VIRGINIA GEOLOGICAL SURVEY
UNIVERSITY OF VIRGINIA
THOMAS LEONARD WATSON, PH. D.
DIRECTOR

Bulletin No. XXII

The Geology and Coal Resources of Russell County, Virginia

BY

CHESTER K. WENTWORTH

PREPARED IN CO-OPERATION WITH THE
UNITED STATES GEOLOGICAL SURVEY

WITH A CHAPTER ON

The Forests of Russell County, Virginia

BY

J. W. O'BYRNE

PREPARED IN CO-OPERATION WITH THE
OFFICE OF STATE FORESTER

CHARLOTTESVILLE
UNIVERSITY OF VIRGINIA
1922

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Designers
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Lynchburg, Va.
Established
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BY CHESTER K. WENTWORTH.

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LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, MARCH, 1922.

Governor E. Lee Trinkle, Chairman, and Members of the State Geological Commission:

Gentlemen:—I have the honor to transmit to you, herewith, and to recommend for publication as Bulletin No. XXII of the Virginia Geological Survey Series of Reports a manuscript and illustrations of a report entitled "The Geology and Coal Resources of the Coal-bearing Portion of Russell County, Virginia," by Mr. Chester K. Wentworth, with a chapter on "The Forests of Russell County, Virginia," by Mr. J. W. O'Byrne.

This report was prepared by the Virginia Geological Survey in coöperation with the United States Geological Survey and the Office of State Forester. It is the sixth one of a series of detailed reports published by the Virginia Gological Survey on the coal resources of southwest Virginia, under coöperative agreement with the United States Geological Survey, and the fourth one of the county reports on coal. The report is accompanied by topographic and geologic maps of the coal-bearing portion of Russell County, folded and inserted in pocket on the inside of back cover.

Respectfully submitted,

THOMAS L. WATSON,
Director.

THE GEOLOGY AND COAL RESOURCES OF THE COAL-BEARING PORTION OF RUSSELL COUNTY, VIRGINIA

By Chester K. Wentworth.

INTRODUCTION

Importance of field.—The coal field of Russell County is only a small part of the coal fields of the western part of Virginia which produced in 1918 slightly more than ten and one-quarter million tons of coal. Though the coal-bearing portion of the State is small compared with the coal fields

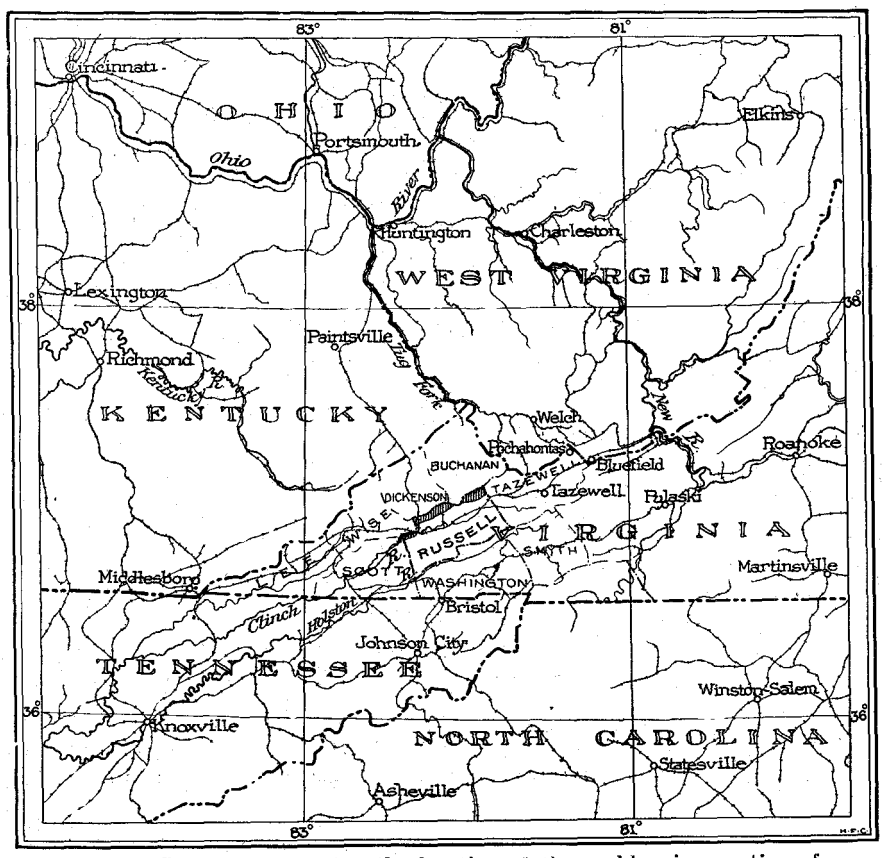

Fig. 1. Index map showing the location of the coal-bearing portion of Russell County.

of West Virginia, Pennsylvania, Ohio, and several other states, it contains nevertheless an enormous quantity of high grade coal which, even estimated conservatively, would maintain this annual production for considerably more than 2,500 years.

Of the entire output of the State, Russell County contributed in 1917 over two million tons valued at more than $3,600,000, and in 1918 the total of 1,998,000 tons valued at more than $5,000,000. Because of the comparatively small area of the coal field the coal resources of Russell County are not so large as those of several other counties in the State but are nevertheless extremely important, consisting, according to estimates made by the writer, of 706,000,000 tons of recoverable coal. Until very recently (1904) this vast resource had not been utilized except locally, but since that time development has been very rapid and coal mining is now one of the leading industries of the county.

Location of field.—Russell County is in southwestern Virginia and the part described in this report is a narrow belt varying from 3 to 5 miles in width along its northwest border. It is bounded on the northeast by Tazewell County; on the northwest by Buchanan and Dickenson counties; and on the southwest by Wise County—all coal-producing counties. The coal land of Russell County is continuous with the coal land of the above mentioned counties and lies on the southeast border of the great Appalachian coal field. It will for convenience be referred to as the Russell coal field and includes parts of the Richlands, Bucu, Carterton, and Coeburn quadrangles of the United States Geological Survey, surveyed in coöperation with the Virginia Geological Survey.

The total area of Russell County is 496 square miles, of which 84.0 square miles or 16.9 per cent is coal land.

Coal is the most valuable product of the region. Most of the inhabitants not directly engaged in mining coal are indirectly connected with the industry as producers of farm products, such as fresh vegetables, corn, hogs, and small quantities of milk and butter, which find a ready market in the mining towns. The steep and heavily timbered slopes of the coal land, where the few clearings have generally been made by girdling the trees, are ill adapted alike for farming or grazing and stand in contrast to the more fertile rolling land of the limestone region in the southeastern part of the county where farming and stock raising are carried on extensively. (See Plate I.)

Dante, the largest town in the Russell field, is entirely dependent on coal mining. The town of Clinchfield (post office, South Clinchfield), located

on the flood plain of Dumps Creek about three-fourths mile southwest of the older town, was in 1919 being built up rapidly in connection with the development of the plant of the International Coal Products Co.

Method of field work.—The object of this survey was to make available to the public information concerning the coal resources of the county and data which would be of value in their development. Both the topographic and geologic work was done in coöperation by the Virginia Geological Survey and the United States Geological Survey; the expenses being divided equally between the two organizations. The topographic mapping of the above named quadrangles included in part within the county was done during four seasons, 1913 to 1916 inclusive. The geologic survey of the portion of Russell County east of Big A Mountain was completed in 1916 by Henry Hinds of the United States Geological Survey and T. K. Harnsberger of the Virginia Geological Survey. The geologic work on the part lying within the Bucu quadrangle was done by Messrs. Hinds and Harnsberger in 1913 and 1914 and the remainder of the western part of the field in the Carterton and Coeburn quadrangles was mapped by Albert W. Giles, of the State Survey, and the writer, of the Federal Survey, in 1919. During parts of May and June, 1920, J. B. Eby, of the latter Survey, rendered material assistance in the preparation of this report.

The general method of work consisted of making many detailed traverses along roads, streams and ridge-tops carrying vertical control with the aneroid barometer and incorporating all observations in a vertical section of the route. Whenever opportunity offered the barometer was checked and corrected and errors in elevation are believed not to exceed ten or fifteen feet. In a region as heavily timbered as this part of Russell County it is impossible to trace the outcrop of a given coal bed for any considerable distance. In some places prominent sandstone members may be traced for some miles but for the most part correlations have been made by very detailed studies of the sections in adjacent stream valleys. In this work the general succession of sandstones, shales, and coal beds is of value and also the detailed sections of individual coal beds especially where these carry characteristic and persistent partings or other identifiable features throughout considerable areas. In any case it is necessary to be constantly on guard and avoid correlations for distances greater than a mile or two for great changes are known to take place in the section and reliable and widespread key rocks do not occur. Coal openings were visited and all accessible sections of the coal beds measured. There is considerable variation in the amount of detail shown on different parts of the map and in corresponding

text descriptions because of the contrast between the regions in which little prospecting has been done and others in which mining is actively carried on and many data are available.

Acknowledgments.—George H. Ashley, of the United States Geological Survey, had general supervision of the work until September, 1919. After that date M. R. Campbell, of the Federal Survey, took general charge. To both of these men, to David White, Chief Geologist of the United States Geological Survey, to Thomas L. Watson, State Geologist of Virginia, to his colleague in the field, Albert W. Giles, of the latter Survey, and to J. B. Eby, the writer is indebted for much valuable assistance and many helpful suggestions.

Outcrop maps with elevations, many measurements of coal in prospect holes, and numerous records of diamond core drill prospect holes by the Clinchfield Coal Corporation were made available through the kindness of W. D. Tyler. These data were utilized for a large part of the county west of Big A Mountain and have been of invaluable aid in preparing this report.

The earliest report on the geology and coal of this part of the country was by M. R. Campbell[1] in the Tazewell and Bristol folios of the U. S. Geological Survey. R. W. Stone[2] in 1906 made a reconnaissance survey of adjacent areas in Dickenson County.

Coal mining at Dante, Va.,[3] is described briefly by the same author in 1906. A report on the Clintwood and Bucu quadrangles by Henry Hinds[4] was published by the State Survey in 1916. A series of county reports on coal resources, of which the present report is one, have been prepared and Buchanan County by Henry Hinds[5] and Tazewell County by T. K. Harnsberger[6] have been published. A third, the Dickenson County report, by Albert W. Giles,[7] has also been published.

All of these have been used in preparing the present report.

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[1] Campbell, M. R., U. S. Geol. Survey Geol. Atlas, Tazewell folio (No. 44), 1897, and Bristol folio (No. 59), 1899.

[2] Stone, R. W., Coal resources of the Russell Fork basin in Kentucky and Virginia: U. S. Geol. Survey Bull. 348, 1908.

[3] Stone, R. W., Coal mining at Dante, Virginia: U. S. Geol. Survey Bull. 316, pp. 68-75, 1907.

[4] Hinds, Henry, Coal Resources of Clintwood and Bucu Quadrangles, Virginia: Bull. XII Virginia Geol. Survey, 1916.

[5] Hinds, Henry, The geology and coal resources of Buchanan County, Virginia: Virginia Geological Survey Bull. XVIII, 1918.

[6] Harnsberger, T. K., The geology and coal resources of the coal-bearing portion of Tazewell County, Virginia: Virginia Geol. Survey Bull. XIX, 1919.

[7] Giles, Albert W., The geology and coal resources of Dickenson County, Virginia: Virginia Geol. Survey Bull. XXI, 1921.

To Mr. Stevens of the Clinchfield Coal Corporation, to Mr. Easter, formerly with the company, and to many others, officers and men of that company, the writer is indebted for assistance in the course of the work. The people of the region have been at all times ready to assist in guiding the way to coal openings and this and other courtesies have greatly aided in the carrying on of the work in the field.

SURFACE FEATURES.

TOPOGRAPHY.

The entire Russell coal field is characterized by steep, mountainous topography. It lies on the southeastern edge of the physiographic province of the United States known as the Allegheny plateaus and its surface is an excellent example of the typical maturely dissected topography of that province. All its features have been cut in the essentially flat lying rocks of the coal measures by the erosion of running water and there are few if any regions in the United States where the drainage net is more perfectly developed to carry off the water from every part of the area.

The highest point in this part of the county is Big A Mountain (3,735 feet) on Sandy Ridge which forms the divide between the Clinch River drainage on the southeast and the Big Sandy drainage on the northwest. The lowest point on this part of Sandy Ridge is Bowen Gap at 2,215 feet above sea-level, and many of the passes in the ridge are at elevations between 2,400 and 2,700 feet. The summit of the ridge, for the most part, ranges from 2,800 to 3,100 feet, culminating in Big A Mountain as mentioned above. The lowest land in the vicinity of the Russell coal field is on the Norfolk & Western Railroad (elevation 1,903 feet), just west of the Tazewell County line and 1,481 feet on Clinch River at Boody. Elevations at the edge of the coal field range slightly higher, about 2,000 feet at the northeast and 1,800 feet at the southwest.

The local relief is considerable, being 1,000 to 1,200 feet in distances of one to two miles. Practically the entire field consists of steep slopes; the ridge tops are narrow, in many cases barely wide enough for convenient building of a road, and the valleys are equally narrow. Probably not over two or three per cent of the total area is even moderately flat.

As the rocks are for the most part nearly horizontal, the details of the topography have no very definite arrangement except where the rocks are upturned along the edge of the coal field. Sandy Ridge is rudely parallel to the northeast-southwest trend of the Appalachian folds. The divides be-

tween the streams which flow away from it on either side trend roughly at right angles to it but the details make up a maze of winding and branching ridges and spurs which divide the waters of adjacent forks of the creeks.

Along the border of the coal field many of the valleys and ridges show a northeast-southwest alineation as Gravel Lick Branch of Lick Creek, branches of Weaver Creek, Hurricane Fork of Dumps Creek near Grizzle, Stone Mountain, Buffalo Mountain, and Red Oak Ridge.

DRAINAGE.

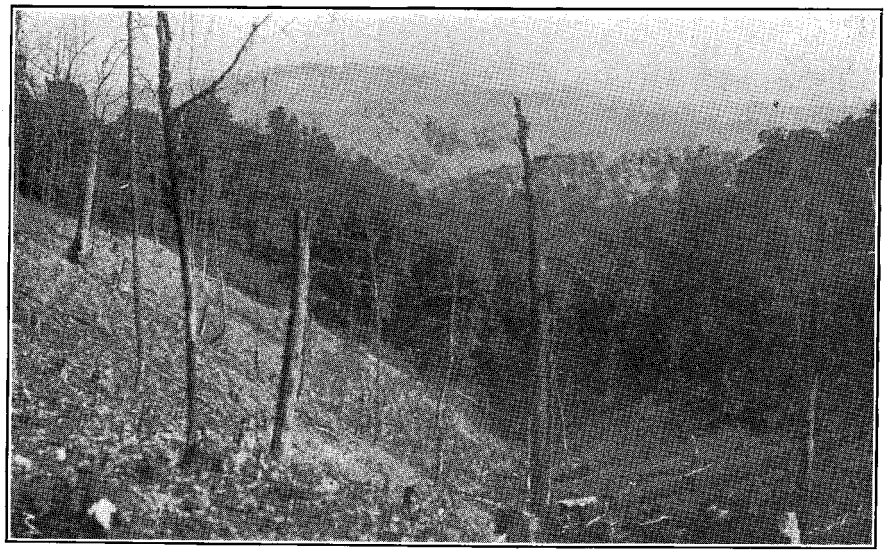
The entire Russell coal field drains into Clinch River, the waters of which reach Ohio River through the Tennessee. The principal tributaries of Clinch River which drain the field are Mill Creek, Swords Creek and its branches, and Lewis Creek in the portion east of Big A Mountain, and Hart and Musick forks of Weaver's Creek, Hurricane, Road and Chaney forks of Dumps Creek, and Lick Creek in the west part.

Small portions of Dickenson County northwest of Wilder and Dante drain into Clinch River through Road Fork and Lick Creek respectively. With these exceptions the county line follows the Big Sandy-Clinch divide.

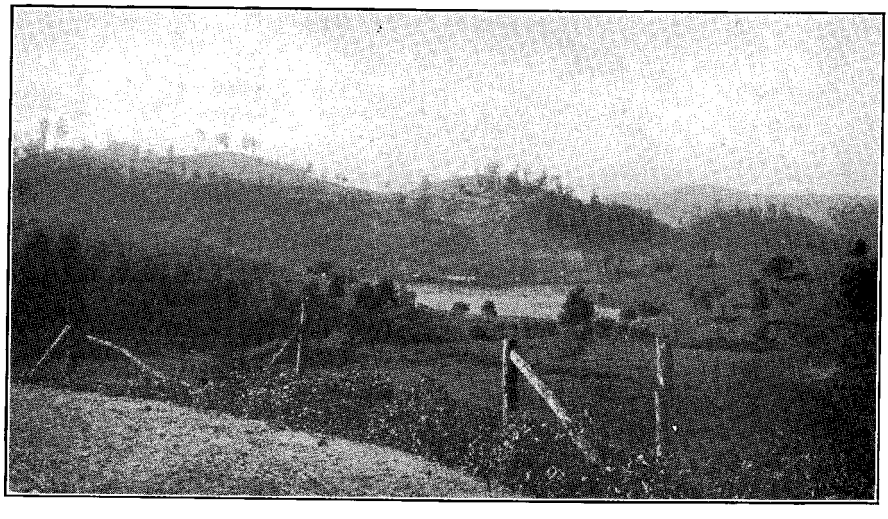
The rainfall of the region is about 50 inches per year. Because of the dense vegetation, the run-off is well distributed through the year, even the smaller streams having some flow in all but the driest months. There are numerous springs in the coal field, many of which are located on the outcrops of coal beds, being fed by water percolating along the joints of the coal and retained by the relatively impervious underclays and shale partings.

VEGETATION.

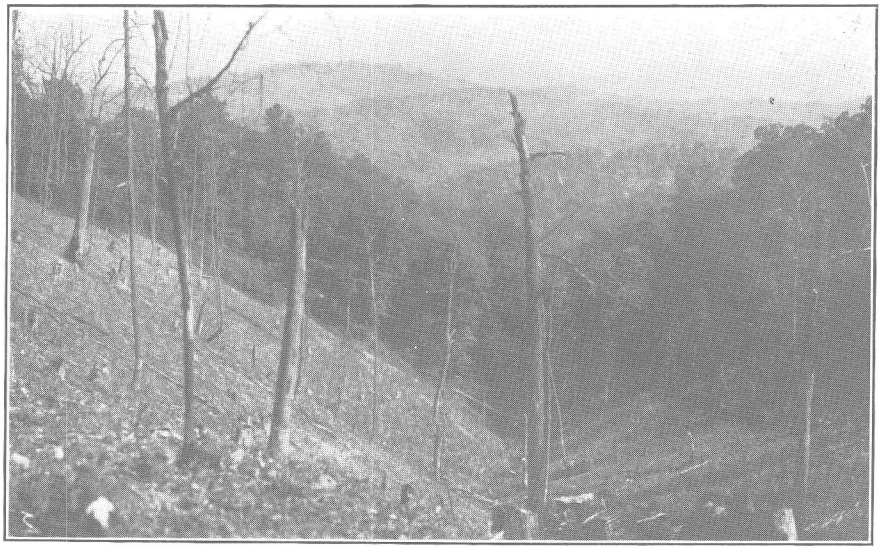
When the first settlers came into this mountain country they found it entirely covered with a dense growth of large trees which included chestnut, several varieties of oak, tulip or yellow poplar, hickory, basswood, beech, buckeye, maple, hemlock, several species of pine, and black walnut. In addition, there was a heavy undergrowth of rhododendron or "laurel" as it is known to the inhabitants, mountain laurel or "ivy," sassafras, and a wealth of other shrubs, herbs, mosses and other plants. Grape and other vines grew to great size and added to the difficulty of penetrating the forests. The first clearings were made by girdling the trees and some land is cleared in this manner at the present time. Lumbering operations have removed some of the more valuable timber trees and coal mining has profited by the ready access to large quantities of timber suitable for mine



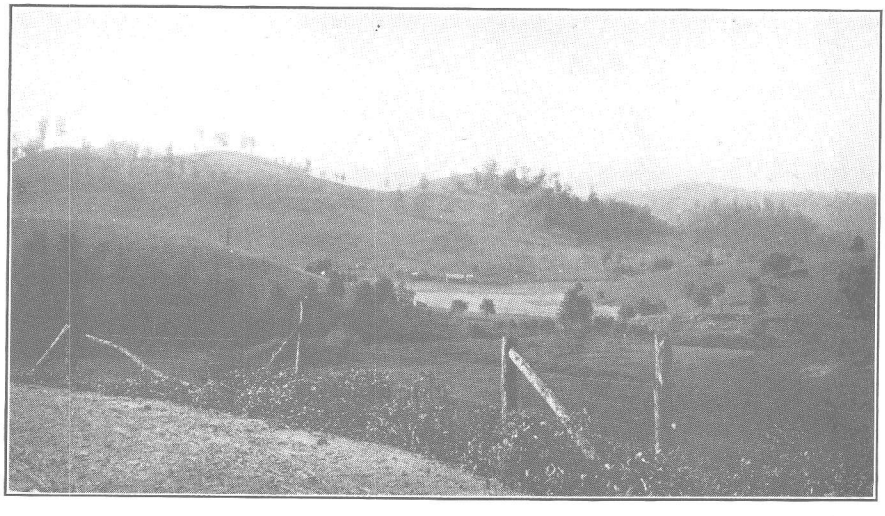
(A) Mature topography of the Pennsylvanian rocks. Looking northwest from point near summit of Buffalo Mountain. In foreground is a cornfield cleared by girdling the trees.



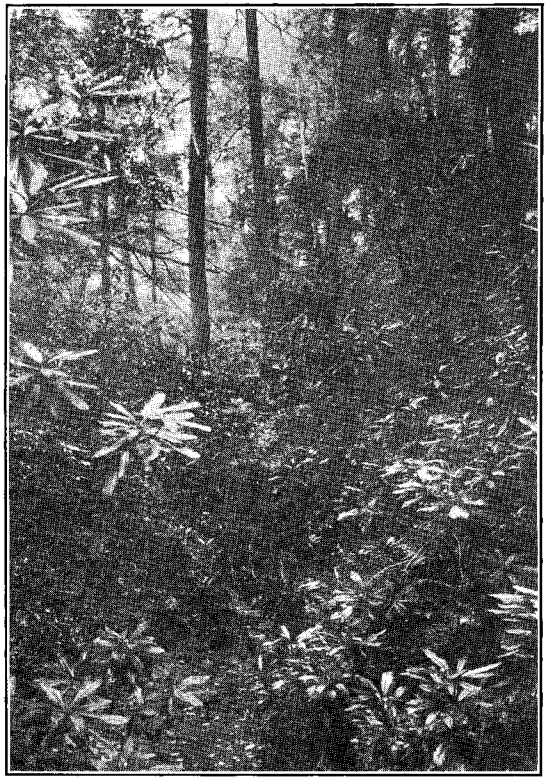
(B) Rolling topography of pre-Pennsylvanian rocks. Looking south across Gravel Lick Creek from south border of Lee formation 2½ miles east of Hamlin. The gravel from which the creek is named is composed largely of white pebbles weathered out from conglomerate of the Lee formation.



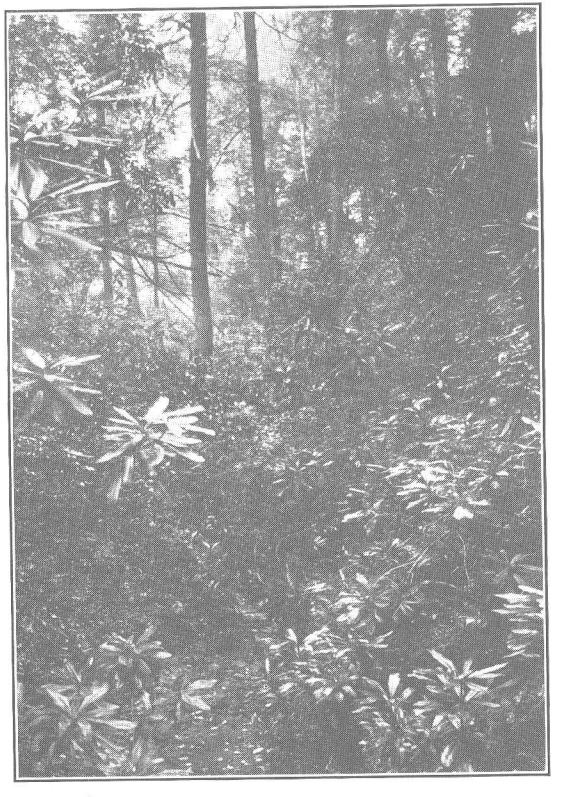
(A) Mature topography of the Pennsylvanian rocks. Looking northwest from point near summit of Buffalo Mountain. In foreground is a cornfield cleared by girdling the trees.



(B) Rolling topography of pre-Pennsylvanian rocks. Looking south across Gravel Lick Creek from south border of Lee formation 2½ miles east of Hamlin. The gravel from which the creek is named is composed largely of white pebbles weathered out from conglomerate of the Lee formation.



Views showing character of forest and undergrowth in coal measures of southwest Virginia. Branch of Powell River west of Lipps. View at left shows young rhododendrons and other plants growing on decayed trunk of a fallen tree.



Views showing character of forest and undergrowth in coal measures of southwest Virginia. Branch of Powell River west of Lipps. View at left shows young rhododendrons and other plants growing on decayed trunk of a fallen tree.

buildings and props. In spite of all these attacks on the forest, a large part of the field is still forest clad and there are many reasons for the belief that, next to coal resources, the greatest potential value of this rugged country is as producing forest land and it is to be hoped that by the introduction of scientific methods of forestry the wastefulness of present methods may be largely eliminated and an abundant supply assured for future generations. For further information in regard to this subject the reader is referred to a description of the forests of Russell County, which is the last chapter in this report, pages 151-172.

GEOGRAPHY AND MAN

From the beginning of human development on the earth the life of man has been profoundly controlled by the geographic conditions which have in various times and places made up his physical environment. Among savage and barbarous peoples everywhere the customs and appliances of life: food, clothing, shelter, even the elements of man's intellectual and moral development, are intimately related to the country in which he lives. Among civilized peoples this relationship is somewhat less apparent though none the less real.

In each locality of the United States to-day are many examples of this dependence of man on his surroundings, and nowhere are they more striking than in the region considered in this report.

The first settlers in Russell coal field and similar parts of southwest Virginia and adjacent States were the pioneers who penetrated the mountains on their tours of discovery from the older settlements on the Atlantic coastal plain. These pioneers were in many cases poorer people who were not able to buy the richer lands of the valley country, but many of them were probably people of a roving disposition who had tired of the older settlements. They were doubtless the more adventuresome spirits of the older settlements and found in the freedom of the new surroundings a home much to their liking. They lived largely by hunting, but at the same time made shift to continue in a small way the farming to which they were accustomed. Clearings were made, as they still are to some extent to-day, by girdling the trees and crops of corn, beans and a few other vegetables were raised. For the most part agriculture in this section has never developed beyond these simple beginnings. The geographic factors have controlled the white man even as they did the red man in this region which is

not adapted by nature for a highly developed agriculture. Cattle and hogs are raised to considerable extent for purely local markets and home consumption, but take slight part in outside markets. Proximity to coal-mining towns has given considerable impetus to farming and production of dairy products and permitted a competition in these commodities with more remote centers of production. With the development of the coal-mining and lumber-cutting industries, occupation has been furnished to many of the inhabitants of this part of the county, either for a part or the whole of the year.

Foremost among geographic influences on the life of man are routes of travel. Russell coal field is poor in natural routes of travel, its upland is too deeply dissected to permit travel for any considerable distance along the ridge tops, its valleys are not yet widened sufficiently to make road-building practicable except where a large volume of traffic justifies great expense. Such a volume of traffic does not exist, except at one or two places in the field; the volume of agricultural products from this region is not sufficient to pay for such outlay and the nature of the two other great products of the region, coal and timber, favors their development largely by great corporations which build tramways and railroads rather than wagon roads. As a result Russell coal field is still largely without roads and nearly all travel is by trails on foot or horseback. The trails follow the stream courses most commonly and cross the ridges at the lowest passes. Because the valleys are very narrow and streams are cutting against the rock walls first on one side and then the other trails cross and recross the streams, and in many places find precarious foothold in their rocky channels. Travelers by horseback ford the streams and along the more travelled routes footbridges, commonly single "foot-logs," hewn flat on top, are provided for pedestrians. These "foot-logs" are displaced by the torrential freshets which flood the narrow valleys every spring and swept downstream unless the precaution has been taken to secure them by chains and in any case it is necessary each spring to replace the log in position. Passing travel wears the trails low and keeps vegetation down and not uncommonly the waters of the spring floods are diverted to the trails for some distance, removing the soil and leaving them filled with loose stones and in very poor condition for travel. It is very probable that many of these trails were travelled by the Indians on their hunting and fighting expeditions. The writer has found numerous arrowheads or "flints" of Indian origin along them, and especially at the passes where they cross the ridges. Even the presence of these flint relics is indicative of travel, for the flint or chert of which they are made, is not found in

the coal field much south of Kanawha River and must have been transported from the adjacent limestone country. Lack of easy means of transportation results in a scarcity of manufactured goods, especially of heavier articles, and in a utilization of the raw materials at hand.

On the other hand a part in human action nearly as important as that of routes of travel is played by absolute and relative barriers, such as mountain ranges, impassable rivers, broken and barren country, and many geographic features. In a region so restricted as Russell coal field there are no absolute barriers, though the entire region of the Appalachian mountains and Allegheny plateaus, of which Russell coal field is a part, is a relative barrier which played an important part in American colonization. Sandy Ridge, which forms the line between Russell County on the south and Buchanan and Dickenson counties on the north, restricts travel to a few passes or "gaps" which are lower than the rest of the ridge. Farther to the northwest the conspicuous linear mass of Pine Mountain is for many miles an effective barrier to wagon travel, may be crossed only at few places by horsemen, and almost completely separates life on the one side from that on the other. It forms for many miles the State line between Virginia and Kentucky. There are two reasons for the part river and mountain barriers play as political boundaries, first because in the early days they were barriers and naturally separated the life and interests of man into distinct units on either side, and second because easily defined they saved the great expense of surveys and artificial fixation of boundaries.

One of the most difficult problems connected with the mode of living of the people in the mining towns and directly connected with the geography of the region is that of sanitation. The need for considerable numbers of people to live close to the mines leads to a congestion of population in the narrow valleys of the streams. Nearly all the people of the region keep hogs which run wild, and this circumstance, combined with the concentration of human population, makes necessary wise planning in sanitary measures and aggressive action in enforcing them on the part of the coal companies, in order to avoid unhealthful conditions. This difficulty is not felt in the outlying districts where the people live in isolated cabins often some distance from their neighbors. Most of the cabins in this country are built of logs, and the walls made tight by chinking with slabs and clay. Originally wood furnished the fuel for local household use, but more recently coal which is taken from many local openings and burned in grates furnishes heat in winter. Not uncommonly there is a "leanto" addition to the cabin, a sort of kitchenette in which the cooking is done, and this arrangement avoids excessive heating of the house in summer.

The cabins are located apparently indiscriminately wherever the owners' or their ancestors' fancy dictated, in the valleys, on the slopes or high on the ridges, but even here geography has set a limit beyond which none may pass. No permanent homes are located more than a few hundred feet distant from or more than a few feet above the water table of dry seasons. All other necessities can be transported more easily than water, water must be had close by, hence most of the cabins are located near a spring of water.

Though loose stones are as abundant as in many parts of the country where stone walls are used to separate adjacent fields, timber is much more abundant and must be removed in clearing the land, hence most of the fences are rail fences. Such fences are probably more stable on the steep slopes of the region than stone walls as ordinarily built would be.

It is not the purpose of the writer to go into great detail in the relation of man to his geographic environment in Russell coal field, but a few facts have been given to show the closeness of the relation. For further information in this interesting subject the reader is referred to the writings of Semple[1] for general consideration of the subject, as well as application to parts of the United States.

HISTORY OF COAL MINING IN RUSSELL COUNTY WITH REFERENCE TO COAL MINING IN THE STATE OF VIRGINIA

The first bituminous coal mined in the United States was taken from coal beds of Triassic age in what is known as the Richmond basin near the city of Richmond, Virginia. Coal was known to occur in that district as early as 1700 and worked as early as 1750, and in 1789 shipments were made to some of the northern States. Production seems to have continued from this date, but the first statistics of production are those for 1822, when 59,000 short tons were mined. Production increased until 1840, when the total exceeded 424,000 tons, and reached a maximum in 1860, when the total was over 473,000 tons.

Much of this total seems to have been from West Virginia, for the amount was reduced to less than one-tenth of its former value in 1863 when West Virginia was separated from Virginia proper. From that year until 1883 production was low, not exceeding 100,000 tons annually. In the latter year the building of the Norfolk and Western Railroad into Tazewell County initiated the development of the Pocahontas field. (See fig. 15.) Until 1890 the Tazewell County output made up nearly the whole State's yield, but the completion in 1891 of the Louisville and Nashville Railroad

[1] Ellen Churchill Semple, Influences of Geographic Environment.

from Cumberland Gap to Norton, Virginia, and its connection there with the Clinch Valley division of the Norfolk and Western Railroad, which was completed about the same time, started active mining about Big Stone Gap and Norton in Wise County that gave to this county a production in 1893 of over 100,000 tons. This production has increased at a continually accelerated rate nearly to the present time. Tazewell County has gained only slowly in production since 1888. Russell County started extensive production in 1904 and Lee County in 1907; the former has increased rapidly up to the present, but the latter seems to have reached nearly a stationary output. Dickenson County first passed 100,000 tons in 1918. The relation of the production of these various fields to the total State production, the development of the latter since 1822, and the influence of railroad building on production are shown in figure 15.

The recent development of mining in Russell County began with the opening of the mines at Dante by the Clinchfield Coal Corporation in 1904. From their extensive operations there and at Clinchfield comes a large proportion of the coal mined in the county. Since 1910 numerous smaller companies have started mining in different parts of the county. The amount of coal produced in Russell County each year from 1902 to 1918 is given in the following table:

Amount and value of coal produced in Russell County, Virginia, from 1902 to 1918, inclusive.

Year.	Amount.	Value
1902	7,831 [a]	$ 5,900 [f]
1903	9,255 [a]	8,300 [f]
1904	177,133 [b]	142,000 [f]
1905	323,073 [c]	290,000 [f]
1906	302,896 [a]	298,000 [f]
1907	448,515 [d]	459,000 [f]
1908	719,954 [e]	653,000 [f]
1909	931,276 [e]	833,000 [f]
1910	790,066 [e]	713,000 [f]
1911	1,050,600	957,000 [f]
1912	1,293,145	1,229,817
1913	1,512,356 [e]	1,568,041
1914	1,236,114	1,276,828
1915	1,493,421	1,351,469
1916	1,950,036	1,912,643
1917	2,000,540	3,645,529
1918	1,998,144	5,009,780
Total	16,244,355	$20,353,307

[a] Includes Pulaski County.
[b] Includes Pulaski and Montgomery counties.
[c] Includes Pulaski, Montgomery, and Lee counties.
[d] Includes Pulaski, Montgomery, Lee, and Henrico counties.
[e] Includes Pulaski, Montgomery, and Henrico counties.
[f] Estimate based on value and production in entire State.

ACCESSIBILITY

Russell coal field is very well situated with reference to the shipment of coal to various markets. It is crossed near the western end by the main line of the Carolina, Clinchfield and Ohio Railroad and it lies closely parallel to the Clinch Valley division of the Norfolk and Western Railroad, the most remote points being within eight miles of it. Haulage is all down grade to this railroad.

Wilder, Laurel, Clinchfield and South Clinchfield are connected with Carbo on the Norfolk and Western Railroad by a branch line of the Carolina, Clinchfield and Ohio Railroad and there is now a standard gauge branch line from Putnam to Della and Drill. A narrow gauge road has been built by the Kennedy Coal Company up Swords Creek to the mouth of Sulphur Spring branch.

The Russell coal field is thus within convenient reach of markets both on the Atlantic Seaboard and in the Middle West.

Coal from the eastern end of the field can be shipped over the Norfolk & Western Railway to the Atlantic Coast; and by way of Bluefield, W. Va., to Cincinnati and markets farther north and west. Coal from the western end of the field, which is crossed by the Carolina, Clinchfield & Ohio Railway, may be shipped north over this road, connecting with the Chesapeake & Ohio Railway at Ashland, Ky., by way of Elkhorn City, Ky.; southeast by the same railroad to Charleston, S. C.; east over the Norfolk & Western as above mentioned; or west to connect with the Louisville & Nashville Railroad at Norton or the Southern Railway at Appalachia.

Wagon roads are unimproved and poor in most of the coal field and are not adapted for travel by automobile. There is an improved road from Carterton to Dante, but Wilder and Laurel are to be reached only by train, slow wagon travel, or horseback. In the country bordering the coal field on the south, roads are better, and there is considerable automobile travel parallel to the railroad.

FUTURE DEVELOPMENT

Coal mining is increasing rapidly in Russell County, and the tonnage mined seems likely to increase for some time to come. A recent development which is dependent on the coal resources of the county is the locating of the plant of the International Coal Products Corporation, at South Clinchfield, Va., which is about three-fourths mile southwest of the old village of Dumps Creek. The corporation is said to be constructing a

$2,500,000 plant with the partial backing of the War Department to produce the fuel known as carbocoal, which is essentially a low-ash coke.

