it was not possible in the time allotted to this work to trace and map any particular bed or beds. Such correlations as were made are

[a] Report of Inspector of Mines of Kentucky, 1900, p. 264.

stated in the following pages instead of being drawn imperfectly on the map.

Acknowledgments.—The work was done under the direction of G. H. Ashley, who spent two days in the field and to whom the writer is indebted for helpful suggestions in the preparation of the report. To the Clinchfield Coal Corporation, and particularly to W. D. Tyler, land agent, and H. B. Wright, engineer in charge, of the same corporation, acknowledgment is made for assistance in the way of maps and information, and also for personal courtesies. Mr. Hardaway, manager of the Cranes Nest mine at Georgel, Va., added greatly to the completeness of the report by furnishing many sections measured by himself at points where the coal can not now be seen. James W. Fox, of New York, and John C. C. Mayo, of Paintsville, Ky., furnished private reports by H. W. Rietz, Jansen Haines, and others, which contain notes on parts of the area, and for which acknowledgment is made. The South and Western Railway kindly supplied topographic maps of routes surveyed across Dickenson County. D. E. Llewellyn, of Wise, Va., has provided the writer with maps and other data. C. W. Dodge, jr., assisted in the geologic work during the first two weeks. An attack of typhoid fever prevented his finishing the season, but he spent part of the following winter in the office preparing the illustrations for this report. To each of these gentlemen the writer acknowledges his indebtedness, and to the inhabitants of the district he extends his thanks for courtesies and assistance rendered in various ways.

GEOGRAPHY.

Location.—The area discussed in this report is that part of the drainage basin of Russell Fork of Big Sandy River which lies in Virginia. It includes Dickenson County and adjoining portions of Buchanan and Wise counties. The area extends from the head of Russell Prator Creek, near Grundy, to the head of Pound River, at Black Mountain, and is bounded on the other two sides by Pine Mountain and Sandy Ridge. It contains about 550 square miles of heavily wooded, thinly populated, mountainous country.

Surface relief.—Sandy Ridge, the southeastern boundary, has a general elevation of 3,000 feet. Pine Mountain, called locally "Cumberland Mountain," having an equal elevation and separating Virginia and Kentucky, forms the northern and western boundary. Black Mountain, at the head of Pound River, attains an altitude of 3,800 feet and is the highest point in the field. The divide between Russell Fork and Levisa Fork is from 2,000 to 2,500 feet above sea. The general elevation of the main streams is 1,500 feet, and the lowest

point is where Russell Fork passes through the Breaks at the northeastern end of Pine Mountain. The elevation on the State line at the mouth of Grassy Creek is approximately 900 feet.

For the most part the country is made up of steep-sided, narrow-topped ridges, and may be classed as mountainous. The ridges between Fryingpan, Lick, and McClure creeks are examples, and Big Ridge, as it is called, between McClure Creek and Cranes Nest River, is a strong feature of the topography. It is 15 miles long, and rises from 500 to 800 feet above the creeks, which are from 1 to 4 miles apart. The crest of the ridge is from 2,100 to 2,500 feet above sea level and varies scarcely a quarter of a mile from a straight line throughout its length.

There are no level areas of great extent in this section of the State, the largest being some of the flat tops of the ridges, which are comparatively level for a mile or more, but not over a few hundred yards wide. The valley bottoms are narrow, often affording little more than room for a road along the side of the stream.

Drainage.—As the area here described is the basin of Russell Fork all the drainage passes into Kentucky through the Breaks of Sandy at the north end of Pine Mountain. The principal streams tributary to Russell Fork are Pound River, McClure Creek, and Fryingpan Creek. Pound River, the largest, rises at Black Mountain on State-line Spur and flows northeast parallel with Pine Mountain for 25 miles. Cranes Nest River, a fork of Pound River, is of about the same size as McClure Creek, each having a basin about 20 miles long. The winding courses of the streams make their total lengths much greater than the length of the basins. In this report the "right" and "left" sides of a stream are relative to the position of a person facing *upstream*, thus conforming to the usage of this region.

Forests.—Much of this country is still covered with a fair growth of typical southern Appalachian hardwood forest. Cleared tracts are not at all extensive. Chestnut, yellow poplar, white and red oak, maple, beech, ash, hickory, and sycamore are common. Papaw, buckeye, cucumber tree, and black walnut are less common but not rare. Black walnut trees of any considerable size are scarce and bring a high price, though not many years ago they were cut up for firewood and fence rails.

Lumbering is fast stripping some of the best stands of timber, and at the present rate of increase in the industry the day is not far distant when many hillsides, worthless for any other purpose, will be cleared and left bare of timber or soil. Logs to the number of 30,000 or 40,000 were jammed in the Breaks for four years and may have retarded the lumber business in that section temporarily, but the jam broke in January, 1907. On Pound River near the mouth of North and South forks a steam tramroad has been built, portable

sawmills have been introduced and logs are coming out at a rapid rate. The lumber is hauled by the tram to the railroad at Norton.

The timber in this country is sufficient to attract considerable attention and should be the basis of a thriving industry, but with the present wasteful and unscientific methods of lumbering a once valuable asset will soon be exhausted and the region will be left in a condition unfavorable for the further production of forest growth. As the area lies near the heads of the river the resulting increased flood danger will not be so great here as it will be in Kentucky.

The timber resources of the section described are sufficient in quantity and quality to support any coal-mining industry that may be developed here.

Settlement.—Dickenson County has an area of 324 square miles and a population of 7,747. The area of the Russell Fork basin in Virginia is 550 square miles and the population probably does not exceed 10,000. The settlements are confined to the valleys and are all very small, only one having a population of more than 100 people, and that is the county seat, Clintwood, which numbers 255. There is only one colored resident in Dickenson County, a little girl living at Haysi.

Farming and lumbering are the principal occupations of the people. Corn is the chief crop and is of necessity raised in small patches on steep hillsides.

Accessibility.—There is no ready access to this country except by some gap in the surrounding mountains. Pine Mountain, State-line Spur, and Sandy Ridge form a continuous barrier on three sides, with a general elevation of 3,000 feet, while the fourth side, the divide between Russell and Levisa forks, is but little less of a barrier.

Wagon roads are not numerous. One of the principal roads is from Dumps Creek over Sandy Ridge, down Fryingpan Creek to Russell Fork, down that stream to the mouth of Russell Prator, and then over the hills to Grassy Creek and through the Breaks to Elkhorn City, Ky. The road from Grundy comes down the Russell Prator, crosses Russell Fork at the mouth of McClure, crosses the hills to the mouth of Cranes Nest, and follows the crest of the ridge to Clintwood. It goes up Georges Fork, down Hamilton Creek to Pound River, and dividing follows up both forks to Flat Gap. A road from Pound leads over Pound Gap to the head of Elkhorn Creek, Ky., and another goes up Indian Creek to Glamorgan and Wise.

Entering the region from Dante the road crosses either Flint Gap or Trammel Gap, goes down McClure to a point 2 miles below the mouth of Caney Creek, crosses to Cranes Nest River, and then up Long Branch to Clintwood. From Clintwood one may continue north down Brush Creek, cross Pound River, and climb the mountain to Blowing Rock Gap, which leads to Ashcamp, on Elkhorn Creek, in

Kentucky. Traveling by wagon on any of these roads is slow. The customary method of traveling in this country is on horseback. Haul roads and bridle paths are numerous, so that almost any point is accessible by these.

The nearest railroads are the Clinch Valley division of the Norfolk and Western Railway on the south and the Big Sandy branch of the Chesapeake and Ohio Railway at Elkhorn City, Ky., on the north. A railroad into the region from the north through the Breaks could be built at considerable expense. The South and Western Railroad has a route surveyed through the Breaks to the mouth of Cranes Nest River with a maximum compensated grade of less than 1 per cent. This route, which would connect the railroad at Dante with the Chesapeake and Ohio at Elkhorn City, extends up McClure to Trammel Gap, where Sandy Ridge would be pierced by a long tunnel. Another feasible route would be up Dumps Creek, under Kisers Gap by a tunnel, and down Fryingpan Creek. A narrow-gage steam railroad extending from Norton to Pound is used exclusively for lumbering.

GENERAL GEOLOGY.

STRATIGRAPHY.

GENERAL STATEMENT.

The rocks of this field belong to the Pottsville group of the Carboniferous. Three formations are represented in whole or in part. The lowest is the Lee conglomerate. This is overlain by the Norton formation, which makes the surface of the greater part of the area. The lower members of the Wise formation cap some of the higher portions of the ridge along the southern and eastern boundary of the region. The Lee conglomerate is about 1,000 feet thick, the Norton approaches 1,100 feet, and 200 or 300 feet of the Wise formation are present, making a total stratigraphic section of about 2,400 feet. These formations are described in detail.

LEE CONGLOMERATE.

A sandstone and conglomerate, 1,000 or more feet thick, which is prominent in this part of the Appalachians, is known as the Lee conglomerate, named from Lee County, Va., where it is conspicuous in the Cumberland escarpment. This is composed largely of massive sandstone, but may contain some thin sandy or shaly beds. Two or three coal beds have been found in it at various places. The name conglomerate was applied to this formation because some portions of it, particularly the top and bottom, carry considerable quantities of

small white quartz pebbles up to the size of a robin's egg. The formation as a whole weathers to a grayish white, may be somewhat iron-stained on the inside, and is coarse grained. Cross-bedding is commonly found near the top of the formation.

The Lee conglomerate is exposed along the east side of Pine Mountain (Cumberland Mountain) from State Line Spur to the Breaks of Sandy, where it has a thickness of about 1,000 feet. In the gorge known as the Breaks the formation is exposed in sheer cliffs several hundred feet high. The fault along the west side of Pine Mountain throws it high in air, so that the base of the formation is seen at Pound Gap and a little above Osborns Gap. In fact, the bottom of the formation forms much of the crest of the mountain. North of the river the amount of displacement along the fault decreases, and on Cow Fork of Grassy Creek it is so small that the escarpment is lost and the top of the formation is but little above creek level.

The conglomeratic character of the formation can be seen near the mouth of Camp Branch, a tributary of Russell Fork, at the Breaks, and along the crest of Pine Mountain, where in places the surface is strewn with quartz pebbles weathered from the base of the Lee.

On Russell Fork above the mouth of Indian Creek a massive sandstone which carries white quartz pebbles and is believed to be the top of the Lee is exposed for several miles. At the mouths of Indian and Hurricane creeks it forms cliffs 100 feet high and, rising gradually to the east, keeps above water nearly to the heads of the streams. The top of the Lee, according to a hurried field correlation, is but a few feet above Council post-office, on Russell Fork, and reaches water level one-half mile above there, near the coal bank of Isaac J. Hurt. The identification of the Lee on the head of Russell Fork is based on

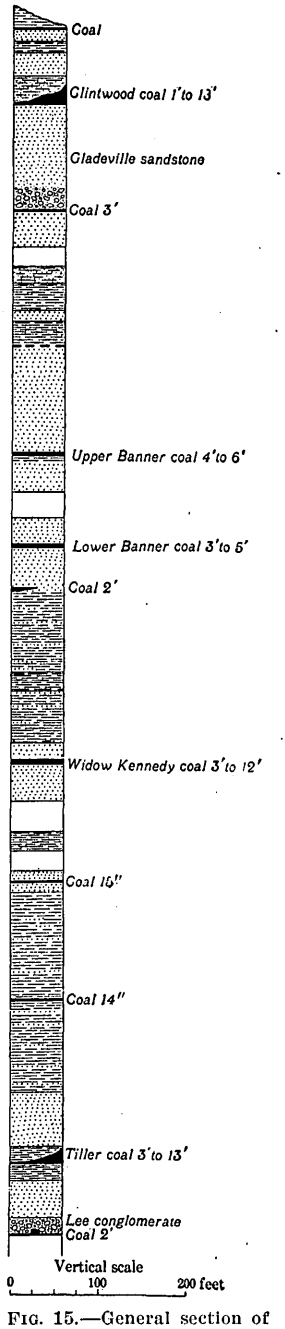


FIG. 15.—General section of rocks in Dickenson County, Va.

the close lithologic resemblance to its occurrence in Pine Mountain and on the impression gathered by riding over the country that the rise of the rocks in this corner of the county ought to bring the Lee to the surface. Confirmatory paleontologic evidence was not obtained.

NORTON FORMATION.

A series of sedimentary rocks consisting of sandstone, shale, and coal, and having a thickness of 1,000 feet or more, lies above the Lee conglomerate and is known in this part of the Appalachians as the Norton formation. It was first described by M. R. Campbell in Bulletin No. 111, on the Big Stone Gap coal field of Virginia and Kentucky. He ascribes a thickness of 1,280 feet to the formation and defines it as lying between the Lee conglomerate and the Gladeville sandstone. The formation probably varies in thickness, for there is some disagreement among sections containing it; the sections in the bulletin just mentioned and in the Bristol and Estillville folios by the same author are not alike, and the section measured by the writer is a little different from any of the others.

According to a section of the rocks measured by aneroid from Trammel Gap to Dante on the edge of this field, to which was added the record of a diamond-drill hole at Dante, the thickness of the formation is 1,060 feet. This estimate is based on an assumption that a heavy sandstone found in the drill hole 257 feet below the surface is the top of the Lee conglomerate, and that a sandstone carrying white quartz pebbles and exposed in Trammel Gap is the Gladeville. The base of this conglomeratic sandstone is only 250 feet above the Upper Banner coal, and this raises a question as to the correctness of the correlation, as Mr. Campbell has described the Upper Banner as being 400 feet below the Gladeville sandstone.

The Gladeville has not been described as conglomeratic, but always is referred to as a massive sandstone about 100 feet thick. As this conglomeratic bed at Trammel Gap is the nearest approach to a massive sandstone found in the ridge above the Upper Banner coal, and as it is at the same elevation above the coal as the massive Gladeville in the ridge between Cranes Nest River and Pound River, the writer has accepted the correlation of the bed bearing quartz pebbles in Trammel Gap as the Gladeville, thus obtaining an almost direct measure on the thickness of the formation.

So far as known a detailed section of the Norton formation has never been published. That which follows is based on a fairly complete section seen at Dante, Russell County, on the south side of Sandy Ridge, and on shorter sections measured at various points in Dickenson County:

Section of Norton formation.

	Feet.
Coal	3
Sandstone, thin-bedded	80
Shale	60
Coal, small bloom seen	1
Sandstone, massive	100
Coal, Upper Banner	5
Sandstone, shaly, and shale	80
Sandstone	20
Coal, Lower Banner	3–4
Sandstone, massive	50
Coal	2
Sandstone and shale	190
Coal, Widow Kennedy	6
Sandstone	30
Shale and thin sandstone	90
Sandstone carrying 15 inches of coal	20
Sandstone and shale	230
Sandstone, massive	60
Shale	15
Coal	3–15
Shale	15
	1,063

From this it appears that the Widow Kennedy coal is approximately 450 feet, the Lower Banner coal 700, and the Upper Banner 800 feet above the Lee conglomerate.

GLADEVILLE SANDSTONE.