The process is a new one, still in the experimental stage, and the merits of the product are discussed in Bulletin 137 of the American Institute of Mining Engineers.[1]

The distillation is carried on in two stages, first in a low temperature retort at 800° to 900° C., through which the coal is fed continuously. In this retort 85 per cent of the volatile matter is driven off, including practically all the tar. The residue from this stage is made into briquets with pitch and these are run through the high temperature retorts at 1400° C., where the pitch and the rest of the volatile matter are driven off. The product is of about the same composition as ordinary coke. The yield of carbocoal is about 70 per cent of the weight of the coal, and a great advantage of the process is that non-coking coals can be used.

The by-products are the same as in ordinary by-product coke ovens—benzol, tar, ammonia, light oil, naphtha, toluol, etc. The location of this important new industry in Russell County close to its large coal resources is likely to be a great stimulus to the development of these resources and a great addition to the industrial development of northwestern Russell County.

GEOLOGIC FORMATIONS

GENERAL STATEMENT

This report is confined to the coal-bearing formations of Russell County and only rocks of Carboniferous age will here be described. Pennsylvanian (Upper Carboniferous) rocks form the solid or "bed" rock in the entire area as mapped. They are covered almost everywhere with a thin mantle of weathered rock debris which, with some addition of organic material, makes up the soil. Throughout most of the field this mantle rock lies immediately on the solid rock from the disintegration of which it resulted, except for the slumping of soil and loose rock fragments down the steep hillsides. In the larger stream valleys are small alluvial deposits of this same material as clay, sand, and gravel; the moderate rounding of the softer rocks and the slight rounding of the very hard rocks indicating that it has been transported a very short distance, a few miles at most, by the streams.

The bed rock is exposed, however, at the surface in many places. These exposures, which the geologist calls "outcrops," amount to only a very small

[1] Am. Inst. Min. Eng. Bull. 137, pp. 971-978, 1918.

part of the total area and are located where the ledges of harder rock make surfaces so steep or exposed to the action of the wind and rain that no mantle rock can accumulate or where in gullies and the channels of streams running water keeps the bed rock, whether it be soft shale or hard sandstone or coal, scoured clean.

It is from a study of the rocks in these outcrops and in the few exposures which man has made, such as road and railroad cuts, core drill holes, wells, and mines, that the kinds of rocks and their arrangement or structure are learned.

CARBONIFEROUS SYSTEM.

Classification and character of formations.

In outlining the past history of the earth some geologists have divided the enormous duration of time, amounting to many millions of years, into five major divisions, as follows:

Cenozoic—most recent.
Mesozoic.
Paleozoic.
Proterozoic.
Archeozoic—most ancient.

In the classification of the United States Geological Survey all pre-Paleozoic rocks are included in the Proterozoic.

During this entire known history sedimentary rocks have been in process of formation at one place or another on the earth's surface, and it is chiefly by studying these bedded or stratified rocks and the fossil remains of animals and plants they contain that geologists have been able to learn much of this extremely complex history.

The later part of Paleozoic time has long been known to geologists as the Carboniferous period and was the time when many of the most important coal-bearing formations of the world were laid down. More recently, as a result of more detailed studies, the Carboniferous period has been divided into three epochs, as follows:

Permian—late Carboniferous.
Pennsylvanian—middle Carboniferous.
Mississippian—early Carboniferous.

The sediments deposited in each of these epochs, which are now for the most part indurated into solid rock, are called by these names—Permian, Pennsylvanian, or Mississippian series, as the case may be.

All the commercially valuable coal of this field occurs in the coal-bearing portion of the Carboniferous system, which consists of sandstone, shale, clay, and coal beds. The rocks above the Newman limestone (Mississippian series) have been divided by Campbell in his reports on the Bristol and Estillville quadrangles, into the Pennington, Lee, Norton, and Wise formations. In these folios the entire Pennington was regarded as of Mississippian age, and the Lee, Norton, and Wise, of Pennsylvanian age, and while the same formations are recognized in this report, recent work has shown that the Pennington shale carries at least two coal beds, the one near the top of the formation, as shown by fossil leaves associated with it, is of Pennsylvanian age. The Pennsylvanian series thus includes the Lee and overlying formation as well as the upper part of the Pennington shale. As the Wise and Gladeville formations underlie a very small part of Russell County, and as the Lee and Pennington formations come to the surface only in a narrow belt along the edge of the coal field, the greater part of the Russell field is underlain by rocks of the Norton formation.

There is no certain way of identifying the rocks of any of these formations by their lithologic characters except in very limited areas. Only careful study by the methods described above of lithologic characters, structure, and fossil content has made it possible to correlate the coal beds and other rocks throughout the coal-bearing portion of Russell County and to determine their relation to the rocks of adjacent areas.

The coal-bearing rocks of Russell County are, with the exception of the coal, of the sort known as clastic rocks, i. e., rocks formed by the deposition and recementation of particles resultant from a mechanical breaking up of older rocks. In some of the layers the rounding of the grains and absence of all but the harder and more durable minerals indicates that the materials suffered much wear through long transportation before they were deposited, as in the case of quartz pebbles of parts of the Lee formation.

On the other hand, sandstone containing grains of feldspar, mica, and other less resistant minerals, in addition to the quartz, which is known as arkose, indicates deposition at points nearer the source of the material. By far the larger part of the sandstones of the coal field is of this sort.

About one-third to one-half of the coal-bearing rocks are sandstone and most of the rest are shale. Of this sandstone, not over a half or a third of the total thickness is hard, well cemented quartzose sandstone, and much of the rest grades into shale, being known to many of the core-drill operators as "sandshale." The resistant sandstone layers which make prominent ledges or cliffs are very valuable as key rocks in following the beds but they

are variable and may fray out and others come in in a few miles and their continuity must be demonstrated if they are to be so used.

The commonest type of sandstone is a medium-grain gray to buff arkose in which the mica and feldspar may be easily seen even with the naked eye. The beds or laminæ vary from one inch to a foot or more in thickness. It weathers to a dirty gray or brown and is usually much softer than the more quartzose sandstone.

Sandstone which contains rounded quartz pebbles is found locally at many horizons of all the formations of the Pennsylvanian. Such pebble-bearing rocks are known as conglomerates. The pebbles are rarely over an inch in diameter and the layers containing them extend for such small distances at any one horizon that, with the exception of some conglomeratic strata in the Lee formation, they are of no value in correlation. Nearly all the sandstones are cross-bedded at some localities, and some have ferruginous concretions or ferruginous recementation material along joints, but these characters are not constant.

As has been pointed out above, the sandstone grades into shale, and many of the shale beds are distinctly sandy. Drab is the most common color, though brown, gray-blue, black, and yellow shales are not uncommon. Weathering tends to transform all the original colors of the shale into the browns and yellows of the iron oxides. The laminæ in the shale vary from very thin paper-like layers to very thick layers in the clay-like or sandy shale. What seems to be a massive shale or sandstone will in many cases develop very minute bedding laminæ on weathering so that this character as well as color has to be used cautiously in correlation of beds in very restricted localities.

The beds of clay which make up a very small part of the total thickness are usually associated with the coal beds. They are rarely over a few feet thick and are in most cases somewhat laminated and grade into shale. They occur usually under the coal beds, but in some cases as partings or even above the coal.

The only fossils found in the Pennsylvanian of Russell County are plants which are very abundant in association with the coal beds, usually in the roof shale. Identifications of plants collected in this field by David White have been of great aid in correlating these beds with those of adjoining areas. Fossil marine shells have been found in both the Norton and Wise formations at a very few localities in nearby parts of Kentucky and West Virginia but none in Russell County so far as known to the writer.

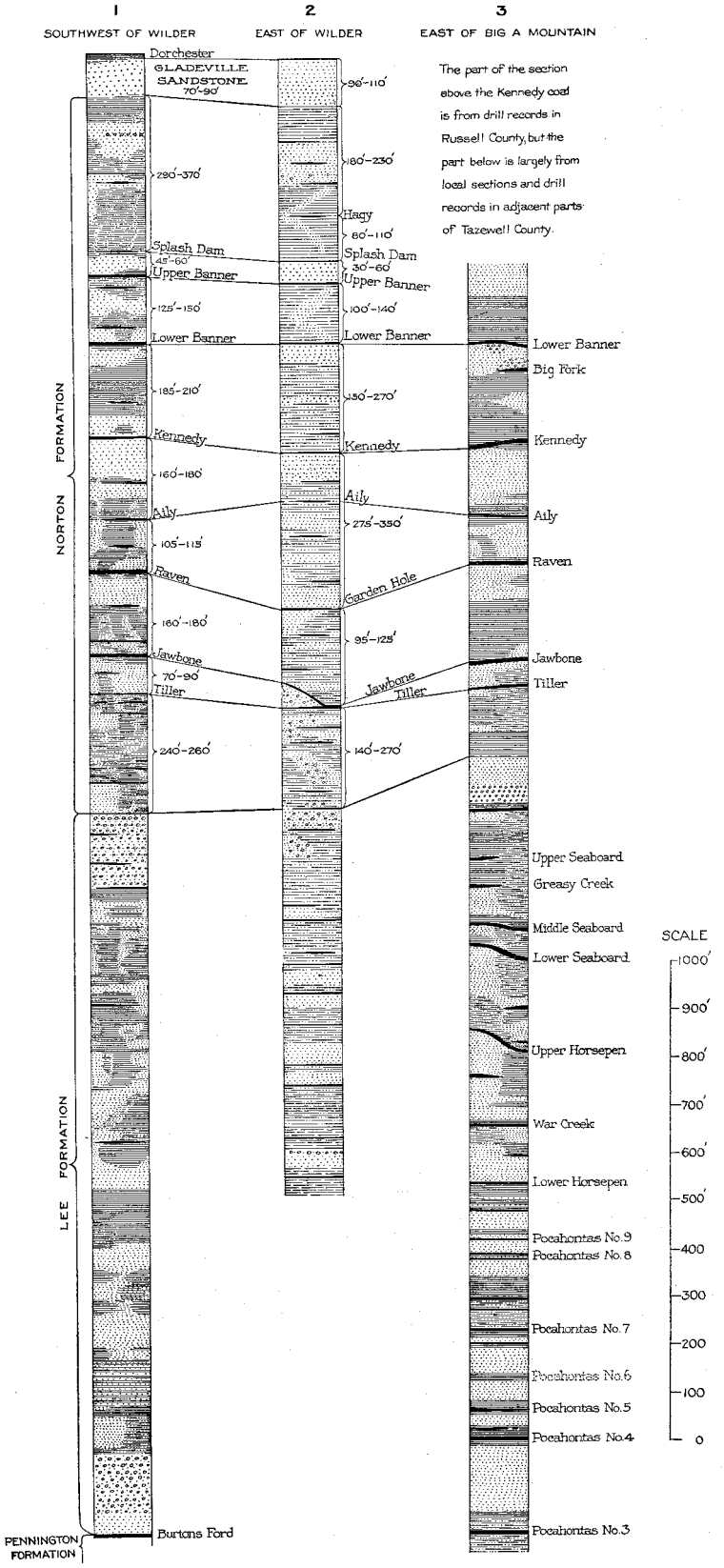


Fig. 2. Generalized sections of the Pennsylvanian series in Russell County coal field.

Mississippian Series.

PENNINGTON SHALE.

The uppermost formation of the Mississippian series was named by Campbell, in the Estillville Folio, the Pennington shale from the excellent exposure of the formation at Pennington Gap, Lee County, Va. This formation overlies the Newman limestone and underlies the massive conglomerate of the Lee formation. It is composed predominantly of shale of various kinds, and in addition carries in places thin beds of limestone, at least one or more beds of economically valuable coal, and in most places a thick bed of very resistant sandstone near the middle. In outcrop the thickness of the formation ranges from 1,000 to 1,100 feet.

The Pennington shale is generally sharply upturned and in many places overturned along the border of the coal field, but in places it is cut out by the Hunter Valley fault, which limits it on the southeast from the Burton Ford district as far east as Dumps Creek. It also underlies the entire basin of the coal field and was penetrated to a depth of 800 feet by the drill in the deep wall (S1) on Cranes Nest River, drilled by the Clinchfield Coal Corporation.

In this field the Pennington may generally be differentiated from the overlying coal-bearing rocks by the red or green color of its shales and by the finer grain of its sandstones.

Pennsylvanian Series.

LEE FORMATION.

The Lee formation, the lowest of the Pennsylvanian series, is exposed at the surface or immediately underlies the mantle rock in a narrow zone from one-fourth to one mile wide along the southeast edge of the coal field from the Wise County line to Big A Mountain. It is also included in the undifferentiated disturbed Pennsylvanian from near Della to Raven. Below the surface it is continuous as shown by drill records all the way under the Norton formation until it is exposed on the northwest side of the basin in the slopes of Pine Mountain.

The top member of the Lee formation is a massive conglomerate which contains well-rounded white pebbles of vein quartz that are for the most part not over one-half inch in diameter but locally individual pebbles are as much as three inches in their longest dimension. This conglomerate, which is about 100 feet thick, is very resistant to erosion, and forms, where

the Lee is upturned, a conspicuous high crest commonly with a dip slope on one side and a cliff not infrequently overhanging on the other. In some places it is a nearly impassable barrier even to pedestrians for distances of several hundred feet. This member is the "Bee Rock" of Campbell's report on the Estillville quadrangle.

Below the "Bee Rock" of the Lee is a mass of softer rocks, shale with some less resistant sandstone and a few thin coal beds. Most of the sandstone of the Lee is composed of a larger percentage of clean quartz sand than that of the Norton formation, but this distinction is not very sharp.

From 1,000 to 1,200 feet below the top of the formation is another resistant conglomerate forming a second high crest which is in some places more conspicuous than the "Bee Rock" crest. These two resistant rocks form the two ridges of Buffalo Mountain, the first two ridges in the Russell coal field south of Wise County, on the south side of Clinch River and two parallel ridges at several other places.

No accurate measure of the thickness of the Lee formation was obtained in Russell County but estimates at several places average from 1,500 to 1,700 feet, thicknesses which accord well with the measurement of 1,740 feet given by Harnsberger in the Tazewell County report. The thickness is subject to variation because it is composed of heterogeneous material which must have been largely transported by swift currents and deposited in beds of irregular thickness.

NORTON FORMATION.

The Norton formation is present in all of the Russell coal field except in the area where the Lee outcrops as just described. It is continuous in its surface exposure from the Lee contact northwestward to the few places on Sandy Ridge where the Gladeville and Wise formations have not yet been removed by erosion, and the Norton, of course, is beneath the surface even at these places. The formation is composed of sandstone and shale with a number of important coal beds. The sandstone is for the most part made up of lesser proportions of quartz sand and is more arkosic than that of the Lee formation.

The thickness of the Norton formation varies from about 1,300 feet at the eastern end of the field to nearly 1,500 feet at the western end. A fair average in the western part where it has been more thoroughly explored by drilling is 1,440 feet. The stratigraphic succession is shown in the gen-

eralized sections, Fig. 2, page 17, and a detailed description of the coal beds and their associated rocks will be given in the part headed "Coal Resources."

GLADEVILLE SANDSTONE.

The Gladeville sandstone was named from the town of Gladeville, now Wise, the county seat of Wise County, where it is an important horizon marker. In Russell County it is present only at a few places on Sandy Ridge west of Big A Mountain. It is here 80 to 100 feet thick, rather arkosic, medium to coarse-grained and becomes stained with brown iron oxide on weathering. Mica and other ferromagnesian minerals are common. Though it is thick bedded and is readily traceable for considerable distances, it is not so conspicuous a key rock in Russell County as it is at Wise, where it is a massive, hard, white, and quartzose sandstone—a very resistant rock.

WISE FORMATION.

The Wise formation is present only in a very small part of Russell County as a few small remnants on the higher parts of Sandy Ridge, where they are encircled by the outcrops of the Gladeville sandstone mentioned above. No coal beds of economic importance are found in the lower part of the Wise formation exposed in Russell County, though farther west these same strata contain thick coal beds. The formation consists of a mass of sandstone and shale, details of which are shown in the generalized sections. (Fig. 2, page 17.) At some places the rocks of the Wise formation are somewhat lighter colored with more yellow, white, and cream colors and fewer browns, grays, and sombre colors than the Norton rocks, but it is not possible to apply this very confidently in distinguishing the two.

UNDIFFERENTIATED PENNSYLVANIAN.

At the southern edge of the eastern portion of the coal field there has been very severe thrusting from the southeast and the rocks have been upturned or even overturned in a narrow zone extending from Raven in Tazewell County to near Della and from Big A Mountain to near Grizzle. The strata in this zone consist of shale, sandstone and a few coal beds of the Norton and Lee formations and they are shown on the areal map (Plate XXVIII in pocket) as "Undifferentiated Pennsylvanian." There are a few outcrops of coal in this area but the rocks are so disturbed and broken that the coal is likely to be of little value except where mined solely for household use in local coal mines. The coal beds exposed in this part of the field

were not correlated and as the rocks dip for the most part at high and discordant angles it was not practicable to draw structure contours to indicate the elevations of any one of the coal beds.

West of Grizzle the faulting along the edge of the coal field was more completely restricted to a single sharp break and though the strata of the coal measures are folded and pushed to the northwest in a great overturn the line between the Lee and Norton formations is nearly everywhere distinct and has been indicated on the map.

QUATERNARY SYSTEM.

Recent Series.

ALLUVIUM.

In the valleys of all the streams of the region lie considerable quantities of unconsolidated rock debris which has been washed down by the streams from places higher up in their courses. High up in the heads of the valleys the steep gradient enables the water to sweep the channel clean, but even such conditions are rare because commonly the slope wash brings into the valleys from the side more waste material than the stream can carry away and probably not over a half of one per cent of the total length of the streams are in clean-swept rock channels.

The material which partially fills the valleys and in which the actual channels are cut consists of gravel, sand, and clay, commonly rather rudely assorted. The material carried by a stream depends on the velocity of the stream; a stream with the high velocity of flood moves clay, sand, and gravel alike, but as its velocity decreases it drops the larger boulders and then smaller and smaller boulders progressively. Sand and then clay are deposited if the velocity continues to grow less. Most of this alluvium is close to the stream and is not likely to remain many years in place before it is again taken up by the stream and carried farther down its course.

SOIL.

In this region the soil is the result of decay of the underlying rocks and its qualities depend largely on the character of those rocks. On the northward-facing slopes where the soil is not too readily washed away it is fairly fertile. For the most part the slopes are so steep that as soon as the original forest cover is removed the soil is rather continuously washed down and the newer rock debris has not become sufficiently decomposed or acquired

the vegetable matter necessary to make good soil. The washing and gullying of the hillsides is very much accelerated by the ordinary methods of cultivation, and such farming as is carried on by the residents of the region is done at an increasing disadvantage. The soil derived from the rocks of the coal measures is thin and sandy and generally not capable of producing good crops. With careful attention to fertilization to supply the deficiencies of the soil, especially the needed lime, it is possible to build it up so as to raise moderately heavy crops but the steep slopes, poor access to markets and impossibility of using modern farm machinery to any extent in cultivating the fields combine to prevent the development of agriculture along progressive lines.

On the other hand, the forests preserve the soil and improve it and are capable of producing splendid timber especially if handled systematically in accordance with the principles of modern forestry. (See pages 151-172.)

CORRELATION WITH ADJOINING AREAS.

In the course of the work done by the writer in the southwest part of Russell County no new correlations were made. The formation names used are those employed in previous reports on this region, including the recent reports of Hinds[1] and Harnsberger.[2]

Hinds' discussion is quoted in full below:

"The correlations made by the writer between coal beds in southwest Virginia and the Elkhorn coal field in Kentucky differ from those previously made (see Pl. V) chiefly because early ties were necessarily made across the gap formed by Pine Mountain and the Pine Mountain fault, where no actual tracing of beds from one field to the other is possible. The work upon which the present report is based was continued so as to include the northern half of Buchanan County to the boundaries of Kentucky and West Virginia and a tie line was made by the author in 1915 from Elkhorn City down Russell Fork, up Marrowbone Creek, and over the Flatwoods to Shelby Creek, where it joined detailed private surveys carried from Jenkins. The results of detailed private surveys in southeastern Pike County confirmed the conclusions reached. Correlations were also greatly strengthened by a preliminary examination of fossil plant collections by David White.

"There can be no question concerning the accuracy of the identifications of the Upper and Lower Banner and Kennedy coal beds in the Clintwood and Bucu quadrangles. The position of the Jawbone coal bed and the top

[1] Hinds, Henry, Coal resources of Clintwood and Bucu quadrangles, Va.: Bull. XII, Va. Geol. Survey, 1916, pp. 14-17.

[2] Harnsberger, T. K., Coal resources of the coal-bearing portion of Tazewell County, Va. Bull. XIX, Va. Geol. Survey, 1919, pp. 19-23.

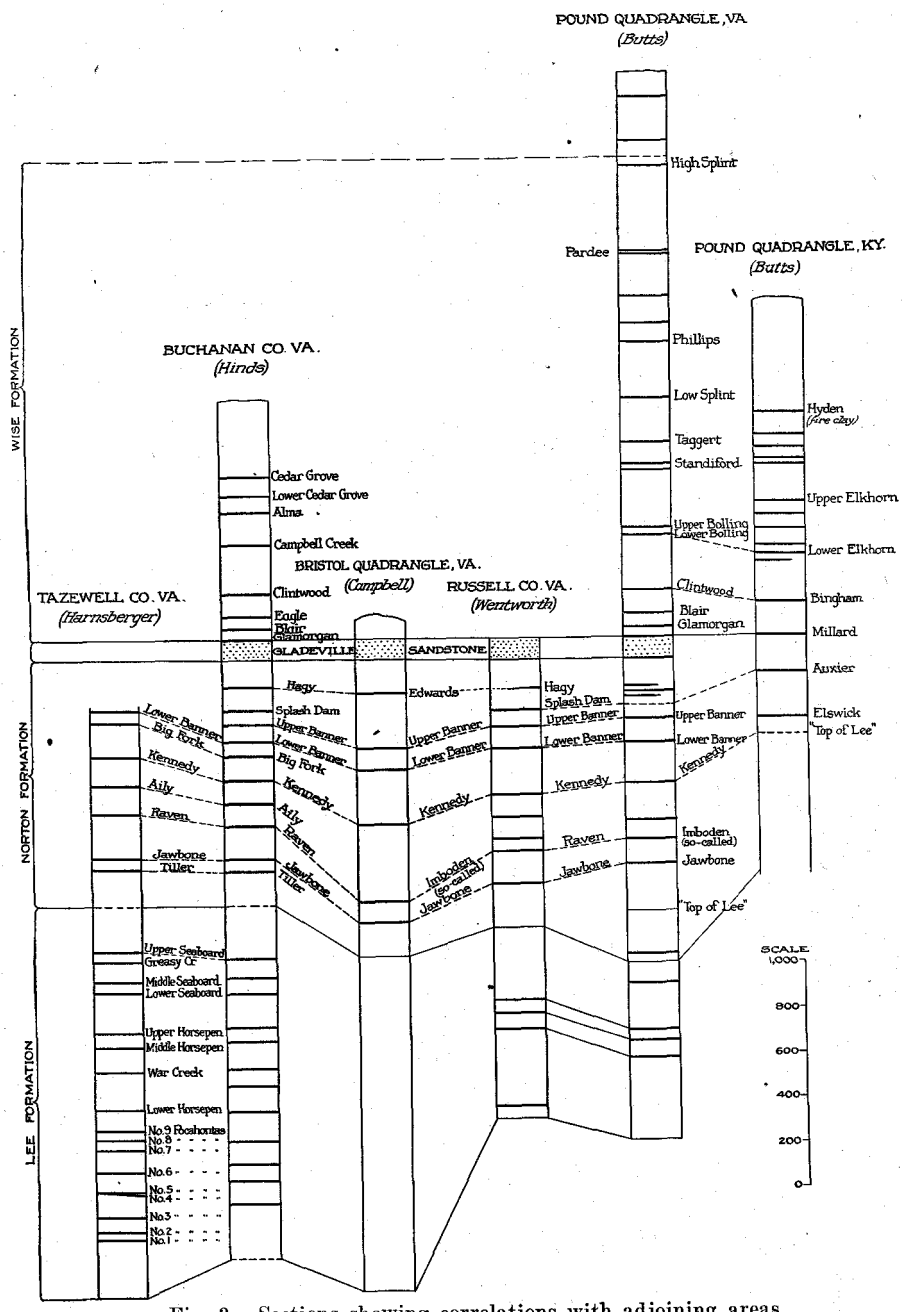


Fig. 3. Sections showing correlations with adjoining areas.

of the Lee formation in this area is based upon the stratigraphic intervals and somewhat meager lithologic descriptions given by Campbell for neighboring parts of the Bristol quadrangle. If the Jawbone correlation is correct the "so-called Imboden" is the equivalent of the Garden Hole coal bed. The Gladeville sandstone was traced by Butts from its type locality at Wise through the Pound quadrangle to the Clintwood. On parts of the Sandy Ridge, Campbell has apparently included in his mapping of the Gladeville a thin but conspicuous resistant white sandstone that is separated from the Gladeville of Butts by a moderately thick shale bed.

"The identification of horizons above the Norton in this report agrees essentially with those made by Butts in the Virginia portion of the Pound quadrangle. His identifications of certain Norton coal beds and of the top of the Lee formation in drill holes S 1, S 13, and S 15, which are in the Clintwood quadrangle, have been slightly changed on the basis of a careful study of outcrops and many drill records east of the Pound quadrangle where the available data concerning the lower two Pennsylvanian formations are exceptionally good. As previously explained, the Lee-like sandstone near the foot of Pine Mountain and at the top of the canyon at The Breaks, naturally considered by both Butts and Stone to be the top of the Lee, is now known to be the stratum lying a few feet below the Kennedy coal bed, near the middle of the Norton formation. This sandstone is the cliff-former upon which Elkhorn City, Ky., is built, and the change in its correlation necessitates an entirely new conception of the stratigraphic position of strata in the Elkhorn district of eastern Kentucky (Pl. V).

"In recent reports on Mingo and McDowell counties, West Virginia,[1] great cliffs on Tug Fork at and near War Eagle are correlated with the Nuttall sandstone and placed at the top of what is called the New River group, underlying the Kanawha group. The top of the Nuttall is a few feet below the Lower Banner coal horizon, and is the same as Campbell's Dotson sandstone. The bed mapped by Campbell as Dotson farther south, in the western and central parts of the Tazewell quadrangle, appears to be slightly higher in the section, probably just above the Upper Banner horizon. The sandstone mapped by Campbell as the Raleigh in the western part of the Tazewell quadrangle is the bottom-rock of the Jawbone coal, and is probably higher than the bed mapped as Raleigh in the eastern part of the quadrangle.

"The coal beds called the Eagle and Campbell Creek (No. 2 Gas) by the West Virginia Geological Survey have been traced into the Clintwood and Bucu quadrangles and the names retained. The Eagle coal is locally known as the Middle War Eagle and Mohawk on Tug Fork. The Campbell Creek coal is the bed to which the name Lower Bolling was applied in the Pound quadrangle. This coal is locally called the Lower Elkhorn, Lower Marrowbone, Warfield, Freeburn, Burnwell, and Upper War Eagle in Pike County, Kentucky, and Mingo County, West Virginia. The Lower War Eagle coal of Tug Fork is the same as the Hagy of Virginia."

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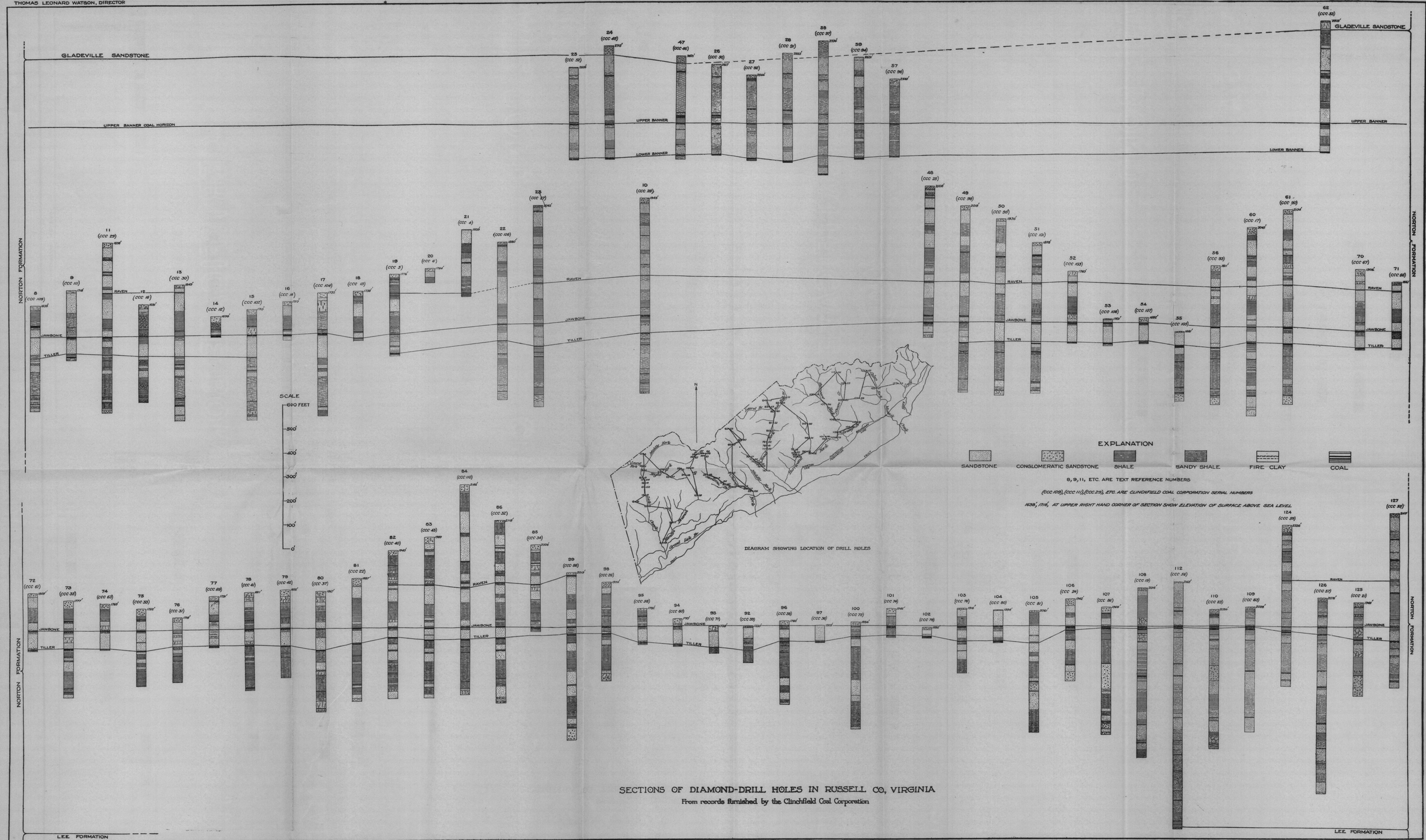
[1] Hennen, R. V., and Reger, D. B., Logan and Mingo counties, West Virginia Geological Survey, 1914.
Hennen, R. V., Wyoming and McDowell counties, idem, 1915.



SECTIONS OF DIAMOND-DRILL HOLES IN RUSSELL CO, VIRGINIA

From records furnished by the Clinchfield Coal Corporation

LOCAL SECTIONS.

The local sections given below have been inserted to show the general character of the beds. They are subject to correction for dip as indicated and should be used with caution as parts of most of them are poorly exposed. Intervals are approximately correct but cannot be considered in any sense as averages.

Section from Dante, northwest to Austin Gap and west to summit near Cherry Knob School. Section extends into Dickenson County in part. Section 50 feet too long because of dip.

	Thickness Feet.	
Coal (Glamorgan, elevation 2,760 feet.)		
Gladeville sandstone:		
Sandstone and clay, red	60	130
Sandstone, coarse grit	15	
Sand and clay, red	55	
Norton formation:		
Shale	15	250
Sandstone, massive	20	
Shale, sandy	20	
Coal		
Shale, brown	55	
Sandstone	70	
Shale, sandy	30	
Shale	40	
Coal = Splash Dam.		
Sandstone	40	40
Coal (Upper Banner, elevation 2,330 feet).		
Clay	2	169
Sandstone	10	
Shale	30	
Sandstone, massive	60	
Sandstone, argillaceous	10	
Shale	40	
Shale, sandy	7	
Shale	10	
Coal (Lower Banner, elevation 2,170 feet)		
Concealed	40	200
Sandstone	20	
Shale	100	
Sandstone, massive	40	
Coal (Kennedy, in Dickenson County, elevation 1,970 feet)		
Shale	40	170
Sandstone, massive	40	
Shale, sandy	10	
Shale, buff	10	
Sandstone	10	
Concealed	25	
Sandstone	35	
Coal (Aily, location 37, elevation 1,810 feet)		
Sandstone, massive, medium-grained	50	50
	1009	1009

Section from Dante north up Straight Hollow to Location 42. Section 40 feet too short because of dip.

	Thickness Feet.	
Norton formation:		
Sandstone	10	10
Coal (Upper Banner, location 42, elevation 2,260 feet.)		
Concealed	40	468
Sandstone, massive concretionary	30	
Sandstone, argillaceous	18	
Concealed	14	
Sandstone, medium bedded	10	
Concealed	198	
Sandstone	10	
Shale	32	
Sandstone, weathers red to buff	28	
Shale, sandy, massive	8	
Shale, sandy	20	
Shale	40	
Sandstone	20	
	478	478

Section from Dante northeast up Right Fork of Lick Creek to Hazel and west three-fourths mile along ridge to high knob on Sandy Ridge.

	Thickness Feet.	
Wise formation:		
Sandstone	75	95
Shale	20	
Coal (Glamorgan, elevation 2,890 feet)		
Clay	10	10
Gladeville sandstone:		
Sandstone, coarse-grained	70	70
Norton formation:		
Concealed, probably shale	145	355
Sandstone	30	
Concealed	26	
Conglomerate	4	
Concealed	150	
Black shale (probably horizon of Splash Dam coal)		
Shale	30	66
Sandstone	30	
Shale	6	
Coal (Upper Banner, location 45, elevation 2,340 feet)		
Sandstone	15	148
Concealed	45	
Sandstone	50	
Concealed	38	
Coal (Lower Banner, location 40, elevation 2,192 feet)		

	Feet.	Feet.
Clay	1	
Concealed	50	
Sandstone	20	
Shale	12	
Shale, concretionary	2	195
Shale	50	
Coal, thin		
Shale	40	
Shale, sandy	20	
Coal (Kennedy, location 39, elevation 2,015 feet)		
Concealed	10	
Sandstone	40	
Concealed	10	
Shale	14	
Sandstone, thin bedded	22	199
Sandstone, massive	10	
Sandstone, thin bedded	75	
Shale, sandy	8	
Shale	10	
Total	1,138	1,138

Section from Hazel to Chaney Fork School.

	Thickness Feet.	
Gladeville sandstone:		
Sandstone, massive	70	90
Sandstone, thin bedded	20	
Norton formation:		
Concealed	120	
Sandstone, massive	40	
Conglomerate	10	
Sandstone	40	
Shale	30	332
Shale, sandy	10	
Shale	40	
Sandstone	38	
Shale, sandy	4	
Coal (Upper Banner, location 69, elevation 2,350 feet)		
Shale	20	
Sandstone, thin bedded	10	
Sandstone, massive	20	85
Shale, sandy	18	
Shale	17	
Coal (Lower Banner, location 66, elevation 2,265 feet)		
Sandstone	60	
Shale, in part concealed	120	190
Sandstone	10	
Total	697	697

Section north up road toward Grizzle from Clinchfield Post Office.

	Thickness Feet.	
Norton formation:		
Shale	30	240
Sandstone, massive	110	
Concealed	90	
Shale, sandy	10	
Coal (Jawbone, location 115, elevation 1,750 feet)		
Total	240	240

Section from location 163 in bottom of a small drain of main hollow, one-half mile north of Camp Hollow, to location 179 on east side of narrow gully.

	Thickness Feet.	
Norton formation:		
Sandstone	40	173
Concealed	10	
Sandstone, medium-grained	30	
Shale (?)	85	
Shale	8	
Coal (Lower Banner, elevation 2,555 feet)		
Concealed	10	232
Sandstone, fine-grained	60	
Shale (?)	50	
Sandstone, medium-grained	20	
Shale	70	
Sandstone	22	
Coal (Kennedy, elevation 2,320 feet)		
Concealed.		
	405	405

Section from location 232 down the slope to the nearest house on Strow Fork.

	Thickness Feet.	
Norton formation:		
Shale	24	24
Coal (Lower Banner, elevation 2,600 feet)		
Conglomerate	20	200
Sandstone, fine-grained	40	
Conglomerate	10	
Sandstone	20	
Sandstone, medium-grained	30	
Shale	80	
Coal (Kennedy, elevation 2,400 feet)		
Sandstone	50+	50+
	274	274

Section from location 236 down the trail to station elevation 1,980 feet at the junction of Swords Creek and Sulphur Spring Branch.

	Thickness Feet.	
Norton formation:		
Shale	32	32
Coal (Lower Banner, elevation 2,400 feet)		
Sandstone	10	
Shale	115	
Sandstone	15	220
Shale (?)	60	
Shale	20	
Coal (Kennedy, elevation 2,165 feet)		
Sandstone, massive	25	
Conglomerate	40	
Concealed	35	145
Sandstone and conglomerate	25	
Shale	20+	
	397	397

Section from juncture of trails slightly northwest of location 241 down slope of narrow hollow to house, at elevation 2,420 feet, on road by Pine Creek.

	Thickness Feet.	
Norton formation:		
Shale	106	106
Coal (Lower Banner, elevation 2,700 feet)		
Shale, sandy	20	
Sandstone, massive	65	
Shale	10	
Sandstone, coarse-grained	10	247
Shale (?), poorly exposed	60	
Shale	55	
Sandstone, medium-grained	10	
Shale	17	
Coal (Kennedy, elevation 2,460 feet)		
Sandstone, conglomeratic	30	
Sandstone, poorly exposed	85	150
Sandstone or conglomerate	35	
	503	503

GEOLOGIC STRUCTURE

METHOD OF REPRESENTATION.

The position in which coal and other beds lie in a region of low dips is best shown by means of structure contour-lines connecting points of equal elevation on some important or easily recognized reference stratum, successive contours being at multiples of some conventional distance above or

below. The structure contours thus represent the form of the surface of the reference stratum just as the topographic contours represent the form of the land surface. The contour interval used in this report is 50 feet and the datum or zero plane of the elevations shown by the structure contours is mean sea-level.

In the Russell coal field two different reference beds have been used, the Raven coal bed in that part east of Big A Mountain and the Upper Banner coal west of Big A Mountain. These beds were chosen chiefly because it seemed best to use as reference beds the same as were used in the reports on the adjacent counties, Tazewell and Dickenson respectively.

In the part of the field adjacent to the fault where the rocks are upturned it has not been possible always to identify the individual beds, and as the structure contours in this part of the field have been drawn on the Upper Banner coal horizon they naturally merge into one line where that coal bed was upturned to verticality.[1] Along most of this line the Upper Banner has long since been removed by erosion. Some of the very lowest beds of coal are horizontal or nearly so for a few hundred feet southeast of the line of merged structure contours but for the most part all the rocks between this line and the edge of the coal field have been disturbed by the forces which produced the folding and faulting and the elevations of the coal beds could not be accurately indicated by the use of structure contours. The general attitude of the beds in this part of the field is shown in the structure sections (Plate XXVIII, in pocket).

By reading the structure contours on the geologic map it is possible to determine the direction and magnitude of the dip at any point and to determine the position and elevation of any of the coal beds. It is frequently convenient to employ the contours for the latter use when the edge of a coal bed is deeply buried beneath broken rock and soil, or when the bed is below drainage. For example, if it is desired to find the position of the Garden Hole coal near Dante, the elevation of the Upper Banner coal at the locality in question is first noted. Then the interval between the Garden Hole and the Upper Banner is ascertained for that locality from the proper generalized section. The Garden Hole is below the Upper Banner and the distance

[1] The plan of the author to stop structure contours at the line where the Upper Banner coal bed was upturned has been changed by M. R. Campbell and J. B. Eby as a result of more recent field work. Although the author's position is correct, it leaves in many places broad areas without any indications of structure, and therefore does not meet the need of the prospector or operator. The extension of these lines, based on the assumption of parallelism and the former presence of the Upper Banner bed seem to meet this need, and therefore have been given on the map.

is therefore subtracted from the elevation of the latter bed to find the elevation of the former. By means of this elevation and reference to the surface contours the position of the Garden Hole is readily learned. If the elevation of the bed in question is less than surface elevations at that point the depth of drilling necessary to reach it is the difference between the two.

FOLDS.

Dry Fork anticline.—The most prominent structural feature of the eastern part of the coal field of Russell County is Dry Fork anticline, a long arch of the rocks which extends from near Big A Mountain to Mercer County, West Virginia. Its axis or crest line from which the rocks dip to either side intersects the Russell County-Tazewell County line about one mile south of the Buchanan County line and extends in a direction a little south of west to a point north of Drill where it turns to the southwest and crosses into Buchanan County. In the narrow strip, about a mile wide, which lies north of this line in Russell County the strata dip to the northwest about 50 feet to the mile. South of the axis of Dry Fork anticline the beds dip nearly due south at gradients averaging about 100 feet to the mile. The fold has a considerable pitch to the west along its crest being about 300 feet lower near Drill than it is at the Tazewell County line.

Extending from near Della northward well up on the flank of Dry Fork anticline is a trough-like depression or synclinal fold.

Sourwood Mountain anticline.—West of Big A Mountain the coal measures of Russell County rise more than 500 feet in the 1½ miles between Bowen Gap and Rasnake. Dips are nearly due east and the rocks continue to rise until the crest of Sourwood Mountain anticline is reached about three-quarters of a mile west of Flat Gap. This rather irregular and curved fold crosses the Russell County line about half a mile east of the southeast corner of Dickenson County and from this point its crest extends to a point just east of Grizzle. About 1½ miles northeast of the southern end of Sourwood Mountain anticline, as mapped by the writer, is a small anticlinal nose at location 274, the axis of which is parallel to that of the main anticline. Hinds, in his map of the Clintwood-Bucu area, has drawn the axis of the main anticline through this smaller fold in spite of the presence of a marked synclinal trough separating it from a spur of the main fold. It seems to the writer that the axis of the main fold is farther west as drawn on the map which accompanies this report. This is a continuous though pitching crest from which the beds dip in either direction.

On the west slope of the Sourwood Mountain anticline an anticlinal nose runs southwestward, the axis of which passes just north of Chaney Fork School.

Powell Valley anticline.—West of the anticlinal nose just mentioned and separated from it by a low saddle is the end of an anticline which has but faint development in Russell County but becomes very conspicuous farther west. It is the Powell Valley anticline which Campbell has described in the Estillville folio and which extends across Wise County and into Russell County just south of Dante. Its axis is nearly parallel to the border of the coal field and between this fold and the edge of the coal field is a shallow syncline.

The axis of this border syncline pitches from both the west and the east toward its lowest point near the head of Hamlin Branch in a distinct hollow or basin situated just south of the saddle between the Powell Valley anticline and the spur of Sourwood Mountain anticline above mentioned.

FAULTS.

Hunter Valley fault.—The coal field of Russell County as far east as Dumps Creek is bounded on the south by a great overthrust fault known as the Hunter Valley fault. It was so named by Professor Stevenson[1] because it traverses Hunter Valley in Scott County. This fault is continuous from West Virginia along the border of the coal field in Tazewell, Russell, and Wise counties and across pre-Carboniferous rocks in the same general direction to the Tennessee line and beyond.

After the sandstones, shales, and coal beds of the Pennsylvanian rocks were laid down on top of the limestones and other sedimentary rocks of earlier epochs there came a time of intense lateral compression in the Appalachian region with the stresses from the southeast. In the country to the southeast of the present coal field the rocks yielded to these stresses in a series of parallel upfolds or wrinkles which were in most cases pushed over toward the northwest so that the dips were steeper on the northwest side or the strata were even overturned so that beds on both sides of the fold dipped to the southeast.

As the thrust continued and the closely compressed folds could yield no more by folding many of them broke on the northwesterly side where the rocks had been most weakened by the folding and gave rise to a number of long linear overthrust faults in which the rocks on the southeast in every

[1] Stevenson, John J., A geological reconnaissance of parts of Wise, Lee and Scott counties, Va.; Proc. Amer. Philos. Soc. 1881, Vol. XIX, pp. 219-262.

case were shoved up and over the rocks to the northwest. Thus though the coal-bearing formations of the Pennsylvanian once extended an unknown distance to the southeastward of their present border, they have long since been eroded and older rocks exposed in the area where faulting and folding have uplifted the rock strata.

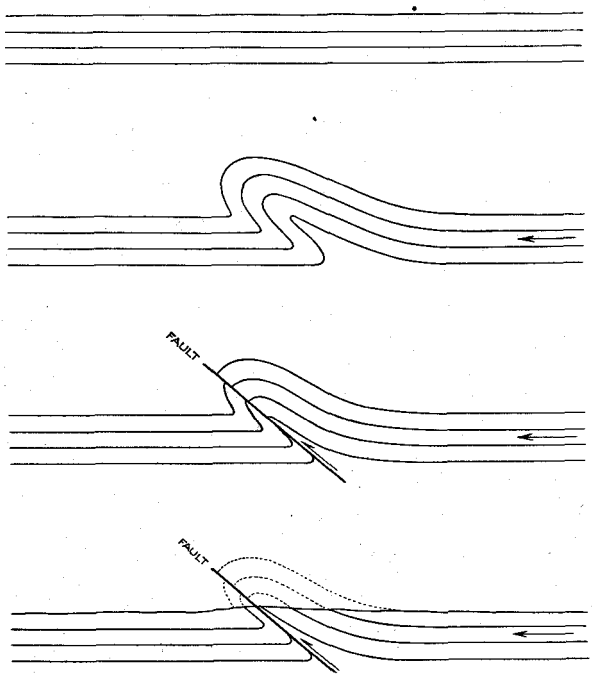


Fig. 4. Diagrams showing development of Hunter Valley fault.

The Hunter Valley fault is the most northwesterly of these great breaks of the Appalachian Valley and it brings Cambrian limestone and other pre-Pennsylvanian rocks over upon the coal measure rocks along the border of the coal field. Part of the original synclinal fold is preserved in the overturned edge of the Pennsylvanian rocks especially from Big A Mountain west to the Wise County line. East of Big A Mountain the coal measures are overturned at their edge but the plane of overthrust truncated them lower down with respect to the present surface and the conspicuous crest of the overturned "Bee Rock" is lacking. The Norton and Lee rocks have not been differentiated in this overturned and disturbed zone just north of the fault and are mapped as "Undifferentiated Pennsylvanian."

At Big A Mountain there was more nearly complete relief of the stresses from the southeast than in the areas on either side and the Silurian sandstones of the Clinch and "Rockwood" formations were thrust to an elevation of over 3,700 feet and at present these resistant rocks cap the summit of the mountain. The greater encroachment of the pre-Carboniferous rocks at this point has divided the coal field of Russell County into two principal parts.

Within the coal field faults are not common; small faults with displacements of a few inches or at most a few feet are known at some places, but none was found of sufficient extent or displacement to show on the map.

COAL RESOURCES

GENERAL DESCRIPTION OF COAL BEDS.

Introduction.

There is a total thickness of about 3,000 feet of Pennsylvanian or coal-bearing rocks exposed in Russell County. Seven coal beds are known that are 30 inches or more in thickness throughout considerable areas. For the most part the coal is of excellent quality, with a low ash content and high fuel value. The good quality of the coal and its accessibility to the railroad will make possible the mining of thinner beds than in many other coal fields but in general beds under three feet in thickness will not be extensively mined until much of the thicker coal is mined out.

Coal in beds under two feet in thickness cannot be considered as economically available at the present time, but all coal in beds over 14 inches thick[1] should be regarded as an exceedingly valuable reserve which will become available when the coal in thicker beds is exhausted.

The quality and thickness of any given coal bed may vary widely in comparatively short distances and the information available about the beds is contained in the geographical treatment which makes the body of this report. Only a brief statement of the salient features of the several beds is given below.

Before commencing active mining operations, the coal bed it is proposed to open should be thoroughly prospected by drilling or by digging numerous

[1] The arbitrary thickness of 14 inches is here used as a minimum limit for the thickness of workable coal because it has been so adopted by the Land Classification Board to the U. S. Geological Survey in the classification of the public lands of the West. Under exceptional conditions thinner coal beds have been worked profitably and there is no doubt that with the gradual exhaustion of the coal in this and other countries coal will become differentially more valuable among the world's commodities and the result will be a slow decrease in the lower limit of thickness for profitable mining. How low the ultimate limit may be is impossible to say.

prospect pits on the outcrop to get measured sections of the undisturbed coal and to determine its elevation or "lay" and the area under which it is present. Only in this way can sufficient information be obtained about thickness and quality of the coal, character of the roof and presence or absence of partings, the attitude of the coal bed, and the proper point of entry to secure drainage to enable the operator to economically develop his territory. If this is done serious mistakes may be avoided and the initial investment returned many times over. In case the coal in question is below drainage the prospecting will need to be done by drilling and is more expensive but is even more necessary than where the coal is known at the outcrop.

The most common rock overlying a coal bed is shale or sandstone or a rock intermediate in character between these two and known as sandy shale. In many places between the sandstone which forms the real roof of the mine and the coal is a so-called "draw slate" which is a shale that comes down when the coal is mined and has to be removed either by hauling to an outside shale dump or is dumped or "gobbed" as it is generally termed by the miners in a worked-out part of the mine. Coal beds in this field of over two or three feet in thickness are rarely clear coal without layers of shale or other material, and the character of these layers of impurities influences to a large extent the value of the bed. If the layer of impurity separates readily from the coal it is properly called a "parting," but if it does not it is known as a "binder." Thin partings or binders of less than three-eighths inch can rarely be removed from the coal in mining and increase the ash of the coal as loaded. Partings over three-eighths inch to several inches in thickness can be removed economically if they are fairly compact and separate readily from the coal. It is probable that in mining a bed of coal four or five feet thick, a compact parting of eight to ten inches of shale can be economically separated from the coal under the most favorable conditions. If, on the other hand, the parting is friable and breaks up as the coal is shot down it may be impossible to remove it at a reasonable cost and the result is a high-ash coal; or, if the ash is too high, it may be impracticable to market the coal at all. In large operations shale and other impurity can be removed by washing, but this requires a continuous supply of water and an expensive plant.

The under rock is most commonly clay of a light drab color, but not infrequently is shale and more rarely sandstone. In some cases the coal grades upward or downward into a carbonaceous shale, and in some places considerable lenses of "rash" or mixtures of coal and shale which have been

mashed and contorted are associated with the coal bed. Certain coal beds contain layers of "bone," which is a hard, tough, high-ash substance intermediate between coal and carbonaceous shale. There is a complete transition from coal through bony coal and bone to carbonaceous shale and the terms are not clearly defined nor used with much uniformity. The bone occurs in layers up to several inches in thickness and more commonly than otherwise is marketed with the coal. As much of it will burn fairly well and in small quantities merely adds slightly to the ash content of the coal, it is perhaps not economical in many cases to attempt its removal. Even where considerable of the thickness of the bed is bony coal and the ash content is high the coal as mined has found a ready market especially if the ash does not clinker excessively.

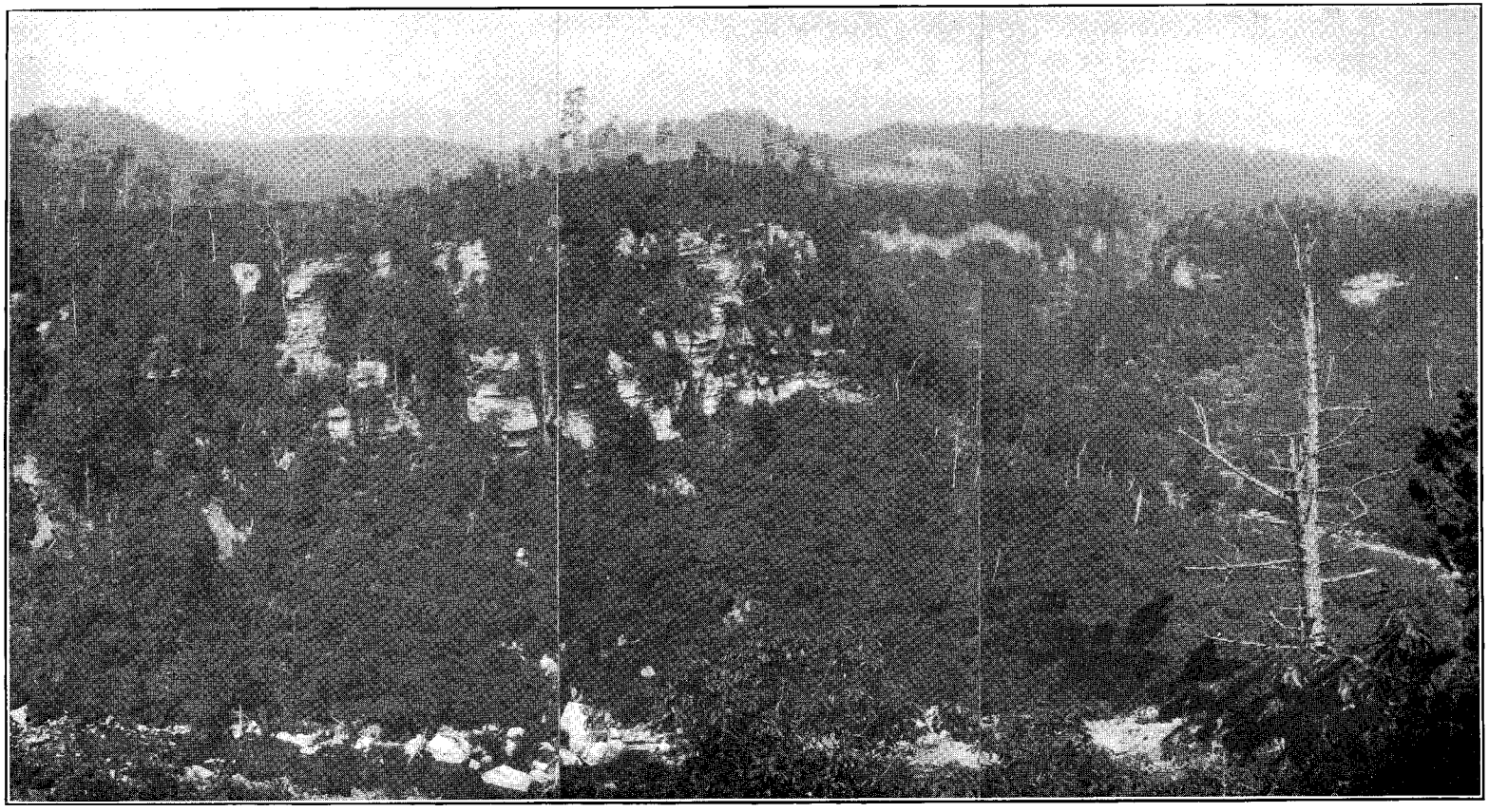
In the description of the individual beds which follows and the detailed descriptions by drainage basins the completeness of information obtained is very unequal in different parts of the Russell coal field. All the information that was obtained is presented concerning the localities where less mining and prospecting has been done, but where this is inadequate the probable condition and character of the coal must be inferred from those in the parts of the field where the coal is better known.

No coals of commercial importance in Russell County are known to occur in rocks lower than Pennsylvanian. The Pocono formation, in which the semi-bituminous coals of Pulaski and Montgomery counties are found, is not believed to be present in this field, or if its equivalent is present it contains no coal. The Pennington shale, which immediately underlies the Lee formation, contains at least one coal bed in the Big Stone Gap field,[1] which has been described by Campbell, but it has not, so far as known, been mined. The following description of coal beds is confined, therefore, to the Pennington and higher formations mainly in the Pennsylvanian series.

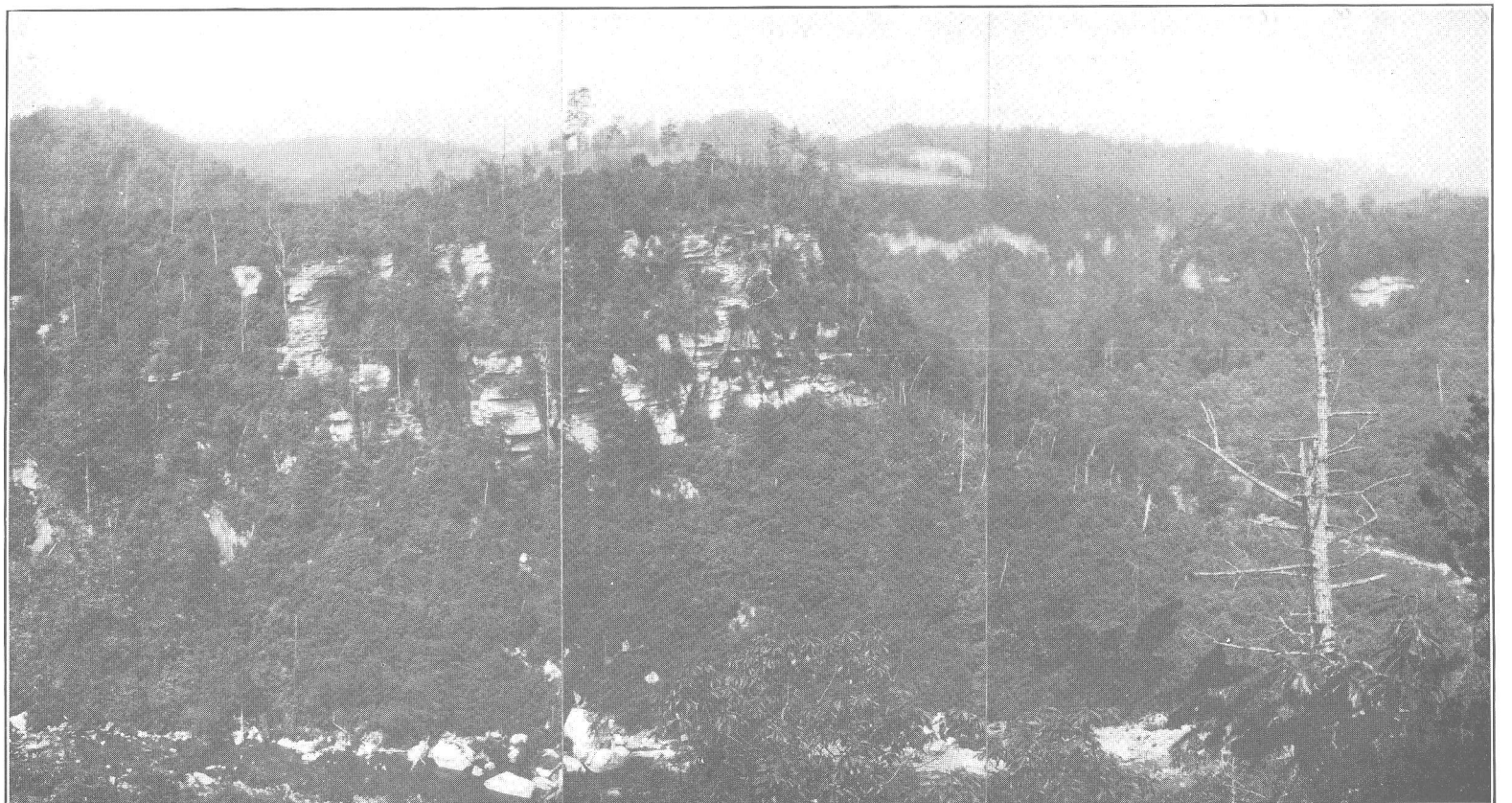
COAL BEDS IN THE PENNINGTON SHALE.

No coal beds of commercial importance are known in this county below the Newman limestone. The coal beds of Montgomery, Pulaski, and Wythe counties in the Price sandstone underlie the Newman limestone, but the Price sandstone is not present in Russell County and its possible representative, the Grainger formation, is not coal-bearing.

[1] Campbell, M. R., Geology of the Big Stone Gap coal field of Virginia and Kentucky: U. S. Geol. Survey Bull. 111, p. 39.



View looking west across gorge of Guest River ½ mile above its mouth, in Wise County. The massive sandstone which forms the cliff is the "Bee Rock" of the Lee formation. Above it in the background is the subdued topography of the less resistant shale and sandstone of the remnant of Norton formation which overlies the Lee in this vicinity. The beds here dip in general to the south on the south limb of the Powell Valley anticline and the Lee formation is deeply cut by Guest River which flows across the anticline from north to south.



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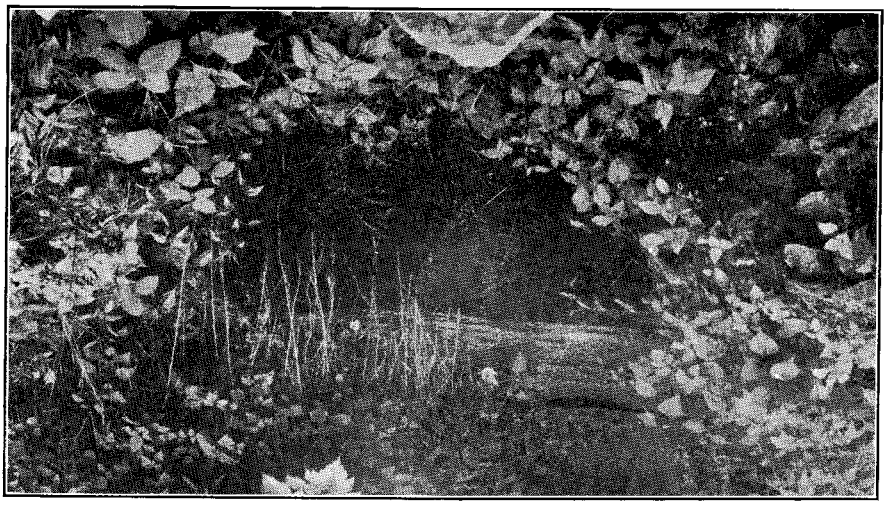
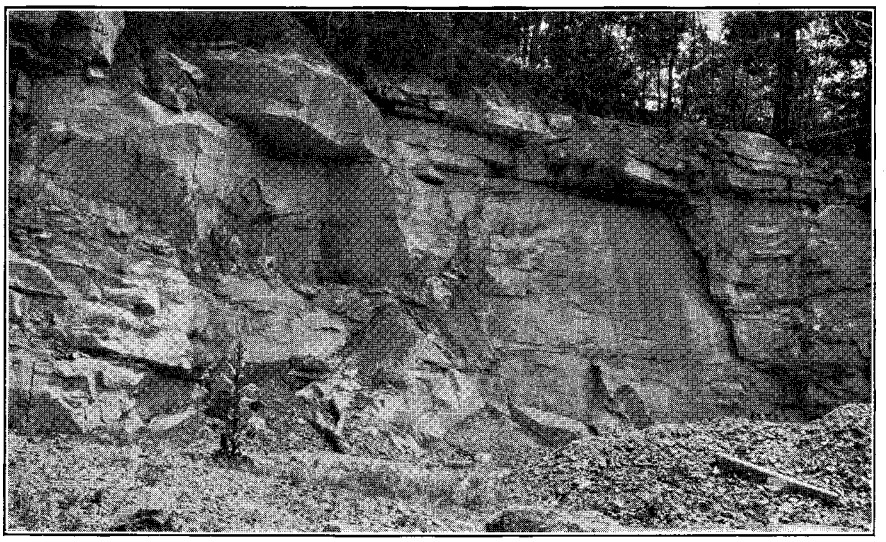
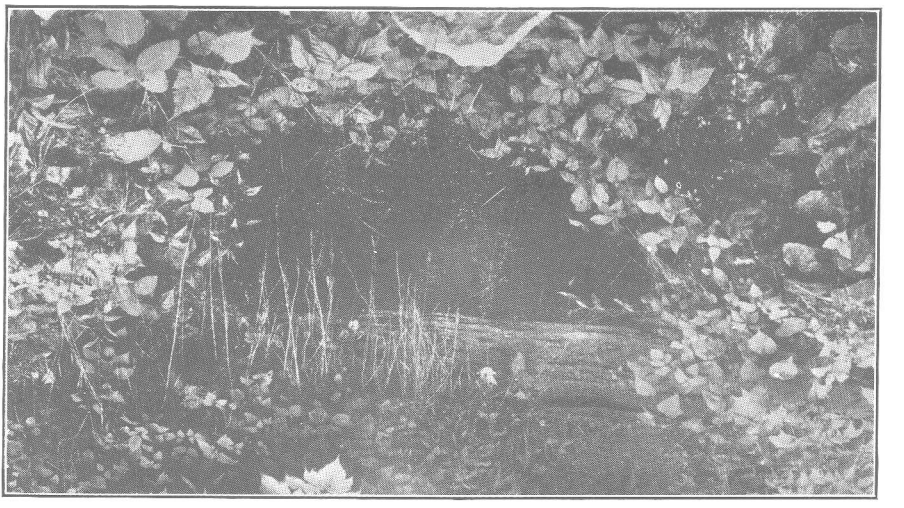


(A) View of old abandoned coal entry on Upper Banner coal bed overgrown with vegetation. Near Dante, Va.



(B) Quarry in massive sandstone of Norton formation, southeast of Coeburn in Wise County. The rock is very similar to that found in parts of the same formation in Russell County.



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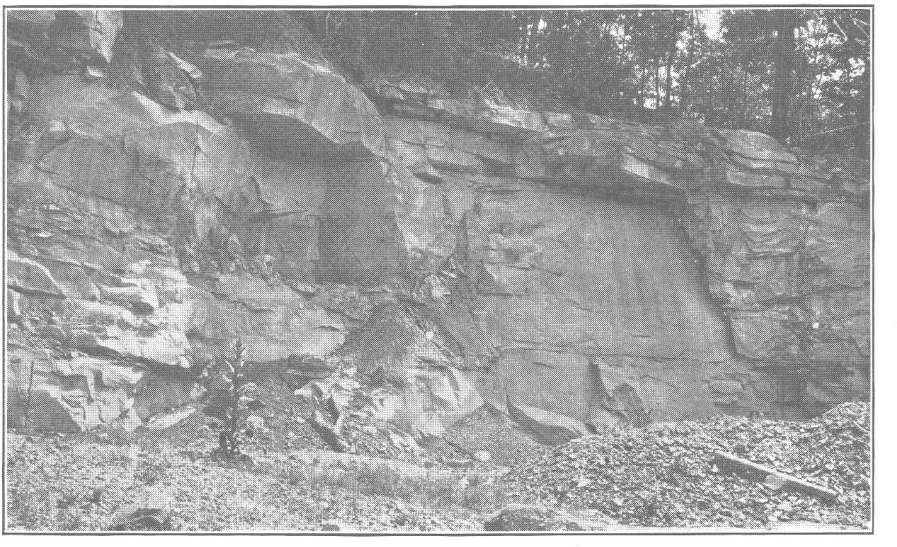


(B) Quarry in massive sandstone of Norton formation, southeast of Coeburn in Wise County. The rock is very similar to that found in parts of the same formation in Russell County.

The Pennington shale which overlies the Newman limestone contains an important coal bed near its top, generally within 20 feet of the conglomerate of the Lee formation, and another of unknown though probably little value near the middle of the formation. The higher coal is being mined on a commercial scale at Burton Ford in Russell County, and it has been prospected quite extensively farther west in Scott County.

COAL BEDS IN THE LEE FORMATION.

There are a number of thin coal beds in the Lee formation. Very few coal exposures were seen in the outcrop of Lee rocks in Russell County from Hamlin northeastward, and it seems unlikely there is any considerable amount of minable coal in them.

To the northeast, in Tazewell County, there are thick coal beds in the equivalent of the Lee formation, including the famous Pocahontas beds, but these are known to thin toward the southwest and it is doubtful if they are present in this field in workable thickness. Several coal beds in the Lee are of workable thickness in the western portion of Tazewell County, but many others which are of economic value in other parts of the county are here too thin to be of value.[1]

The prospect drill holes of the Clinchfield Coal Corporation have penetrated coal beds in the Lee formation at a number of localities in Russell County, but the thicknesses of these beds have not been made public. Coal was seen in outcrop at several other horizons in the formation in this part of Russell County, but none of the other beds is believed to be of commercial value at the present time.

In Wise, Lee, and Scott counties, Virginia, where the Lee is exposed in a large area, it contains a number of coal beds that are thin in most places and a few that are fairly thick in small districts. Thin coal beds are probably present in the Lee in other parts of Russell County. The Lee formation becomes more and more sandy and conglomeratic as it is followed from northeast to southwest along the border of the coal field, and at the same time the coal beds become thinner and thinner as their places are taken by the clastic rocks.

[1] Harnsberger, T. K., The geology and coal resources of the coal-bearing portion of Tazewell County, Virginia. Va. Geol. Survey Bull. XIX, pp. 28-33, 1919.

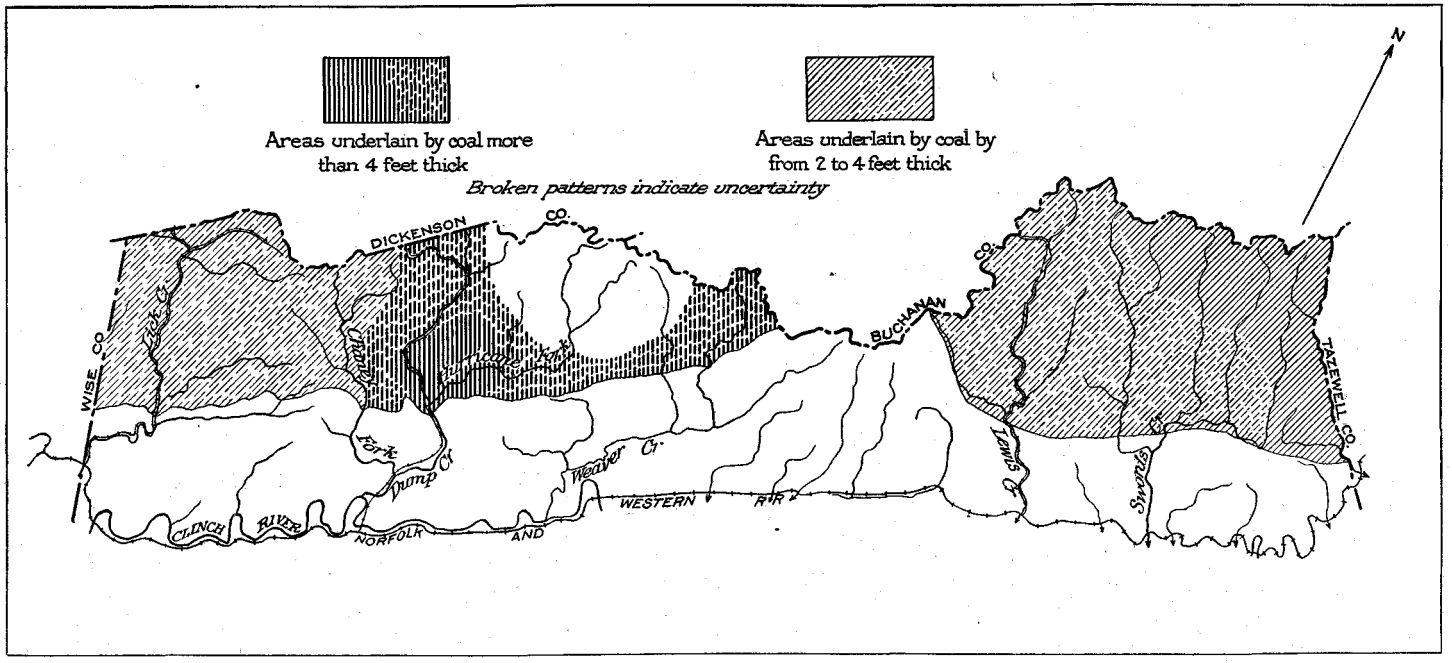


Fig. 5. Sketch map of Russell County coal field showing areal extent and thickness of Tiller coal bed.

COAL BEDS IN THE NORTON FORMATION.

TILLER COAL BED.

The lowest coal bed in the Norton formation of much commercial importance is the Tiller, which is 250 feet above the top of the Lee formation. The rocks in the interval between the Tiller and the top of the Lee formation are alternating shale and sandstone and a few thin coal beds with no striking characteristics, though an exceptionally coarse and locally conglomeratic sandstone lies a few feet below the coal. The name Tiller was applied by Stone in his report on the coal resources of the Russell Fork basin to a thick coal bed on Indian and Cane creeks. As the upper part of this thick bed is now known to be the equivalent of the Jawbone, the name Tiller is restricted in this report to the lower part.

The Tiller horizon is exposed only along a line just north of the Lee-Norton contact parallel with the border of the field where the rocks are overturned and dip at high angles.

Although the Tiller is concealed throughout much of the field it may be safely estimated from openings made on it at Clinchfield and near Hamlin that it is everywhere a minable bed containing five or six feet of coal from Big A Mountain southwest to Chaney Fork and thinning to two or three feet in the Lick Creek drainage basin. It will probably be mined on a large scale in the near future, and a beginning has already been made at the "slope mine" of the Clinchfield Coal Corporation on Hurricane Fork, at Clinchfield post-office.

In Dickenson County near Bucu and southeastward the Tiller is united with the overlying Jawbone coal to form a very thick bed which contains 7 to 15 feet of coal in parts of the Indian Creek drainage basin.

JAWBONE COAL BED.

The Jawbone coal bed commonly lies above a coarse, quartzose, locally conglomeratic sandstone that separates it from the Tiller bed, the interval between the two being 60 to 100 feet. The bed takes its name from Jawbone Hollow, a tributary of Bull Run between Virginia City and Banner, in Wise County, in the Bristol quadrangle. It has been called the Ratliff in private reports on the upper Levisa Fork drainage basin.

The Jawbone coal is exposed in a manner similar to the Tiller along the edge of the field and also near the mouths of Road and Hurricane Forks of Dump Creek and again near Grizzle on the latter Fork.