There is a question in the mind of the writer as to the identification of the Gladeville sandstone in Sandy Ridge, where the greater part of the above-described section was measured. Nothing in the ridge closely resembles the Gladeville as it is conspicuously developed between Wise, Clintwood, and the mouth of Cranes Nest River. East of Nickels Gap, near Puncheon Tree Branch of Cranes Nest River, the Upper Banner coal is 250 feet below the base of the Gladeville sandstone. In this part of the county the Gladeville is 100 feet thick, makes strong ledges, and strews the surface with large blocks which are conspicuous because of their abundance and gray color. The rock is coarse grained, resembling the Lee in all respects except that, so far as observed, it is not conglomeratic. At the same elevation above the Upper Banner in Sandy Ridge is found a sandstone which carries a few quartz pebbles and which it is assumed may be the equivalent of the Gladeville, although, according to Mr. Campbell, the interval between the Gladeville and Upper Banner coal at a point a few miles farther west is 400 feet, or 150 feet greater than the interval here.

WISE FORMATION.

The lower portion only of the Wise formation is found in this area. Its extent and distribution is not known because the Gladeville sandstone has not been traced over the whole field. It occurs only in the tops of the ridges except in the vicinity of Clintwood where it is brought down to an elevation of about 1,800 feet by a structural depression. From Clintwood northeast the Wise formation caps the ridge for several miles, or until the Gladeville rises to the top near the mouth of Cranes Nest River. It is probable that the Wise formation also makes part of the crest of Sandy Ridge and of Big Ridge between Cranes Nest and McClure creeks.

The Wise formation is composed of sandstone and shale like the Norton formation and contains a few coal beds. One coal bed which lies at or near the base of the formation attains a thickness of 8 feet on Lick Fork and Georges Fork near Clintwood.

STRUCTURE.

GENERAL STATEMENT.

Second in importance only to the determination of the amount and quality of coal in a prospective field is the detailed determination of the structure of the beds in that field. On this depends the proper location of development work for economical exploitation of the coal, for natural drainage of the mines, for favorable grade to loaded cars, and other points which make coal mining a paying or a losing proposition.

The determination of structure which shall be of any value to mining engineers or others interested in the development of a coal field must be made with considerable care and accuracy. Frequent exposures of the reference stratum or of the deformed surface being mapped are necessary to the success of the work, and if the barometer is used for elevations it should be checked regularly at some bench mark of known elevation.

In this field, covering 550 square miles, there is no bench on which to check the barometer readings, and, on account of the heavily wooded character of the country and undeveloped condition of the coal resources, it was not possible to carry the correlation of any particular stratum over the entire field. Consequently in the six weeks given to the work it was not possible to work out the structure in detail.

DESCRIPTION.

For the most part the rocks in this area lie comparatively flat. The average dip will scarcely exceed 50 feet to the mile. Only

the general features or most conspicuous structure will be described. From the crest of Pine Mountain to Pound River and Russell Fork below the mouth of Pound River the rocks dip strongly to the southeast at angles decreasing in greatness toward the southeast. At the top of the mountain the conglomerate and massive sandstone at the base of the Lee dips to the east at angles as high as 25°, whereas near Pound River the dip is less than 10°. This carries the Lee conglomerate rapidly below the surface, so that it is not seen east of the river except below the mouth of Pound River on Russell Fork.

In the triangle between Pound River, Cranes Nest River, and the county line the structure as shown by the Gladeville sandstone dips in a general way toward Brush Creek or a point on Pound River north of Clintwood. In other words the Gladeville is lowest on Brush Creek or in that vicinity, a little higher at Clintwood, and rises to the southwest to the head of Lick Fork, and to the northeast reaches the top of the ridge near the mouth of Cranes Nest River. This makes a syncline or basin along Pound River.

In that portion of Wise County which is included in this discussion the syncline along Pound River is readily recognized. The axis seems to lie between North and South forks and the lowest point is near the junction of the two, for the rocks dip down South Fork, Indian, Bowlecamp, and Mill creeks.

Throughout the rest of the area under discussion, from Sandy Ridge to Cranes Nest River, the rocks, as far as could be discovered in a hurried reconnaissance, dip generally to the north and northwest. There are some minor interruptions, such as the south dip on Russell Fork near the mouth of Indian Creek and on Russell Fork from Birchleaf post-office to Duty Branch, but these are not thought to be numerous or extensive.

FAULTS.

It is well known that a great fault extends along the west side of Pine Mountain for many miles, interrupting the continuity of the Virginia and Kentucky coal fields. The effect of this overthrust fault is very plain on the Virginia side of the mountain, for it tilts the rocks up to an angle of 25° and brings all of the Lee conglomerate to the surface. This fault is on the Kentucky side of Pine Mountain, but north of the Breaks of Sandy it crosses the State line on Grassy Creek and is marked by an escarpment which decreases in height toward the northeast until on Cow Fork it is scarcely recognizable. It is possible that the fault terminates in a northward-plunging anticline on Levisa Fork, though such an anticline, if it exists, must be a very minor feature as compared to the fault.

An escarpment 100 feet or more in height on the flank of Pine Mountain near the head of Skeet Rock and Lower Twin branches

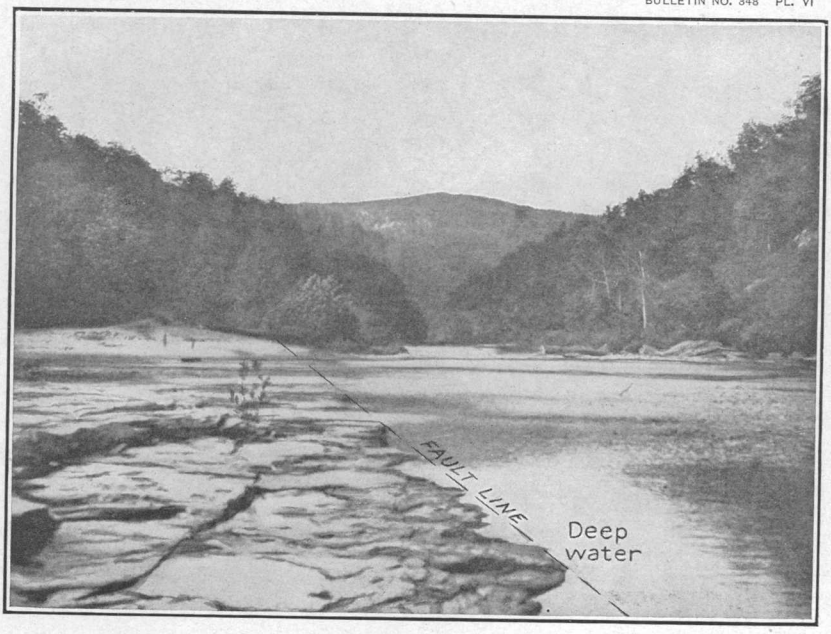
suggests that it is a fault face, but for lack of time and because it is beyond the limits of the coal beds, it was not studied. The road runs along the crest of this escarpment for some distance. A notch in the crest of Pine Mountain, known as "Skags Gap," suggests cross faulting in the ridge. One side of the notch as seen from the south is nearly perpendicular, and in that way differs from the other gaps.

Parallel faults 75 yards apart and trending N. 40° W. were found at the mouth of Pound River. The amount of displacement was not ascertained. One of these faults crosses Pound River at the dam and directly under the gristmill which is situated here. On the lower side of the dam is the Lee conglomerate, rising 40 feet above the water, while on the upper side beds of shale dip away from the fault. Angular blocks of the Lee are seen in the fault at the door of the mill. Sandstone overlying the shale dips upstream for a short distance, but at the ford, less than one-fourth mile above the mill, the dip is downstream.

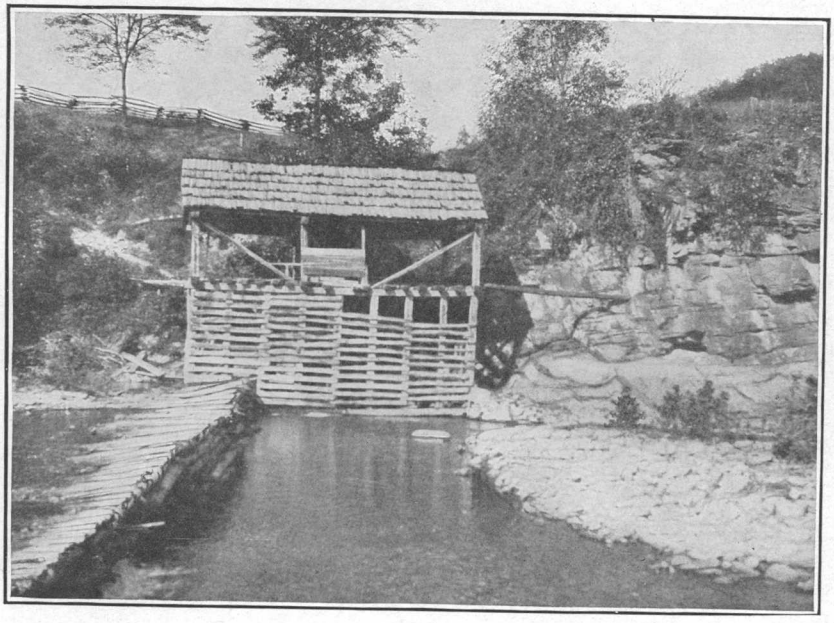
The second fault makes a displacement in the Lee and extends along the west bank of Russell Fork, crossing Pound River at its mouth. This fault is conspicuous at low water, for the rock floor of Pound River breaks off abruptly in a straight line into the deeper water of Russell Fork. Time did not permit of a determination of the extent of these faults. The accompanying illustrations (Pl. VI, *A* and *B*) show the faulting better than it could be shown by any further description.

A small fault making a displacement of about 20 feet in a massive sandstone was noted at the ford just below Colley post-office, near the mouth of Fryingpan Creek. On Priest Fork, less than one-fourth mile above the mouth, the dips in some of the outcrops are very strong, and a cliff in the stream above John Kiser's house shows some disturbance which seems to indicate a small fault. A coal opening above the road near Kiser's house also shows a little displacement of the strata. It is not known that there is any relation between the faults at these two places, but the suggestion that there may be is strengthened by the occurrence of a very sharp little fold at the third bend in Russell Fork above Murphy. These three points are in line and may be related.

On Russell Fork, about 1 mile above the mouth of Hurricane Creek and near Spencer Ball's house, there is some indication of a fault. A massive sandstone, supposed to be the top of the Lee, which can be traced from the head of the river to this point, gradually decreasing in elevation, here suddenly disappears, and shale standing at high angles is seen at the same elevation. A short distance below Ball's the heavy sandstone ledges appear again and continue to the mouth of Hurricane Creek, where the top of this conspicuous stratum is about 70 feet above the creek. The dip continues downstream for



A. FAULT LINE SHOWN BY ROCKS IN BED OF STREAM, MOUTH OF POUND RIVER.



B. FAULT AT MOUTH OF POUND RIVER.

The mill conceals brecciated zone. Lee conglomerate on right, shale on left of picture.

a short distance, but reverses, so that the same sandstone makes a cliff 100 or more feet high at the mouth of Indian Creek. Although highly tilted strata or faults were not seen on Indian Creek, it is notable that there is a possibility of the continuance of the above-described disturbance a little below Duty. The heavy sandstone, supposed to be the Lee, on Caney Fork of Indian Creek, dips gently downstream to a point about one-fourth mile below the mouth of Caney. There the conspicuous ledges disappear, and it is said the large coal bed in this vicinity shows evidence of disturbance. Farther downstream the massive sandstone ledges appear again, but they are dipping strongly upstream. This is not sufficient evidence for drawing the continuation of the fault seen at Ball's across to Indian Creek, but to those considering investment in this part of the field the suggestion may be of value.

At Haysi, a few rods east of C. M. Heyter's store, sandstone, shale, and thin streaks of coal are exposed in the highways, standing vertical and striking north and south. Just west of the store, in the road in front of Mr. Garrett's house, there is a 2-foot coal which dips 70° and strikes N. 65° W. In the head of a ravine on Mrs. Winnie Scyphers's land and below Garrett's house the rocks are greatly disturbed and indicate proximity to a fault. Sandstone at the head of the ravine stands vertical, and a few rods below is shale which is both contorted and vertical. Between these outcrops coal dipping only a few degrees is exposed under a roof of jointed sandstone. The relation of this sandstone to the other rocks suggests that its broken condition is due to the strain of faulting. Farther down the ravine the rocks are horizontal.

It is possible that other minor faults or sharp folds of small extent may be found on closer investigation of the field.

COAL RESOURCES.

GENERAL STATEMENT.

On account of the undeveloped condition of the coal resources of this region and because of the reconnaissance character of the survey, it is not possible for the writer to name and describe the extent of the various coal beds occurring in the area. Many of the coal outcrops lie several miles from the next, and in the wooded condition of the country it was impossible to carry correlation over distances so great. Certain beds were traced throughout small areas, but in some parts of the field no horizon was recognized with certainty.

Five coal beds of economic importance were recognized and will be referred to by name wherever the identity is established. The lowest of these is a bed from 3 to 15 feet thick which, in the author's opinion, occurs a few feet above the top of the Lee conglomerate. Paleonto-

logic or other evidence has not yet been obtained to confirm this point. This horizon is below the surface of the greater part of the area, but is exposed on the head of Russell Fork and its tributary, Indian Creek. Here the coal has a thickness of 8 feet or more at a number of openings. Because of the interest of S. J. Tiller, postmaster at Duty, Va., in the development of this coal, it will be called in this report the Tiller coal. It probably corresponds to the Elswick coal of the Elkhorn field of Kentucky.

The Widow Kennedy coal, which has been mined for a number of years at Dante and is exposed east of Tacoma, Va., is 400 to 450 feet above the Lee conglomerate. So far as the writer's limited observations go this coal has sandstone for both roof and floor. The roof sandstone at some places is fractured by numerous joints. The bed varies greatly, thicknesses of 3 feet and 12 feet having been seen in the same mine, and at another point it decreases from 7 feet to 1 foot in 50 yards. Faulting strains or other forces seem to have disturbed this coal more than the others, and in many places it is crushed, contorted, and filled with balls and bands of clay, so that its value is greatly decreased.

Approximately 700 feet above the Lee conglomerate is the Lower Banner coal, which is mined at Dante and Toms Creek. This coal is about 4 feet thick and occurs above 50 feet of massive sandstone. It is little known in the area described, and the fact that it has not been found elsewhere may indicate that it is thin and unimportant.