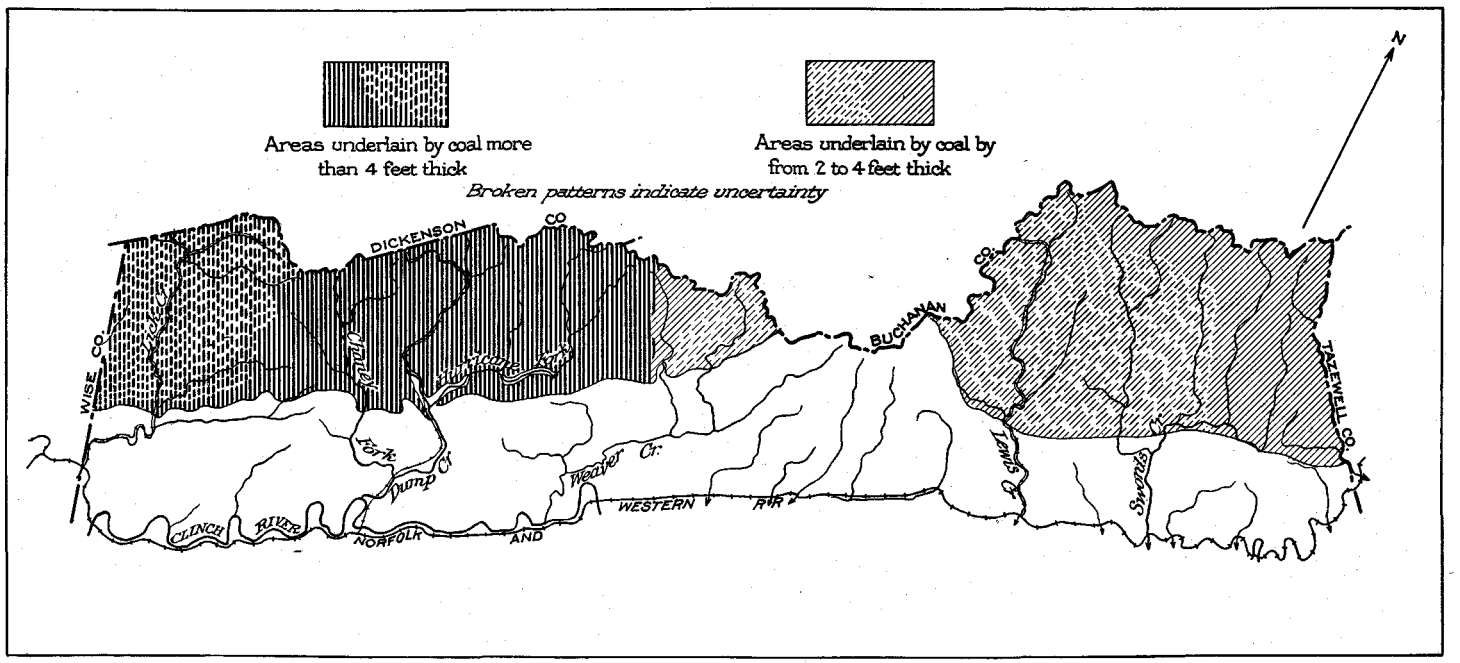


Fig. 6. Sketch map of Russell County coal field showing areal extent and thickness of Jawbone coal bed.

The Jawbone coal bed makes its best showing where it is united with the Tiller bed near Bucu as mentioned above. In its exposures on Hurricane Fork it is 3½ to 8 feet thick though somewhat impure. No thick coal was found at its horizon on Musick Creek. In the basins of Road and Chaney forks and Lick Creek the Jawbone coal is exposed at only a few places, but it is believed to be of commercial value throughout most of their extent.

No drill records are available for that part of the field east of Big A Mountain and nothing is known of its condition under that area. Near Richlands and Raven in Tazewell County it is nearly 6 feet thick and it is probable that it is workable throughout a part of the eastern section of the Russell County field, though data from the southern part of Buchanan County indicate that it thins to the west toward Big A Mountain.

RAVEN COAL BED.

The Raven coal is from 340 to 500 feet above the Lee formation and 140 to 230 feet above the Jawbone coal, the greater distances being toward the eastern end of the field adjacent to Tazewell County. It has been known as the Garden Hole bed by the prospectors of the Clinchfield Coal Corporation from exposures at the Garden Hole on Russell Fork, near The Breaks, and has been described under this name by Hinds[1] in his Clintwood-Bucu report. The bed is the same as the "so-called Imboden" of Campbell's reports on the Bristol quadrangle.

It is exposed on Cabin Fork of Musick Creek and in Hurricane Fork of Dump Creek. Its horizon is exposed westward from Grizzle to the junction of Road and Hurricane forks, but coal was not seen. It has been identified in many of the drill records and it is probably present as a coal bed varying from 20 inches to 3 or 4 feet in the remainder of the field. It is badly split by partings at many places, and is not likely to prove of commercial value except locally.

East of Big A Mountain the Raven coal bed is beneath the surface and no data concerning it are available. In adjacent parts of Tazewell County it has been extensively mined and sold under the trade name of "Red Ash" coal. It is there rather variable in thickness, averaging somewhat over 3 feet.

AILY(?) COAL BED.

In places there are several thin coal beds in the 200 feet of strata above the Raven coal. The most persistent of these has been described by Hinds

[1] Hinds, Henry, Coal resources of the Clintwood and Bucu quadrangles, Virginia. Va. Geol. Survey Bull. XII, pp. 46-47, 1912.

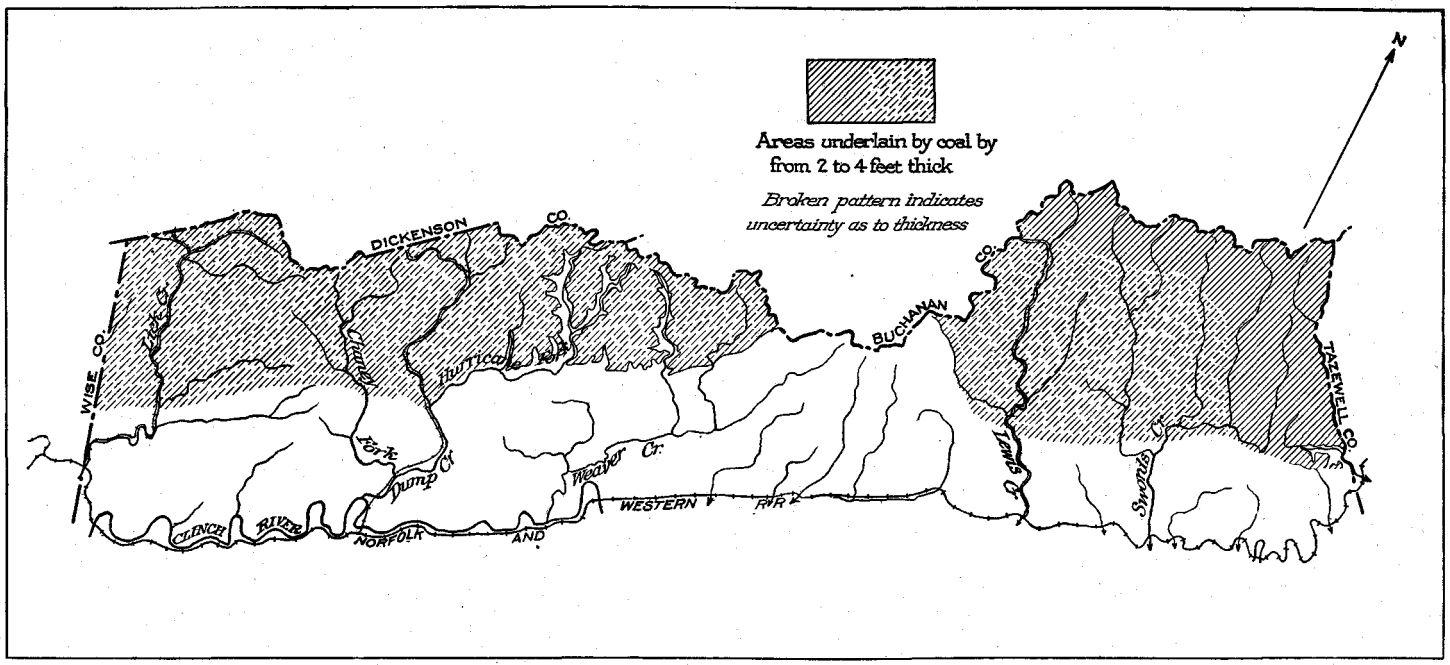


Fig. 7. Sketch map of Russell County coal field showing areal extent and thickness of Raven coal bed.

in the Clintwood-Bucu report as the Aily bed. In Russell County its horizon is rather widely exposed but little is known concerning the coal at the outcrop. At a number of localities from Big A Mountain west to Dante the drill records show a coal bed 120 to 130 feet above the Raven, which is probably the Aily, the distance being here somewhat less than the average given by Hinds. Harnsberger in his Tazewell County report gives the Aily coal as about 125 feet above the Raven, and it is probably to be found at about that position in Russell County east of Big A Mountain, though it has not been definitely located there. All the information available indicates that this coal bed is thin throughout most of the field and of commercial value at only a very few places.

KENNEDY COAL BED.

One of the best known coal beds in this field is the Widow Kennedy or Kennedy as it has been called in previous reports of this series. It lies from 600 to 770 feet above the top of the Lee formation and immediately above a massive, cliff-forming sandstone which is one of the best horizon markers in the Norton formation.

It has yielded considerable coal at shipping mines near Dante but is not now extensively mined there. East of Big A Mountain it is mined at a number of places near Drill and Della and near the mouth of Sulphur Spring Branch and there is increasing activity in its development in this part of the field where it is from 30 to 40 inches thick. In the western part of the field in the vicinity of Dante it varies in thickness from 20 inches to 6 or 7 feet or even more locally. Eastward toward Chaney Fork it thins and is probably less than 15 inches thick in the area between Road Fork and Hurricane Fork. Northward at Wilder and toward Big A Mountain it is somewhat thicker but is not of commercial value except locally.

In large areas in Dickenson County, in the western part of Russell County and beyond in Wise County, the Kennedy is notable for its crushed condition and variable thickness. At most of the localities where it is crushed the coal as mined is high in ash because of streaks of clay which can be removed with difficulty. Its variable thickness makes it rather hazardous mining at places where it has not been thoroughly prospected.

In the eastern section of the Russell coal field it is somewhat thinner than its best showing to the west, but it is more uniform in thickness and less crushed. The Kennedy is the most extensively exposed of all the coals in the field, being above drainage nearly everywhere but low enough to underlie considerable areas.

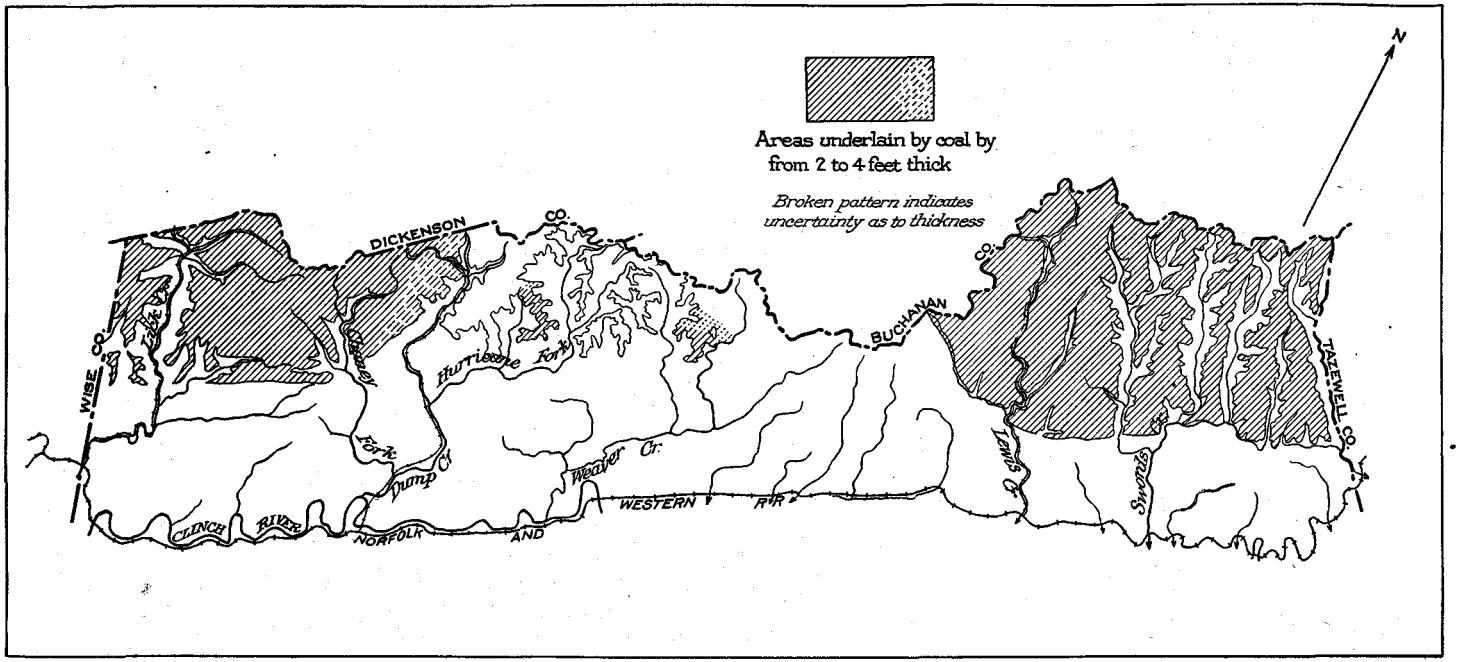


Fig. 8. Sketch map of Russell County coal field showing areal extent and thickness of Kennedy coal bed.

LOWER BANNER COAL BED.

About 175 to 300 feet above the Kennedy bed and 800 feet above the Lee formation is a coal bed which is widely known as the Lower Banner in the mining districts of this field. It was named from its type locality at Banner on the Norfolk & Western Railway east of Coeburn. This coal underlies some small areas on the interstream divides extending south from Sandy Ridge in the eastern part of the coal field and similar areas on Sandy Ridge westward from Big A Mountain. It underlies some broader areas between Chaney Fork and Lick Creek at the western end of the field.

It is from 3 to 5 feet thick throughout its entire area and is everywhere a minable bed of coal. In many localities it is particularly free from partings or binders. It has been and still is extensively mined at Wilder and at Dante.

UPPER BANNER COAL BED.

The Upper Banner coal is one of the best known and most important coal beds in southwest Virginia and is extensively mined at Wilder, Dante, Tom's Creek, and elsewhere. The bed is about 85 to 140 feet above the Lower Banner and 900 feet above the Lee formation. A prominent cliff-forming sandstone is about 20 feet above it at most localities. A persistent sandstone parting less than 2 inches thick in the upper half of the bed is present in an area of several hundred square miles and is one of the most valuable identification characters known in any coal bed in the field.

The Upper Banner coal is present in the higher areas on Sandy Ridge and in the vicinity of Dante and Wilder. In the eastern section of the coal field of Russell County it has not been identified with certainty and it is probably very thin if present at all in most of the area. In the Dante and Wilder localities the Upper Banner is extensively mined and is 4 to 6 feet thick throughout nearly, if not quite, all the area it underlies.

SPLASH DAM COAL BED.

The Splash Dam coal bed is so called from its type locality at the splash dam just north of the mouth of Pound River on Russell Fork. It is about 960 to 1,000 feet above the Lee. It lies just above the sandstone cap rock of the Upper Banner and is probably to be correlated with the "Black slate" bed so called which is about 60 feet above the Upper Banner in the vicinity of Dante.

The Splash Dam bed is of commercial value only in very limited areas on Sandy Ridge east of Big A Mountain in Russell County and possibly in

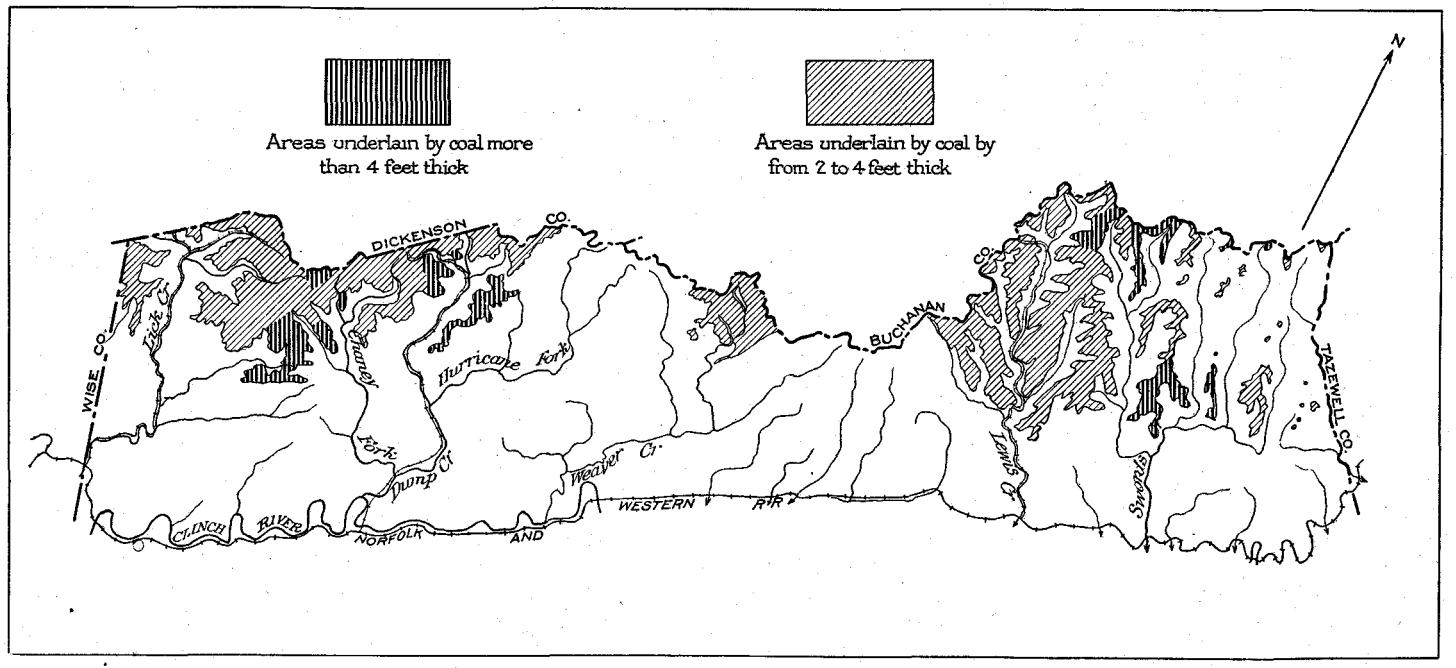


Fig. 9. Sketch map of Russell County coal field showing areal extent and thickness of Lower Banner coal bed.

a few small areas west of Big A Mountain on the same ridge. It is from 2 to 3 feet thick in these areas but has not been thoroughly prospected and is not well known.

COAL BEDS IN THE WISE FORMATION.

GLAMORGAN COAL BED.

The Glamorgan coal bed, so named from the type locality at Glamorgan in Wise County, underlies small areas on the higher parts of Sandy Ridge north of Dante. It is here split into three benches of less than a foot each of coal separated by thick clay beds and is not of commercial value.

DETAILED DESCRIPTION OF COAL BEDS.

GENERAL STATEMENT.

In this region of considerable relief and mature topography the natural units are drainage basins. Railroads generally follow the streams and coal development will be planned with reference to the different valleys. The detailed description of the coal beds is therefore arranged by drainage basins. Each coal bed is described separately beginning with the lowest, the locations and descriptions following along the outcrop on one side of the valley to the head and then back along the other.

Each coal exposure, mine entry or drill hole represented on the map is assigned a number, and similar numbers are given on the sections of the coal beds. The numbers run from west to east across the map and are assigned in the order in which they are mentioned in the text. Drill holes of the Clinchfield Coal Corporation are indicated by a circle on the map but are given numbers in the same series with the other location numbers. A table of the equivalent location number for each Clinchfield Coal Corporation number and vice versa may be found on page 82. When not otherwise stated the sections were measured by the writer or those associated with him.

Some of the elevations are from outcrop maps furnished by the coal companies; others were determined with somewhat less accuracy by aneroid barometer.

Many of the coal measurements given in the text are shown graphically also. Numbers on the right side of these graphic sections indicate the thickness in inches of the layers of coal; those on the left side, the partings or binders that would be excluded in mining.

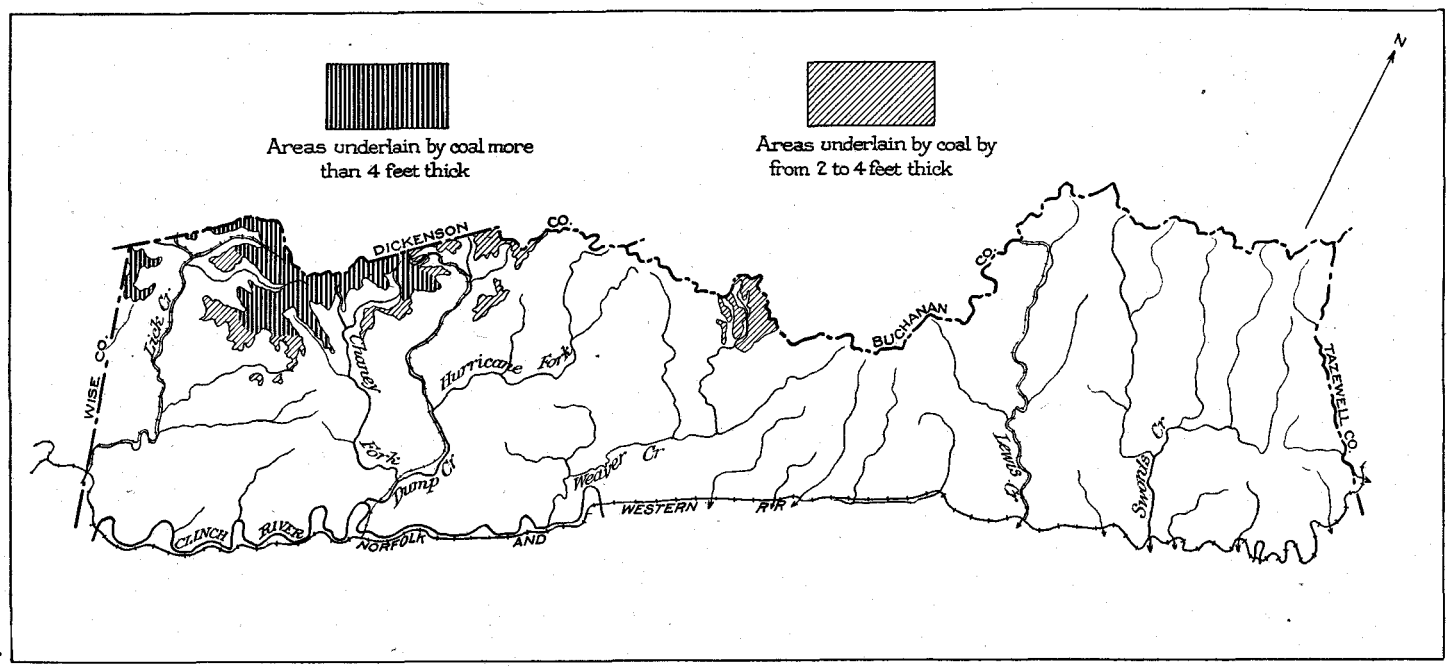


Fig. 10. Sketch map of Russell County coal field showing areal extent and thickness of Upper Banner coal bed.

BURTON FORD DISTRICT.

General features.—Clinch River encroaches on the coal fields at two places only in southwest Virginia. At one of these places just west of St. Paul the river swings north and on the inside of the curve isolates a very small area of the Pennington shale, a few acres at most. Farther southwest near Burton Ford it again swings north and invades the coal field for a distance of five or six miles until it crosses the Scott County line at Bangor Station. The small area bounded by Clinch River on the northeast and northwest, by the Scott County line on the southwest and by the Hunter Valley fault and the limestone country to the southeast lies within Russell County and is here described as the Burton Ford District.

The structure of this portion of the coal field is shown in the section at the bottom of Pl. XXVIII. There is only a very small band of horizontal coal measures along the northwest edge of the district and the remainder are sharply overturned.

The resistant "Bee Rock" at the top of the Lee formation forms a conspicuous line of crags from the high point just southwest of B. M. 1,605 feet southwest first one side and then the other of the river and passing into Scott County a quarter of a mile southeast of B. M. 1,409 feet. This resistant rock is cut three times by the entrenched meanders of Clinch River and the view of these features from the high point about three-quarters of a mile N. 70° E. of Blue Grass triangulation station is a most inspiring one to the student of geologic processes. The hard basal member of the Lee, conglomerate like the "Bee Rock," forms a second high crest which includes the high point just mentioned and the Blue Grass triangulation station. To the southeast of this ridge are two more parallel ridges, the positions of which are determined by two quartzitic members of the underlying Pennington shale.

Coal has been found at a number of localities in this district as described below. All the strata including the coal show evidence of intense deformation and the weaker rocks are crushed and foliated. In regions where intense folding has taken place the coal beds especially suffer and are frequently doubled up and pinched out and this variable character of the coal makes mining very expensive. Actual mining operations in such areas should be preceded by careful prospecting and plants and workings developed with great caution to avoid heavy loss if coal disappears or is found to entail too great expense in mining.

The lowest coal stratigraphically in this district lies just under the resistant conglomerate at the base of the Lee formation. Farther west in Big

Stone Gap, Campbell[1] found a coal bed a few feet below red shale beds which mark the top of the Pennington formation, and the writer has recently found a coal bed about 400 feet below the top of that formation. The question of the position and character of these coal beds will probably be discussed in more detail in a subsequent report.

This coal is being mined at the present time at Burton Ford by the Russell Fork Coal Mining Co. in a slope mine (location 1). The coal at the present working face is from 5 feet to 6 feet 8 inches thick. The roof is clay or shale and the floor is commonly hard sandstone and this condition and others indicate that the coal bed is overturned. In at least three places the workings have run into a thick body of clear coal which measures from 12 to 17 feet between floor and roof. This thickness is the result of folding and doubling up of the bed and the structure of the coal which has produced this thickness can be clearly seen at certain places. The bed has this great thickness only in a small area and is very sharply pinched to very slight thicknesses at those places where entries have traversed it.

The following sections were measured in this mine where the coal dips S. 20° E. at about 15° to 20°.

Sections of Burton Ford coal bed in Burton Ford mine of Russell Fork Coal Mining Co.

(Location 1, elevation of entry 1,480 feet)

Section A measured on rib at entry.

	Ft.	in.
Clay		
Coal	2	7
Clay		
Coal	2	7

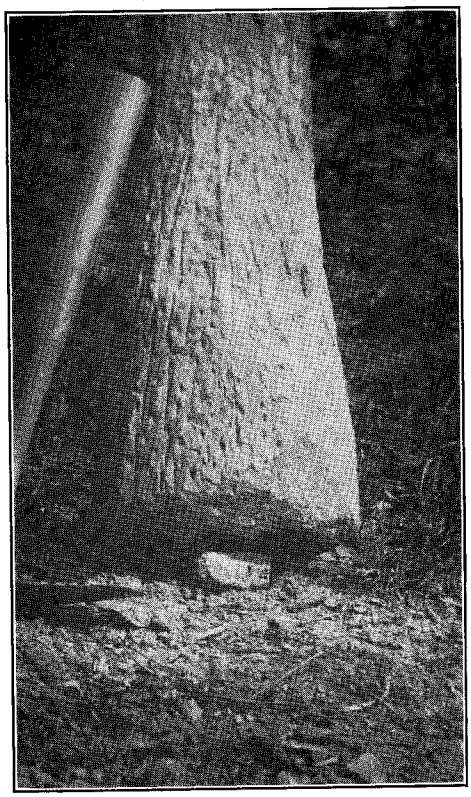
Section B measured on rib 50 feet from entry.

	Ft.	in.
Clay		
Coal		7
Shale		½
Coal	1	10
Shale		1
Coal		1
Shale		1
Coal		1
Shale		
Coal	2	7
Partings		2½

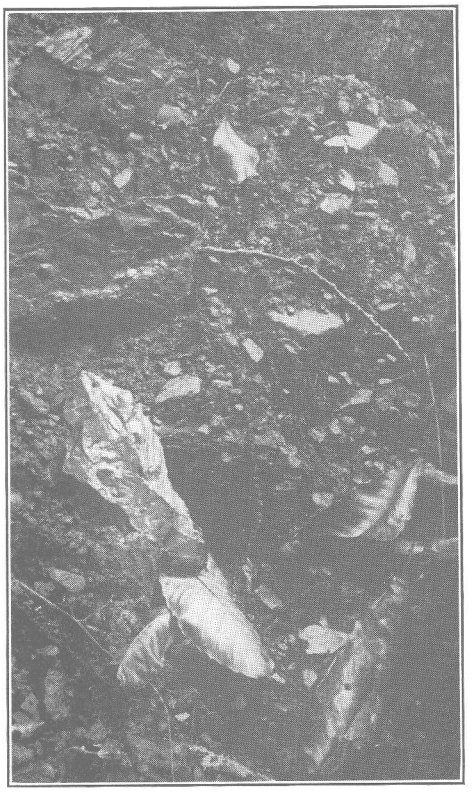
The sections given above are of essentially undisturbed coal and are believed to represent the original bed.

[1] Campbell, M. R., Geology of the Big Stone Gap coal field of Virginia and Kentucky: U. S. Geol. Survey Bull. 111, 1893.

(A) In the foreground of this picture are chestnut, oak and beech leaves from trees of the present forest. On the shale blocks in the upper left corner of the picture are the impressions of leaves (Neuropteris) of the Pennsylvanian forests from the trees of which the coal was derived. Head of Black Creek in Wise County.



(B) Sandstone cast of Pennsylvanian tree trunk east of Cane Patch Creek in Wise County.



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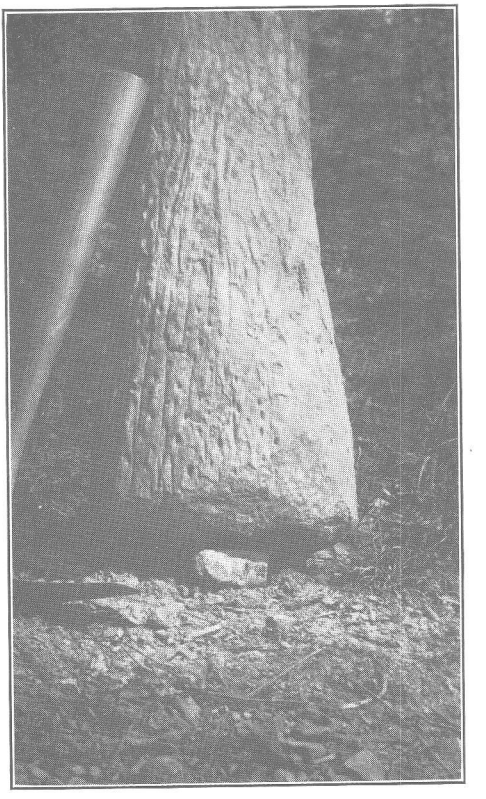

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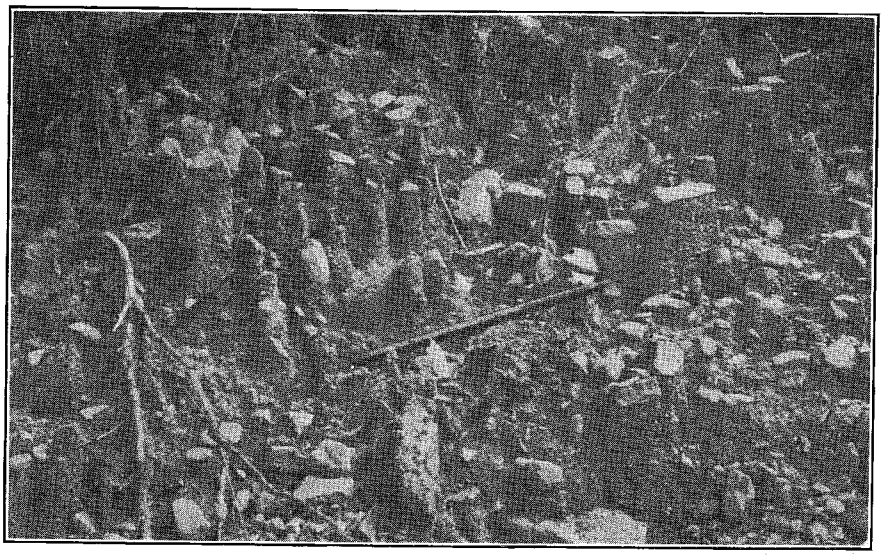
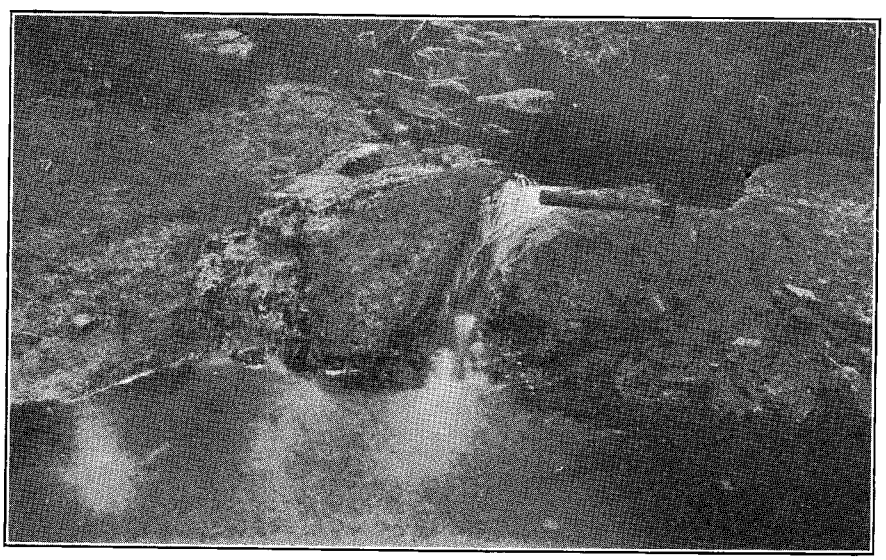
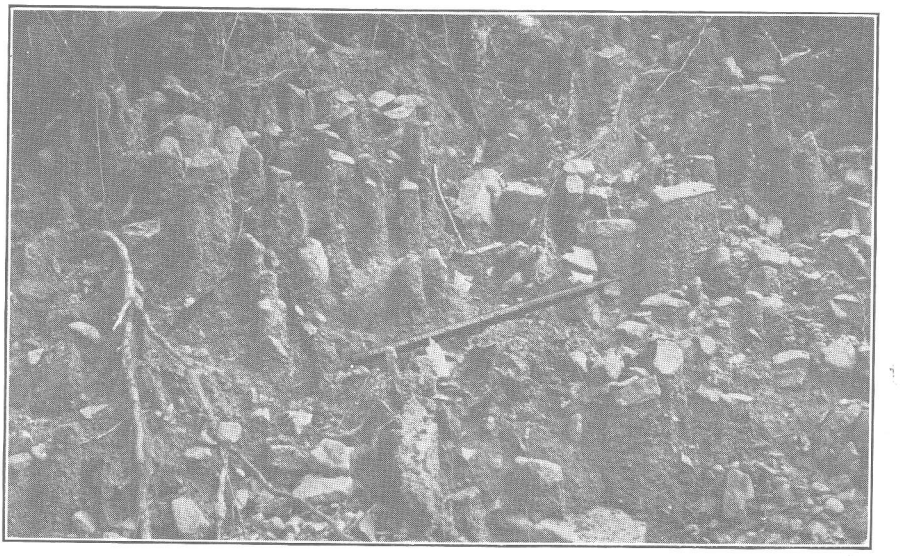


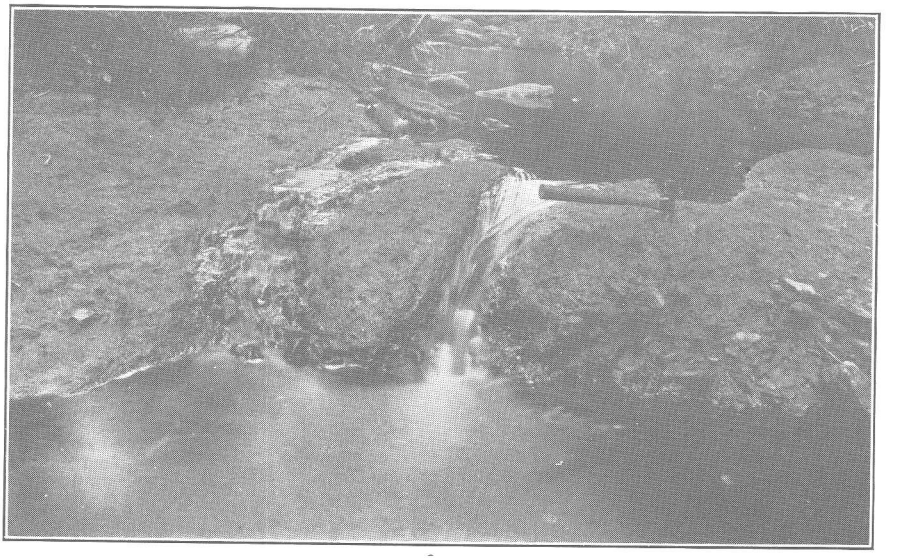
(A) Detail view of portion of roadside cut in Wise County near Lipps showing soil composed of clay and sand with bits of shale and sandstone. Falling rain has formed erosion columns each of which is capped and has its form determined by a protecting bit of rock.



(B) Low water fall over comparatively resistant stratum of recent pebbly clay. Russell Creek, north of Virginia City.



(A) Detail view of portion of roadside cut in Wise County near Lipps showing soil composed of clay and sand with bits of shale and sandstone. Falling rain has formed erosion columns each of which is capped and has its form determined by a protecting bit of rock.



(B) Low water fall over comparatively resistant stratum of recent pebbly clay. Russell Creek, north of Virginia City.

Section of Burton Ford coal bed in Burton Ford mine of Russell Fork Coal Mining Company.

Section at face of room near main entry.

	Ft.	in.
Clay		
Coal	5	6
Sandstone		
Coal	5	6

Section at face, main entry.

	Ft.	in.
Clay		
Coal	6	6
Sandstone		
Coal	6	6

In an old air-course coal was found measuring 12 to 14 feet thick but the thickness of the bed is extremely variable. An analysis of coal (No. 32513) from this mine, where the bed measures 2 feet 11 inches thick (Pl. XXVI), is given on page 105.

One-half mile southeast of the west portal of the Carolina, Clinchfield, and Ohio tunnel at location 2 this coal is 3 feet 6 inches thick; at location 3 a little farther southwest it is 3 feet 1 inch thick. At these points the dip is variable, averaging 45° about S. 20° E. In Scott County southeast of Bangor this bed measures about 2 feet in thickness. It is believed to have an average thickness of not more than 3 feet, perhaps less. Greater thicknesses resulting from folding and faulting have been produced at the expense of continuity and the coal is probably everywhere variable and much broken.

Coal was seen at several other horizons in this area but outcrops have not been correlated. At location 4 a coal bed measuring 19 inches in thickness is exposed and at location 5 coal is exposed in two benches: an upper of 12 inches and a lower of 22 inches with 20 inches of shale between. Both of these dip to the southeast at high angles.

At location 6, 4 feet of coal is reported at a horizon about 150 feet below the top of the Lee. This thickness is probably local only for this horizon is widely exposed in the gorge of Clinch River and no evidence of a coal bed of such thickness was seen.

South of Carfax station (location 7) on the hillside an opening has been made on a coal bed reported on reliable authority to be 14 feet in thickness. This is probably the Jawbone coal which is mined by the Virginia Iron, Coal & Coke Co. across the river at Shannon. The opening is very close to the line of overturn and the coal is believed to be abnormally thick at this place and not to average more than 5 or 6 feet elsewhere. The Jawbone is practically horizontal here but the area under which it is horizontal is very small and will hardly warrant extensive operations.

Just west of St. Paul, where a very small area of Lee formation is present on the south side of Clinch River, an opening has been made on a coal bed in the Pennington shale about 20 feet above the river. No measurement was obtained at this place but a bed which appears to be the same is about 14 inches thick across the river in Wise County.

LICK CREEK BASIN.[1]

General features.—This basin extends from the Wise County line east to the divide between Lick Creek and Chaney Fork and north to the Russell County line at the heads of the three forks of Lick Creek. It includes all the drainage basin of Lick Creek and its branches which is north of the boundary of the coal field. A small part of it lies in Wise County but only the Russell County part will be described here. All the strata of the Norton formation outcrop in the basin and openings have been made on the Upper and Lower Banner, Kennedy, Jawbone, and Tiller coal beds.

The east-west axis of the Powell Valley anticline crosses Lick Creek about one mile south of Dante and beds dip gently to the north and south from it as well as to the east along its inclined axis east of Lick Creek. At the head of Hamlin branch in a basin-like syncline the strata are lower than corresponding beds in any other parts of the county except in a small area just west of Big A Mountain.

Coal beds in the Pennington shale.—In the bank of the stream southeast of the railroad bridge and nearly level with it at location 29 three-fourths of a mile north of Boody a small prospect shows 14 inches of coal, near the top of the Pennington shale. The coal dips at an angle of about 30 degrees and is crushed and offset by small faults. It is overlain by standstone and underlain by gray shale.

At locality 30, about one-half mile northeast of locality 29, a recent prospect shows only 5 inches of coal at about the same horizon in the Pennington formation as the opening mentioned above. At location 31 at an elevation of 1,550 feet a local mine has been opened. The coal on the outcrop appeared to be nearly 7 feet thick but on driving the entry a few feet into the hillside the coal disappeared. A close examination shows that the thickness which first attracted the prospector is a result of the coal being doubled back on itself, the normal thickness of the bed being 3 feet or less. Of this doubled back coal only 10 or 15 feet is left by erosion. The strata

[1] Locations 8-28 inclusive are prospect holes of the Clinchfield Coal Corporation. See table on page 82.

here dip 40° S. 25° E. and the overlying and underlying beds being in reality the same bed are sandstone. This coal is approximately at the same horizon in the Pennington formation as the coal of location 29.

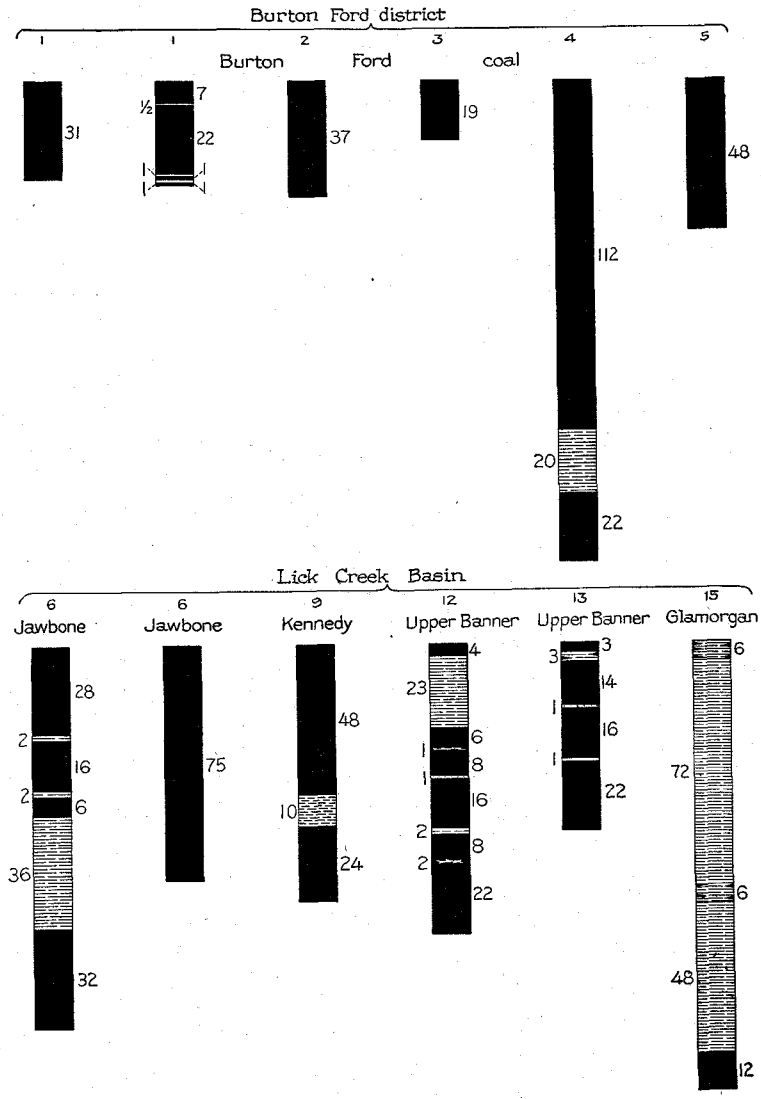


Fig. 11. Sections of coal beds in the Burton Ford district and the Lick Creek basin.

Coal beds in the Lee formation.—The horizontal portion of the Lee formation is nowhere exposed in the basin of Lick Creek but its entire thickness is traversed by Lick Creek above Hamlin, where it is sharply overturned.

Coal beds in the Norton formation.—Two, and in some localities three, coal beds in the Norton formation at horizons 50 to 100 feet above the top of the "Bee Rock" and about 500 feet below drainage, have been penetrated in one or more of the holes drilled by the Clinchfield Coal Corporation. Thicknesses of these beds have not been made public but no beds of workable thickness are known in this part of the formation where it is exposed at the surface. Above these coal beds is about 100 feet of sandy shale followed by 20 to 30 feet of sandstone. At the top of the sandstone, as shown by the drill, is one, and in some places two, coal beds, 10 to 20 feet apart, followed by 40 or 50 feet of shale and sandy shale below the Tiller horizon.

Tiller coal bed.—The Tiller coal bed is about 250 feet above the top of the Lee formation and is below drainage throughout the entire basin except where it is upturned at the edge of the coal field. At location 32 about one-half mile north of Hamlin the Tiller coal bed has recently been opened by the Litton Coal Co. At this place it appears to be clear and of good quality. It is overturned and dips to the southeast at an angle of about 16 degrees. It shows here the following section:

Section of the Tiller coal bed one-half mile north of Hamlin.

(Location 32, elevation 1,660 feet)

	Ft.	in.
Shale		
Coal	2	5
Shale		8
Coal	3	1
Shale		
Coal	5	6
Parting		8

This coal bed has not been identified with certainty at the surface at any other locality in the basin of Lick Creek. It was penetrated by the drill 265 feet below the surface at location 9 and at Dante was identified in drill holes about 300 feet below the surface. Between the Tiller and Jawbone beds is 70 to 90 feet of sandstone which in some localities is slightly more shaly and clayey toward the top.

Jawbone coal bed.—The Jawbone coal, like the Tiller bed below it, is below water level in the drainage basin of Lick Creek except as it is brought

to the surface in the overturned fold at the edge of the field. It has been mined at several places near Hamlin, but is known only in core-drill sections elsewhere in this basin.

At location 33 one-half mile north of Hamlin in the mine of the Hamlin Coal Co. the Jawbone bed ranges from 4 to 8 feet in thickness. About one hundred feet from the mouth of the entry two coal beds come together to make the maximum thickness mentioned above. The coal bed is overturned and dips southeast at an angle of about 40 degrees. It is possible that the upper bed of the two is the Tiller but the writer is inclined to think not, as the Tiller is separated from the Jawbone by a thickness of at least 70 feet of sandstone and shale at location 34 only a few rods west on the other side of Lick Creek. It is more probable that these two beds are the Jawbone and an unnamed coal bed which lies just above it in the drill holes described below.

About 200 feet northwest of the entry which has recently been driven on the Tiller bed by the Litton Coal Co. at location 34 is the entry to a mine on the Jawbone bed which is operated by the same company. The section measured here is as follows (Fig. 11, No. 6):

Section of the Jawbone coal bed one-half mile north of Hamlin.

(Location 34, elevation 1,660 feet at mouth of entry)

	Ft.	in.
Shale		
Coal	2	4
Shale		2
Coal	1	4
Shale		2
Coal		6
Shale	3	0
Coal	2	8
Clay		
Coal	6	10
Partings	3	4

(Section in the main entry one hundred feet from the mouth of the mine.)

Shale, carbonaceous		
Coal	6	3
Clay		
Coal	6	3

The coal in this mine is crushed and variable in thickness showing the result of intense deformation. The bed is overturned and what is now the top was the base when it was formed. Mining operations are more expensive in coal beds which dip at high angles as entries must be driven along

the strike and rooms driven up the rise of the coal bed. These methods are followed in much of the anthracite mining in the United States but a very small part of the bituminous coal mined in this country is produced from beds having any considerable dip. Mines in steeply dipping coal will hardly be able to compete on a large scale, especially when there is much coal in nearly horizontal beds nearby, though they may of course be able to produce small quantities for local use at a profit.

The Jawbone coal bed has been identified in every drill hole which has penetrated its horizon in this drainage basin but the thicknesses have not been made public. Judging from its thickness and quality east of this basin near Clinchfield and west in the vicinity of St. Paul and beyond at Virginia City it is believed to be a valuable coal bed of an average thickness of at least 4 feet and probably of workable thickness throughout the entire basin. Where it is best known it is rather high in ash as shown by analyses (pp. 106-107) and it probably has that character under this basin. Owing to the greater expense of mining coal, which is below drainage and which must be reached by a shaft or slope, this coal is not likely to be extensively mined until production from the most accessible coal beds above drainage has declined to a considerable extent but the coal ultimately available in this bed, because of its unbroken extent under the whole basin is much greater in amount than that of any other bed.

Above the Jawbone coal and separated from it by from 20 to 40 feet of sandstone and sandy shale is a persistent bed of coal which is shown in the record of every drill hole which reaches its horizon. It has not, however, been identified at the outcrop in Russell County. This coal bed appears to extend into Wise County, for a short distance west in Wise County on the left fork of Lick Creek there are two coal beds mined which are about 30 feet apart and which are probably the Jawbone and the overlying bed mentioned above. The lower of these, stratigraphically (actually the higher in these overturned beds) is probably the Jawbone coal, the other may be the coal in question which is above the Jawbone in the drill holes. The opening on this coal was caved when visited by the writer but appearances on the outcrop indicated a coal bed 3 or 4 feet in thickness. It is impossible, on account of lack of data, to estimate its thickness or quality in the Lick Creek basin.

Above the coal last mentioned is 60 to 70 feet of sandy shale followed by about 70 feet of sandstone. Directly upon the sandstone or at some places separated from it by 10 or 15 feet of shale or sandy shale is the Raven coal bed. In the strata between the previously mentioned coal and the Raven

coal only one drill section has shown coal and no persistent bed has been seen at the outcrop. It is certain therefore that in the Lick Creek drainage basin there is no coal of sufficient extent to be commercially important in this part of the Norton formation.

Raven coal bed.—In the report by Hinds on the Clintwood and Bucu quadrangles this coal bed was described under the name of Garden Hole coal, but as it has long been known in Tazewell County as the Raven bed the latter name is used here. It is 160 to 180 feet above the Jawbone coal bed and about 500 feet above the top of the Lee formation. This coal bed is identified in most of the drill holes in the upper portion of the Lick Creek basin and a bed which is referred to this horizon with some hesitancy is to be seen at two local mines as described below.

At location 35 about 1¼ miles north of Hamlin the following section was measured:

Section of the Raven(?) coal bed one and one-fourth miles north of Hamlin.

(Location 35, elevation 1,750 feet)

	Ft.	in.
Shale		
Shale, carbonaceous		6
Coal	2	10
Clay		
Coal	2	10

A short distance north of the mouth of Granny Branch at location 36 in the caved entry to a local mine this bed shows the following section:

Section of the Raven(?) coal bed north of mouth of Granny Branch.

(Location 36, elevation 1,730 feet)

	Ft.	in.
Sandstone		
Shale, carbonaceous	1	3
Coal	1	6+
Concealed		
Coal	1	6+

From what is known of the Raven coal bed on Hurricane fork of Dumps Creek and at the two localities mentioned above it is not believed to average more than 18 to 20 inches in thickness throughout most of the basin of Lick Creek and therefore is of little present commercial value.

Above the Raven coal bed the section is variable, the rocks being sandstone in some places and largely shale in others. About 70 feet above the

Raven bed, as shown in several of the drill sections, is a coal bed which is probably the Aily coal as described by Hinds. It is exposed at several places in the Lick Creek basin and is everywhere thin and not of commercial value at the present time.

In a rock cut on the Carolina, Clinchfield and Ohio Railroad half a mile west of Dante, it shows the following section:

Section of Aily (?) coal bed one-half mile west of Dante (see Pl. XXVI).

(Location 37, elevation 1.810 feet.)

	Ft.	in.
Sandstone		
Shale, carbonaceous		6
Coal	1	2
Bone		1
Clay		
Coal	1	2

A sample of this coal (No. 32454) taken at location 37 and analyzed by the Bureau of Mines shows a remarkably low ash content and good fuel value, considering that it was taken from an exposure which has been open to the weather for several years. Above the Aily(?) coal is a massive, resistant sandstone which underlies the Kennedy coal bed. It ranges from 120 to 150 feet in thickness and is an important key rock.

Kennedy coal bed.—The Kennedy coal bed is about 770 feet above the top of the Lee formation in this part of the field. It outcrops well up on the hill slopes in the lower part of the Lick Creek basin and in the stream channels toward their heads to the west and north of Dante. It is from 1 to 12 feet thick and is very variable in thickness even in the short distance of a few rods. The bed contains on an average probably four or five feet of minable coal in the western part of the Lick Creek basin. It is known to be thinner toward the east though it is probably thick enough to be of commercial value throughout the entire basin. At location 38 in the mine of the Laurel Branch Coal Co. it shows the following sections:

Sections of Kennedy coal bed in mine of the Laurel Branch Coal Co.

(Location 38, elevation 1,930 feet)

Section at mouth of mine (see Pl. XXVI).

	Ft.	in.
Sandstone		
Coal	5	4
Clay		
Coal	5	4

Section in main entry 50 feet from the mouth of mine.

	Ft.	in.
Sandstone		
Coal	1	0
Clay	1	8
Coal	1	8
Coal	2	8
Parting	1	8

It is very variable in this mine and there are in it many lenses of clay which change from foot to foot of the section. The coal is much mashed and broken with numerous slip surfaces and does not show the columnar structure characteristic of much of the coal of this field. The Kennedy bed carries a high percentage of ash at this locality though the sample (No. 32453) which was taken here may have given a result slightly higher than normal because the mine had not been worked for some months when visited and it was not practicable to get entirely fresh coal for the sample.

The Kennedy bed was formerly mined at several places in the vicinity of Dante but has not been mined there recently. Its variable character and high-ash content make it a less attractive mining proposition than some of the other coal beds, though here, as in other localities, it was one of the first coals to be mined. On the north side of the right fork of Lick Creek the following section of the Kennedy bed was measured (Fig. 11, No. 9):

Section of Kennedy coal bed on Right Fork of Lick Creek.

(Location 39, elevation 2,020 feet)

	Ft.	in.
Sandstone		
Coal	4	0
Clay		10
Coal	2	
Clay		
Coal	6	0
Parting		10

Above the Kennedy coal bed the Norton formation is composed of 40 or 50 feet of sandstone followed by about 100 feet of shale. Above the shale is 50 feet of sandstone immediately below the Lower Banner coal bed.

Lower Banner coal bed.—The Lower Banner coal lies about 200 feet above the Kennedy bed and outcrops well toward the heads of the tributaries of Lick Creek. It underlies the high ridges on either side of Lick Creek as far as about 1½ miles south of Dante and farther east it underlies the divide between the Lick Creek basin and the Chaney Fork basin southward nearly to the border of the coal field. It is generally 3 to 4 feet thick in this basin but in places may exceed this thickness. On the west side of Middle Fork of Lick Creek just over the line in Dickenson County the following section was measured:

Section of Lower Banner coal bed on west side of Middle Fork of Lick Creek in Dickenson County.

	Ft.	in.
Clay		
Coal	4	1
Shale		3
Coal		3
Coal	4	4
Parting		3

East and south of Dante this bed is poorly exposed and sections were rarely obtainable. At location 40 in Mine No. 52 of the Clinchfield Coal Corporation the bed shows this section:

Section of Lower Banner coal bed in Mine 52 of the Clinchfield Coal Corporation.

(Location 40, elevation 2,192 feet)

(Analyses 32329, 32330 and 32331, p. 111)

	Ft.	in.
Shale, black		
Coal	4	8
Clay		
Coal	4	8

For analyses see page 111, for description see pp. 120-121, and for graphic section see Pl. XXVI.

At the time of the writer's visit in 1919 the daily output of coal from this mine was about 350 tons. Two samples taken in it by the writer were analyzed by the Bureau of Mines. The analyses of these (Nos. 32329 and 32330) and samples taken by Harnsberger and others given in the table on pages 110 and 111 show the excellent and uniform quality of this coal.

Below is a section measured in Mine No. 52 in connection with sample 4057 taken previous to the writer's visit:

Section of Lower Banner coal bed in Room 4, off left entry.

	Ft.	in.
Shale		
Coal	1	7
Coal, laminated		3
Coal, solid	1	5
Clay [a]		6
Coal [a]		2
Coal sampled	3	3

[a] Excluded. Analysis given on p. 110, description on p. 120, and graphic section in Pl. XXVI.

At the head of the left fork of Hamlin Branch the Lower Banner bed is reported to contain 4 feet of coal but it was not seen by the writer.

At a distance of 30 to 40 feet above the Lower Banner bed and separated from it by sandstone and sandy shale there is a coal bed which is known only in the drill sections and was not seen by the writer at the outcrop. Its thickness has not been made public but as it is not conspicuous in several good exposures between the Upper and Lower Banner coals it is not believed to be more than a few inches. About 15 to 25 feet below the Upper Banner is another coal bed which is shown in drill sections but is believed to be thin. Between these beds is 50 to 60 feet of sandstone which grades downward into shale.

Upper Banner coal bed.—The Upper Banner coal is 120 to 140 feet above the Lower Banner in this basin. It is present in a similar but slightly smaller area near the top of the higher spurs and ridges. It has a thickness averaging 5 feet and is extensively mined at the present time at Dante by the Clinchfield Coal Corporation. The coal is overlain by 2 to 6 feet of shale followed by a massive sandstone which makes a good roof in the mine in places where the shale comes down. The Upper Banner coal bed is readily identified by the characteristic sandstone parting about one-third of its thickness down from the top. Though owing to erosion it contains considerably less tonnage of coal ultimately available than some of the lower beds, the Upper Banner is at Dante as at many other localities the most valuable coal bed at the present time and it has yielded immense quantities of coal here and at Wilder. Its cleanness, accessibility, height above drainage, good cap sandstone and nearly uniform thickness of more than 5 feet make it a very valuable coal bed.

At location 41 north of Dante on Middle Fork of Lick Creek the following section was measured:

Section of Upper Banner coal bed on Middle Fork of Lick Creek.

(Location 41, elevation 2,270 feet)

	Ft.	in.
Sandstone		
Clay		7
Coal		5
Clay, fine, white	1	3
Bone		6
Coal	1	9
Sandstone		1½
Coal	1	10
Sandstone		
Coal	4	0
Partings	1	10½

In Mine No. 2* of the Clinchfield Coal Corporation the sections given below were measured in connection with collecting mine samples for analysis. Results of these analyses are given on page 114.

Section of Upper Banner coal in Mine No. 2 of Clinchfield Coal Corporation.

No. 10 right cross entry, 200 feet from main entry, analysis No. 32168.

	Ft.	in.
Shale, sandy		
Coal	1	7½
Sandstone [a]		1
Coal	1	6
Clay [a]		1
Coal		3
Clay [a]		1
Coal	2	0
Shale		
Coal	5	4½
Partings		3

Near room 20 off No. 4 left cross entry off main entry, analysis No. 32169.

	Ft.	in.
Sandy shale		
Coal		1½
Shale, carbonaceous [a]		1
Coal	1	5
Sandstone [a]		2
Coal	1	5
Clay, sandy [a]		1½
Coal		3
Clay [a]		1
Coal	2	0
Shale		
Coal	5	2½
Partings		5½

Third left air-course off No. 7, right cross entry, analysis No. 32170.

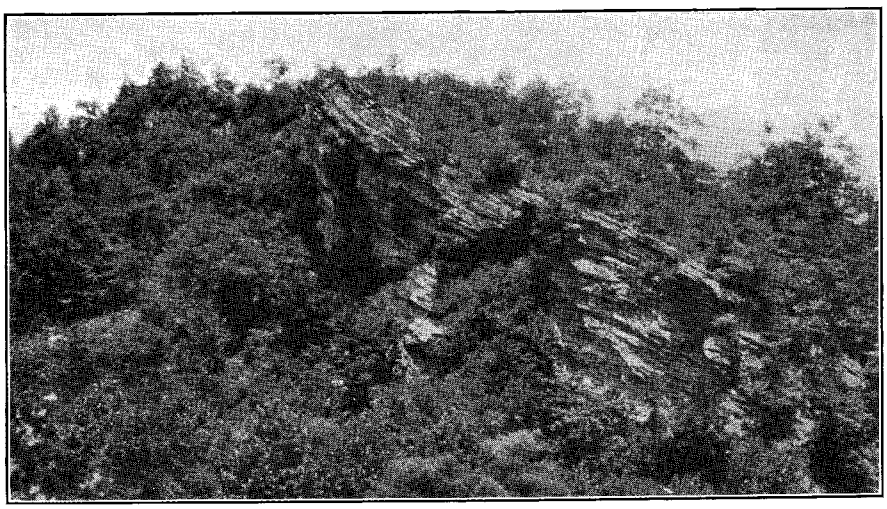
	Ft.	in.
Shale, sandy		
Coal		1
Shale [a]		2
Coal		2
Shale, sandy [a]		5
Coal	1	4
Sandstone [a]		1½
Coal	1	2
Clay [a]		1
Coal		5
Clay [a]		1½
Coal	1	8
Clay [a]		1
Coal	1	9
Shale		
Coal	6	7
Partings	1	0

Room 39, off 5th left cross-entry, analysis No. 32171.

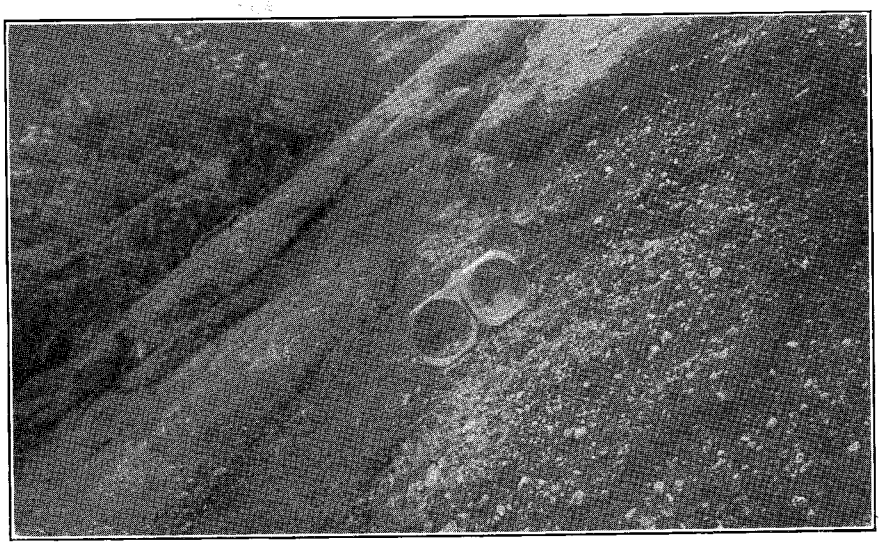
	Ft.	in.
Shale		
Coal	1	6
Sandstone [a]		1½
Coal	1	4
Clay [a]		1
Coal	2	5
Clay		
Coal	5	3
Partings		2½

* Reached through Mine No. 5 (mine mouth at Location 42.)

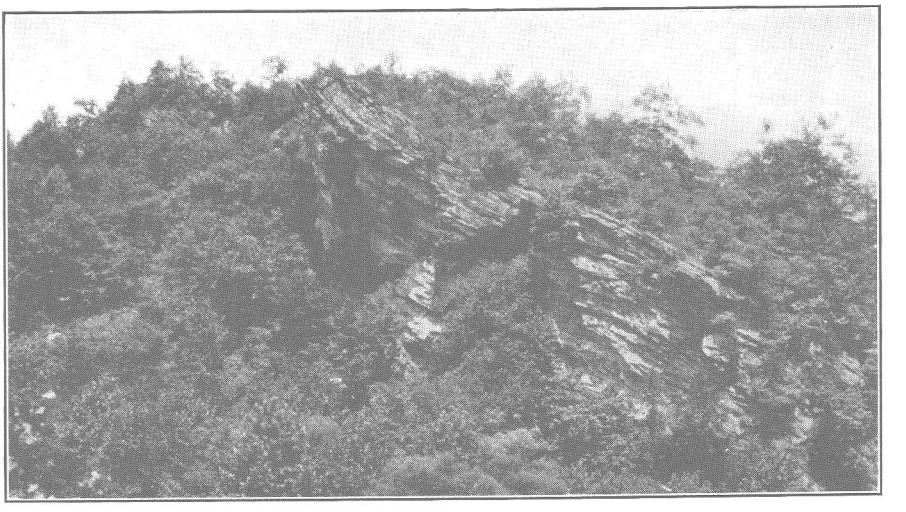
[a] Excluded. Analyses given on page 114, description on page 122, and graphic sections in Pl. XXVI.



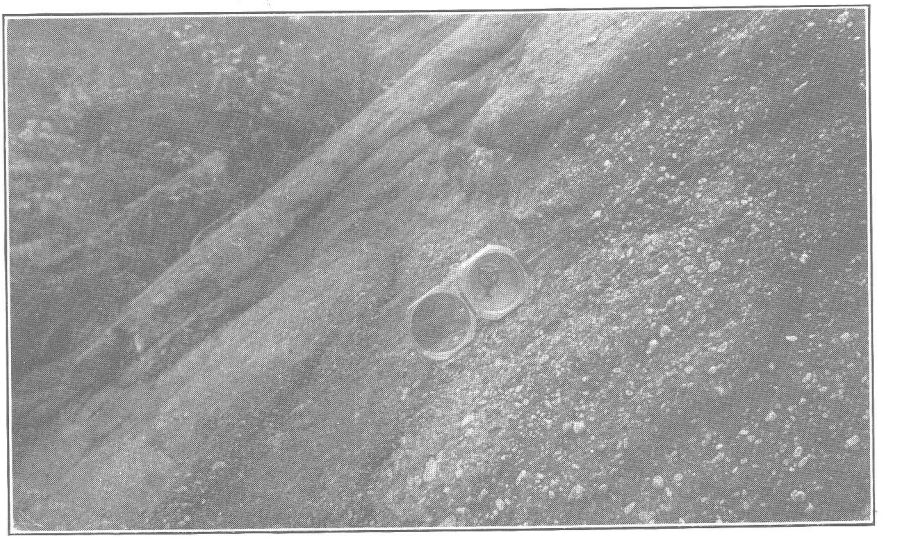
(A) High crest of "Bee Rock," upper conglomerate member of Lee formation. View is looking east and the rocks are overturned. This high ridge formed by the overturned edge of "Bee Rock" is a striking feature at many points along the edge of the coal field. Photo taken 1 mile west of Burton Ford, Russell County.



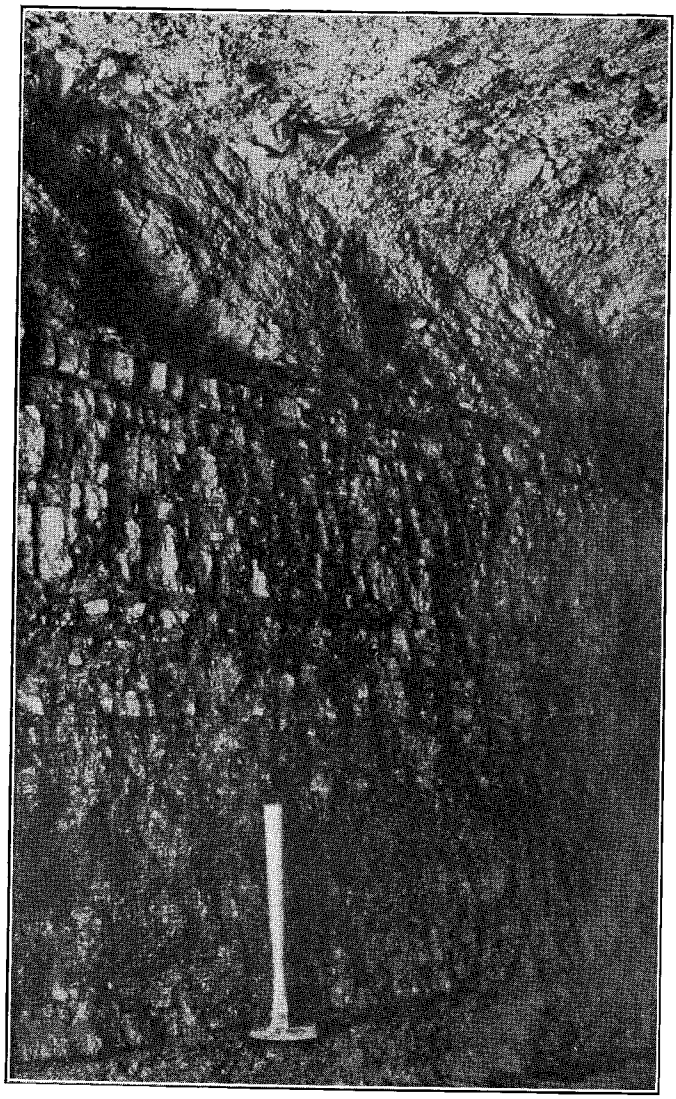
(B) Detail of conglomerate of "Bee Rock" member of Lee formation. Looking west at point southwest of Hamlin, Russell County, and showing overturned strata with dip of 36°.



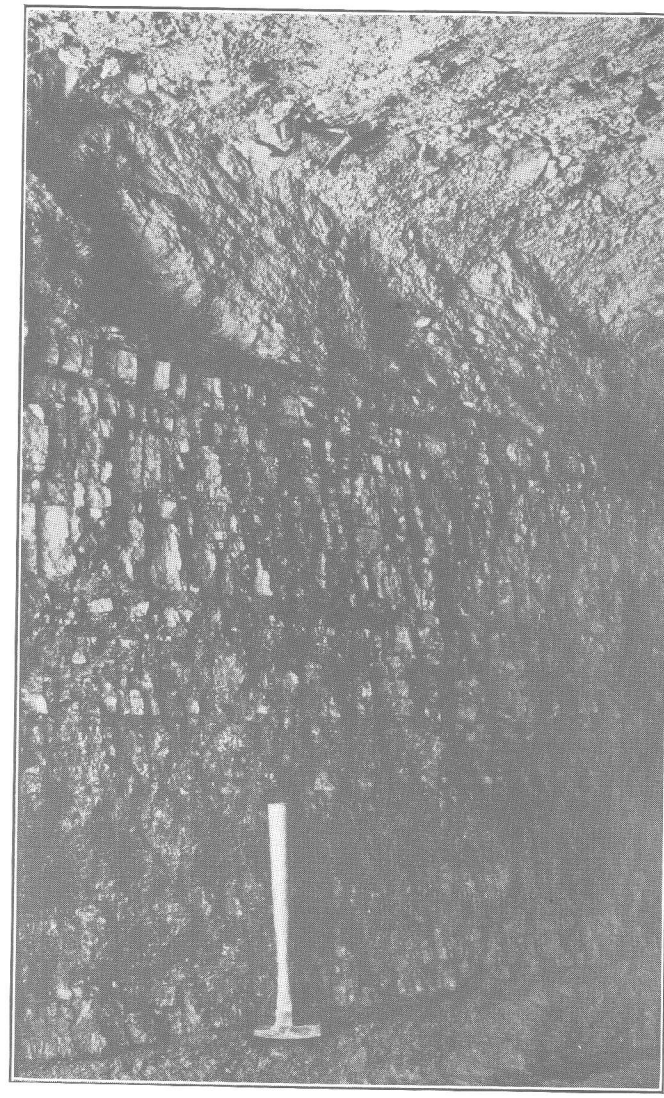
(A) High crest of "Bee Rock," upper conglomerate member of Lee formation. View is looking east and the rocks are overturned. This high ridge formed by the overturned edge of "Bee Rock" is a striking feature at many points along the edge of the coal field. Photo taken 1 mile west of Burton Ford, Russell County.



(B) Detail of conglomerate of "Bee Rock" member of Lee formation. Looking west at point southwest of Hamlin, Russell County, and showing overturned strata with dip of 36°.



Detail view of Upper Banner coal bed near head of Russell Creek 2 miles west of Russell County line in Wise County. View shows the columnar structure resulting from the two systems of joints, the "face" and "butt" cleavages, respectively, and which is characteristic of nearly all the coal in this region. The mine workings, rooms, etc., are so oriented as to take advantage of these cleavages, which are constant in direction throughout large areas, in blasting out the coal.



Detail view of Upper Banner coal bed near head of Russell Creek 2 miles west of Russell County line in Wise County. View shows the columnar structure resulting from the two systems of joints, the "face" and "butt" cleavages, respectively, and which is characteristic of nearly all the coal in this region. The mine workings, rooms, etc., are so oriented as to take advantage of these cleavages, which are constant in direction throughout large areas, in blasting out the coal.

These sections are on the north side of Sandy Ridge in Dickenson County but the coal from Mine No. 2 is hauled through Mine No. 5 to a tipple one-half mile north of Dante in Russell County.

Sections of Upper Banner coal bed east of Dante (Fig. 11, Nos. 12 and 13).

(Location 43, elevation 2,360 feet)

	Ft.	in.
Sandstone		
Shale	6	
Coal		4
Shale	1	11
Coal		6
Coal, bony		1
Coal		8
Sandstone		1
Coal	1	4
Clay		2
Coal		8
Coal, bony		2
Coal	1	10
Clay		
Coal	5	7
Partings	2	2

(Location 44, elevation 2,370 feet)

	Ft.	in.
Shale		
Coal		3
Shale and coal		3
Coal	1	2
Sandstone		1
Coal	1	4
Shale		1
Coal	1	10
Clay		
Coal	4	7
Partings		5

The shale parting 23 inches thick at location 43 thins rapidly to the east and is represented by 3 inches of shale and coal in the section given above at location 44. In Mine No. 3 of Clinchfield Coal Corporation the Upper Banner coal bed is about 5 feet thick as shown by the following sections:

Sections of Upper Banner coal bed in Mine No. 3 of Clinchfield Coal Corporation at Dante (see Pl. XXVI).

(Location 45, elevation 2,370 feet)

Third right cross-entry, off main entry, analysis No. 32327.

	Ft.	in.
Shale, carbonaceous		
Coal		3
Bone[a]		2
Coal	1	4
Sandstone[a]		1½
Coal	1	5
Shale[a]		1
Coal	2	1
Clay		
Coal	5	1
Partings		4½

Room 22, off 5th left cross entry, analysis No. 32326.

	Ft.	in.
Shale, carbonaceous		
Coal		1
Bone[a]		1
Coal	1	2
Sandstone[a]		1½
Coal	1	4
Shale[a]		1½
Coal	1	10
Clay		
Coal	4	5
Partings		4

[a] Excluded from mine sample.