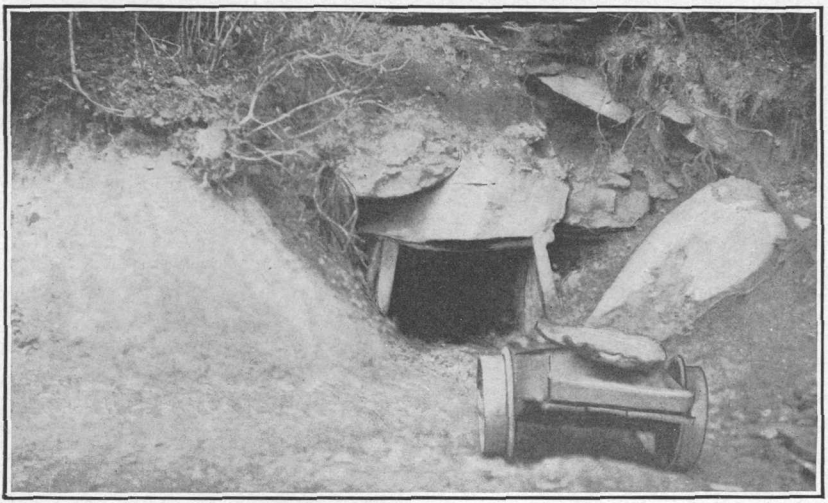
One hundred feet above it is the Upper Banner coal, 4 to 5 feet thick, which is widely known in Dickenson County by numerous prospects. A sandstone parting 1 to 3 inches thick occurring in the upper part of the bed is a peculiar characteristic of this coal.

In the vicinity of Clintwood a coal bed 5 to 9 feet thick occurs just above the Gladeville sandstone and has been opened in a number of places. The fuel supply of the county seat comes from this bed. The writer can not definitely correlate it with any seams previously described, and in this report will call it the Clintwood coal. Its greatest development is west of Clintwood.

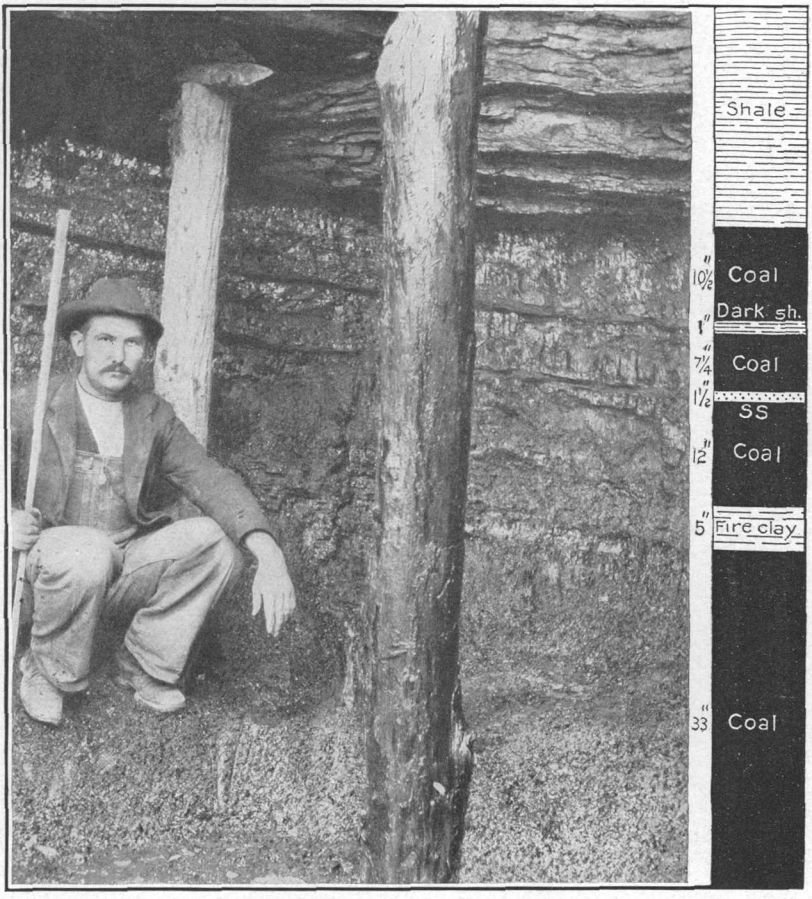
A description of the exposures seen at prospect trenches, coal banks, and natural outcrops in all parts of the area will give an idea of the character and distribution of the coal beds. To facilitate description the field will be divided into four parts, namely, the drainage basins of Pound River, Cranes Nest River, McClure Creek, and Russell Fork.

RUSSELL FORK.

General statement.—The section of the field described under the heading Russell Fork includes all the tributary drainage of Russell Fork on the east from its head to Grassy Creek, at the State line,



A. ISAAC HURT COAL BANK, RUSSELL FORK.



B. UPPER BANNER COAL AT FLOYD VIERS, LOW GAP BRANCH.

B from photo loaned by H. Hardaway.

and Fryingpan and Lick creeks on the west. Most of this section is very thinly settled and little prospecting has been done for coal except on Indian Creek, where there is an unusually thick bed, and on Fryingpan Creek near Bucu post-office.

Council.—A coal was once opened about 20 feet above the store at Council, on the head of Russell Fork, but the opening is caved now. One-third of a mile above Council, beside the road and only a few feet above the creek, there is a coal bank belonging to Isaac J. Hurt, where coal is mined regularly. An entry has been driven 100 feet N. 10° E. slightly up the rise of the coal, which dips northwest. The bed is 5½ feet thick (1)[a] and contains 2 inches of clay and 30 to 36 inches of laminated coal in the middle. It has a sandstone roof and floor (Pl. VII, *B*).

The term "laminated" used in this paper is applied to coal which is crushed, soft, and flaky, which slacks readily and is high in ash. "Rash" is another word for the same thing. In places the laminated coal is crumpled and has many smooth, polished surfaces. The evidence indicates that it is the result of lateral movement in the inclosing rocks.

A few rods upstream from the Hurt coal bank the sandstone which forms the floor of the coal is seen to be of sugary texture and finely conglomeratic. The white quartz pebbles and the general rise of the rocks lead to the conclusion that this is the Lee conglomerate. If so, this is a coal not elsewhere described, for the first coal bed known above the Lee conglomerate in Virginia is the Jawbone, which is described in the Bristol folio as 150 feet above the Lee conglomerate. As already stated, this will be called the Tiller coal.

Below Council this coal is higher above the creek and the conglomerate is conspicuous and abundant, making ledges on both sides of the stream. Noah G. Ball opened the coal back of his house and 100 feet above the creek, but it is concealed now. The thickness is reported as 7 feet. About 100 yards below Ball's, in a hollow on the north, there is a prospect which shows a horizontal shale roof and 5 feet of coal with bedding highly tilted. Three-quarters of a mile below Ball's the ledges of Lee conglomerate disappear and shale appears at the same elevation. This change is one-eighth mile above Spencer Ball's and is attributed to a fault. Three hundred yards below Spencer Ball's an outcrop in the road shows shale standing nearly vertical with horizontal shale on both sides. The disturbance from the original position of the beds at this point is apparent. The conglomerate appears again shortly and continues to the mouth of Hurricane Creek, where it makes a conspicuous ledge 70 feet high.

[a] Figures in parentheses correspond to locations numbered on the map (Pl. V) and to coal sections numbered on accompanying group of coal-section figures. A letter following the figures means that two or more sections were measured at one opening.

It is reported that coal has been found on top of the conglomerate in a hollow near the mouth of Hurricane Creek. There is a strong dip to the rocks down Russell Fork for a short distance, but it reverses, bringing up the Lee, which makes a cliff at the mouth of Indian Creek.

In the bank of Russell Fork at the north end of a suspension bridge just below the mouth of Indian Creek there is a 22-inch bed of coal under a 100-foot ledge of sandstone supposed to be the upper part of the Lee. Fossils found in the roof shale were too poor to determine the exact stratigraphic position of the bed.

Indian Creek.—Ledges of heavy sandstone supposed to be the top of the Lee conglomerate are exposed on Indian Creek from its mouth to at least a mile above the mouth of Caney Fork and 2 miles above Duty post-office, on the main fork of the creek.

Near the three forks of the right fork of Indian Creek, on J. H. Musick's land, and 200 feet above the stream, there is an opening which shows a coal bed 12 feet thick containing two shale partings which are 22 and 33 inches thick (2). This section was obtained from H. Hardaway and is believed to represent the coal which lies on top of the Lee.

Near Doctor Comb's house, on the left fork of Indian Creek, there is an opening on the left side of the creek on a coal bed reported by Mr. Hardaway to be nearly 5 feet thick (3). Only 4 feet could be seen at the time of the writer's visit. If this is not the same as the Tiller coal, it is not much over 100 feet above it.

On the Van Sutherland tract at the head of the right fork of main Indian Creek there is an opening which exposes a bed, supposed to be Tiller coal, 12 feet 5 inches thick (4). The thickest parting in this bed is 18 inches, but much of the coal is inferior. The shale roof is fossiliferous and shows concentric structure.

In Cane Gap an opening driven 30 feet S. 10° W. up the rise shows the Tiller coal 15 feet 4 inches thick (5), according to a measurement by Mr. Hardaway. The bottom part of this, 4 feet 10 inches thick, is fine solid coal and the remaining 10 feet contains 4 feet of clay and shale. In the first hollow south of Cane Gap and just over the ridge from Sutherland's there is an opening close to Elijah Rasnick's house which, according to Mr. Hardaway, is driven 50 feet S. 70° E. and shows a bed 6 feet 2 inches thick (6) similar to the lower part of the bed at Cane Gap. The upper part of the bed is concealed. Directly over the ridge from Rasnick's on Caney Fork drainage a drift was once run 20 feet S. 25° E., but is caved now. Only 6 feet 1 inch of the lower part of the bed was exposed (7), of which 18 inches is curly and flaky.

At the head of the left fork of Caney Fork above S. J. Tiller's house this coal has been opened in several places. Near the head of

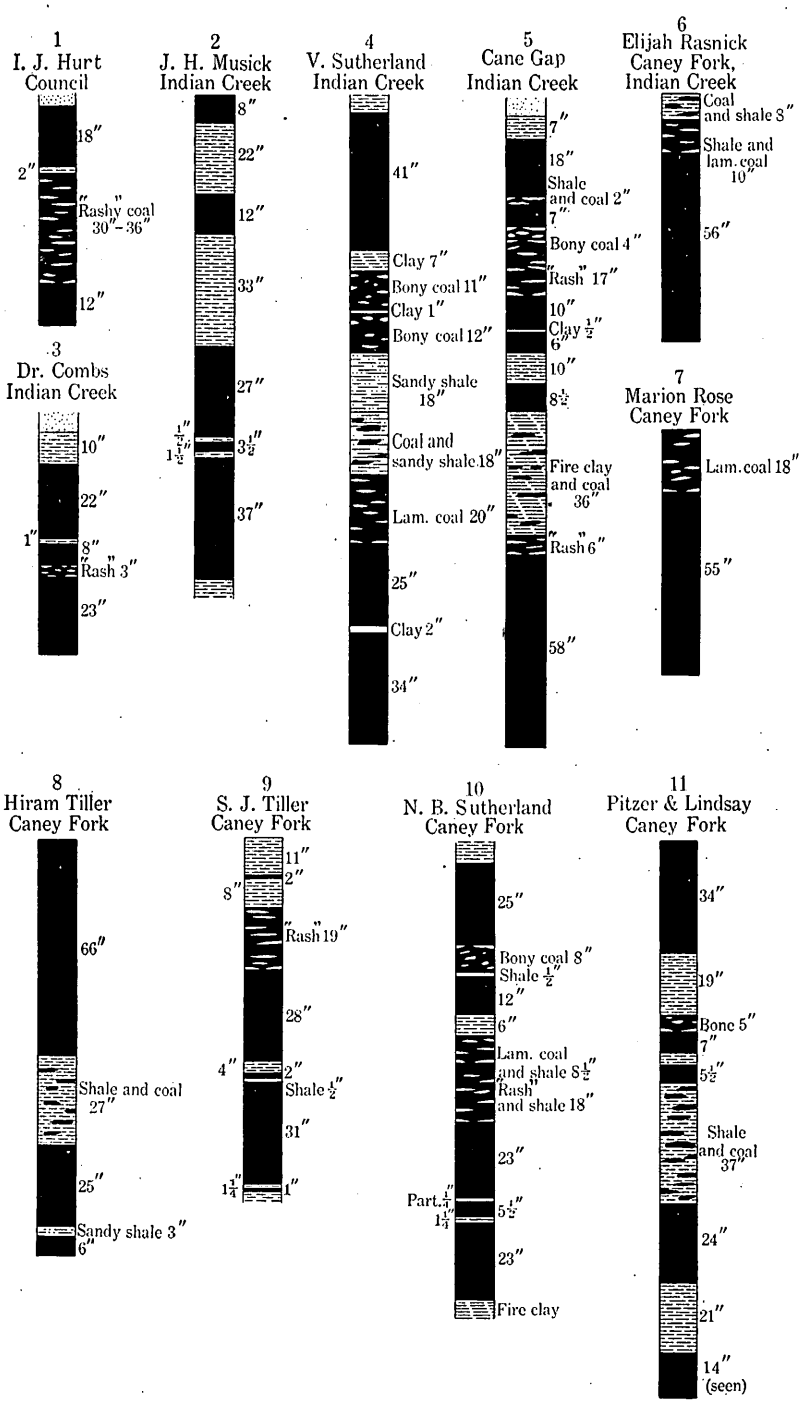


FIG. 16.—Sections of Tiller coal.

the fork Hiram Tiller has dug into the outcrop and reports the bed 13 feet 4 inches thick; the writer saw over 11 feet of coal, but the bed may not have been entirely exposed (8). In the woods 110 feet above the creek an opening was made to obtain fuel for a locomotive used in logging. A "switch back" was built to the entrance and an entry driven east 120 feet on the coal. The bed is 8 feet thick and 5½ feet of it was mined (9).

On Caney Fork above N. B. Sutherland's house this bed has a thickness of 11 feet (10) and is not heavily burdened with shale or clay partings. This section was measured by Mr. Hardaway. According to his classification it contains 26 inches of laminated and rashy coal and shale. The writer did not see the coal at this point, but presumes the laminated coal referred to is a bony coal and that the rash is a soft, crushed, flaky coal. One-half mile below Sutherland's on the right of the creek an opening about 100 feet above the water has been driven S. 45° E. on the same bed, which is a trifle less than 8 feet thick. In a field on the point of the hill on the left, 1 mile above the mouth of Caney Fork, the David Tiller pit driven west down the dip shows the coal just 8 feet thick but the middle 3 feet carries 3 partings which aggregate 17 inches of shale.

Just below the forks of Caney Fork and less than 1 mile above Indian Creek an opening on the west of the stream close to the road is reported by Mr. Hardaway to have shown the Tiller coal over 14 feet thick (11). This is known as the Pitzer and Lindsay opening. When visited by the writer this pit was partly caved and only the upper part of the section could be verified. On the north side of a hollow which joins Caney Fork on the west side at this point there is an exposure at water level of 30 inches of coal under a sandstone roof. Although this is 60 feet lower than the Pitzer and Lindsay opening it is supposed to be the top bench of the same coal brought to water level by a strong northwest dip which is apparent at the last mentioned exposures.