Coal beds higher than Upper Banner bed.—No coal beds of commercial importance are known in that part of the Norton formation which is above the Upper Banner coal or in the lower part of the Wise formation in this section of the county. The so-called "Black slate" bed, which the writer has correlated with the Splash Dam coal bed, is in places 12 to 18 inches in thickness but even these thicknesses are exceptional considering the field as a whole. Just above the Gladeville sandstone near Hazel at location 46 the following section of the Glamorgan coal was measured:

Section of Glamorgan coal bed west of Hazel.

(Location 46, elevation 2,890 feet)

	Ft.	in.
Shale		
Coal and shale		6
Shale	6	
Coal and shale		6
Shale	4	
Coal	1	0
Clay		
Coal	1	0

This section was poorly exposed and it is possible that in a less weathered exposure the two upper benches would show a few inches of clean coal each, but even then it would not be of commercial value.

CHANEY FORK BASIN.*

General features.—Rocks from about 300 feet below the Kennedy coal bed to about 200 feet above the base of the Wise formation are exposed in the basin of Chaney Fork of Dumps Creek within the area of nearly horizontal coal measures. In common with the other drainage basins which extend across the border of the coal field, rocks belonging near the base of the Pennsylvanian are exposed in the steeply dipping or overturned strata except as these have been truncated by the great overthrust fault.

The general succession of strata in this basin is shown in the generalized section for the area southwest of Wilder (Plate IV), by the local section 4, and by records of numerous core-drill holes in Plate III. On the ridge northeast of Chaney Fork school is the highest point of a small dome in the strata and to the southwest of Stone Coal Branch is the round synclinal hollow which is centered in the headwaters of Hamlin Branch of Lick Creek. For the most part the rocks in this drainage basin dip very gently to the west or southwest. It contains a number of important coal beds, but there has been no extensive mining here.

* Locations 46-62 inclusive are prospect holes of the Clinchfield Coal Corporation. (See table on page 82.)

Tiller and Jawbone coal beds.—The Tiller and Jawbone coal beds are not exposed in the Chaney Fork basin except in the disturbed zone adjacent to the fault. No prospect openings were seen here. Both beds are known from the drill records to be present under the entire basin but thicknesses found in these have not been published. From their thickness and quality elsewhere it seems probable that at least one of these coals and possibly both of them are of workable thickness in this basin.

Raven coal bed.—Little is known of the Raven bed in this basin. It is not known to be of commercial value at any point as far west as this and is of little or no value westward in the basin of Lick Creek. It is therefore probable that it is not of economic importance in Chaney Fork basin. No other beds below the Kennedy are of commercial importance though thin coal beds are found locally at several horizons.

Kennedy coal bed.—The Kennedy coal bed is exposed widely on either side of Chaney Fork and Stone Coal Branch. Few exposures of it were seen but such measurements and reports as are available show that it changes from a thick bed on the west side of the basin to a thin non-workable bed on the east side. In an old local mine at location 63 near the point at which it goes below creek level in Stone Coal Branch it shows the following section:

Section of Kennedy coal bed in old local mine on Stone Coal Branch (Fig. 12, No. 16).

(Location 63, elevation 2,000 feet)

Section at mouth of mine.

	Ft.	in.
Sandstone		
Shale	4	0
Coal	7	8
Coal	7	8

Section at face of north entry.

	Ft.	in.
Sandstone		
Shale	4	0
Coal	4	4
Clay		
Coal	4	4

Near Chaney Fork schoolhouse at the mouth of Ambrose Branch at location 64 this section was measured:

Section of Kennedy coal bed near Chaney Fork schoolhouse (Fig. 12, No. 17).

(Location 64, elevation 2,010 feet.)

	Ft.	in.
Sandstone		
Coal	1	8
Shale	2	0
Coal	1	6
Shale		
Coal	3	2
Parting	2	0

On the ridge southeast of Chaney Fork schoolhouse the Kennedy bed is reported to be about one foot thick. Location 65 is approximately at the place pointed out to the writer though the coal was not seen.

Lower Banner coal bed.—The Lower Banner is present under an area somewhat smaller than that of the Kennedy bed and averages 4 feet in thickness. At the head of Stone Coal Branch it is reported to be 4 feet thick but was not seen by the writer.

At location 66 on the road from Chaney Fork schoolhouse to Hazel the Lower Banner bed shows 52 inches of coal with shale above and the bottom of the bed not exposed. At the head of Chaney Fork the following section was measured:

Section of Lower Banner coal bed near head of Chaney Fork (Fig. 12, No. 20).

(Location 67, elevation 2,290 feet)

	Ft.	in.
Shale	5	0
Coal	4	0
Shale, carbonaceous		8
Shale		
Coal	4	0

The Lower Banner bed was not seen on the east side of Chaney Fork but is reported 3 to 4 feet thick near the head of Middle Fork.

Upper Banner coal bed.—The Upper Banner is exposed high up on the spurs on either side of Chaney Fork and is under thin cover at several points on the ridges. In the timber entry of Mine No. 3 of the Clinchfield Coal Corporation at the head of Stone Coal Branch this section was measured:

Section of Upper Banner coal bed at head of Stone Coal Branch (Fig. 12, No. 21).

(Location 68, elevation 2,370 feet)

	Ft.	in.
Sandstone		
Shale	5	
Coal		5
Clay		2
Coal	1	1
Sandstone		1
Coal	1	6
Clay		1
Coal	2	8
Clay		
Coal	5	8
Partings		4

Northwest of Chaney Fork schoolhouse the Upper Banner bed measures as follows:

Section of Upper Banner coal bed northwest of Chaney Fork schoolhouse (Fig. 12, No. 22).

(Location 69, elevation 2,360 feet.)

	Ft.	in.
Sandstone		
Shale, sandy	4	
Coal	1	4
Sandstone		1
Coal	1	4
Clay		1
Coal	1	11
Clay with carbonaceous streaks		
Coal	4	7
Partings		2

The Upper Banner coal has not been mined on Chaney Fork though the workings of the Mine No. 3 at Dante and those of the Mine No. 6 at Wilder are driven to its headwaters. At the head of Chaney Fork the coal in the entry to the Wilder mine is reported to range from 5 to 8 feet in thickness but it was not measured.

ROAD FORK BASIN*

General features.—In the basin of Road Fork of Dumps Creek rocks from the base of the Pennsylvanian to a few feet above the base of the Wise formation are exposed. The stratigraphic succession in this basin is shown by the generalized columnar section east of Wilder (Fig. 2) and by numerous drill-hole sections (Plate III). In the eastern half of the basin the strata dip gently to the west at a rate of about 100 feet to the mile. From a point about one mile south of Laurel the axis of an anticlinal nose extends southwestward to Chaney Fork schoolhouse breaking the regularity of the monoclinal dip east of Road Fork (see Plate XXVIII).

There are a number of thick coal beds in this basin and it has become an important mining district. The Tiller and Jawbone beds are concealed in most of the basin but are probably thick and of considerable commercial value. The Raven and Kennedy beds are of little or no importance but above them the Lower and Upper Banner coal beds are being extensively mined at Wilder by the Clinchfield Coal Corporation. Mine No. 55 in the Lower Banner bed on both sides of Laurel Branch is in coal 3½ to 4½ feet thick. Mine No. 6 in the Upper Banner bed is on the south side of

* Locations 70-86 inclusive are prospect holes of the Clinchfield Coal Corporation. (See table on page 82.)

Laurel Branch in coal 4 to 7½ feet thick and an entry being driven southwest under Sandy Ridge toward the workings of Mine No. 2 at the head of McClure River is in similarly thick coal. Both these mines have a large producing capacity. The product is shipped over a short spur of the Carolina, Clinchfield & Ohio Railroad to Carbo (formerly Kiser) on the Norfolk & Western Railroad. Elsewhere in the Road Fork basin the Lower Banner bed is 3 to 7 feet thick. Outside the mining district near Wilder a shale parting separates the Upper Banner bed into two parts, the lower one of which is commonly worthless and the upper one 2 to 4 feet thick. There are probably places where coals in the Norton formation (higher than the Upper Banner, especially the Splash Dam bed) are 2 or 3 feet thick but the only coal seen was too thin to be of commercial value. Beds in the Wise formation on Sandy Ridge may in places be fairly thick.

Tiller coal bed.—The Tiller coal bed underlies the entire basin of Road Fork and outcrops only at the edge of the coal field in the narrow zone of upturned rocks adjacent to the Lee formation. It was not seen at the outcrop by the writer and its condition under Road Fork is not known with certainty. It is present in the drill sections of the Clinchfield Coal Corporation and is everywhere separated from the Jawbone coal by 60 to 90 feet of strata mostly sandstone. The main slope of the mine at Clinchfield has been driven well toward Road Fork and it is probable from the section of the Tiller bed in that mine that it is a bed of 4 or 5 feet in thickness in much of the Road Fork basin.

Jawbone coal bed.—The Jawbone coal is exposed for slightly over a half-mile up Road Fork from its junction with Hurricane Fork as well as in the upturned strata at the edge of the coal field but it is not well exposed in the latter situation.

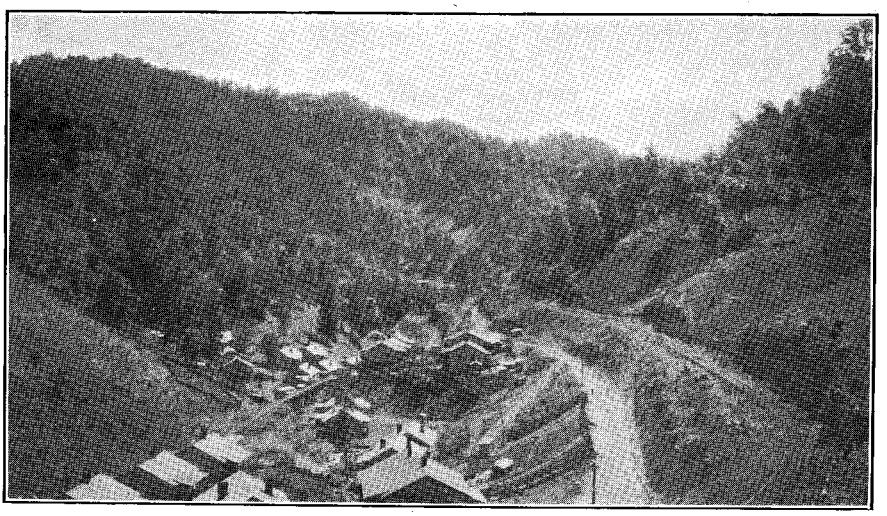
One-half mile up Road Fork from the junction of the creeks at location 87 the following section was measured:

Section of Jawbone coal bed northwest of mouth of Road Fork (Fig. 12, No. 23).

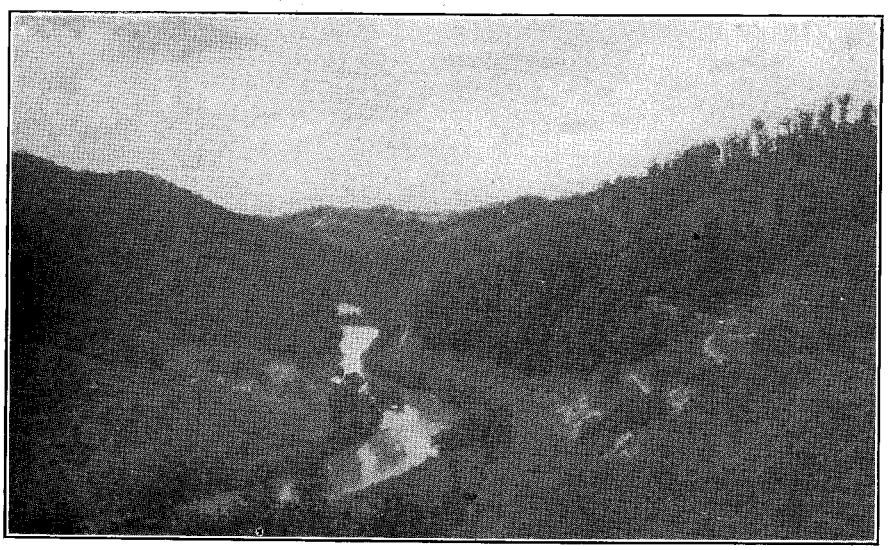
(Location 87, elevation 1,692 feet)

	Ft.	in.
Sandstone	15	
Shale	4	0
Coal	5	10
Shale		
Coal	5	10

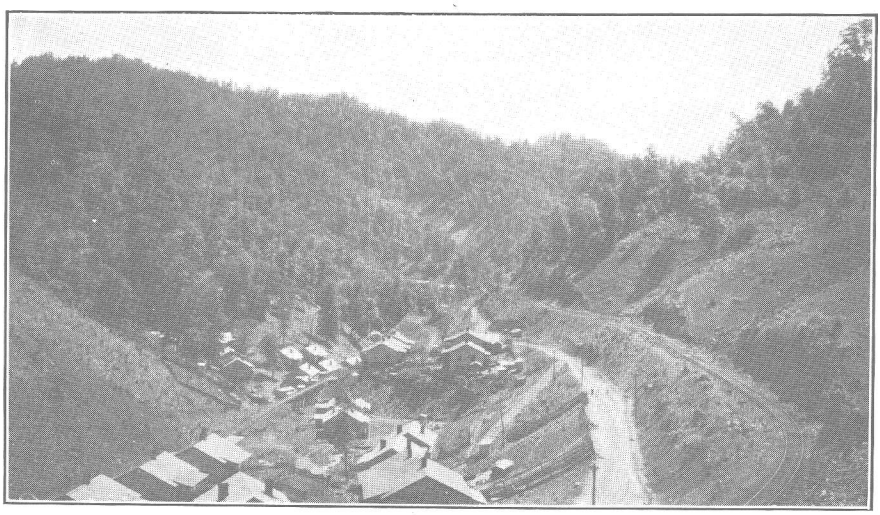
In other parts of the basin the Jawbone is known only from the drill records of the Clinchfield Coal Corporation and thicknesses have not been



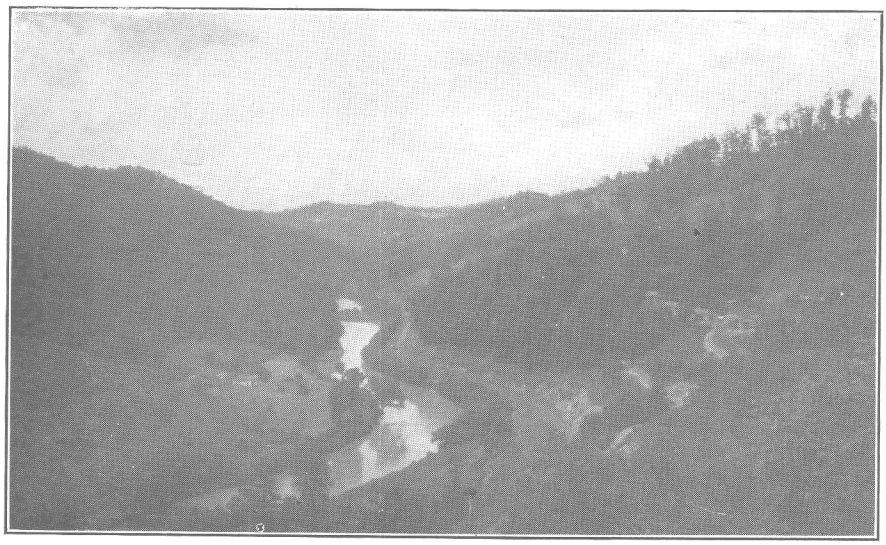
(A) View looking west toward Dante down Right Fork of Lick Creek. Two levels of the "switch back" railway of the Clinchfield Coal Corporation are shown and miners' houses in the foreground.



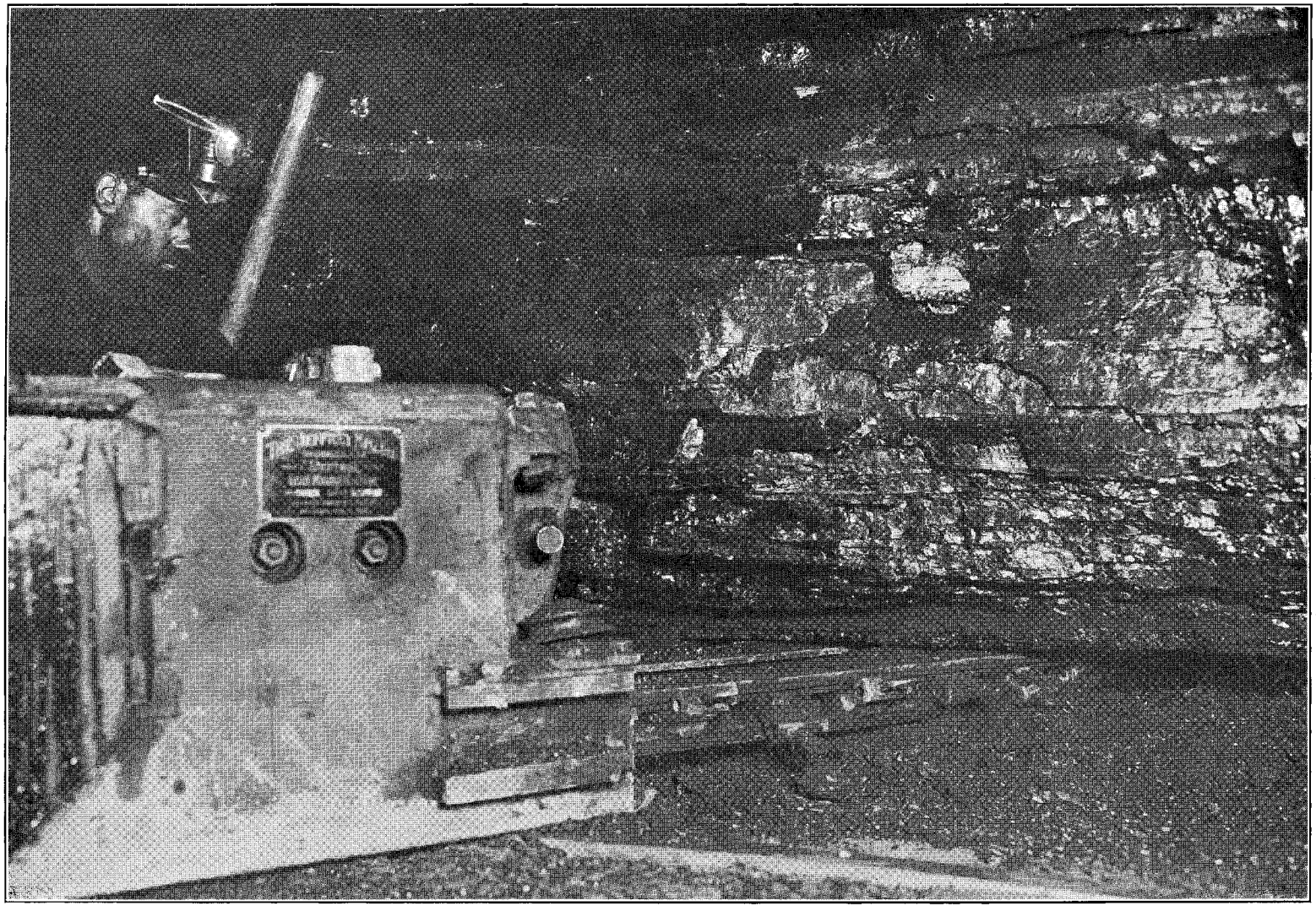
(B) Looking southwest down Clinch River from Virginia Iron, Coal and Coke Co.'s tipple at Shannon, Va. In the middle foreground the base of the Norton formation is at the level of the river. The area south of the river (left-hand side of the picture) is in Russell County.

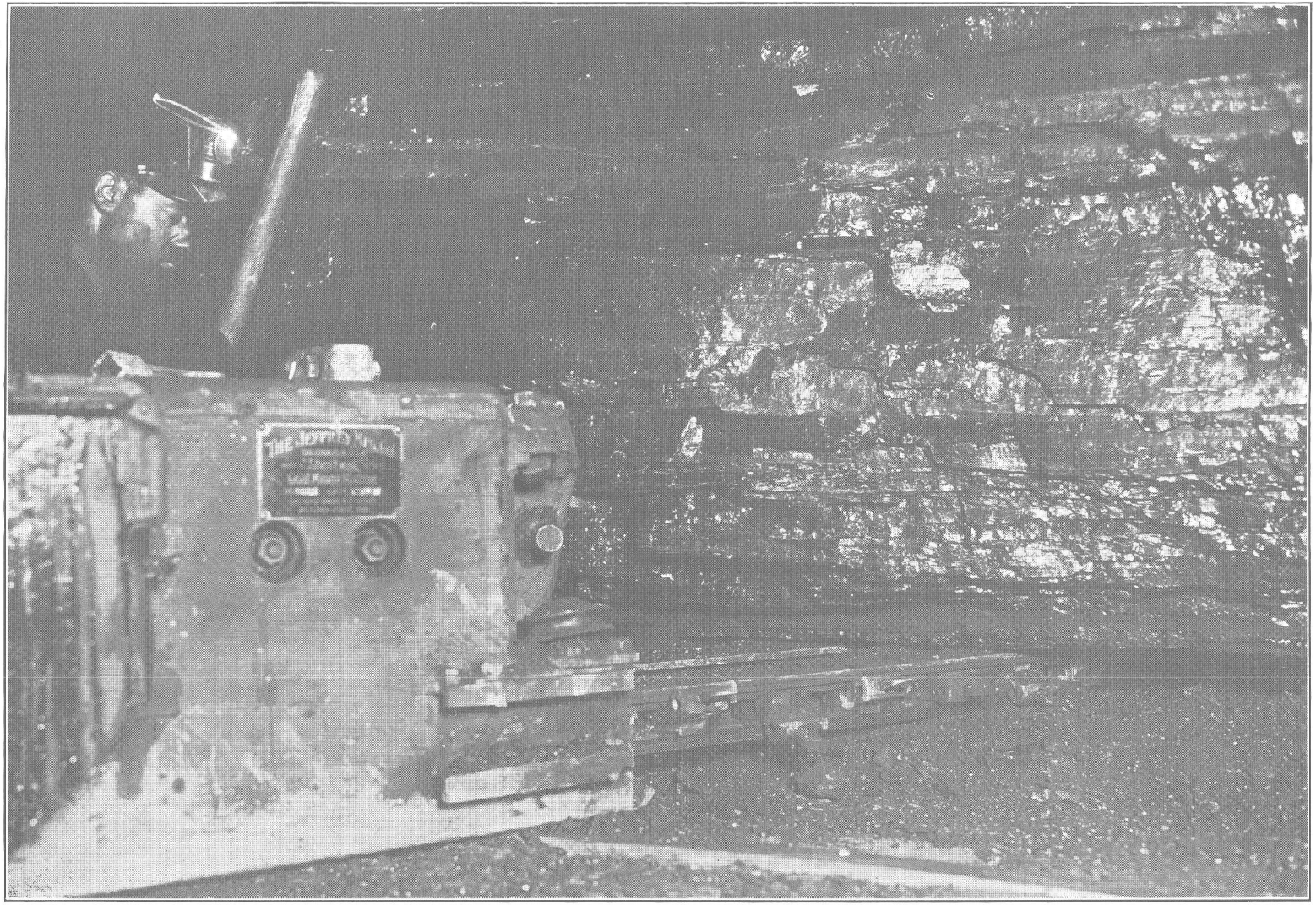


(A) View looking west toward Dante down Right Fork of Lick Creek. Two levels of the "switch back" railway of the Clinchfield Coal Corporation are shown and miners' houses in the foreground.



(B) Looking southwest down Clinch River from Virginia Iron, Coal and Coke Co.'s tipple at Shannon, Va. In the middle foreground the base of the Norton formation is at the level of the river. The area south of the river (left-hand side of the picture) is in Russell County.




THE JEFFREY

made public. From the very fine showing of this bed where it is exposed it seems probable, however, that it is 4 or 5 feet thick under a large part if not the whole of the basin.

Raven and associated coal beds.—The Raven coal bed is 600 to 700 feet below the Upper Banner coal and 150 to 230 feet above the Jawbone bed. It is widely exposed in this basin but it is not known to be anywhere of workable thickness and its position was determined at but few places. The same is true of other beds which occur elsewhere in the interval between the Raven and Kennedy coal beds.

Kennedy coal bed.—The Kennedy coal bed is exposed in much of the basin of Road Fork but is thin at all places where it was seen. In a railroad cut near Wilder it is only 23 inches thick, and is underlain by about 50 feet of fine-grained sandstone and overlain by the same thickness of coarser sandstone. (Location 88, elevation 2,070 feet.) It is not believed to be more than a foot thick under the southern part of the basin.

Lower Banner coal bed.—The Lower Banner coal is 200 to 265 feet above the Kennedy bed and about 120 feet below the Upper Banner bed. It is present in the high ridges on either side of the Road Fork basin. The following section shows the character of the Lower Banner at a place on Negro Camp Branch (elevation 2,290 feet) in Dickenson County:

Section of the Lower Banner coal bed on Negro Camp Branch in Dickenson County (Fig. 12, No. 25).

	Ft.	in.
Shale	4	
Coal	5	10
Clay		2
Coal, reported	1	4±
Coal	7	2±
Parting		2

In most parts of Mine No. 55 of the Clinchfield Coal Corporation on both sides of Laurel Branch near Wilder (mine mouth at location 89, elevation 2,275 feet) the Lower Banner is 3½ to 4½ feet thick and nearly or quite without partings. The floor of the mine is commonly a compact shale and the roof either shale or sandstone. Thin layers of "rash"[1] occur both

[1] The term rash is applied by the miners to a crushed and broken mixture of coal and shale which is of rather variable character. In some places it is separated from the coal in mining and at others where it is more largely coal it is allowed to remain with the coal probably increasing the ash content to some extent.

at the top and at the bottom of the bed. The following sections were measured in the mine in connection with sampling for analysis:

Sections of Lower Banner coal bed in Mine No. 55 at Wilder.

Section at point 900 feet S. 60° W. of mouth of Mine No. 3, Analysis No. 18243.

	Ft.	in.
Shale		
Coal	3	4
"Rash"		3½
Shale		
Coal	3	4

Section at point about 2,500 feet S. 35° E. of mouth of Mine No. 5, Analysis No. 18244.

Shale		
Coal		7
"Rash" [a]		2
Sandstone [a]	1	9
Coal	3	5
"Rash" [a]		7
Shale		
Coal	4	0
Partings	1	11

Section at point about 1,300 feet N. 35° W. of mouth of No. 2 Mine, Analysis No. 18245.

Shale		
"Rash" [a]		½
Coal	3	6
"Rash" [a]		4
Shale		
Coal	3	6

Analyses given on page 110, descriptions on page 120, and graphic sections in Pl. XXVI.

On the west side of Road Fork at location 90, elevation 2,380 feet, the Lower Banner bed is reported to be 3 to 4 feet thick.

Upper Banner coal bed.—The Upper Banner coal is present under a somewhat smaller area than the Lower Banner. From Wildcat northward

[a] Excluded from sample.

the Upper Banner is split by the thickening of a parting into two benches, only the upper of which is recoverable. South of Wilder the entire bed is readily mined, the parting being so thin that it can be separated in mining. The section of the Upper Banner bed where both parts are united is illustrated by the following measurements made in Mine No. 6 of the Clinchfield Coal Corporation south of Laurel Branch.

Sections of Upper Banner coal bed in Mine No. 6 at Wilder.

(Location 91, elevation 2,402 feet)

	Ft.	in.
Shale		
Coal	1	7
Sandstone		1
Coal	1	8½
"Rash"		5½
Coal	1	11
"Rash"		6
Coal	1	5
Coal	6	7½
Partings	1	½

	Ft.	in.
Sandstone		
Coal	1	2
Sandstone		1
Coal	1	6
"Rash"		4
Coal		4
Shale		½
Coal	1	5
"Rash"		6
Coal		8½
Shale		
Coal	5	1½
Partings		11½

Sections measured in connection with mine sampling are given below:

Sections of Upper Banner coal in Mine No. 6 at Wilder.

Section at point 3,000 feet S. 71° W. of mouth of Mine No. 1, analysis No. 18235.

	Ft.	in.
Sandstone and shale		
Coal	1	6
Sandstone [a]		1
Coal	1	6¾
Shale [a]		1
Coal	2	2
Shale [a]		3¼
Coal	1	1½
Shale		
Coal	6	4¼
Partings		5¼

Section in room 5, about 1,250 feet S. 35° E. of mouth of Mine No. 3, analysis No. 18236.

	Ft.	in.
Sandstone and shale.		
Coal	1	2
Sandstone [a]		1
Coal	1	6¼
"Rash" [a]		4¼
Coal		4¼
Shale [a]		½
Coal	1	5
Coal and shale [a]		6
Coal		8½
Shale		
Coal	5	2
Partings		11¾

[a] Excluded from samples.

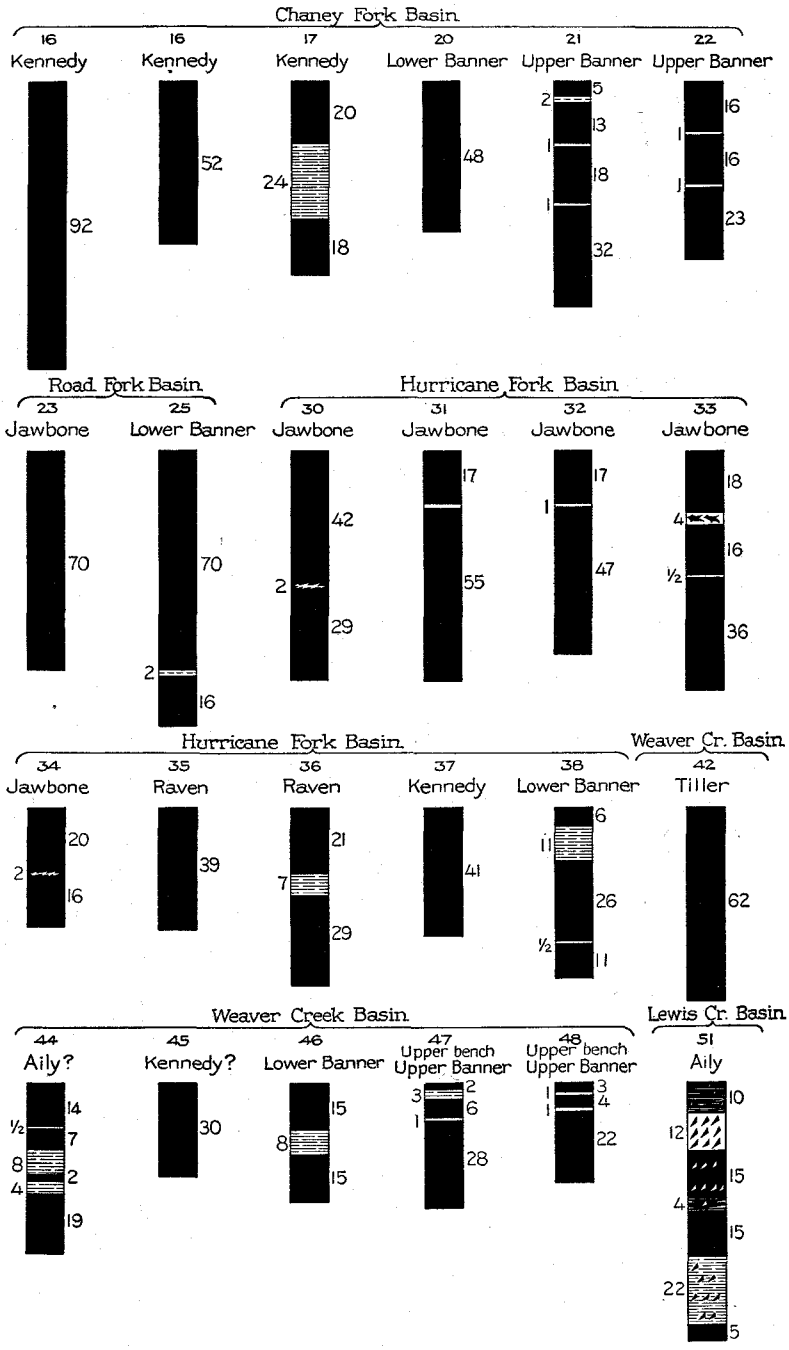


Fig. 12. Sections of coal beds in Chaney Fork, Road Fork, Hurricane Fork, Weaver Creek, and Lewis Creek basins.

Section at point about 4,000 ft. S. 10° W. of Mouth of Mine No. 3, Analysis No. 18237.

	Ft.	in.
Sandstone and shale		
Coal	1	7
Sandstone [a]		1
Coal	1	8½
Shale [a]		1
"Rash" [a]		4½
Coal	1	11
"Rash" and clay [a]		6
Coal	1	5
Coal	6	7½
Partings	1	½

Analyses given on page 112, descriptions of samples on page 121, and graphic sections in Pl. XXVI.

HURRICANE FORK BASIN *

General features.—This basin includes the land which drains into Hurricane Fork of Dumps Creek. All the Pennsylvanian rocks from the base of the series nearly to the top of the Norton formation are exposed in the basin but only the strata above the Jawbone coal are exposed as horizontal coal measures, the lower strata outcropping in the zone of overturned rocks adjacent to the fault. The strata seem to be less broken than they are farther east and the greater part of the overturned rock is of the Lee formation which dips at angles varying from 40 to 60 degrees. The Lee, except for the resistant "Bee Rock" at its top and the conglomerate at its base, is poorly exposed and no coal beds of commercial value were seen in it. The succession of beds in the Hurricane Fork basin is shown in Fig. 2, by many drill logs in Plate III, and by Fig. 12.

The Hurricane Fork basin lies nearly on the axis of the Sourwood Mountain anticline from which the rocks dip at low angles to the east and to the west. The fault which was mapped by Hinds [1] as separating the undifferentiated Pennsylvanian rocks from the Norton formation dies out to the southwest and the structure is comparatively simple consisting of the sharply overturned edge of the Lee formation with a few feet of the Norton formation overturned but inconspicuous in the hollow of the overturned Lee (see sections, Pl. XXVIII).

There are some important coal beds in this basin (see Fig. 12). Under most of the basin of Hurricane Fork the Tiller and Jawbone coal beds

[a] Excluded from samples.

* Locations 92-112 inclusive are prospect holes of the Clinchfield Coal Corporation. (See table on page 82.)

[1] Hinds, Henry, The coal resources of the Clintwood and Bucu quadrangles, Virginia: Va. Geol. Survey, Bull. XII, 1916.

are beneath the surface, but are undoubtedly thick in much of it. Several beds are present between the Jawbone and Lower Banner but they are thin at most localities. The Raven coal is 3 to 4 feet thick at the head of Skeen Creek and the Kennedy bed has in some places a thickness of 3 feet.

Tiller and Jawbone coal beds.—The Tiller coal lies 850 to 950 feet below the Upper Banner coal bed. The Jawbone is as much as 100 feet above the Tiller in parts of this basin but in other parts, as shown by drill records (Plate III), the two beds unite. The interval between the beds where they are separate is occupied chiefly by coarse-grained, siliceous sandstone that contains a few quartz pebbles. The Tiller bed is nowhere exposed in a horizontal position, though it outcrops in the zone of overturned rocks just north of the northern limit of the Lee formation. It is poorly exposed here and no data bearing on its thickness or quality could be obtained.

The Tiller has been mined for several years at Clinchfield Post-office in Mine No. 201, a slope of the Clinchfield Coal Corporation. In this mine there is a small amount of gas and safety lamps are used. The output when the writer visited the mine in 1919 was about 400 tons per day. The following sections show the character of the Tiller bed in this mine and results of several analyses are given in the table on page 105:

Sections of Tiller coal bed in Mine No. 201 of Clinchfield Coal Corporation.

(Location 113)

Rib at left entry No. 13.

	Ft.	in.
Sandstone		
Coal		3
Shale, black with coal laminæ.....		6
Coal	1	4
Shale		2
Coal	2	4
Clay		
Coal	3	11
Partings		8

Room 4, off left entry No. 12.

	Ft.	in.
Sandstone		
Shale, black with coal laminae.....		8
Coal	1	8
Shale		2½
Coal	2	10
Clay		
Coal	4	6
Parting		2½

Rib on left entry No. 9.

	Ft.	in.
Sandstone		
Shale, black with coal laminæ.....		7
Coal	1	10
Shale		4
Coal	2	6
Clay		
Coal	4	4
Parting		4

Room 21, off left entry No. 9.

	Ft.	in.
Sandstone		
Shale, black with coal laminæ.....	1	1
Coal	1	9
Shale		3
Coal	3	0
Clay		
Coal	4	9
Parting		3

The following sections were measured in connection with mine sampling:

(Location 113)

Section in main entry, 4,900 feet N. 30° W. of bottom of slope, analysis No. 18239.

	Ft.	in.
Sandstone and shale.		
"Rash"[a]		9
Coal	2	0
Sandstone and shale[a]		3
Coal	3	1
Clay, hard		
Coal	5	1
Parting		3

Section at point about 1,200 feet N. 64° W. of slope and 800 feet W. of main entry, analysis No. 18240.

	Ft.	in.
Sandstone and shale.		
Coal	1	9½
Sandstone and shale[a]		5
Coal	2	3
Clay, hard		
Coal	4	½
Parting		5

Section in a right entry, about 800 feet of the main entry and 2,600 feet N. 20° W. of the slope. Analysis No. 18241.