S. J. Tiller reports that a 4½-foot bed of coal has been opened in this vicinity about 100 feet above the big coal bed, but it is nowhere accessible at the present time. He also states that an 18-inch bed has been seen at water level near the mouth of Caney Fork. It was not observed by the writer, but if the correlation is correct this would be the same as the 22-inch bed at the mouth of Indian Creek. Between the mouth of Indian Creek and Abners Branch, a mile below, there is a coal bloom at the highest point in the road on the south side of the creek. Probably it is an unimportant bed of small thickness.

Bee.—The rocks rise rapidly up Abners Branch and it is possible that an 18-inch coal bed exposed about 75 yards up the hollow back of Bee may be the same as that just mentioned. At John Burrill's

in the gap at the head of Abners Branch an outcrop shows 17 inches of coal under 20 inches of shale and a sandstone roof (12).

Murphy.—The only coal seen on Russell Fork between Abners Branch and Fryingpan Creek is a small outcrop on Little Pawpaw Creek 300 yards above Robertson's house. Here 15 inches of coal is exposed under a ledge of sandstone close to water level. The whole bed may not have been seen. On the opposite side of the branch and a few rods farther up there once was an opening which is reported to have shown 3 feet of coal. It is said that there is a bed exposed 3 miles up Little Pawpaw Creek, where Charles Green gets fuel for his sawmill. Two feet of coal is reported back of Samuel Deel's house just below Murphy, but it is not now exposed.

Fryingpan Creek.—At the gap between the heads of Fryingpan and Indian creeks on the road from Carrie post-office to Jeff Power's there is a coal 4 feet 3 inches thick (13) which is believed to be the Upper Banner. This conclusion is based both on the stratigraphic position of the coal and on the presence in the upper part of the bed of a thin band of sandstone, which is a distinguished characteristic of the Upper Banner bed. It is reported that one-fourth of a mile southwest of Jeff Power's house the same coal is over 6 feet thick, but contains a parting of clay 1 foot thick (14). It seems from the evidence in the two sections that in one (13) the whole thickness of the bed is not exposed and more coal will be found in the floor.

In the yard at Sutherland's store, at Bucu, coal has been taken from the outcrop of a 32-inch bed (15) lying under shale; and close to the road on Left Fork one-third mile above Bucu there is an entry driven N. 35° W. on a 5-foot bed, another coal lying a little higher than the one just described, under heavy sandstone. The coal is in two benches separated by 10 inches of clay (16). The rocks seem to dip westward in this vicinity, and it is possible that the same coal has been opened one-fourth mile below Bucu in the east bank near Adolphus Kiser's store and on the opposite side of the stream at Z. T. Sutherland's.

An opening at Kiser's shows 3 feet 10 inches of coal with only one-half inch of parting (17). Twenty-five feet above it 20 inches of coal is exposed. On the opposite side of the creek the Sutherland opening shows a 5-foot 10-inch bed, which is peculiar in that the lower 2 feet 3 inches is a mixture of clay and laminated coal standing on edge. From 10 to 15 inches below the roof there is a foot of bony, mashed, slickensided coal (18). This may be the Widow Kennedy bed.

One mile below Bucu there is an opening by the roadside now partly caved, which has a roof of sandy shale that shows conchoidal fracture. The coal is disturbed, being particularly curly in the lower

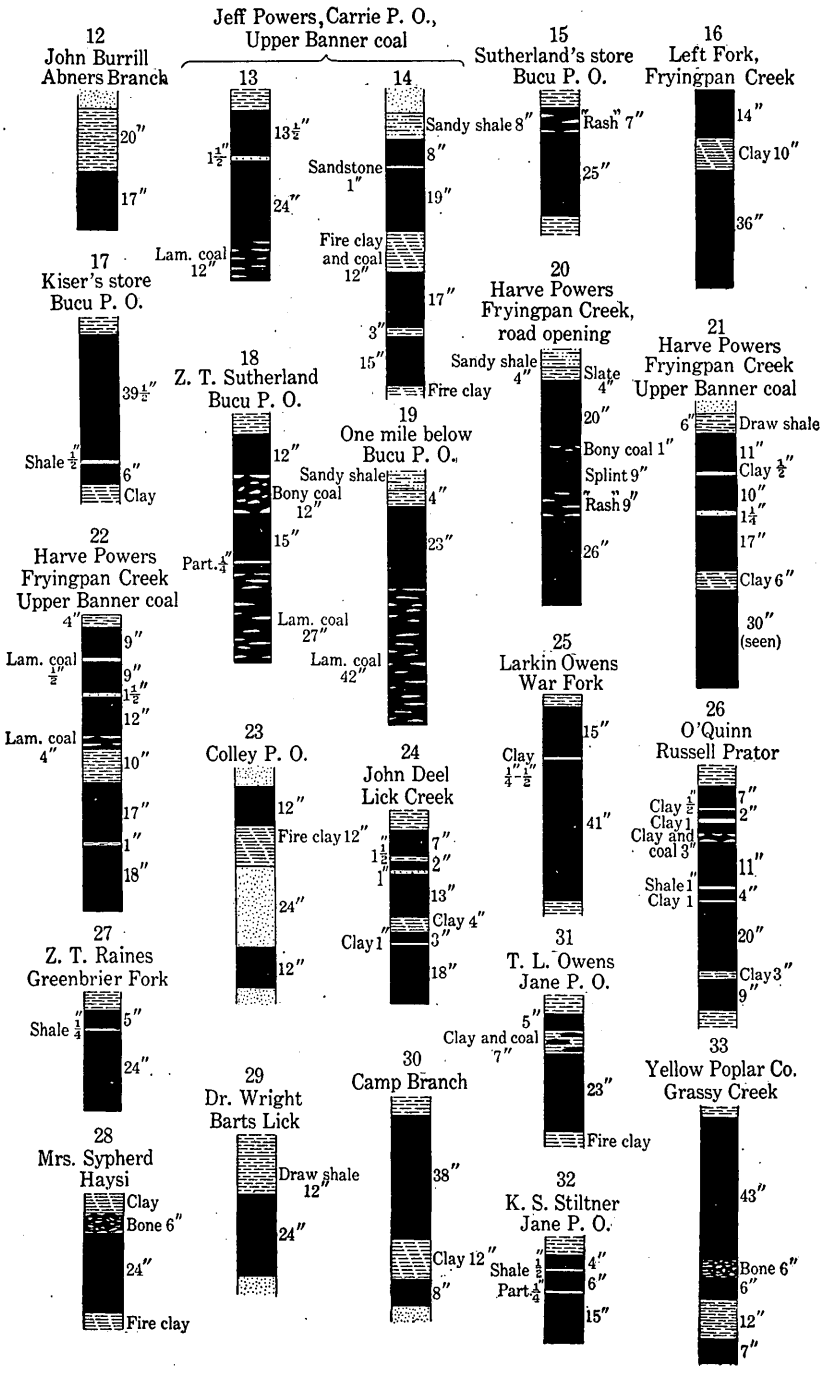


FIG. 17.—Coals on Russell Fork and its tributaries.

part of the bed, which is reported to be 5 feet 7 inches thick (19). Near Harve Power's, farther down the creek, another opening by the road is reported on the same bed and with the same thickness (20).

The Upper Banner coal has been opened in the head of the hollow back of Harve Power's, not far from Clement V. Rasnick's, on top of the ridge between Fryingpan and Lick creeks. It is 500 feet higher than the creek at Power's house. The coal is exposed in a 20-foot drift on the farther side of a spur 300 yards from W. G. Honaker's house. It is under a 50-foot ledge of sandstone and is over 6 feet thick (21). On the other side of the same branch a drift run 20 feet N. 80° W. down the dip shows the Upper Banner coal bed nearly 7 feet thick (22), according to a measurement by Mr. Hardaway. Less than 20 inches of the bed is clay or bone.

At the ford just below Colley there are two bands of coal 12 inches thick separated by 3 feet of sandstone and clay (23). The bed is of no value and is terminated at one end of this outcrop by a fault. There is 1 foot of coal in the road at the mouth of Priest Fork.

Lick Creek.—Coal exposures are few on Lick Creek. A 1-foot bed outcrops in the cliff one-fourth mile below the mouth of Dog Branch, and a pit on the left fork of Dog Branch one-half mile above Lick Creek near J. W. Self's house reveals a little coal. The shale roof at this point is regular and horizontal, but the coal is in irregular blocks or gobs mixed with contorted clay. Although the coal has been mined along the crop for 30 feet, no regular bedded coal was seen. The condition of the bed and its geologic relations suggest that this is the Widow Kennedy coal. An opening at creek level near the head of Beech Branch, at John Diel's, is on the Upper Banner coal. The bed is 4 feet thick (24) and has the characteristic sandstone parting.

Birchleaf.—A road opening on Russell Fork near Birchleaf, one-eighth mile south of Dicks Branch, is reported to have shown 4 feet of coal, and a short drift at T. K. Colley's at the mouth of Duty Branch shows about 4 feet of crushed and rolled coal under a roof of badly crushed or jointed sandstone. The roof is so treacherous that the pit is not kept open. Some of the coal has slickensided faces, and the whole appearance suggests the Widow Kennedy bed. The dip from the mouth of Fryingpan Creek to Dicks Branch is downstream.

Russell Prator Creek.—Russell Prator Creek, which enters Russell Fork opposite McClure Creek, is the largest of the eastern tributaries, but its coal resources have received little attention. There is a 1-foot bed in the road above Albert Owen's and a 15-inch bed one-fourth mile above Prator, on the left fork. C. C. Clevinger reports a bed 5 feet 10 inches thick in the top of the mountain 1 mile above the mouth of Greenbrier Fork. At the head of War Fork, 2½ miles above Prator, there is an opening in the hillside opposite and 130

feet above Larkin Owens's house and 100 feet below the top of the ridge. It has been driven 12 feet S. 70° E. up the rise and shows a bed (25) 4 feet 8 inches thick containing only one-half inch of clay. This coal is probably less than 200 feet above the creek at the mouth of War Fork and may be the Upper Banner. W. G. Raines reports that a 5-foot coal with no partings has been opened at the head of War Fork by Isaac Viers. This coal is caught only in the knobs on top of the ridge. A 3-foot bed of coal is reported near the head of the left fork above Prator.

On Greenbrier Fork of Russell Prator there are some small openings by the roadside a short distance above the mouth on a 15-inch and a 2-foot bed which are only 4 feet apart. On the east of Greenbrier, 2 miles above the mouth and 400 feet above the road, Albert and Wiley O'Quinn have recently run a drift about 20 feet in a southwesterly direction. The bed is over 5 feet thick, but has several thin partings (26).

An opening on Z. T. Raines's land at the head of Greenbrier Fork shows (27) 29 inches of coal, and two small openings on the same bed close to Joshua O'Quinn's house show about 2 feet of coal.

Haysi.—In the road a few rods west of the store at Haysi a 2-foot coal bed dipping north at an angle of 70° indicates a fold or fault at this point. The exposure is in front of a house occupied by Mr. Garrett on Mrs. Winnie Scyphers's land. In a ravine beyond the house, under a strongly jointed sandstone and between rocks standing vertical, there is an outcrop showing 15 inches of coal, 3 feet of fire clay, and at least 1 foot of coal below. The bed dips at a small angle and can be of no value on account of the greatly disturbed condition of the rocks.

At the head of the first west branch of Russell Fork above Pound River is a small excavation from which Mrs. Winnie Scyphers has taken a little coal. Six inches of bone and 2 feet of coal (28) compose the bed which dips strongly toward the northwest. One going from Haysi finds this opening in the first field on the right of the road, beyond the woods north of Mount Olive church. Along this road to the mouth of Pound River several coal blooms are seen, and one striking N. 20° W. crosses the road with a vertical dip.

Barts Lick.—On the road from the mouth of McClure Creek to Jane, on Hunts Creek, a coal bloom is exposed in the gap at the top of the ridge between Russell Prator Creek and Barts Lick, and at three points within 150 feet below the gap on the north side of the ridge. At the foot of the steep grade in the bed of the run tributary to Barts Lick a small amount of coal has been obtained by stripping a 1-foot bed in the road. One mile up Barts Lick from where the road going north leaves the main stream a 2-foot coal bed (29) occurs at the mouth of the first right hollow below the splash dam, in a pit 12

feet above the branch and 300 yards below Dr. J. W. Wright's house. It also shows in the bed of the branch close to the house. In 1906 coal was being mined at this place for use in a sawmill. At the crook of the road on the right fork of Camp Branch there is an opening on a coal bed nearly 5 feet thick (30) which has a 12-inch clay parting. The dip is strong to the east. This coal is not over 100 feet above the Lee conglomerate which shows in the branch below the forks, and may possibly be the Tiller coal.

Grassy Creek.—On Hunts Creek, the main fork of Grassy Creek, there is an opening by the roadside 2 miles above Jane, on the road to Grundy, which shows 2 feet 10 inches of coal with a shale roof and sandstone floor. A drift has been driven 15 feet down the dip which is toward the southeast. Half a mile farther the same coal has been opened in two places close together. These are caved now, but appear to have exposed between 2 and 3 feet of coal. On the south of Hunts Creek, one-half mile below the gap leading to Bull Creek, there is a timbered opening on the Yellow Poplar Company's land driven south 10 feet which shows 4 feet 1 inch of coal with one-half inch of clay 5 inches from the top of the bed. This opening is directly across the creek from a rocky ledge in the road. In a sag close to this ledge and 30 feet above the road this coal was opened once, but is now concealed.

On the branch which joins Hunts Creek from the east at Jane three openings were seen. The first of these is about one-third mile above Jane, in the hill on the left of the creek back of Tom L. Owens's house. It is 200 feet above the creek and is being worked by a drift which has been driven north 20 feet. The bed (31) is 2 feet 11 inches thick and contains a 7-inch clay parting. On the same side of the creek 1¼ miles from Jane, on the K. Silas Stiltner farm, there is an opening back of the house and 50 feet above the creek showing a 2-foot bed of coal with two thin partings (32).

About 1 mile above Jane, on Noah Mullins's land, there is a pit in a hollow on the south from which coal is taken every winter. It has been driven 30 feet in a southwest direction and shows from 28 to 30 inches of coal with shale roof and fire-clay floor. On the east of Abes Fork of Grassy Creek, in Old House Branch, the Yellow Poplar Company made three openings on a bed 1,270 feet above sea level. At one opening the bed is 4 feet 2 inches thick with a 7-inch clay band near the bottom, and at another it is reported to be 5 feet thick with the same clay parting. An opening on the left of Old House Branch shows the same bed over 6 feet thick (33) at the face of the drift, which is 1 foot more than at the outcrop. These openings are very close to the Pine Mountain fault and within a few rods of the State line.

M'CLURE CREEK.

McClure Creek heads against Sandy Ridge between Carrie and Fuller Gap, and flows north and east to join Russell Fork 3 miles above the mouth of Pound River. The occurrence of coal prospects in this basin will be described in geographic order from the head of the creek to the mouth.

Trammel Creek.—At the head of Trammel Creek a drift driven 20 feet S. 15° E. at the bend of the road 275 feet below Trammel Gap, on the Brooks farm, shows the Upper Banner coal (34) 4 feet 11 inches thick. The sandstone parting is 21 inches below the roof and is practically the only part of the bed that is waste material. The section is the same in the mine of the Clinchfield Coal Corporation at the head of Lick Creek on the other side of the ridge. This mine, known as No. 3, is situated on a tract of land lying under Low Gap and eventually it may be extended through to the north side of the ridge for natural drainage.

The Lower Banner coal has been opened in Trammel Creek, on Laban Phillips's place, to get coal for a steam engine used in diamond drilling. The drift extends a distance of 30 feet S. 20° E. and shows 4 feet of coal underlain by 3 inches of clay and 4 inches of bone. In the Clinchfield mine No. 2 at Dante on the other side of the ridge the average thickness of the Lower Banner coal is about 3½ feet.

A pit opposite the schoolhouse near the mouth of Trammel Creek shows the Widow Kennedy coal 7 feet thick, but decreasing rapidly with depth. A diamond-drill hole 150 feet away showed only 1 foot of coal at this horizon.

Homade.—Back of the post-office and store at Homade on the head of McClure Creek Reuben Owens has faced up a coal bed, which probably is the Lower Banner. The northwest dip makes the bed lower here than on the south side of Sandy Ridge. Nearly 4 feet of solid coal was visible, but the floor was hidden so that the whole bed was not measured (35). A small coal seen in the road farther upstream, and 100 feet higher than this exposure, is also believed to be the Lower Banner. Blooms of two other coals were seen higher in the ridge at 250 and 450 feet below the gap. The elevation of Flint Gap is approximately 2,750 feet, or 1,000 feet higher than the mouth of Trammel Creek. Trammel Gap is 2,533 feet above sea level.

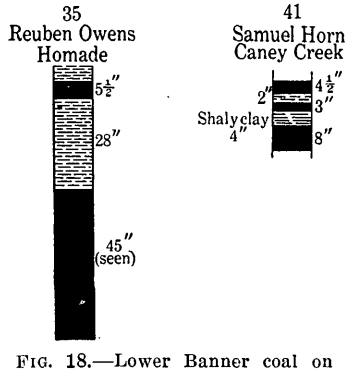


FIG. 18.—Lower Banner coal on McClure Creek.

The Widow Kennedy coal was once opened in the north hillside at the mouth of Roaring Fork 50 feet above water, but the pit is caved

and nothing was learned of the character of the bed. No openings were seen between Roaring Fork and Open Fork.

Open Fork.—The Grissell opening (36) at the head of Open Fork and on the opposite side of Sandy Ridge from Big Laurel Branch of Lick Creek shows the Upper Banner coal nearly 7 feet thick. Four feet of this bed is good available coal, leaving 8 inches of fire clay and 11 inches of coal in the floor, and 3 inches of coal over 7 inches of shale in the roof.

The Milton Carico opening (37) on the Upper Banner at the head of Middle Fork shows the bed divided by the same partings as at Grissell's, but the total thickness of the bed is less. At the outcrop it measures 6 feet 3 inches and at the face of the drift 6 feet 5 inches. The graphic section was measured by Mr. Hardaway at the face. An opening three-fourths mile above this, on the right of the stream, shows the Upper Banner less than 5 feet thick, but there is less waste in the bed.

An opening (38) on Coon Branch of Open Fork at Rasnick's, according to Mr. Hardaway, shows the Upper Banner coal over 9 feet thick, but containing a 35-inch clay and shale bed 41 inches from the floor. The Lower Banner, exposed near Mr. Rasnick's house, is 6 feet thick, but has 2½ feet of fire clay in the middle of the bed. The Widow Kennedy coal is reported from 3 to 5 feet thick near the mouth of Middle Fork. At Rasnick mill, on McClure Creek below the mouth of Open Fork, there are three openings on the Widow Kennedy coal about 75 feet above the road. The bed is in the midst of heavy sandstone and is 6 feet thick, but is so badly mashed and distorted as to be of questionable value. Jointing is conspicuous in the roof sandstone.

Caney Creek.—At the head of Caney Creek, close under Gibson Gap, the Upper Banner coal has been prospected by a drift 100 feet long at Alec Odle's. The bed at the outcrop (39) is 8 feet thick and at the face of the drift (39 a) 8 feet 10 inches thick. It contains a number of very thin partings. On Samuel Horn's land, on Hornspring Branch, the Upper Banner carries the same number of thin partings and is 7 feet 5 inches thick (40). At a distance of 50 feet this bed shows 3 partings aggregating nearly 2 feet in thickness (40 a). The Lower Banner (?) coal as seen in the stream bank at the mouth of Hornspring Branch (41) is 21 inches thick. These sections on Caney Creek were kindly furnished by Mr. Hardaway. Probably other openings have been made on this creek, for coal is reported on Rock House Branch, but none was seen.

On McClure Creek 1 mile above the mouth of Caney Creek 25 inches of coal is exposed in an old opening close to the road, and at George Dyer's, one-fourth mile above Caney Creek, there are two openings on the same bed, one of which is caved. An entry driven 40

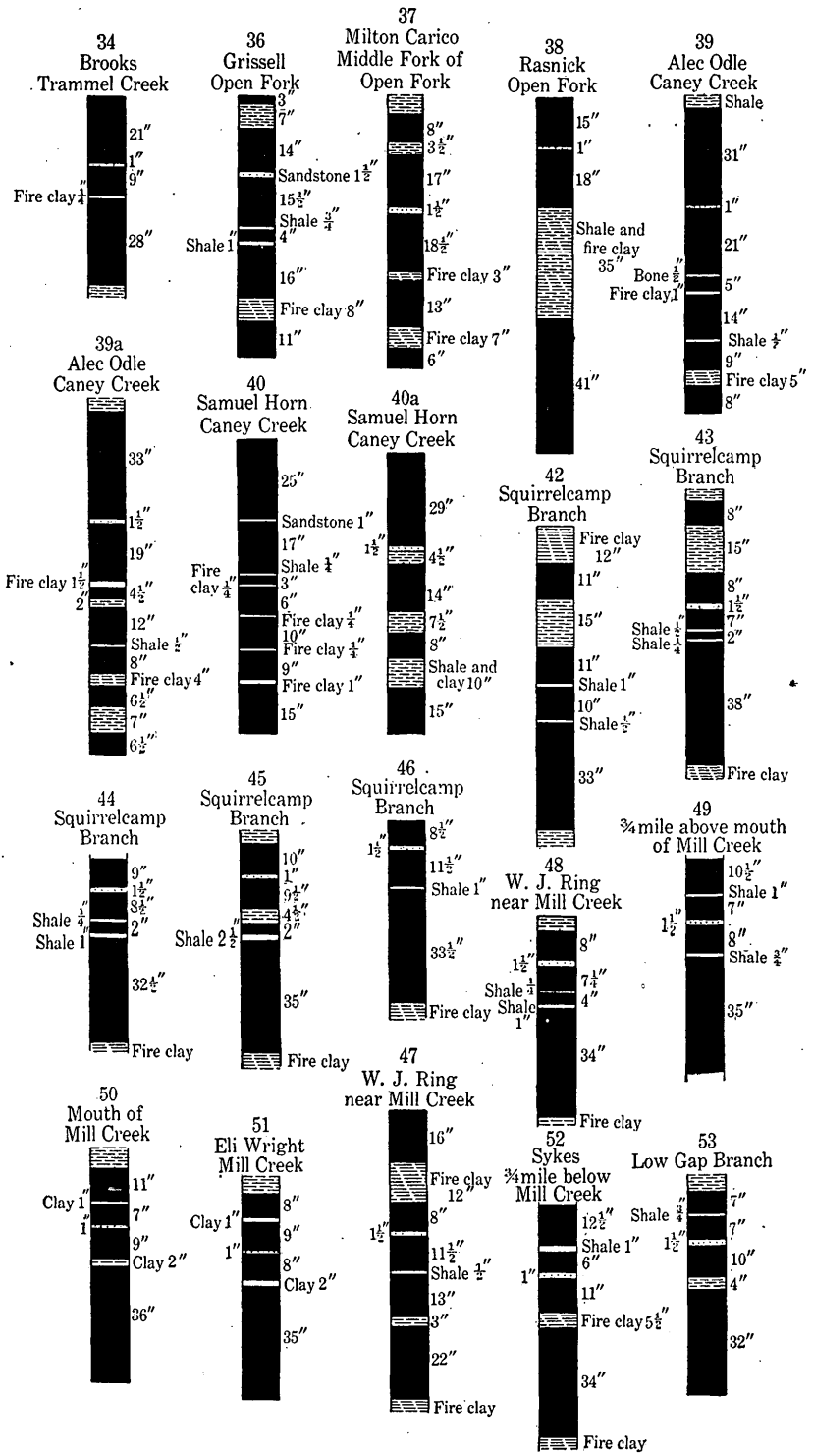


FIG. 19.—Upper Banner coal on McClure Creek.

feet down the dip is filled with water, and the thickness of the bed could not be determined, but it appeared to be about 5 feet. This may be the Widow Kennedy coal.

Squirrelcamp Branch.—Just below the forks of Squirrelcamp Branch on the right of the stream, near a house, and 120 feet above the water, there is a 15-foot entry (42) on the Upper Banner coal. The bed, which dips S. 35° E. at an angle of 6°, is 6 feet 9 inches thick, including 15 inches of shale near the top. On the right of the left branch one-eighth mile above the forks the Upper Banner is divided by the same number of small partings and one thick one (43), while on the left of the branch (44) the bed is in the same condition, except that the top bench of coal and the thick parting are wanting. At the head of Squirrelcamp Branch on the left of the stream and 100 yards below a house the Upper Banner coal is 5 feet 4 inches thick (45), and one-fourth mile below this on the Love Stanley tract on the right of the creek and just above the road it measures 4 feet 8 inches (46). It is possible that prospecting in the roof will show another bench of coal here just as at the forks.

On the east of McClure Creek one-half mile below Squirrelcamp Branch at the lower end of the W. J. Ring tract the Upper Banner coal is over 7 feet thick, a 16-inch bench of coal occurring in the roof (47). On the west of McClure Creek, opposite the first bend one-fourth mile below Squirrelcamp Branch (48), this bed is 4 feet 8 inches thick. The section includes only 8 inches of coal above the sandstone parting. At the head of a hollow on the Ring tract there are two openings, in one of which the Upper Banner is 4 feet 10 inches and in the other 5 feet 5 inches thick. These sections resemble very closely the measurements of the Upper Banner on Squirrelcamp Branch.

Mill Creek.—In the vicinity of Mill Creek the Upper Banner coal has been prospected extensively and several sections have been obtained showing the character of the bed in detail. Most of the measurements are by Mr. Hardaway.

On the northwest bank of McClure Creek three-fourths mile upstream from Mill Creek and 200 feet above water level the Upper Banner is 5 feet 3 inches thick (49), with three thin partings. On the opposite side of McClure Creek, at the bend 1 mile above Mill Creek, there is another prospect, but the thickness of the coal was not learned.

An opening opposite the mouth of Mill Creek 190 feet above the water (50) has been driven a distance of 30 feet N. 70° W. The bed is 5 feet 7 inches thick and is divided by three partings aggregating 4 inches. The Lower Banner should be about 75 feet below, but has not been opened.

The Upper Banner coal on House Fork of Mill Creek is 5 feet 8 to 10 inches thick, having the usual three thin partings found in this region, which aggregate less than 6 inches of waste. These features are shown by three openings, one at the head of the fork and two on the left of the stream.

On Toms Fork of Mill Creek the Upper Banner was measured by the writer in a 15-foot drift just above Eli Wright's place (51). The coal is under a 40-foot sandstone, is 5 feet 4 inches thick, and shows a persistence of the three thin partings in this vicinity. An opening opposite Wright's house, measured by Mr. Hardaway, duplicates this section within an inch or two.

A prospect on Sykes's land, one-fourth mile below Low Gap Branch on the east of McClure Creek, 260 feet above the water, shows the Upper Banner 6 feet thick (52). This coal has practically the same section on the Floyd Viers tract; the appearance of the bed is shown in Pl. VII, *A* (p. 92), from a photograph furnished by Mr. Hardaway. Two pits near the head of Low Gap Branch revealed the same bed 5 feet 2 inches thick. One of these pits (53) was driven 60 feet, and supplied coal to the neighborhood. So far as learned there are no coal openings on the lower 5 miles of McClure Creek.

CRANES NEST RIVER.

Extensive prospecting at the head of Cranes Nest River shows the character and position of the Upper Banner coal on Steele Fork and Trace Fork. The writer did not visit this section and the measurements are all by Mr. Hardaway.

Steele Fork.—On the west side of Steele Fork there are five openings, beginning one-half mile above the mouth, which show the Upper Banner varying from 1 foot 5 inches to 2 feet 7 inches in thickness. It seems likely that the bed is split and only the lower portion was found, for in an opening 1¼ miles from the mouth of the fork (54) the bed is 9 feet 4 inches thick, but carries 5 feet 9 inches of shale and clay in two partings.

At the head of Steele Fork the Upper Banner is exposed in three openings, having a lower bench of coal from 15 to 20 inches thick and an upper bench from 19 to 22 inches thick separated by 1 inch of sandstone. Three openings near Boatwright's house, which is on the west side of Steele Fork 2½ miles above the mouth, show (55) practically the same division and thickness of the bed, but openings one-half and 1 mile below Boatwright's show the bed with increased thickness due to the addition of several inches of carbonaceous shale and 9 inches of coal to the top of the bed (56).

Trace Fork.—Openings made at short distances from Fuller Gap to the mouth of Trace Fork show the character of the Upper Banner

coal. At the head of the creek, where the coal is at water level, the bed is 3 feet 2 inches thick and contains 1 inch of fire clay and 1½ inches of sandstone. At places a little farther downstream it measures 3 feet 4 inches, 3 feet 9 inches, and 4 feet, and in each place has 1 inch of sandstone 12 to 18 inches from the top. At John Lodge's house, which is 1¾ miles above the mouth of the fork, the Upper Banner coal is 35 inches thick on the right and 26 inches thick on the east of the creek (57). At Harrison Adkins's 27 inches is exposed and one-fourth mile farther downstream, on the east, the bed is 5 feet thick. In the latter place the increased thickness is due to the presence of a 21-inch seam of coal separated from the main

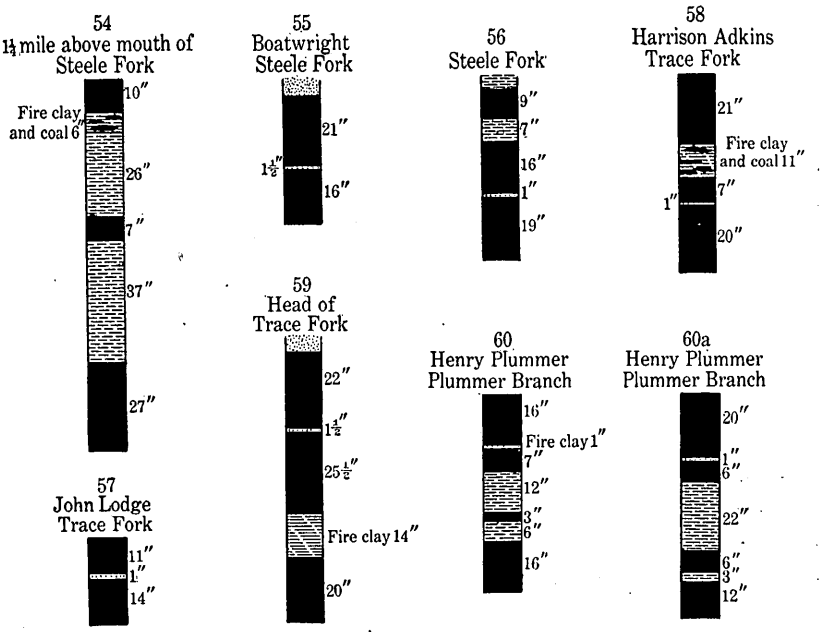


FIG. 20.—Upper Banner coal, head of Cranes Nest River.

bed by 11 inches of fire clay (58). Whether this is a local development or a case of more thorough prospecting is not known. It may be the former because in an opening reported to be up the hollow below the fan house of the Cranes Nest mine, on the head of Trace Fork, a bed measuring 7 feet 1 inch (59) diminishes to about 3 feet in a drift 300 feet long by the disappearance of the bottom fire clay and coal.