	Ft.	in.
Sandstone and shale		
Coal	1	4½
Sandstone and shale[a]		3½
Coal	2	3
Clay, hard		
Coal	3	7½
Parting		3½

Analyses given on page 105, descriptions of samples on page 118, and graphic sections in Pl. XXVI.

The Tiller coal bed is present in all of the drill holes which have reached its horizon and in part of the basin it combines with the Jawbone bed mentioned above. Thicknesses in the drill sections have not been made public.

The Jawbone coal outcrops just above creek level for about three-quarters of a mile above Grizzle and half a mile below it and also from just north of Clinchfield Post-office near elevation 1,767 feet to the junction of Road and Hurricane forks. On the west end of Buffalo Mountain the following section was measured:

[a] Excluded from samples.

[a] Excluded from sample.

Section of Jawbone coal bed at west end of Buffalo Mountain (Fig. 12, No. 30).

(Location 114, elevation 1,800 feet)

	Ft.	in.
Sandstone		
Shale	3	
Coal	3	6
Coal, bony		2
Coal	2	5
Coal	6	1

Three-fourths of a mile north at locations 115 and 116 on the west and east sides of Hurricane Fork the following sections were measured:

Sections of Jawbone coal bed south of Clinchfield (Fig. 12, Nos. 31 and 32).

(Location 115, elevation 1,740 feet.)

	Ft.	in.
Shale		
Coal	1	5
Clay		1½
Coal	4	7
Shale		
Coal	6	0
Parting		1½

(Location 116, elevation 1,740 feet.)

	Ft.	in.
Shale		
Coal	1	5
Sandstone		1
Coal	3	11
Shale		
Coal	5	4
Parting		1

Farther north, in the creek bed opposite the entry to Mine No. 201 the section given below was obtained:

Section of Jawbone coal bed across the creek from Mine No. 201 (Fig. 12, No. 33).

(Location 117, elevation 1,750 feet)

	Ft.	in.
Shale		
Coal	1	6
Bone		4
Coal	1	4
Shale		½
Coal	3	0
Clay		
Coal	5	10
Partings		4½

The Jawbone is somewhat impure at its outcrop and commonly is high in ash, but nevertheless it is a valuable coal bed and is probably minable throughout the entire basin of Hurricane Fork. About half a mile northeast of Grizzle the following section was measured in an old prospect pit:

Section of Jawbone coal bed in old prospect pit (Fig. 12, No. 34).

(Location 118, elevation 1,885 feet)

	Ft.	in.
Shale		
Coal	1	8
Coal, bony		2
Coal	1	4
Clay		
Coal	3	2

In an old pit about a third of a mile southwest of this prospect was seen 42 inches of coal under shale. The base of the bed was not exposed but from the character of the exposure the coal was judged to be somewhat more than 4 feet thick.

The Jawbone is known throughout the entire basin in the drill records and from its character where exposed it is believed to be 4 or 5 feet thick under much of the basin.

Raven and associated coal beds.—The Raven coal bed is 600 to 700 feet below the Upper Banner coal and 150 to 230 feet above the Jawbone. It is exposed along Hurricane Fork nearly to its head. At the head of Skeen Creek it contains 3 to 4 feet of coal but elsewhere is not known to be more than 30 inches and at many localities is less than 14 inches thick.

Sections of Raven coal bed near head of Skeen Creek (Fig. 12, Nos. 35 and 36).

(Location 119, elevation 2,210 feet)

	Ft.	in.
Coal	3	3
Coal	3	3

(Location 120, elevation 2,210 feet)

	Ft.	in.
Sandstone		
Shale		8
Coal	1	9
Shale		7
Coal	2	5
Coal	4	2
Parting		7

South and east of the locality last mentioned little is known of the outcrop of the Raven coal bed. It is present in many of the drill holes of the Clinchfield Coal Corporation but is believed to be too thin to work except in the vicinity of the locations noted above.

Kennedy coal bed.—The Kennedy coal bed is 300 to 380 feet below the Upper Banner coal bed. In much of the basin it is thin and of no importance commercially but at a few places it is moderately thick. At the head of a tributary of Hurricane Fork, one mile west of Dumps Creek School (location 121, elevation 2,340 feet, Fig. 12, No. 37) it is 41½ inches thick

including half an inch of shale. At this place it is overlain by at least 8 feet of sandy shale. Most of the drill holes have been driven from locations below the Kennedy coal bed and those which are above have been driven only to the Lower Banner. Little data as to the presence of the Kennedy coal bed are available, therefore, from this source and the absence at most localities of notable thickness at the outcrop would seem to indicate that the Kennedy is not workable, except locally near thick sections noted above.

Lower Banner coal bed.—The Lower Banner coal is from 200 to 270 feet above the Kennedy and 100 to 140 feet below the Upper Banner bed. It is present only in the high ridge between Hurricane Fork and Road Fork and ranges from 3 to 7 feet thick. At the head of a tributary of Hurricane Fork the section given below was measured:

Section of the Lower Banner coal bed (Fig. 12, No. 38).

(Location 122, elevation 2,445 feet)

	Ft.	in.
Shale	20	
Coal		6
Shale		11
Coal	2	2
Shale		½
Coal		11
Coal	3	7
Partings		11½

In an old prospect pit about half a mile southwest of the prospect mentioned above the Lower Banner measures as follows:

Section of Lower Banner coal bed.

(Location 123, elevation 2,410 feet)

	Ft.	in.
Shale	6	
Coal		5
Shale	1	6
Coal	3	6+
(Base concealed)		
Coal	3	11+
Parting	1	6

Upper Banner coal bed.—The Upper Banner bed is present in an area similar to though smaller than that of the Lower Banner, but no measurements of it were obtained in this basin. Where it is known to the northwestward in the valley of Road Fork it is split by a thick parting which

renders the lower bench nearly worthless. The upper bench is reported to be from 2 to 4 feet thick in Hurricane Fork basin but the writer was not able to verify this report. Near Wilder the parting thins and the combined benches aggregating 4 to 7½ feet in thickness are extensively mined.

No higher coal beds are present in this basin, the upper part of the Norton and overlying formations having been removed by erosion.

WEAVER CREEK BASIN.*

General features.—The area to be described includes only the drainage basins of Hart and Musick creeks, the valley of Weaver Creek itself and the area east of it, being in faulted and folded pre-Pennsylvanian rocks. The Pennsylvanian rocks exposed include all of the series from its base to beds about 50 feet above the base of the Wise formation, but the Lee and the lower 200 feet of the Norton formation can be seen only southeast of the great fault, in the district in which they have been overturned and thrust up over younger strata. These rocks, shown on the geologic map in the undifferentiated Pennsylvanian pattern, dip to the southeast at angles of 30 to 70 degrees, so that it is impossible to ascertain the exact stratigraphic succession in an area so heavily forested. The succession in less disturbed areas is shown by the columnar section for the area east of Wilder (Fig. 2), and by numerous drill logs (Plate III).

West of the faulted area dips are relatively very low and the structure is dominated by the Sourwood Mountain anticline, the axis of which trends in a north-south direction. The drainage basin of Hart and Musick creeks lies wholly east of the axis of the anticline and dips are therefore for the most part to the east at rates varying from 150 feet to 500 feet to the mile. Even close to the fault the beds are not much disturbed, for the break appears to have been a sheer one that had little effect on the rocks on the northwest side of it.

This basin contains some very important coal beds. (See fig. 12.) The Tiller and Jawbone beds are concealed in most of the basin but are believed to be thick. There are several coal beds between the Jawbone and Lower Banner beds, but in most places they are thin. The Raven bed, however, is 3 to 4 feet thick, exclusive of partings, at the head of Skeen Creek just west of this basin. The Kennedy is 3 feet thick in a few places.

Outcrops of coal beds not correlated.—Exposures are poor in the steeply dipping rocks mapped as undifferentiated Carboniferous and only a few coal beds were found in them. This fact is probably due in part to a lack

* Locations 124-127 are prospect holes of the Clinchfield Coal Corporation. (see table on page 82.)

of thick coal beds in the Lee formation of this basin. One caved opening near the south boundary of the Bucu quadrangle (location 128, elevation 2,120 feet) is said to have been in coal a little more than 4 feet thick but this report could not be verified. Another coal exposure, which may be of the same bed, was found on a northeastern tributary of Hart Creek (location 129, elevation 1,950 feet) where coal 4 feet thick was seen and the total thickness may be 5 or 6 feet. The bed dips S. 35° E. at about 55° and is separated from a locally conglomeratic sandstone 50 feet thick by about 2 feet of shale containing plants of lower Norton age. The fact that the shale, though now under the coal, has the characteristics of material overlying a coal bed indicates that the beds are overturned. The relations of the coal to the associated beds strongly resemble those of the Tiller.

Tiller and Jawbone coal beds.—The Tiller coal bed lies 850 to 950 feet below the Upper Banner bed. The Jawbone is as much as 100 feet above the Tiller in parts at least of this basin but as shown by drill records (Plate III) the two beds unite farther west. Where the beds are separated the interval between them is occupied chiefly by coarse-grained siliceous sandstone that is conglomeratic in places. Both beds are below the surface except near the fault along Musick Creek where the Tiller is 5 feet or more thick and the Jawbone probably much thinner.

The Tiller is 62 inches thick in a small mine 1¾ miles from the mouth of Musick Creek (location 130, elevation 1,850 feet, Fig. 12, No. 42) and has an overlying sandstone cap-rock more than 50 feet thick. A natural exposure of the same bed down the creek 1,200 feet contains 66 inches of coal at one end and twice as much at the other end, the greater thickness probably being caused by folding. The bed is more than 57 inches thick in a small drift (location 131, elevatinon 1,820 feet) beside the Sourwood Mountain road.

Raven and associated coal beds.—The Raven coal bed, which is the lowest one exposed in most of this basin, is 600 to 700 feet below the Upper Banner coal bed and 150 to 230 feet above the Jawbone bed. It is below the surface on Hart Creek, except in the area of steeply dipping rocks, but is exposed along Musick Creek nearly to its head. It is less than 30 inches thick in the drainage basin of the tributaries of Weaver Creek, being less than 14 inches thick in some localities.

There are several more or less lenticular coal beds between the Raven and the Jawbone beds and between the Raven and the Kennedy beds, but none of them is of much commercial importance as a thickness of as much as two feet is exceptional. The thickest bed measured is the following which may be the Aily bed, here only 40 feet below the Kennedy coal:

Section of Aily (?) coal bed on Sourwood Mountain (Fig. 12, No. 44).

(Location 132)

	Ft.	in.
Shale	3	
Coal	1	2
Shale		½
Coal		7
Shale		8
Coal		2
Shale		4
Coal	1	7
Coal	3	6
Partings	1	½

Kennedy coal bed.—The Kennedy is 300 to 380 feet below the Upper Banner bed. It is a very thin and commercially unimportant bed in most of this basin, but is moderately thick at a few places. A coal 30 inches thick in an opening by the road on Hart Creek (location 133, elevation 1,948 feet, Fig. 12, No. 45) may possibly be the Kennedy.

Lower Banner coal bed.—The Lower Banner coal is 200 to 270 feet above the Kennedy and 100 to 140 feet below the Upper Banner. It shows in outcrop only along Hart Creek where it is thin in most places though fairly thick in the pits described below.

The Lower Banner is at least 3 feet thick and perhaps thicker in a pit near the level of Hart Creek, three-quarters of a mile southeast of Rasnake (location 134, elevation 2,125 feet). It shows two benches of coal 15 inches thick separated by clay shale 8 inches thick and overlain by a thick bed of sandstone in an opening at the head of the branch of Musick Creek at Rasnake (location 135, elevation 2,125 feet, Fig. 12, No. 46).

Upper Banner coal bed.—The distribution of the Upper Banner is much the same as that of the Lower Banner bed. In the Hart Creek district the bed is split into two parts by a thick shale parting, the upper bench being 2 to 4 feet thick and the lower bench worthless or nearly so. The character of the upper bench is shown by the following two sections:

Sections of upper bench of the Upper Banner coal bed near Rasnake (Fig. 12, Nos. 47 and 48).

(Location 136, elevation 2,340 feet.)

	Ft.	in.
Sandstone	20	
Coal		2
Shale		3
Coal		6
Sandstone		1
Coal	2	4
Coal	3	
Partings		4

(Location 137, elevation 2,460 feet)

	Ft.	in.
Shale		
Coal		3
Shale		1
Coal		4
Sandstone		1
Coal	1	10
Coal	2	5
Partings		2

Table of equivalent location numbers of Diamond Drill Prospect Holes.

Serial Location Number	Clinchfield Coal Corporation Number
8	109
9	111
10	28
11	29
12	16
13	30
14	12
15	102
16	14
17	104
18	13
19	5
20	6
21	4
22	106
23	27
24	48
25	52
26	50
27	92
28	91
47	46
48	25
49	98
50	95
51	101
52	103
53	104
54	107
55	105
56	93
57	96
58	97
59	94
60	17
61	90
62	53
70	67
71	66
72	61
73	35
74	63
75	33
76	31
77	69
78	41
79	42
80	37
81	22
82	40
83	43
84	110
85	34
86	32
92	39
93	71
94	60
95	58
96	38
97	36
98	26
99	88
100	72
101	74
102	78
103	76
104	80
105	81
106	24
107	86
108	19
109	83
110	23
112	56
124	59
125	21
126	57
127	55

LEWIS CREEK BASIN.

General features.—The chief coal-producing centers of the eastern portion of the Russell coal field lie in the district drained by Lewis Creek and its principal tributaries, Flatrock Creek and Laurel Branch. The coal-bearing strata belong wholly to the Norton formation. The only stratigraphic section obtained in this basin was measured at location 179 and is given on p. 28. The Raven coal bed is the lowest and the Lower Banner the highest bed of any mining value exposed in the eastern field. Traces of the Upper Banner and Splash Dam coal beds are found in the western edge of the Lewis Creek basin, but they are negligibly thin.

The predominating structural features of the Lewis Creek basin are the Dry Fork anticline in the northern part and a rather sharp synclinal trough with an axis starting near Della and running due north well into the south flank of the Dry Fork anticline. The axis of the anticline passes from Tazewell County on the east to Buchanan County on the west, crossing Lewis Creek just north of Drill. The coal beds under the influence of this structure lie nearly horizontal from Drill north, whereas south of the axis they dip gently, with a gradient that is nearly uniformly that of the major streams. This relationship of coal beds to the anticline accounts for the continuous and extremely circuitous outcrops of the Kennedy and Lower Banner as indicated on the map (Pl. XXVIII).

The rocks of the Lewis Creek basin are sharply cut off on the southwest side by the Boissevain fault which extends from near Doran and Raven in Tazewell County in a northeasterly direction across the corner of Russell County to the north side of Big A Mountain in Buchanan County. The term Boissevain is carried over from the Tazewell County report and applies to the most northwesterly fracture in the zone of faults which earlier reports have grouped under the general term of Hunter Valley fault. These faults have been developed in the upturning of the southeastern edge of the Appalachian coal measures and the northwestward thrusting of the older rocks to the east. As the result of this upturning of the coal-bearing strata, coal beds that are elsewhere in the Russell coal field entirely buried are exposed in a narrow belt northwest of the Boissevain fault. It is not improbable that the outcrop at location 138 (elevation 2,000 feet) represents the Jawbone coal bed, which nowhere else in the eastern field comes to the surface.

The maximum relief of the eastern field is found in this basin, where elevations range from 2,850 feet above sea-level in the northwest corner to 1,900 feet where Lewis Creek leaves the field. Direct railroad communi-

cation has led to the greater development of the coal beds of the Lewis Creek basin than the much more extensive basin of Swords Creek. The Lumber Railroad, a branch of the Norfolk and Western system, follows Lewis Creek from the south to Drill, at which place it turns west into Buchanan County. The commercial mines of the basin are concentrated on Lewis Creek in the vicinity of Drill. The coal mined comes almost exclusively from the Kennedy bed.

The lowest coal bed outcropping in the Lewis Creek basin is supposed to be the Aily. It comes to the surface along Laurel Branch in the southern margin of the coal field. The Kennedy and Lower Banner are the chief commercial coal beds of this basin and both beds outcrop almost continuously along the valleys of Lewis Creek and Flatrock Creek. The Upper Banner coal is practically unknown, but a bed at the Splash Dam horizon is reported at many places on the high ridges between the western tributaries of Lewis Creek. The Splash Dam bed is thin and at present of no commercial value.

Raven and lower coal beds.—The Raven coal bed is about 200 feet above the Jawbone bed and slightly over 400 feet above the base of the Norton formation, and no exposures of it were seen in the Lewis Creek basin. In the absence of drill-hole records, no thicknesses of the Raven bed have been obtained. In the Swords Creek basin the Raven coal bed outcrops with an average thickness of 3 feet to 3 feet 4 inches, and as there is no evidence of pinching out to the west, it is assumed that it is beneath the surface in the Lewis Creek basin—an assumption that is borne out by the structural relations of the two basins. Thus it is apparent from the accompanying map that the syncline at Della causes the beds to lie considerably lower in the Lewis Creek basin than they do in corresponding positions in the Swords Creek basin.

Coal beds lower than the Raven have nowhere been encountered in the eastern part of the Russell field, but as the Tiller and Jawbone beds are exposed in Buchanan County to the north and west and in Tazewell County to the east, it is thought that these beds also underlie the Russell coal field.

Aily(?) coal bed.—A bed outcropping at a few places near stream level on Laurel Branch has tentatively been called the Aily. It lies about 100 feet below the Kennedy bed. A local mine (location 139, elevation 2,030 feet) is operated in this bed by W. N. Jackson. The stratigraphic position of the bed is rendered somewhat uncertain by the irregular dips in the vicinity and the proximity of the Boissevain fault. Dips measured in the

mine range from 5 to 18 degrees to the northeast and north, and thickness of coal from 2½ to 11 feet, the average being 4 feet. Both the floor and roof are hard clay and give little trouble.

A small local mine is being worked at present in the Aily(?) bed at location 140. The coal here is much broken and shattered, and appears to have a slight dip to the southeast.

Section of Aily (?) coal bed three-fourths of a mile southwest of Della (Fig. 12, No. 51).

(Location 140, elevation 2,030 feet)

	Ft.	in.
Shale	4	0
Coal, thin partings, impure coal and "rash"		10
"Rash"	1	0
Coal, thin streaks of "rash"	1	3
"Rash" and dirty coal		4
Coal	1	3
Shale and "rash"	1	10
Coal		5
Clay		5+
Coal	3	9
Partings	3	2

No other exposures of the Aily(?) coal are reported in the Lewis Creek basin. From the very variable thicknesses reported in the two foregoing outcrops it is impossible to assign an average thickness and hence to estimate the amount of coal in this bed that underlies the basin.

Kennedy coal bed.—By far the most important coal bed in the Lewis Creek basin is the Kennedy. All the shipping mines and the majority of the local mines are operated in this bed. It averages in this region 250 feet above the Raven and about 350 feet below the Splash Dam bed. The thickness of the bed is variable with fairly moderate limits, running from 30 to 54 inches.

The outcrop of the Kennedy bed follows the banks of Lewis Creek and its branches from the southern limits of the field to about a mile north of Della. At this place the bed dips slightly below the level of the stream and reappears a mile to the south of Drill. Sandy shale and sandstone almost uniformly overlie it.

A small drift has been opened in the Kennedy bed at location 141 (elevation 2,000 feet). It has not, however, been worked recently, and it was impossible to measure the thickness of the coal, but it is more than 30 inches. The bed so far as exposed showed in the middle streaks of impure coal and "rash," and is separated from an overlying thick bed of fine to medium grained sandstone by 6 inches of *"draw slate."*

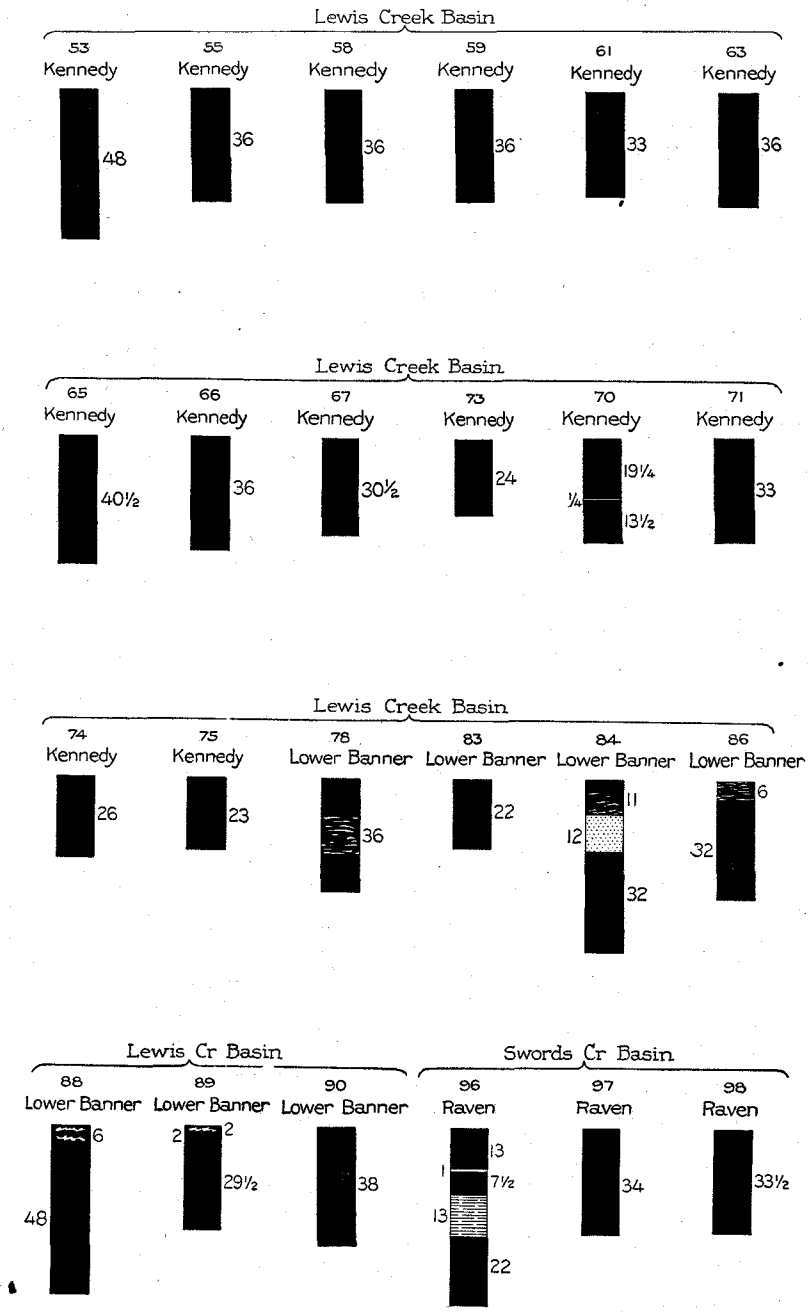


Fig. 13. Sections of coal beds in Lewis Creek and Swords Creek basins.

Across the creek at location 142 (elevation 1,960 feet, Fig. 13, No. 53) the coal is 48 inches thick and overlain by 30 feet of sandstone. Sixty feet of shale lies on the sandstone at this place.

A producing mine in this bed is operated by the Lewis Creek Coal Co. at location 143 (elevation 2,255 feet). The output of the mine averages 25 tons daily. The thickness of the Kennedy bed in this mine is variable, running from 1 to 4 feet, with an average thickness of 3 feet (Fig. 13, No. 55). According to a test of a carload of the coal it runs in the neighborhood of 72 per cent lump.

Another mine on Lewis Creek just north of the last mentioned mine is owned by the Fuller Coal Co. It produces about 25 tons a day, obtaining its coal from the Kennedy bed which has a thickness of 36 inches (Fig. 13, No. 58). The mine is situated at location 144 (elevation 2,290 feet).

In a local mine in the Kennedy bed, at location 145 (elevation 2,340 feet), now not in use and partly filled with water, the Kennedy bed, according to report, has a thickness of approximately 36 inches (Fig. 13, No. 59). An old mine on the east side of Lewis Creek is reported by its owner to be in coal from 4 to 5 feet thick. Its position is marked by location 146 (elevation 2,343 feet). The front of the mine is caved.

The Sandy Ridge Coal & Coke Co. has opened two mines half a mile south of Drill, indicated on the map by locations 147 and 148 (elevation 2,334 feet). One drift enters the north side of a small spur and the other the south side. The thickness of the coal is 2½ to 5 feet 3 inches, with a general average of 3 feet. The roof is shale and the floor a hard clay with rolls that cause many of the variations in the thickness of the bed. Analyses of samples of the coal from these mines are given under laboratory numbers 22345 and 19528 (p. 108). The sections of the coal bed at the places where the samples were cut are as follows:

Sections of the Kennedy coal bed in mines of the Sandy Ridge Coal & Coke Co. (see Pl. XXVI).

(Locations 147 and 148, elevation 2,334 feet)

Section in north drift, 170 feet S. 70° W. of mine mouth, analysis No. 22345.

	Ft.	in.
Shale		
Coal	2	9
Clay, hard		
Coal	2	9

Section in room off main entry in south drift, 150 feet from mine mouth, analysis No. 19528.

	Ft.	in.
Shale		
Shale, carbonaceous		2
Coal	2	10
Clay, hard		
Coal	2	10

The mine of the Drill Coal Mining Co. at location 149 (elevation 2,345 feet), is among the largest producers in the eastern Russell coal field. The

output of this mine runs from 400 to 500 tons per day, and the coal is separated on a stationary screen with 3-inch perforations. That which passes over the screen is sold as lump coal and that which passes through, as slack. The thickness of the coal bed at the face of the main entry in 1916 was 2 feet 2 inches to 2 feet 5 inches, apparently becoming thicker as the face of the entry advanced. A short distance northwest of Drill (location 150, elevation 2,315 feet) the Kennedy bed reaches a thickness of 2 feet 9 inches (Fig. 13, No. 61). This thickness is maintained farther north at location 151 (elevation 2,345 feet), where a stripping exposes 2 feet 6 inches to 3 feet of coal.

The Kennedy bed thickens northward near the headwaters of Lewis Creek, as evidenced by several exposures. A prospect at location 152 (elevation 2,340 feet) shows a minimum thickness of 3 feet (Fig. 13, No. 66). A small drift mine by the side of the wagon road (location 153, elevation 2,335 feet) shows the Kennedy bed to be 6 feet 5 inches thick at the mouth and 4 feet 6 inches at the face. The thickness of the coal bed is reduced by lenses of shale which come in between the fine-grained shaly sandstone roof and the coal. The roof itself is uneven and slight movements along the bedding planes of the coal have had the effect of making the thickness of the bed variable. The coal has all the appearances of being much squeezed. A short distance south, in a gully of the Lewis Creek Valley (location 154, elevation 2,345 feet) a prospect on the Kennedy coal bed shows a thickness of 3 feet 4½ inches (Fig. 13, No. 65).

Several mines have been opened on the left bank of Lewis Creek north of Drill. In a drift at location 155 (elevation 2,320 feet) the Kennedy coal bed shows a thickness of 3 feet (Fig. 13, No. 66). This bed is also mined at location 156 (elevation 2,316 feet), where it has a thickness ranging from 1 foot 6 inches to 3 feet 7 inches. This mine is operated by the Honaker Lumber Company to supply the engines on its railroad, and in 1914 gave employment to about ten men. The Honaker Lumber Company operates a mine at location 157 (elevation 2,316 feet) in which the average thickness is nearly 3 feet. The coal is shot from the solid, but, due in part to the fairly soft floor and roof, it does not break up badly, there being consequently little loss. At location 158 (elevation 2,375 feet) a local mine consists of a drift driven north more than 50 feet. The face of the drift, however, was partly under water, and the exact thickness of the coal bed could not be measured but it apparently ranges from 2 to 3 feet.

The second most important mining center of the Lewis Creek basin is in the vicinity of Della on Flatrock Creek. Two entries have been driven in the Kennedy bed by the Flat Rock Coal Company of Lynchburg, Va.

The two openings at locations 159 and 160 (elevation 2,010 feet) are known by the name of the Flat Rock mine. Fifteen inches to 4 feet 10 inches is the range in thickness of the coal bed. The following sections were measured in this mine at points at which samples were cut for analysis:

Sections of Kennedy coal bed in Flat Rock mine (Fig. 13, Nos. 70 and 71).

(Location 159, elevation 2,010 feet)

Section at face of 1st left entry, 750 feet N. 30° E. of mine mouth, analysis No. 25367.

	Ft.	in.
Soft clay ("buckfat")		1
Coal	1	7¼
Shale[a]		¼
Coal	1	1½
Coal	2	7¾
Parting		¼

Section at face of 2d right entry, 900 feet S. 75° E. of mine mouth, analysis No. 25368.

	Ft.	in.
Soft clay ("buckfat")		1½
Coal	2	9
Coal	2	9

Analyses of samples of coal from this mine are shown in the table on page 108 under laboratory numbers 25367 and 25368, respectively. The coal is undercut by machine, the cut being made in the bottom 2½ to 3 inches of coal. In 1916 the Flat Rock Coal Company employed 18 miners and produced on the average 100 tons daily. The mine has a firm shale roof overlain by sandstone cap rock, and a floor of hard clay from 2 to 3 inches thick which is underlain by sandstone.

Two miles north of Della on Flatrock Creek 30 inches of coal is reported in the Kennedy bed in an old opening at location 161 (elevation 2,293 feet) and on the north side of the small branch of Flatrock Creek, at location 162 (elevation 2,300 feet) a stripping shows it to have a thickness of 24 inches (Fig. 13, No. 73). The stripping is practically at the level of the stream.

In a small gully on the left side of Flatrock Creek a prospect discloses a thickness of 2 feet, 2 inches of coal in the Kennedy bed, as shown by the following section:

Section of Kennedy coal bed two miles north of Della (Fig. 13, No. 74).

(Location 163, elevation 2,320 feet)

	Ft.	in.
Sandstone, medium-grained		
Shale		5
Soft clay, "buckfat"		1
Coal	2	2
Coal	2	2

[a] Included in sample.

The overlying sandstone has a uniform thickness of 20 feet, the upper part of which is flaggy. Seventy feet of shale overlie the sandstone.

A small local mine has been opened near the head of Stone Branch (location 164, elevation 2,100 feet) in a coal bed 23 inches thick which has been correlated with the Kennedy (Fig. 13, No. 75). The coal, in spite of nearness to the faulted and disturbed area just to the south, has no appearance of having been crushed, and the bed is nearly flat, having a slight dip downstream. The mine has a 4-inch roof of sandy shale grading into sandstone.

Lower Banner coal bed.—Throughout the Lewis Creek basin the Lower Banner coal lies on an average 250 feet above the Kennedy bed. Its outcrop, due to the slight dip on the south flank of the Dry Fork anticline, follows the drainage basins with the regularity of that of the Kennedy bed. The Lower Banner coal bed has a thickness ranging from 28 inches to 4 feet, but it has not as yet been mined to any considerable extent. This may be accounted for by the fact that the Lower Banner bed usually outcrops well up the slopes of the ridges, whereas the thick Kennedy coal bed lies nearer the bottoms of the valleys, and is more accessible to railroad cars and wagons.

On the upper part of Laurel Branch the Lower Banner bed is 3 feet thick. At location 165 (elevation 2,396 feet) it is reported to be 3 feet 8 inches thick, and in an old opening on Lewis Creek (location 166, elevation 2,155 feet) a bed which has been correlated with the Lower Banner is reported to be 4 feet thick. The decrease in elevation of the Lower Banner bed from location 165 to location 166 is evidence that the axis of the syncline crosses the creek just east of location 166. A pit on the west side of Grassy Creek (location 167, elevation 2,460 feet) shows the Lower Banner coal bed to be 3 feet thick, the middle third being rather impure (Fig. 13, No. 78).

Several prospects have been opened on the Lower Banner coal bed, on the west side of Lewis Creek, about 1½ miles south of Drill. At an old prospect (location 168, elevation 2,340 feet) the bed is reported to have a thickness of 3 feet, whereas on the east side of the creek in an old opening, according to report, it is 4 feet thick (location 169, elevation 2,340 feet). Thirty-six inches of coal is said to have been measured in a pit slightly north of location 170 (elevation 2,375 feet). This bed is also reported to be a little more than 3 feet thick at an old prospect at location 171 (elevation 2,395 feet) and about a mile south of Drill it is 22 inches thick, as measured at location 172 (elevation 2,430 feet, Fig. 13, No. 83). The Lower Banner bed from location 172 to location 168 dips, under the influence of the syncline near Della, fairly regularly to the south 180 feet to the mile.

At a prospect (location 173) on the south side of the valley the Lower Banner coal bed has the following section:

Section of Lower Banner coal bed three-fourths mile northwest of Drill (Fig. 13, No. 84).

(Location 173, elevation 2,520 feet)

	Ft.	in.
Sandstone, medium-grained	10	
Coal, impure except at top		11
Sandstone, fine-grained	1	
Coal	2	8
Coal	3	7
Parting	1	

Near the head of Lewis Creek and 225 yards south of the Buchanan County line a prospect (location 174, elevation 2,540 feet) exposes the Lower Banner coal bed with a thickness of about 3 feet 7 inches. In a prospect at location 175 (elevation 2,575 feet) the total thickness of the bed is 3 feet 2 inches, the top 6 inches of which is bony and shaly coal (Fig. 13, No. 86). A timbered prospect with a caved front, at location 176 (elevation 2,585 feet) is reported to have exposed 3 feet 9 inches of coal. A little to the west (location 177, elevation 2,570 feet) the Lower Banner bed was measured in a timbered prospect and found to be 4 feet 6 inches thick with the top 6 inches bony coal (Fig. 13, No. 88).

At the head of Hatfield Creek a timbered prospect has been driven into the south ridge about 30 feet (location 178, elevation 2,615 feet). The measured section shows 29½ inches of bituminous coal overlain by 2 inches of cannel coal and 2 inches of bony coal (Fig. 13, No. 89).

The only measured section of the Lower Banner coal bed in the Flatrock Creek basin is at a timbered prospect, location 179 (elevation 2,555 feet) in the gully north of Camp Hollow. Here the Lower Banner shows a thickness of 3 feet 2 inches, overlain by 5 feet of shale (Fig. 13, No. 90). A stratigraphic section is given in the table of local sections (p. 28), showing the strata from the Kennedy coal bed to 150 feet above the Lower Banner bed. Measurements were made from location 163 in the bottom of a small drain, one-half mile north of Camp Hollow, to above location 179.

SWORDS CREEK AND LITTLE MILL CREEK BASINS.

General features.—In this section is included all of the territory in the eastern part of the Russell coal field drained by Swords Creek and its tributaries, Pine Creek, Sulphur Spring Branch, Fuller Fork, and Little Mill Creek, a tributary of Mill Creek. Hollow Poplar Ridge, with a maximum

elevation of 2,680 feet, divides the basin roughly into two parts, with Fuller Fork and its branches on the west and the other larger streams on the east. Fuller Fork has cut its valley around the southern end of Hollow Poplar Ridge and joins Swords Creek just beyond the limits of the undisturbed coal beds but slightly north of the Boissevain fault.

The dip of the coal beds in this basin is governed by the Dry Fork anticline. As its axis passes across the northern end of the county, the greater part of the Russell coal field lies on the southern flank of the anticline, and consequently the beds of the Swords Creek basin have a gentle dip to the south that is practically equal to the topographic gradient of the surface drainage.

The lowest coal bed exposed in the basin, with the possible exception of the exposure at location 138, which has previously been described (page 83), is the Raven coal. This bed is slightly over 400 feet above the base of the Norton formation and the structure contours on the map have been drawn on it. The outcrop of the Raven coal has been drawn on the map only in the Mill Creek and Little Mill Creek basins. Approximately 300 feet above the Raven lies the Kennedy coal. This bed outcrops throughout the whole basin, following with sinuous continuity the valleys of the tributary streams. The Lower Banner bed, which is the uppermost coal in the Swords Creek basin, lies at a distance varying from 250 to 300 feet above the Kennedy coal. In the eastern portion of the field erosion has removed nearly all of this bed from Little Fork Ridge, Toll Ridge, and Big Lick Ridge. A stratigraphic section from the Kennedy to the Lower Banner coal bed was measured at location 232.

There are very few shipping mines in the Swords Creek basin. This is due in large part to the lack of direct railroad connections but many local mines and a great number of prospects have been opened on both the Kennedy and Lower Banner beds. The Norfolk and Western Railroad follows Clinch River valley parallel with and from one to two miles south of the edge of the coal field. Wagon roads are the only transportation routes through the many north-south valleys of the basin. With the establishment of railroad spurs up these valleys a large development awaits the Swords Creek basin as both the Kennedy and Lower Banner coals are of commercial importance, averaging more than 3 feet in thickness.

Raven and lower coal beds.—The Raven is the lowest coal bed exposed in the Swords Creek basin. No drill hole records for the Swords Creek basin are available and the presence of lower coal beds can only be inferred from measurements in adjacent territories. In Tazewell County the Tiller

coal bed is 160 to 170 feet above the base of the Norton formation and 27 to 50 feet below the Jawbone coal bed. Both beds average 2 to 3 feet in thickness, and are believed to be present in workable thickness under much of the basin.

On Fuller Fork several old prospects have been made on the Raven coal bed that just comes to the surface at stream level. At location 180 (elevation 2,085 feet) an old prospect is reported to show 4 feet of coal. Slightly north (location 181, elevation 2,108 feet) a prospect shows a thickness of 3 feet or more; and an old opening a little farther upstream and at water level shows from 2 feet to 2 feet 6 inches of coal above water and possibly 1 foot or more below water. The coal here (location 182, elevation 2,111 feet) is overlain by more than 3 feet of shale. Toward the head of Long Branch a stripping at location 183 (elevation 2,205 feet) is reported to expose 1 foot 6 inches of coal.