On the Wilson Adkins tract, one-fourth mile below the mouth of Steele Fork, an opening on the east of Cranes Nest River reveals 4 feet 5 inches of coal separated into two benches by 8 inches of fire clay. This is reported to be near the horizon of the Upper Banner, but it does not show the usual sandstone parting.

Birchfield Fork.—So far as learned there has been but little prospecting on Birchfield Fork. The only opening reported is on Henry Plummer's land in a hollow on the east of the fork 2 miles above the mouth. In this pit, according to measurements by Charles Addington, the thickness of the Upper Banner varies from 5 feet 1 inch (60) to 5 feet 10 inches (60a). The increase in thickness is due largely to a band of shale which swells from 12 to 22 inches. In the mine at Glamorgan, which is on the opposite side of the ridge from the head of Birchfield Fork, the bed averages 4 feet 4 inches thick and contains two very thin partings, but the writer did not have opportunity to attempt a correlation with any of the coals of Dickenson County.

Lick Fork.—About 2 miles above the mouth of Lick Fork and 400 feet higher than Jim Robinson's house a prospect (61) shows the Clintwood coal nearly 13 feet thick. In addition to the remarkable thickness, according to Mr. Hardaway, this bed is noteworthy for containing only 7 inches of shale or other partings. Isom Mullins opened this coal at the head of Lick Fork (62) and found the bed nearly 10 feet thick with 3 inches of partings. At the time it was visited in 1906 the opening was partly caved, and only 4 feet of coal was visible. In a field above this on the east of Lick Fork the bed is 10 feet 7 inches thick with 5 inches of shale in three partings (63). The prevailing dip is northwest.

Clintwood.—Carload samples of the Clintwood coal have been shipped from the Beverley opening (64) to test the coking quality. This opening is on Honeycamp Branch, a small tributary of Cranes Nest River south of Clintwood, and the coal is reported by H. W. Reitz to be 6 feet 9 inches thick without partings. At the head of Keel Branch prospects made by Henry Keel show this bed to be 10 feet 4 inches thick (65) in the opening at the edge of the woods and 8 feet 7 inches thick (66) at the field opening. An entry has been driven 100 feet, but the roof is weak and requires heavy timbering.

The John Lane opening, on Holly Creek one-half mile west of Clintwood, has an entry about 250 feet long, and shows 4 feet 6 inches of coal at the face. A combination of the upper part of the bed as seen at Lane's and the lower part as shown at Vanover's, on the opposite side of the creek, according to Mr. Hardaway, gives a total thickness (67) of 10 feet. It does not pay to remove the 20-inch fire clay to get the lower benches of coal. The same bed at the Joe Glenn opening, near by, is reported to be 6 feet thick with a 4-inch parting 13 inches above the floor. Two entries on the Clintwood coal just south of the village and 150 feet above Holly Creek are caved, and the sections were not obtained. The bed is said to be of the same thickness as at the Lane opening.

A considerable part of the coal used at Clintwood for domestic purposes is supplied by a small mine at the head of Long Branch owned by R. E. Chase and J. K. Damron. The opening is on the Clintwood coal, which is above the Gladeville sandstone, and at this point about 1,960 feet above tide. An entry has been driven over 150 feet on a bed reported to be 6 feet 3 inches thick (68). Only the

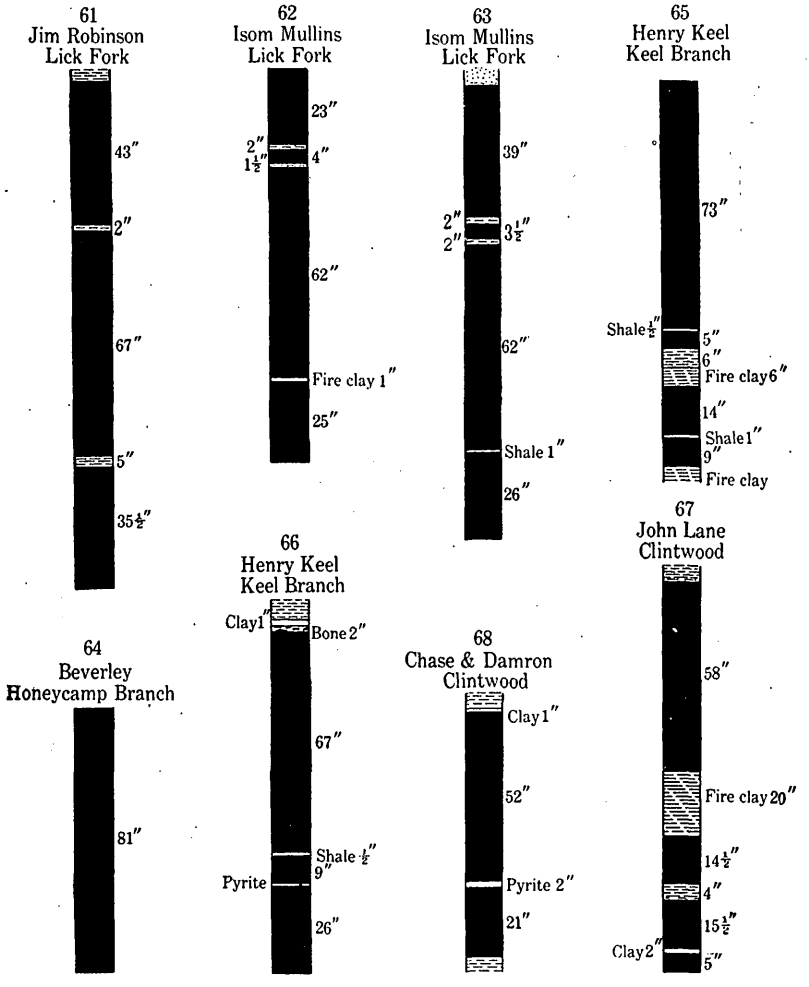


FIG. 21.—Clintwood coal on branches of Cranes Nest River.

upper bench is mined. This is 4 feet 4 inches of solid coal. A sample of this coal was taken by C. W. Dodge for analysis, and the result is given in the table on page 119.

The Upper Banner coal has been opened at a number of points between Honeycamp Branch and the mouth of Cranes Nest River. On the south of Cranes Nest, one-fourth mile above Keel Branch, on

Pres. Flemings's land, the bed is 5 feet 11 inches thick (69), with 10 inches of fire clay near the bottom, and one-fourth mile above this it is 5 feet 4 inches thick with 8 inches of shale near the top (70). Near the latter point the Lower Banner coal has a thickness of 3 feet 2 inches with a streak of shale in the middle (71).

At R. G. Baker's, above the mouth of Camp Creek, an opening 100 feet above the water shows at least 2 feet of coal (72). The bottom of the bed was hidden, so the entire thickness was not determined.

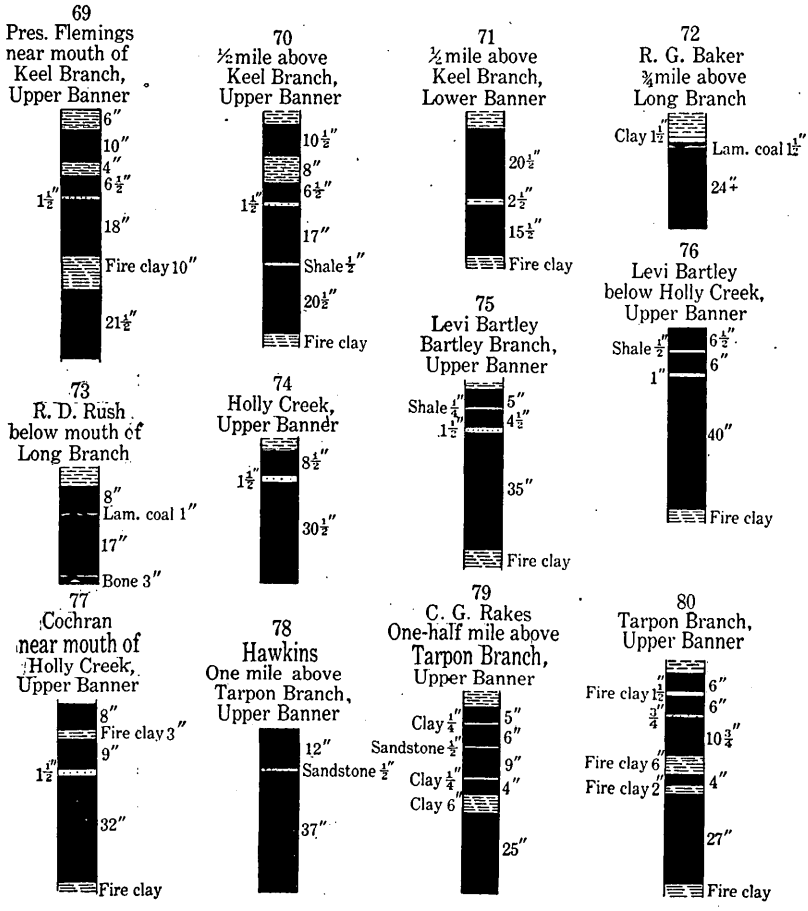


FIG. 22.—Coals on Cranes Nest River.

On the same side of the river below the mouth of Long Branch a bed (73) a little over 2 feet thick has been opened by R. D. Rush for domestic use.

The Upper Banner coal, according to Mr. Hardaway, has a thickness of 3 feet 4 inches (74) on Holly Creek, and 3 feet 10 inches (75) on Chase's land in Bartley Branch, which is the next branch below Holly on the same side of Cranes Nest River. Another opening

on the north of Cranes Nest above Levi Bartley's house, which is above the mouth of Bartley Branch, is said to show the Upper Banner coal 4 feet 6 inches thick (76), and an opening on the Cochran property, one-half mile above the last, shows 4 feet 5 inches (77).

Delaney's mill.—The Upper Banner coal has been prospected at a number of points near Delaney's mill on Cranes Nest River below Dwale. One of these, in a small watercourse close beside the trail which leaves the river about one-fourth mile above the mill, is under a sandstone ledge and has over 4 feet of coal (78) with only a thin sandy parting. Another is 180 feet above the river at C. G. Rakes's, the next house below Delaney's. This bed, as measured by the writer, is 4 feet 9 inches thick and has 8 inches of waste (79). Openings on Sugarcamp Branch opposite the mill and in the hill on the left of the river opposite Delaney's house have caved, but are reported to have shown the Upper Banner coal 4 feet thick with the usual thin sandstone parting and two or three one-fourth-inch shale bands. It is said to be 4 feet 1 inch thick on Honey Branch above J. F. Newberry's, and 5 feet 3 inches (80) at the head of Tarpon Branch one-half mile below Low Gap. At this point, according to Mr. Hardaway, there is an extra parting of 2 inches of fire clay 27 inches above the floor. No prospects were heard of below Tarpon Branch on Cranes Nest River.

The above notes show an average thickness of 4 feet for the Upper Banner coal on Cranes Nest River below Clintwood. It is a good mining proposition, because the coal is high grade and the amount of waste in partings is small. The bed is 100 to 300 feet above the river and has a gentle dip to the northwest.

POUND RIVER.

Pound River heads at Black Mountain and flows northeast 25 miles to join Russell Fork. Its course is parallel with Pine Mountain, but its length is greatly increased by loops and bends. Prospects for coal are more numerous on Indian Creek, Bowlecamp Creek, and Georges Fork than elsewhere on Pound River or its tributaries.

South Fork.—Reuben Bowling has taken coal from the bank of South Fork about 1½ miles below the source or one-fourth mile above the road to Flat Gap. The bed (81) is over 4 feet thick, but contains a 10-inch clay parting. Two drifts have been driven 25 feet S. 30° E. This bed is said to have been opened at one or two other places in the vicinity. Good coal is reported on C. F. Robinet's land, in the hollow below the road forks leading to Flat Gap, and an 18-inch coal is exposed in the road near the forks. On G. W. Hilton's land, at the mouth of Fox Gap Hollow, there is 28 inches of coal in a pit dug in the hillside across the road from his house. Coal blooms

were seen near Bond Mill and it is reported that 2 feet of coal has been found on John Stedman's land and was once stripped below the milldam.

Farther down South Fork a 2-foot bed of coal shows in the road, and in the creek bluff close under the road at the upper end of Thurston Banner's land there are two coal beds 10 or 15 feet apart. The lower one is almost at water level and shows 23 inches of coal, and

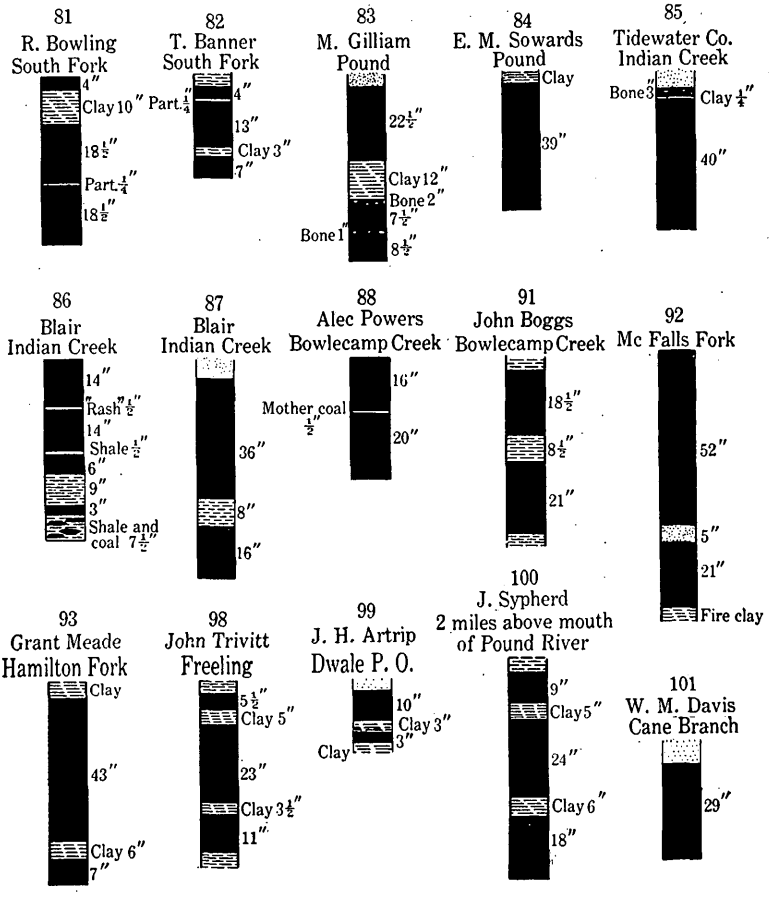


FIG. 23.—Coals on Pound River and its branches.

the upper one (82) is 2 feet 3 inches thick. Opposite Thurston Banner's house there is a prospect which, he reports, disclosed 23½ inches of coal. The coals from Bond Mill to Banner's rest on a massive sandstone and probably are the same bed.

At the mouth of Glady Fork a small pit dug by J. P. Qualls shows 3 feet of coal, the upper part soft and the lower part hard. This bed shows 2 feet 9 inches of coal in the river bank a short distance below the mouth of Glady Fork.

Several coal blooms are exposed in the road along the lower part of South Fork, but the only pits noted are on the land of Milburn Gilliam, above the road on the east of South Fork, about one-fourth mile from its mouth. Two old entries, one of which is said to be 150 feet long, are badly caved, and a third was opened in the autumn of 1906 to supply fuel for a locomotive operating on a lumber tramroad. The bed (83) is 4 feet 4 inches thick but contains a clay parting 1 foot thick. It has a fossiliferous shale roof.

North Fork.—Very little coal was seen on North Fork, and the chances of there being any worth much attention on the right or mountain side of the stream are small. It is reported that W. A. Bowling has a pit at Flat Gap on a 4-foot bed and that there is a 20-inch bed at George Adams's, 4 miles below Flat Gap. At Henry Short's, 1 mile above Meadow Branch, there is said to be a 2-foot bed of coal in the watercourse below the house, and a 4-foot bed is reported in the head of the hollow but it is not now exposed. In the hollow just below Meadow Branch and back of Josh Mullins's house a 12-inch and an 18-inch bed of coal are exposed in the shale bed of the branch. One is 30 feet above the other.

The only coal pit seen on North Fork is in the south bank opposite the Pound Gap road, or less than one-fourth mile above the forks. It is merely a small drain under a sandstone ledge where E. M. Sowards has dug a few tons of coal. The bed is 3 feet 3 inches thick (84) and the lower 2 feet is block coal. It is about 125 feet above the creek.

Coal blooms were seen in two or three places on the road from Pound to Pound Gap and a 1-foot coal is exposed on top of the Lee conglomerate about 500 feet below the gap.

Indian Creek.—Near the head of Indian Creek the bloom of a coal apparently about 2 feet thick is exposed in the road in two or three places. The bed dips downstream. There is also on the upper end of the creek and 100 feet above it an old entry now partly filled with water in which 3½ feet of coal (85) can be seen. The whole thickness of the bed was not learned. It dips S. 80° W. at an angle of 4°. Farther down the creek, 2 miles above the mouth, Mr. Hardaway reports a bed at water level and gives a measurement of 4 feet 6 inches (86), with the note that there is said to be 2 feet of coal below the visible portion of the bed. This is at J. H. Blair's, where a pit 25 feet above the creek is reported to have shown a 5-foot bed (87) containing an 8-inch parting. There is evidence of slight local folding of the rocks along this part of the creek.

An opening just above the Craft house, on the Chase tract, is said to have been driven 150 feet on a coal bed, the upper bench of which is 2 feet 9 inches thick. There is a coal bloom in the road above

the Tidewater Lumber Company dam, and at the mouth of Indian Creek a 16-inch bed of coal shows beside the road 200 feet from Pound River.

Bowlecamp Creek.—At the head of the main fork, known as Dotson Fork or Baker Ford, a 3-foot bed of coal is reported below Alec Power's (88), and one-eighth mile farther downstream and at the same elevation this bed is 3 feet 5 inches. On the George L. Baker place, in the same locality, an opening has been made on a bed of coal over 10 feet thick (89) which has a close resemblance to the Clintwood coal at the Lane and Keel openings (Pl. VIII, *A*). It is on top of the Gladeville sandstone and 150 feet above a coal which shows as

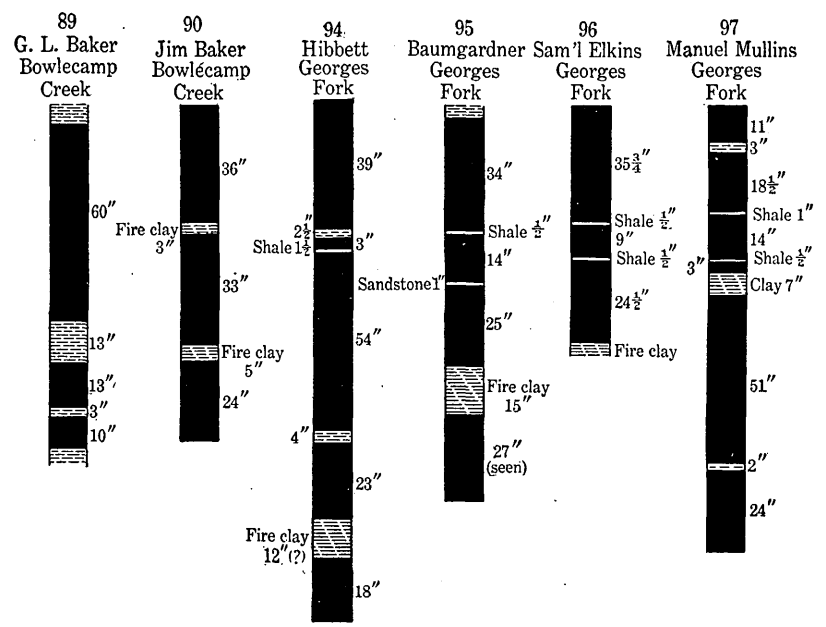
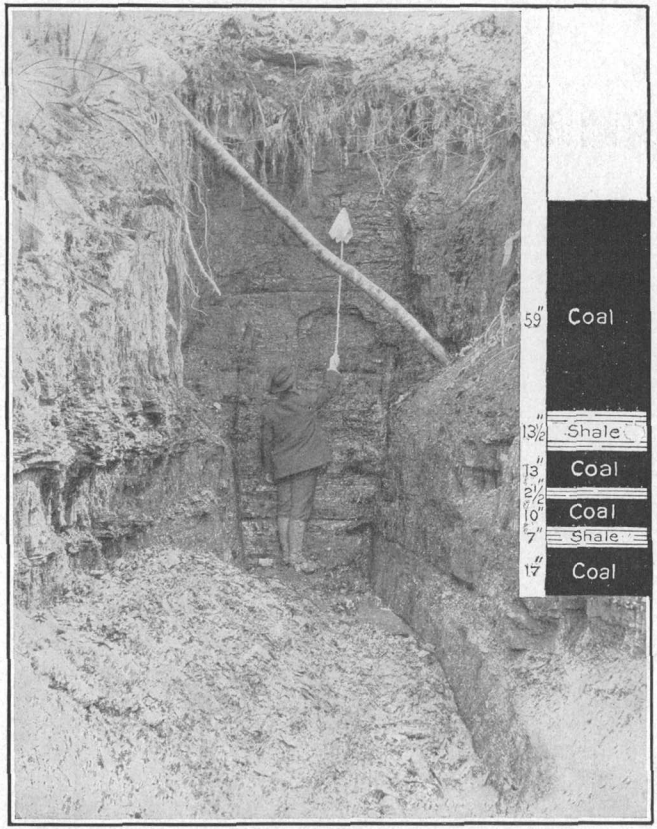


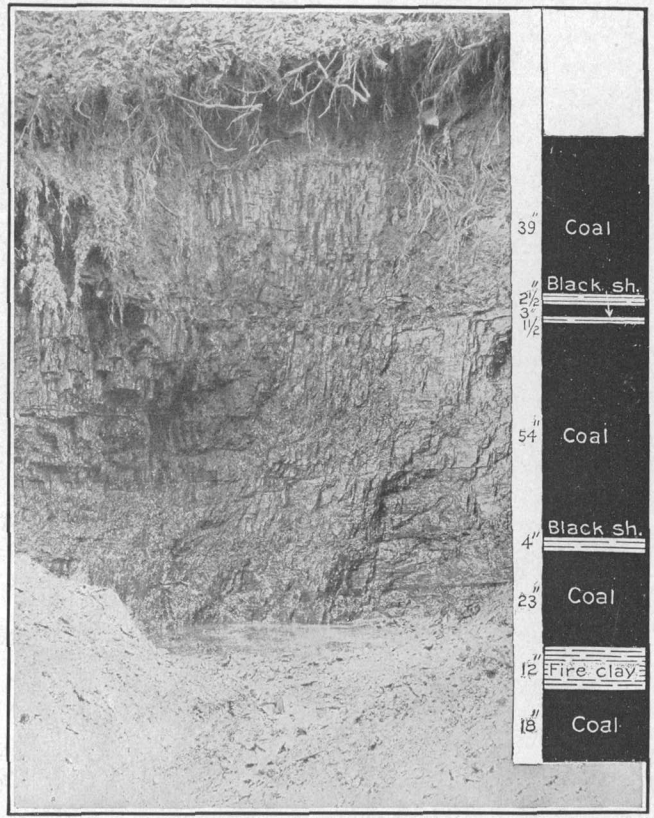
FIG. 24.—Clintwood coal on Bowlecamp Creek and Georges Fork.

a small bloom in the road. One hundred and seventy feet above Jim Baker's house (90) the same bed has thinner shale partings and is 8 feet 6 inches thick.

A 4-foot coal (91) has been exposed on the John Boggs place, on Mullins Fork of Bowlecamp Creek, and the same bed is reported on the main fork below Bud Hamilton's. In the bed of McFalls Fork, at an elevation of 300 feet above Pound River, there is a coal bed (92) reported to be 6 feet 6 inches thick. Near the head of Hamilton Fork, about 90 feet above the creek in a pit back of Grant Meade's house, overlying a massive sandstone believed to be the Gladeville, is the Clintwood coal bed, from 4 feet 8 inches to 5 feet thick (93). A 4-foot 10-inch bed is reported 300 feet higher in the hill above the Meade opening on the land of Ira Mullins, and



A. TEN-FOOT COAL AT G. L. BAKER'S, BOWLECAMP CREEK.



B. HIBBETT OPENING, GEORGES FORK.

Photos loaned by H. Hardaway.

a bloom which may be this coal shows in the road about 70 feet below Georges Gap. At the head of Mill Creek, in a pasture one-fourth mile back from J. E. Alley's house, about 4 feet of coal is exposed in a surface pit. This bed lies on top of a conspicuous massive sandstone seen along the road below Alley's house and is probably the Clintwood coal. On the trail from the head of Mill Creek to the mouth of Bear Branch a 1-foot coal outcrops 200 feet above Pound River, and a similar bed occurs in a hollow back of Filmore Edington's on the west bank of Pound River between Bear and Whiteoak branches.

Georges Fork.—The Clintwood coal, described as 10 feet thick on Lick Fork of Cranes Nest River, has been prospected at a number of points at the head of Georges Fork and found to be over 8 feet thick under a considerable acreage. On the east of the creek, one-half mile below Georges Gap, on property of the Cranes Nest Coal and Coke Company, 4 feet of coal is exposed at the Hibbett prospect. The pit is partly caved and filled with water, however, so that the whole bed could not be seen. The thickness, according to Mr. Hardaway, is 13 feet 1 inch (94), of which only 20 inches is shale or fire clay (Pl. VIII, *B*). Three-fourths of a mile below this, on the left of Georges Fork, is the Baumgardner opening, in which the Clintwood coal is 9 feet 8 inches thick (95). An entry has been driven about 25 feet.

Two miles below the head of Georges Fork, in a hollow on the west side of the creek, an opening (96) on Samuel Elkin's land shows the Clintwood coal nearly 6 feet thick, and another prospect on the left of the creek belonging to Manuel Mullins (97) is reported over 11 feet thick with an aggregate of 14 inches of waste in 5 partings.

On Georges Fork, 1 mile above its mouth, in the rear of James C. Willis's house, there is a coal bed reported to be 2 feet 7 inches thick, with a 1-inch shale band near the bottom. The dip is strong downstream, and what is believed to be the same bed has been dug into by John Trivitt at water level one-fourth mile up the branch whose mouth is at Freeling. Two entries have been driven 20 feet on the coal, which is 4 feet (98) at this point.

Dwale.—Along the ridge road from Clintwood to the mouth of Cranes Nest River, coal blooms are exposed at a number of places. Two miles north of Clintwood, at a place where Campbell Willis is quarrying building and curbstone from the Gladeville sandstone, the bloom of a coal on top of the Gladeville can be seen, and the same bed, which is probably the Clintwood coal, should be found near the spring at the schoolhouse near Wood's store. Small coal blooms are common in the road at Dwale, and in a spring beside the road 30 feet below Nickels Gap, on J. H. Artrip's land, there is a 16-inch bed (99) containing a 3-inch clay parting.

Coal has been stripped from the bed of a small hollow on the land of W. J. Flemings, 1 mile northeast of Clintwood, but the thickness of the bed is not known. Two feet of coal could be seen above the water. This coal is immediately above the Gladeville sandstone, as is also a bloom seen 2½ miles northeast of Clintwood at Buddy Neal's and at Isom Flemings's, just over the divide, on the head of a branch which flows into Pound River. Isom Flemings has taken coal from the spring opposite his house, but has not uncovered the bed enough to determine its thickness.

Near the ford at W. R. Stone's, below Nickels Gap on Pound River, there is a 13-inch coal bed in the south bank close to water level, from which a small amount of coal has been taken.

East of Dwale and Nickels Gap there is a strong coal bloom in the road above Jim Scyphers's, which is said to mark the location of a 4-foot bed. In the ravine below Scypher's house a small pit in the woods (100) discloses a 5-foot 2-inch bed of coal which seems to be near the base of the Gladeville sandstone. The small coal last mentioned is in the bank of Pound River, just above the mouth of this ravine.

Cane Branch.—Along the road from Draten Musick's store to Mount Olive Church there are a number of small coal blooms, and at water level on Cane Branch, 200 feet below the point where the road crosses the creek, W. M. Davis has drifted 20 feet under a sandstone ledge on a bed of clean coal 2 feet 4 inches thick (101). The dip is northwest at this point.

Pine Mountain.—On the eastern flank of Pine Mountain and down to Pound River there are no important coal beds, for the reason that the greater part of the slope is composed of the Lee conglomerate. It is said that coal has been found at a number of points but not in abundance. The only exposure seen by the writer is a 20-inch bed about 60 feet below the top of the Lee conglomerate a few yards above where the road crosses Skeet Rock Branch. The beds here dip southeast at an angle of 25°.

EAST SIDE OF SANDY RIDGE.

There are three localities south of the area described in which active mining operations have been in progress for several years. These are Glamorgan, Toms Creek, and Dante. The coal mined at Glamorgan by the Stone Gap Colliery Company has an average thickness of 4 feet 4 inches, with only 2 inches of partings (102). It is known locally as the Glamorgan bed and has not yet been correlated with the coals on the north side of Sandy Ridge.

The Upper Banner coal is said to average over 8 feet thick in some of the mines on Toms Creek (103), but carries from 6 to 18 inches of fire clay and coal streaks a little below the middle. At Dante

(104) it is fairly free from partings and averages about 5 feet. The Lower Banner coal at Dante (105, 105 a, 105 b) has a thickness of about $3\frac{1}{2}$ feet and varies considerably in short distances. In mine No. 1 at Dante the Widow Kennedy coal has an average thickness of 7 feet and in mine No. 4 on the opposite side of the creek scarcely 4 feet. It varies from 16 inches to 12 feet in thickness in mine No. 1.

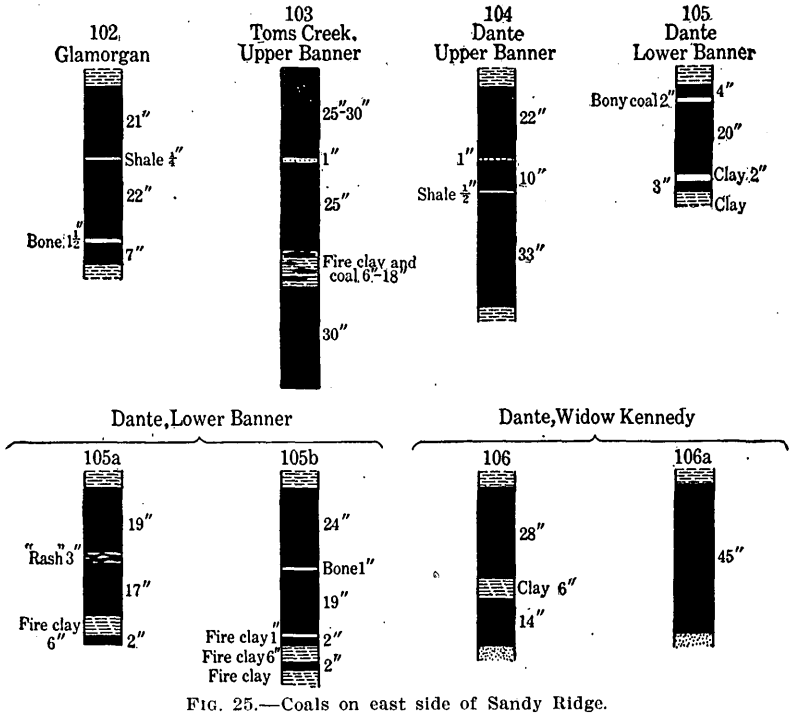


FIG. 25.—Coals on east side of Sandy Ridge.

Anything over 3 feet of clean coal is considered worth mining (106, 106 a). The coals at Dante have been described by the writer in a previous report.[a]

ANALYSES OF COALS.

The following 23 coal analyses are taken from private reports made by mining engineers and others to their clients and kindly furnished to the writer. They show the chemical character of the principal coals in the basin of Russell Fork in Virginia. The method of sampling is not stated. It is presumed that much of the moisture was lost by exposure to the air previous to analyzing.

[a] Stone, R. W., Coal Mining at Dante, Va.: Bull. U. S. Geol. Survey No. 316, 1907, pp. 68–75.

Analyses of bituminous coals in Dickenson County, Va.

Opening.	Location.	Name of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	Fuel ratio.
Baumgardner	Georges Fork	Clintwood	[a]2.44	33,26	58.682	4.90	0.718	0.007	1.76
Beverley	Honeycamp Branch.	do	[a].62	33.63	60.951	3.95	.849	.01	1.81
Do	do	do	([b])	33.96	62.02	4.02	.77	-----	1.83
John Lane	Clintwood	do	[a].59	33.60	62.239	2.86	.711	.008	1.85
C. C. Kilgore	do	do	[a].55	32.11	60.721	6.01	.609	.005	1.89
Glenn	do	do	[c]1.12	29.80	65.156	3.20	.708	.016	2.19
Keel	do	do	[b].70	33.60	60.90	4.80	-----	-----	1.81
Keel, upper bench	do	do	[a].63	32.44	61.662	4.53	.738	.016	1.90
Do	do	do	[c].78	30.02	64.104	4.37	.707	.009	2.14
Keel, lower bench	do	do	[a].46	33.12	60.752	4.78	.888	.023	1.83
Do	do	do	[c]1.30	28.76	61.464	6.62	1.85	.016	2.14
Viers	McClure Creek	Upper Banner	[a].438	29.862	63.355	5.44	.995	.005	2.12
Sikes	do	do	1.05	33.99	60.70	4.26	.82	-----	1.79
Harden Branch	Fryingpan Creek	do	[d]1.56	28.62	61.35	8.47	-----	-----	2.14
Dawson mine	Dante	Lower Banner	.95	37.61	55.62	5.82	.82	-----	1.48
Caney Fork	Indian Creek	Tiller	[d].90	27.33	67.74	4.03	-----	-----	2.48
Barnett, upper bench	Duty	do	[a].304	25.436	64.594	8.88	.786	.021	2.54
Barnett, lower bench	do	do	[a].404	26.306	69.522	3.29	.478	.023	2.64
Taylor Sutherland	Bucu	Wid. Kennedy (?)	[d].95	23.36	61.43	14.26	-----	-----	2.63
Do	do	do. (?)	[a].428	23.022	63.735	12.15	.665	.013	2.77
Sutherland	do	do. (?)	[a].378	22.292	61.601	15.21	.519	.033	2.76
Dawson mine	Dante	do	.90	38.46	56.26	4.38	1.12	-----	1.46
Do	do	do	.85	35.25	58.14	5.76	1.13	-----	1.65

[a] Analyst, A. S. McCreath; sampled by James T. Gardiner.
[b] Analysts, Wuth and Stafford.
[c] Analyst, Otto Wuth; sampled by E. H. Steinman.
[d] Analyst, C. C. Tutwiler; sampled by Jansen Haines.

The above table contains analyses of three samples taken at Bucu which are supposed to be from the Widow Kennedy bed. The horizon of the bed at Bucu suggests this correlation, and the high percentage of ash in the analyses indicates that the bed at that place has suffered disturbance and is not an attractive mining proposition. Three analyses are included from the Dawson mines at Dante. Dawson is the former name of the mines now operated by the Clinchfield Coal Corporation, and these analyses are probably made of samples taken from the same openings as those furnishing the coals whose analyses are given in the second table below. Dante is just over the county line on the south side of Sandy Ridge, and these analyses should represent the character of the beds in the adjoining portion of Dickenson County.

An average of these 23 analyses gives a composite of the several minable coals in Dickenson County, showing 29 per cent volatile matter, 62 per cent fixed carbon, less than 1 per cent moisture, between 4 and 6 per cent ash, 0.831 per cent sulphur, and 0.015 per cent phosphorus. This average composition of the several beds of good coal is equivalent to that of the Pittsburg coking coal.

The averages of 11 analyses of Clintwood, 3 of Tiller, and 4 of Upper Banner coal are as follows:

Average analyses of three coals.

Constituent.	Clintwood.	Tiller.	Upper Banner.
Moisture	0.92	0.536	1.03
Volatile matter	32.20	26.36	31.32
Fixed carbon	61.70	67.28	61.02
Ash	4.55	5.40	6.40
Sulphur	.855	.632	.798
Phosphorus	.012	.022	
Fuel ratio	1.91	2.55	1.95

The following table shows the results of analyses made at the United States Geological Survey's fuel-testing plant at St. Louis from samples taken during the prosecution of this work. The Clintwood coal was sampled by C. W. Dodge and the other three by the writer. Each sample was cut in the mine from a clean face of coal, including all binders or partings under one-fourth inch in thickness. It was crushed, quartered, and sealed air-tight in a can in the mine. By this method the moisture is retained until the sample is opened for analysis.

Analyses of Virginia coals.

[F. M. Stanton, analyst.]

	Name and location of coal bed.			
	Clintwood, Clintwood.	Upper Banner, Dante.	Lower Banner, Dante.	Widow Kennedy, Dante.
Laboratory number	3827	3942	4057	3947
Sample as received:				
Moisture	2.21	2.36	2.79	1.90
Volatile matter	30.13	32.40	32.11	31.54
Fixed carbon	63.68	57.92	59.30	60.87
Ash	3.98	7.32	5.80	5.69
Sulphur	.87	.66	.84	1.47
Calorific value { Calories				6,569
Calorific value { B. t. u.				11,824
Loss of moisture on air drying	1.20	1.30	1.80	.80
Air-dried sample:				
Moisture	1.02	1.07	1.01	1.11
Volatile matter	30.50	32.83	32.70	31.79
Fixed carbon	64.45	58.68	60.39	61.36
Ash	4.03	7.42	5.90	5.74
Sulphur	.89	.67	.85	1.48
Fuel ratio	2.11	1.79	1.85	1.93

The sample of the Clintwood coal was taken at the Chase & Damron mine near Clintwood and represents 4 feet 4 inches of a 6-foot 3-inch bed. It was cut at the face of the main entry, 100 feet from the outcrop. The sample of Upper Banner coal was taken in mine No. 3 of the Clinchfield Coal Corporation at Dante. It was cut from a clean face in butt entry No. 6 off the main gangway, where the bed is 5 feet thick. In mine No. 2 at Dante, at a point where the Lower Banner bed is nearly 4 feet thick, room 4 off the left entry, a sample

was taken of the 3 feet 3 inches of coal which is mined. The Widow Kennedy bed was sampled in mine No. 4, in the second cross heading, 300 yards from the entrance. A point was chosen where the coal is in its best condition and 3 feet 9 inches thick. It was solid and clean, rather than rolled, mashed, and dirty, as at many points in this mine.

The above analyses show that these coals are high-grade bituminous, comparatively low in ash, and have only a small percentage of sulphur.

In the following table are given average analyses of some well-known eastern bituminous coals, including the Elkhorn coals of the adjacent field in Kentucky and the averages of three of the best coals in Dickenson County.

Average analyses of eastern bituminous coals and of Russell Fork basin coals.

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.
Pocahontas (average of 38) [a]	0.73	17.43	77.71	4.63	0.62	4.46
New River (Quinnemont) (average of 17) [b]	.60	19.93	75.20	4.27	.67	3.77
Tiller (average of 3)	.536	26.36	67.28	5.40	.855	2.55
Pittsburg (Connellsville) coking (average of 20) [c]	1.130	29.812	60.420	7.949	.689	2.03
Upper Banner (average of 4)	1.03	31.32	61.02	6.40	.798	1.95
Clintwood (average of 11)	.92	32.20	61.70	4.55	.855	1.91
Lower Elkhorn (average of 22) [d]	1.425	32.105	58.435	7.459	.574	1.82
Upper Elkhorn (average of 19) [d]	1.538	34.985	58.367	4.499	.587	1.67
Clinch Valley gas coal [e]	1.180	37.398	56.732	5.602	.619	1.52
Westmoreland gas coal [e]	1.427	37.521	54.921	5.418	.713	1.46
Pennsylvania gas coal [e]	1.280	38.105	54.383	5.440	.792	1.43

[a] White, I. C., Geol. Survey West Virginia, vol. 2, pp. 695, 696, 700.
[b] Ibid, p. 670.
[c] H. C. Frick Coke Company.
[d] Manufacturers' Record, vol. 45, No. 23, 1904, Supplement.
[e] McCreath and d'Invilliers, Mineral resources of upper Cumberland Valley, 1888, p. 145.

The sequence in this table is in accordance with the fuel ratio and shows the superiority of the coals in this field.

COKE.

The coals of this field duplicate in physical properties and chemical composition the coals on Toms Creek, Wise County, which make good coke, and it is believed that most of them will be found to be good coking coals.

Car samples of the Clintwood coal, taken from the Beverley opening on Honeycamp Branch and shipped to Chattanooga and Connellsville, made coke of the following character:

Analyses of Dickenson County coke.

	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.	Analysts.
72-hour	0.45	90.153	8.575	0.775	0.047	Wuth and Stafford.
48-hour	.031	91.224	7.695	.736	.035	Do.
72-hour	----------	90.91	8.34	.75	----------	Shomberger Steel Co.
48-hour	----------	92.03	7.22	.75	----------	Do.
	1.50	92.30	6.30	.69	.032	Do.
	1.03	92.76	4.373	.841	.026	P. D. Langdon.

To compare these results with analyses of Pocahontas and Connellsville cokes reference should be made to page 120 of this bulletin.

CORRELATION.

In view of the accuracy of the correlation work being carried on in the Appalachian coal field by David White, of the United States Geological Survey, by means of paleobotanic and stratigraphic evidence, the writer is not justified in attempting, on purely stratigraphic evidence, to correlate the coals of Dickenson County with those of the Elkhorn field on the other side of the Pine Mountain fault in Kentucky. It may be remarked, however, that the species of fossil plants from the Lower Elkhorn coal on Marrowbone Creek in the Elkhorn field bear a close resemblance to the plants from the Banner group of coals at Dorchester, near Norton, Va.

SUMMARY.

From the foregoing descriptions it will be seen that the area discussed contains a considerable amount of high-grade bituminous coal which is not yet being mined. On Indian Creek, at the head of Russell Fork, the Tiller coal bed has a thickness of 8 feet or more over an area sufficiently large to be worthy of consideration. Between Clintwood and Pound the Clintwood coal has been prospected at a number of points and found to be 8 to 10 feet thick. Throughout the McClure Creek basin the Upper Banner bed can be depended on to maintain an average thickness of 4 feet. Besides these there are other coal beds of minor thickness and unknown extent which will ultimately be of some value.

The coal in some and possibly in all of the beds of workable thickness will make excellent coke. Until railroads are built into this region, which is difficult of access on account of mountain barriers, the field will constitute a notable reserve of Virginia's coal resources.

BIBLIOGRAPHY.

The following list of publications, in chronologic order, includes only such reports of the United States Geological Survey as describe the distribution and character of coals not far from Russell Fork. A complete list of Survey publications dealing with coal, coke, lignite, and peat is contained in Bulletin No. 316, pp. 518–532, and in Bulletin No. 341 (in preparation):

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The southern Appalachian coal field, by C. W. Hayes. Twenty-second Ann. Rept., pt. 3, 1902, pp. 227–263.

The Cumberland Gap coal field of Kentucky and Tennessee, by G. H. Ashley. In Bull No. 225, 1904, pp. 259–268.

The Southern Appalachian forest, by H. B. Ayres and W. W. Ashe. Prof. Paper No. 37, 1905, 291 pp. Describes the forested condition of southwestern Virginia, not including Russell Fork.

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