On Strow Fork two outcrops of the Raven coal are reported. One outcrop at location 184 (elevation 2,250 feet) is said to have a thickness of 4 feet, and to be overlain by 12 inches of shale, above which is 40 feet of conglomerate. The other is at location 185, in a small valley entering the Strow Fork valley. At the latter a drift has been driven into the coal bed which has the following section:

Section of Raven coal bed in hollow near Strow Fork (Fig. 13, No. 96).

(Location 187, elevation 2,280 feet)

	Ft.	in.
Sandstone		
Shale, bluish	3+	
Coal	1	1
Clay, hard		1
Coal		7½
Clay, hard, shale	1	1
Coal	1	10
Coal	3	6½
Partings	1	2

On Sulphur Spring Branch several outcrops of the Raven bed were encountered. At location 186 (elevation 2,125 feet) 2 feet 10 inches of coal were measured (Fig. 13, No. 97). Twenty-four inches of shale overlie the bed with conglomeratic sandstone above this. Thirty-three and a half inches of coal represent the thickness of the Raven bed a mile to the north on Sulphur Spring Fork, at location 187 (elevation 2,210 feet, Fig. 13, No. 98). The coal is very clean and is overlain by shale. Measurements in a number of old drifts (location 188, elevation 2,216 feet), most of which are con-

nected under the surface, give a range in thickness of the Raven bed from 2 feet 3 inches to 3 feet 5 inches, with 4 to 8 inches of shale. Conglomeratic sandstone forms a substantial roof for the drifts.

Although the bed consists of clear coal at the locality just mentioned, it shows partings at a section measured in a coal stripping at Dye. The thickness and partings are variable, but the following section is a fair average:

Section of Raven coal bed at Dye (Fig. 14, No. 100).

(Location 189, elevation 2,290 feet)

	Ft.	in.
Sandstone	20	
Coal		6
Parting		¾
Coal		3½
Parting		1½
Coal		10+
Coal	1	7½+
Partings		2¼

The Raven bed outcrops on both the Tazewell and Russell County sides of Mill Creek, and for a mile up Little Mill Creek wholly in the Russell field. In two mines not now worked (locations 190 and 191, elevation 2,125 feet) a reported thickness of 3 feet is exposed of a bed that has been considered to be the Raven. Associated beds of sandstone lie flat at the mine but 100 feet to the south they are turned up, having a dip approximating 20 degrees. Coal was observed at location 192 (elevation 2,070 feet) on the hillside south of the stream and about 30 inches is reported in an entry at location 193 (elevation 2,100 feet). The face of the entry was so badly caved that it was impossible to get at fresh coal, but that which was visible had the appearance of having been greatly crushed. On Mill Creek no measurements of the Raven bed were made in Russell County, but in a small mine several hundred yards northeast of the juncture of Little Fork and Mill Creek in Tazewell County the bed consists of 2 feet 9 inches of clean coal.

Aily(?) coal bed.—There is some question regarding the presence of the Aily coal bed in the Swords Creek basin. A coal bed with a reported thickness of 4 feet in a caved prospect at location 194 (elevation 2,050 feet) was referred by Harnsberger in 1916 to this horizon, but there is some doubt about the correctness of this correlation, for with the Raven bed at an elevation of 2,085 feet at location 180, half a mile to the north, it may be that the bed in the caved prospect is the Raven and not the Aily, as supposed by Harnsberger. The uncertainty is still further emphasized by the

fact that local changes in the interval between the Raven and Kennedy beds and also changes in their elevations are typical in the Lower Fuller Fork basin, making it quite possible to have the Aily bed outcrop where the Raven would be expected.

Kennedy coal bed.—The Kennedy is the lowest coal bed to have a continuous outcrop in the Swords Creek basin. Though this bed is sufficiently

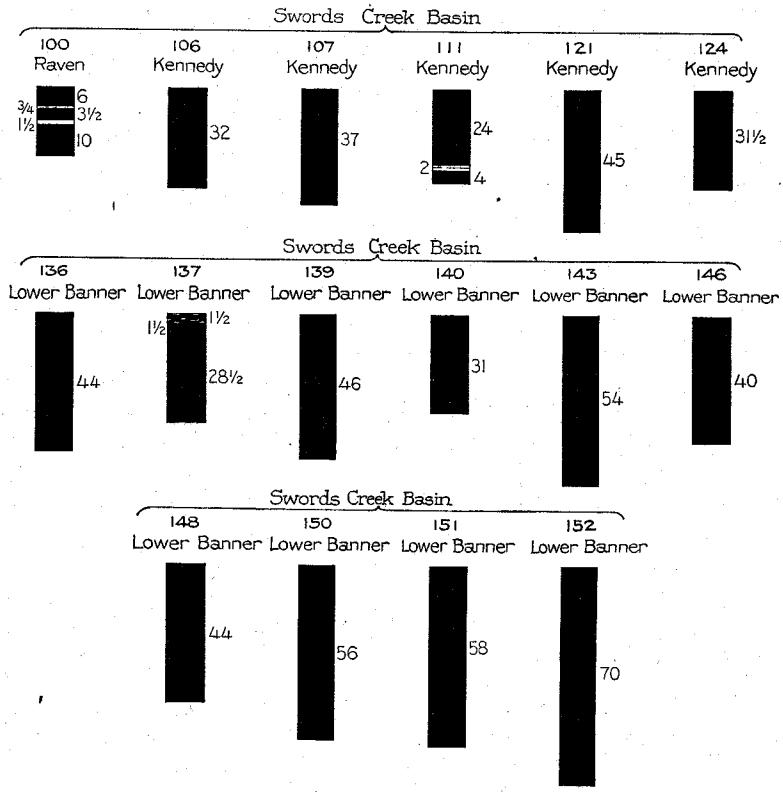


Fig. 14. Sections of coal beds in Swords Creek basin.

thick to be mined profitably, very few mines have been opened. It has been prospected in a considerable area of the basin, however, giving a fairly definite knowledge as to its elevation and thickness.

Two openings on the Kennedy bed, one a prospect, at location 195 (elevation 2,260 feet) and the other a drift mine, at location 196 (elevation 2,260 feet), have been made on Rocklick Branch. Two feet eight inches of coal was measured at the prospect, and 3 feet 1 inch in the mine (Fig. 14,

Nos. 106 and 107). The floor of the mine is sandstone, and 1 inch of soft clay and 12 inches of shale generally come down when the coal is removed, leaving a substantial sandstone roof.

Five feet of coal is said to represent the average thickness of the Kennedy in a drift mine (location 197, elevation 2,200 feet) in the side of a gully east of Fuller Fork and just northeast of the junction of this fork and Rocklick Branch. The mine is caved near the face and the roof is very bad. It is reported that in an old opening 30 feet east of the mine the bed is 11 feet thick, but this may be an exaggeration.

A bed of coal, which is apparently a local lens, was encountered in two prospects at location 198 (elevation 2,290 feet). It is about 85 feet above the Kennedy bed and is reported to contain 3 feet or more of coal. The prospects are on a small spur of Hollow Poplar Ridge which forms the south slope of the gully in which the Kennedy bed outcrops at location 197, but they were caved when visited and the report could not be verified.

Variable thicknesses are given of the Kennedy coal bed in the vicinity of Long Branch, one of the east tributaries of Fuller Fork. At an old opening now closed by caving 3 feet 9 inches of coal with some shale is reported (location 199, elevation 2,250 feet). In a prospect opening toward the head of Long Branch the following section was measured:

Section of Kennedy coal bed on Long Branch (Fig. 14, No. 111).

(Location 200, elevation 2,400 feet)

	Ft.	in.
Shale	10	0
Coal	2	0
Shale		2
Coal		4
Coal	2	4
Parting		2

The identification of this bed is not certain but it is supposed to be the Kennedy, as is also the bed 18½ inches thick showing a little farther north (location 201, elevation 2,390 feet) in a mine that has been operated to supply coal for the local inhabitants.

In a stripping, partly caved, near the headwaters of Fuller Fork (location 202, elevation 2,375 feet) the Kennedy has above ground a thickness of 18 inches and it is probable that it is at least a foot thicker. A coal opening at location 203 (elevation 2,390 feet) shows the Kennedy varying in thickness from 30 to 36 inches. At the head of Strow Fork the bed has a fairly uniform thickness of 30 inches, as reported, in two prospects at loca-

tion 204 (elevation 2,390 feet) and location 205 (elevation 2,410 feet). Farther south in a prospect in a narrow ravine (location 206, elevation 2,465 feet) the Kennedy bed is reported to be 18 inches thick.

In the southern part of the Sulphur Springs valley, the outcrop of the Kennedy coal bed can easily be followed and identified by a thick sandstone which occurs immediately below it. The coal is clean but badly fractured, as it shows in a prospect at location 207 (elevation 2,160 feet). The bed here ranges in thickness from 3 feet 6 inches to 4 feet 6 inches and it is overlain by a thick bed of sandstone. A quarter of a mile to the northeast (location 208, elevation 2,130 feet) the Kennedy bed is about 30 feet lower in elevation, the difference being due to a strong local dip in that direction.

The largest mine in the Swords Creek basin is operated in the Kennedy bed by the Kennedy Coal Company near the mouth of Sulphur Spring Branch (location 209, elevation 2,140 feet). The bed ranges in thickness in the mine from 2 feet 8 inches to 3 feet 2 inches of compact coal, crushed and rather impure. The mine has a shale roof and clay floor, and the coal is shot from the solid. The production of the mine which has been in operation about two years averages 70 tons daily.

Midway up Sulphur Spring Branch in one of the side ravines in Hollow Poplar Ridge (location 210, elevation 2,465 feet) a prospect shows a thickness of 45 inches of clean coal in the Kennedy bed (Fig. 14, No. 121) and a recently opened pit at location 211 (elevation 2,485 feet) gives this bed a thickness varying between 3 and 4 feet, with a general average of 3 feet 8 inches. The bed in a prospect pit to the northwest (location 212, elevation 2,500 feet) has a reported thickness of 3 feet. A mile due north of the locality last mentioned the Kennedy coal bed shows, at the face of the main entry of a small mine, the following section:

Section of Kennedy coal bed a quarter of a mile west of Dye (Fig. 14, No. 124).

(Location 213, elevation 2,450 feet)

	Ft.	in.
Shale	5	0
Soft clay		1
Hard clay		2
Coal	2	7½
Sandstone		
Coal	2	7½

A coal bed that has tentatively been correlated with the Kennedy has a reported thickness of 27 inches at location 214 (elevation 2,510 feet). The bed has been exposed in an old coal opening now partly caved.

The Kennedy coal has been prospected and mined at many places on both sides of Swords Creek, between Middle Ridge on the north and Stone Mountain on the southeast. A small mine in this territory is opened at location 215 (elevation 2,100 feet) on the Kennedy coal bed. In an entry to the east (location 216, elevation 2,105 feet) the bed shows about 30 inches of coal above water, but the full thickness could not be determined. The coal has the appearance of being much crushed. A mine is being operated in the Kennedy bed at location 217 (elevation 2,090 feet) where it is 4 to 5 feet thick. The coal is crushed and rather impure. On the south side of Swords Creek a new opening is being made in this bed at location 218 (elevation 2,080 feet). The Kennedy bed is reported to be 3 feet thick in a prospect that is now caved at location 219 (elevation 2,090 feet), just northwest of the junction of Pine and Swords creeks. South of Swords Creek near the limit of the coal field the entry of a local mine (location 220, elevation 2,080 feet) shows a thickness said to vary from 2 to 5 feet. The coal is very impure through having partings of shale of variable thickness.

Several small pits by the roadside a short distance east of Pistol Gap (location 221, elevation 2,465 feet) have been opened in the Kennedy coal bed, which consists of two benches, the upper bench containing 2 feet and more of good coal, and the lower bench 5 inches of coal 32 feet below the thicker beds in which the pits have been opened. The lower bench apparently disappears to the east and at location 222 (elevation 2,450 feet) a single bench only of the Kennedy coal is reported. A caved pit is said to show a thickness ranging from 24 to 30 inches. Three-quarters of a mile northeast of the juncture of Steckman Branch and Pine Creek, in a hollow of Robinson Ridge (location 223, elevation 2,525 feet) the Kennedy bed is reported to reach 30 inches in thickness.

The Kennedy coal has not been exploited to any extent on Swords Creek from the sharp bend to its source. At location 224 (elevation 2,280 feet) a mine had been worked in the Kennedy coal, but is now abandoned and no measurement of the bed could be made.

Lower Banner coal bed.—All measured coal sections in the Swords Creek basin indicate that the Lower Banner is a much thicker bed than the Kennedy. Two feet 7 inches is the minimum measured thickness and 6 feet 10 inches the maximum, whereas the average thickness ranges from 3 feet 9 inches to 4 feet 2 inches. Still there has been even less prospecting or mining in this coal than in the Kennedy, due to the greater accessibility of the lower bed.

The Lower Banner lies approximately 250 feet above the Kennedy, although this distance decreases in places to 200 feet. At many places erosion has progressed sufficiently to remove the coal. This is especially true in the case of Big Lick Ridge and Little Fork Ridge in the eastern part of the basin. Small isolated areas of Lower Banner coal still remain, however, in many of the higher knolls of Big Lick Ridge.

In Fuller Fork, north of Rocklick Branch; at location 225 (elevation 2,490 feet) 3 feet 8 inches of clear coal was measured (Fig. 14, No. 136). The bed is exposed in a strip mine near the head of a narrow ravine and it is overlain by shale. One mile east of Drill on the south side of the valley of a Left Fork tributary, the Lower Banner coal is excellently exposed at a strip pit, where it has the following section:

Section of Lower Banner coal bed 1 mile east of Drill (Fig. 14, No. 137).

(Location 226, elevation 2,580 feet)

	Ft.	in.
Bone		1
Cannel, impure		1½
Coal, bony		1½
Coal	2	4½
Concealed		
Coal	2	4½

Several measurements were made on the Lower Banner coal bed near the source of Left Fork. In an abandoned mine at location 227 (elevation 2,610 feet) a thickness of 4 to 6 feet is reported for the bed. A newly opened prospect at location 228 (elevation 2,585 feet) shows a thickness of 3 feet 10 inches (Fig. 14, No. 139). The following section was measured in a strip pit in a little drain at location 229:

Section of Lower Banner coal bed at source of Left Fork (Fig. 14, No. 140).

(Location 229, elevation 2,595 feet)

	Ft.	in.
Shale		
Sandstone	2	0
Shale, sandy	6	0
Rash		½
Coal	2	7
Coal	2	7

The Lower Banner coal outcrops at location 230, elevation 2,590 feet. The thickness could not be obtained but a 36-inch bed of coal lies 50 feet below the Lower Banner horizon at that point. Forty feet of conglomeratic sandstone over 10 feet of medium-grained sandstone separate the Lower

Banner from the lower bed. Due east at location 231, elevation 2,590 feet, in a strip pit 29 inches of coal is exposed above water and 12 inches more was measured under water. The bed apparently is even thicker than 41 inches. One-half inch of "rash" is present on top of the coal. A coal mine showing a freshly cut face disclosed a thickness of 54 inches of clean coal (location 232, elevation 2,600 feet). It is underlain by conglomerate. The stratigraphic section from the Kennedy coal bed through the Lower Banner is given in the table of sections, page 28, under location number 232. Toward the head of the right branch of Strow Fork, just south of the Buchanan County line (location 233, elevation 2,665 feet) an old coal entry is reported, by the man who opened it, to contain a bed 30 inches thick.

Location 234, elevation 2,680 feet represents a coal opening in a bed correlated with the Lower Banner. A thickness of 42 inches has been reported for the coal but it measured only 36 inches at the face. The opening was made near the summit of a high knoll on Hollow Poplar Ridge.

East of the Fuller Fork and Long Branch juncture in the southern part of the basin a small pit (location 235, elevation 2,405 feet) shows a thickness of 40 inches. The bed, which is overlain by shale, rests on thick sandstone, and is the Lower Banner coal.

A stratigraphic section from below the Kennedy coal bed to the top of Hollow Poplar Ridge is given for location 236 (elevation 2,400 feet) in the table of sections, p. 29. The thickness of the Lower Banner bed was not measured at this location.

At location 237 (elevation 2,460 feet) the Lower Banner coal bed is 3 feet 8 inches thick (Fig. 14, No. 148). The coal is here underlain by a very massive sandstone and resting upon it is a cross-bedded sandstone 30 feet thick. The coal bed thickens northward to 4 feet 10 inches at location 238 (elevation 2,435 feet) on the north side of the spur. It also dips to the north, as shown by the difference of 25 feet in the two locations. Four inches of clay separate the coal from the underlying thick bed of sandstone.

Light drab to bluish shale replaces the sandstone as the cap rock of the Lower Banner coal bed farther east, as shown by the fact that at location 239 (elevation 2,360 feet) the coal is overlain by 13 feet of drab shale. At this location the coal bed is 4 feet 10 inches thick and consists of a single bench of hard coal resting on sandstone. To the north on the west side of Sulphur Spring Branch, the Lower Banner coal retained a thickness of 4 feet 10 inches, as shown by an exposure at location 240 (elevation 2,405 feet, Fig. 14, No. 151). Here it is overlain by a thick bed of drab shale and underlain by sandstone.

The maximum observed thickness of the Lower Banner coal in the Swords Creek basin occurs in the vicinity of Pistol Gap, where it measures 5 feet 10 inches at location 241 (elevation 2,700 feet, Fig. 14, No. 152). It is underlain by a sandy shale and overlain by shale to a thickness of 100 feet. A stratigraphic section, extending from below the Kennedy bed through the Lower Banner, is given in the table of sections for location 241.

The Lower Banner bed outcrops on a ridge west of Pistol Gap at location 242 (elevation 2,670 feet) within a few hundred feet of the county line, but the thickness of the bed at this place was not obtained. From its high position on the ridge it is evident that very little of the Lower Banner coal bed occurs in that vicinity.

Near Horton School in the southeast corner of the field, the Lower Bannr coal bed has been prospected. On the highest part of Toll Ridge at location 243 (elevation 2,600 feet) a coal entry was driven in on this bed, which ranges in thickness from 3 to 4 feet, but the entry was so badly caved that it was not possible to obtain an exact measurement. As this prospect is high on the ridge, it is evident that the Lower Banner coal is present only in small areas on Toll Ridge, as erosion has lowered the ridge in many places down to and below that horizon.

QUALITY OF THE COAL

PHYSICAL PROPERTIES.

Most of the coal of the Russell coal field has a high luster and clean appearance. It is cut by two principal sets of cleavage planes nearly at right angles to one another and both normal to the bedding planes. One of these, known as the face cleavage, is usually more perfect than the other, which is known as the butt cleavage, but both are well developed. These cleavage planes, together with the bedding planes, cause the coal to break into roughly cuboidal pieces of various sizes. In the fresh coal the cleavage is not so apparent as when some degree of weathering has opened the cleavage cracks.

The coal is for the most part hard and moderately tough, and reasonable care in mining and handling will result in a large percentage of lump coal. There is, however, wide variation in hardness, not only in different beds but in different parts of the same bed or in different localities in the same bed. No determinations of density of the coal of this field are known to the writer, but coal of adjacent fields has an average density of 1.29 or 80.5 pounds per cubic foot or 24.8 cubic feet to the short ton of 2,000 pounds.

The Upper Banner, Lower Banner, and Raven coal beds are nearly everywhere composed of well-jointed columnar coal. At a great many places the Kennedy is very much mashed and disturbed and the columnar structure, if ever present, has been destroyed. The present structure is that of irregular "curly" pieces bounded by slip surfaces. In the eastern part of the field this coal bed is more regular and of the normal columnar structure. The Jawbone coal is commonly very hard and tough and in some places shows moderate development of the columnar structure, but in others seems to be massive and without joints, though these are probably everywhere present to be opened by sufficient weathering.

ANALYSES.

GENERAL STATEMENT.

Chemical analysis is the most easily applied and the most satisfactory basis of comparison between the coals of different fields or different parts of the same field. Although the fitness of a given coal for any especial purpose cannot be absolutely determined by analysis alone, but must be learned by actual trial, improved methods of analysis and standardized procedure in taking samples have added greatly in recent years to the validity of comparisons based on the analyses. Improvements in the methods based on careful studies of results by the United States Geological Survey and later by the United States Bureau of Mines have resulted in the accumulation of a great number of accurate analyses by these two federal bureaus. In the following discussion and tables only analyses made by them are considered.

Somewhat more than half of the samples, of which analyses are given on pages 105 to 117, are from mines in Russell County, but are not well distributed, a large proportion being from the vicinity of Dante. Lack of active mining in other parts of the field has prevented more uniform selection of samples and the table has been supplemented by samples from mines outside the county, which are working in the same beds and probably in coal of essentially similar quality to that of Russell County.

All coal samples were taken with great care so as to be representative of the fresh unweathered coal of the bed. The face of the bed was carefully cleaned for two or three feet on each side of the point of sampling and all loose coal, "slate," and dust brushed down from the adjacent part of the roof. A uniform cut was then made from roof to floor yielding about six pounds of coal for each foot of thickness, the coal being caught on a rubber-coated cloth spread on the floor. Partings over three-eighths of an inch

thick and all "sulphur balls" of a maximum diameter of over 2 inches and over one-half inch in thickness were rejected. The gross sample was then crushed in a mortar to pass a half-inch mesh screen and thoroughly mixed and reduced to about three pounds. The final sample was placed in a galvanized iron can, sealed with adhesive tape before leaving the mine so as to prevent change in moisture and oxidation, and mailed as soon as possible to the laboratory of the Bureau of Mines.

At the laboratory the sample was weighed, dried in air at slightly greater than normal temperature, and reweighed. The difference is the air-drying loss. Because the coal is more easily handled without serious moisture changes in the air-dried form it was analyzed in this condition. Form B gives the results of this analysis. Forms A, C, and D are computed from Form B. Form A represents the coal as received at the laboratory; C, the coal if completely dried; and D, if both ash and moisture were removed.

These analyses have been generalized by rejecting certain figures which result chiefly from computation and do not represent valid accuracy. Thus in the proximate analysis percentages are given to the nearest tenth of one per cent, whereas the ultimate analyses are given to the nearest one-hundredth of one per cent. B. t. u.'s are given to the nearest 10 units and calories to the nearest 5 units.

For the most part, the coals of Russell County are moderately high-volatile coals with fuel ratios, i. e., ratios of fixed carbon to volatile matter, of from 1.6 to 1.9. At only two localities represented in the following tables are found coals of higher percentage of fixed carbon as compared to volatile matter. At Nora in Dickenson County the Kennedy coal has, according to two analyses, a fuel ratio of 2.4, and at Jewell, in Tazewell County, the Raven coal has a fuel ratio of 2.5. Comparisons based on fuel ratios are of little significance when the ratios are less than 2.0, and the significance of the average fuel ratio of 1.74 is its indication that the coals of Russell County are of a distinctly different type from those of the long known Pocahontas field to the northeast, in which the fuel ratios are higher—3.0 to 4.5. The Russell County coal is therefore classified as bituminous coal and that of the Pocahontas field as semibituminous coal.

The ash in the Russell County coals runs very uniformly between 6 and 7 per cent as averaged for the different beds with the exception that at some localities the coal of the Kennedy bed is crushed and contains much shale and clay that is difficult to remove and gives a higher ash value. The Jawbone bed, which is also known as a high-ash coal, was not sampled in Russell County but is probably high in ash there as elsewhere. At Virginia

City, in Wise County, this coal has an average of 16.6 per cent ash according to six analyses. The high-ash value at this locality seems to be due not to shale partings in the coal but to the very hard, bony coal which makes up much of the thickness of the bed. Below is given an analysis of this "bone."

Analysis of "bone" from Virginia City.

Lab. No.	Air-Drying loss	Form of Analysis	Proximate					Heating Value	
			Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Calories	B. t. u.
32508	.4 (Gain)	A	.6	27.8	48.6	23.0	.43	6,340	11,410
		B	1.0	27.7	48.3	23.0	.43	6,310	11,360
		C	.....	27.9	48.8	23.3	.43	6,375	11,470
		D	.....	36.4	63.6	.....	.56	8,300	14,940

Most of the coal of Russell County can be loaded and delivered under 7 per cent of ash. Sulphur averages about .70 per cent and should run less than .9 per cent as delivered. The heating value of the Russell County coals averages about 14,200 B. t. u.'s,[1] which classes them as high grade bituminous coals.

By referring to the table of analyses for representative coals of other fields in the Appalachian region it will be seen that the Russell County coals are excelled in heating quality by those of only five districts—Pocahontas field, W. Va. and Va., New River district, W. Va., Cambria County, Pa., and Wise County, Va. Only four districts have a percentage of ash notably lower, and two only have a slightly smaller percentage of sulphur.

[1] That is, the burning of one pound of coal will raise 14,200 pounds of water 1°F. in temperature.

Analyses of coal samples from in and near Russell County.

A = analyses of sample as received; B = air-dried; C = moisture free; D = moisture and ash free.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Burton Ford .... (Not correlated)	Mine of Russell Fork Coal Mining Company, Burton Ford, Va.	Albert W. Giles. .	32513	2.6	A	3.6	32.1	60.5	3.82	.47	5.32	81.01	1.35	8.03	7,905	14,230
					B	1.1	32.9	62.1	3.92	.48	5.16	83.15	1.39	5.90	8,115	14,610
					C	.....	33.2	62.8	3.96	.49	5.10	84.06	1.40	4.99	8,205	14,770
					D	.....	34.6	65.4	.....	.51	5.31	87.52	1.46	5.20	8,540	15,380
Tiller	"East" mine of the Big Town Hill Creek Coal Corp., 1½ miles west of Richlands, Tazewell Co., Va.	T. K. Harnsberger	25763	2.1	A	3.0	30.5	59.0	7.49	.62	5.00	77.96	1.36	7.57	7,670	13,810
					B	.9	31.1	60.3	7.65	.63	4.87	79.62	1.39	5.84	7,835	14,100
					C	.....	31.4	60.9	7.72	.64	4.81	80.34	1.40	5.09	7,905	14,230
					D	.....	34.1	65.9	.....	.69	5.21	87.06	1.52	5.52	8,570	15,420
Do.....	.....do	.....do	25764	1.5	A	2.4	31.3	57.4	8.86	.47	4.96	77.23	1.32	7.16	7,500	13,500
					B	.9	31.8	58.3	9.00	.48	4.86	78.43	1.34	5.89	7,620	13,710
					C	.....	32.1	58.8	9.08	.48	4.81	79.11	1.35	5.17	7,685	13,830
					D	.....	35.3	64.7	.....	.53	5.29	87.01	1.48	5.69	8,450	15,210
Do.....	Composite of Nos. 25763 and 25764.	.....do	25765	1.8	A	2.7	30.9	58.1	8.30	.59	4.99	77.39	1.35	7.38	7,580	13,640
					B	.9	31.5	59.2	8.45	.60	4.88	78 82	1.37	5.88	7,720	13,890
					C	.....	31.8	59.7	8.53	.61	4.82	79.51	1.39	5.14	7,785	14,020
					D	.....	34.7	65.3	.....	.67	5.27	86.93	1.52	5.61	8,510	15,320
Do.....	No. 201 of the Clinchfield Coal Corp., on Hurricane Fork of Dumps Creek.	.....do	18239	1.0	A	1.8	31.4	60.3	6.5	.52	.....	.....	.....	.....	7,880	14,180
					B	.8	31.7	60.9	6.6	.53	.....	.....	.....	.....	7,960	14,330
					C	.....	32.0	61.4	6.6	.53	.....	.....	.....	.....	8,025	14,440
					D	.....	34.3	65.7	.....	.57	.....	.....	.....	.....	8,590	15,460
Do.....	.....do	.....do	18240	1.8	A	2.5	31.9	59.5	6.1	.44	.....	.....	.....	.....	7,820	14,070
					B	.8	32.4	60.6	6.2	.45	.....	.....	.....	.....	7,960	14,330
					C	.....	32.7	61.1	6.2	.45	.....	.....	.....	.....	8,020	14,430
					D	.....	34.9	65.1	.....	.48	.....	.....	.....	.....	8,555	15,400
Do.....	.....do	.....do	18241	1.9	A	2.4	32.5	58.4	6.7	.49	.....	.....	.....	.....	7,790	14,020
					B	.6	33.1	59.5	6.8	.50	.....	.....	.....	.....	7,940	14,290
					C	.....	33.3	59.8	6.9	.50	.....	.....	.....	.....	7,985	14,380
					D	.....	35.7	64.3	.....	.54	.....	.....	.....	.....	8,575	15,440
Do.....	Composite of Nos. 18239, 18240, and 18241.	.....do	18242	1.6	A	2.2	31.9	59.4	6.50	.46	5.11	79.69	1.04	7.20	7,840	14,110
					B	.6	32.5	60.3	6.60	.47	5.02	80.94	1.06	5.91	7,960	14,330
					C	.....	32.7	60.7	6.65	.47	4.98	81.48	1.06	5.36	8,015	14,430
					D	.....	35.0	65.0	.....	.50	5.33	87.28	1.14	5.75	8,585	15,460

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Jawbone	"West" mine of the Big Town Hill Creek Coal Corp., 1½ miles west of Richlands, Tazewell Co., Va.	T. K. Harnsberger	25757	1.2	A	1.9	31.2	53.8	13.13	.48	4.68	73.57	1.34	6.80	7,210	12,980
					B	.8	31.5	54.4	13.28	.49	4.60	74.43	1.36	5.84	7,295	13,140
					C	.....	31.7	54.9	13.39	.49	4.56	75.02	1.37	5.17	7,355	13,240
					D	.....	36.7	63.3	.....	.57	5.26	86.62	1.58	5.97	8,490	15,280
Do.....	.....do	.....do	25758	1.3	A	2.2	30.7	57.0	10.05	.47	5.04	76.95	1.43	6.06	7,525	13,550
					B	.9	31.1	57.8	10.18	.48	4.95	77.97	1.45	4.97	7,625	13,730
					C	.....	31.4	58.3	10.28	.48	4.90	78.69	1.46	4.19	7,695	13,850
					D	.....	35.0	65.0	.....	.54	5.46	87.71	1.63	4.66	8,575	15,440
Do.....	Composite of Nos. 25757 and 25758.	.....do	25759	1.2	A	2.0	31.1	55.3	11.55	.48	4.91	75.18	1.39	6.49	7,370	13,260
					B	.8	31.5	56.0	11.70	.49	4.83	76.12	1.41	5.45	7,460	13,430
					C	.....	31.8	56.4	11.79	.49	4.78	76.76	1.42	4.76	7,525	13,540
					D	.....	36.0	64.0	.....	.56	5.42	87.02	1.61	5.39	8,530	15,350
Do.....	Mine No. 2 of Twin City Coal Corp., St. Paul, Wise Co., Va.	Albert W. Giles...	32276	1.9	A	3.0	29.3	54.9	12.83	.71	4.80	72.26	1.41	7.99	7,055	12,700
					B	1.1	29.8	56.0	13.08	.72	4.68	73.66	1.44	6.42	7,195	12,950
					C	.....	30.2	56.6	13.22	.73	4.61	74.48	1.45	5.51	7,275	13,090
					D	.....	34.8	65.2	.....	.84	5.31	85.82	1.67	6.36	8,380	15,090
Do.....	Mine No. 3 of Twin City Coal Corp., St. Paul, Wise Co., Va.	.....do	32277	.8	A	2.1	29.9	48.6	19.44	1.01	4.41	66.78	1.27	7.09	6,540	11,770
					B	1.3	30.2	48.9	19.60	1.02	4.36	67.34	1.28	6.40	6,595	11,870
					C	.....	30.6	49.5	19.86	1.03	4.27	68.22	1.30	5.32	6,680	12,020
					D	.....	38.1	61.9	.....	1.29	5.33	85.12	1.62	6.64	8,335	15,000
Do.....	Mine No. 1 of Virginia City Colliery Co., at Virginia City, Wise Co., Va.	K. M. Way.....	5217	2.2	A	3.3	28.6	53.1	15.0	1.18	.....	.....	.....	.....	6,915	12,450
					B	1.2	29.2	54.3	15.3	1.21	.....	.....	.....	.....	7,070	12,730
					C	.....	29.6	54.9	15.5	1.22	.....	.....	.....	.....	7,155	12,880
					D	.....	35.0	65.0	.....	1.44	.....	.....	.....	.....	8,470	15,240
Do.....	.....do	.....do	5235	1.8	A	3.1	27.8	54.2	14.9	1.24	.....	.....	.....	.....	6,895	12,410
					B	1.3	28.3	55.2	15.2	1.26	.....	.....	.....	.....	7,020	12,640
					C	.....	28.7	55.9	15.4	1.28	.....	.....	.....	.....	7,115	12,800
					D	.....	33.9	66.1	.....	1.51	.....	.....	.....	.....	8,410	15,140
Do.....	Mine of Virginia Iron, Coal and Coke Company, Virginia City, Wise Co., Va.	C. K. Wentworth	32503	.7	A	1.8	29.6	49.0	19.6	1.43	.....	.....	.....	.....	6,545	11,790
					B	1.1	29.9	49.3	19.7	1.44	.....	.....	.....	.....	6,590	11,870
					C	.....	30.2	49.9	19.9	1.46	.....	.....	.....	.....	6,665	12,000
					D	.....	37.7	62.3	.....	1.82	.....	.....	.....	.....	8,325	14,980

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Jawbone	Mine of Va. I., C. and C. Co., Va. City, Wise Co., Va.	C. K. Wentworth	32504	.4	A	1.6	31.3	50.1	17.0	1.01	.....	.....	.....	.....	6,775	12,200
					B	1.2	31.4	50.3	17.1	1.01	.....	.....	.....	.....	6,805	12,250
					C	.....	31.8	50.9	17.3	1.03	.....	.....	.....	.....	6,880	12,390
					D	.....	38.5	61.5	.....	1.25	.....	.....	.....	.....	8,320	14,980
Do.....	.....do	.....do	32505	.6	A	1.6	32.3	50.8	15.3	1.76	.....	.....	.....	.....	6,955	12,520
					B	1.0	32.5	51.1	15.4	1.77	.....	.....	.....	.....	7,000	12,600
					C	.....	32.8	51.6	15.6	1.79	.....	.....	.....	.....	7,070	12,730
					D	.....	38.9	61.1	.....	2.12	.....	.....	.....	.....	8,375	15,080
Do.....	.....do	.....do	32506	.4	A	1.5	32.3	49.5	16.7	.81	.....	.....	.....	.....	6,785	12,210
					B	1.1	32.5	49.7	16.7	.81	.....	.....	.....	.....	6,810	12,260
					C	.....	32.8	50.3	16.9	.82	.....	.....	.....	.....	6,885	12,390
					D	.....	39.5	60.5	.....	.99	.....	.....	.....	.....	8,285	14,920
Do.....	Composite of Nos. 32503, 32504, 32505, and 32506.	.....do	32507	.5	A	1.5	31.4	49.8	17.33	1.25	4.70	68.93	1.32	6.47	6,775	12,190
					B	1.0	31.6	50.0	17.42	1.26	4.66	69.28	1.33	6.05	6,810	12,250
					C	.....	31.9	50.5	17.60	1.27	4.60	69.99	1.34	5.20	6,875	12,380
					D	.....	38.7	61.3	.....	1.54	5.58	84.94	1.63	6.31	8,345	15,020
Raven	No. 1 mine of the Jewell Ridge Coal Corp., at Jewell, Tazewell Co., Va.	T. K. Harnsberger	25651	3.1	A	3.7	25.9	64.9	5.5	.70	.....	.....	.....	.....	7,960	14,330
					B	.7	26.8	66.9	5.6	.72	.....	.....	.....	.....	8,210	14,780
					C	.....	26.9	67.4	5.7	.73	.....	.....	.....	.....	8,265	14,880
					D	.....	28.5	71.5	.....	.77	.....	.....	.....	.....	8,765	15,780
Do.....	.....do	.....do	25652	2.5	A	3.1	25.9	65.0	6.0	.79	.....	.....	.....	.....	7,985	14,380
					B	.6	26.6	66.7	6.1	.81	.....	.....	.....	.....	8,190	14,750
					C	.....	26.7	67.1	6.2	.82	.....	.....	.....	.....	8,240	14,830
					D	.....	28.5	71.5	.....	.87	.....	.....	.....	.....	8,785	15,810
Do.....	Composite of Nos. 25651 and 25652.	.....do	25653	2.8	A	3.4	25.3	65.6	5.69	.73	5.16	80.98	1.29	6.15	7,980	14,360
					B	.6	26.0	67.5	5.85	.75	4.99	83.30	1.33	3.78	8,205	14,770
					C	.....	26.2	67.9	5.89	.76	4.96	83.80	1.33	3.26	8,255	14,860
					D	.....	27.8	72.2	.....	.81	5.27	89.05	1.41	3.46	8,775	15,790
Do.....	Red Ash mine of the Raven Red Ash Coal Co., at Red Ash, Tazewell Co., Va.	.....do	25630	2.0	A	3.1	32.1	58.3	6.5	.57	.....	.....	.....	.....	7,840	14,110
					B	1.1	32.7	59.5	6.7	.58	.....	.....	.....	.....	8,000	14,400
					C	.....	33.1	60.2	6.7	.59	.....	.....	.....	.....	8,095	14,570
					D	.....	35.5	64.5	.....	.63	.....	.....	.....	.....	8,680	15,620

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Raven	Red Ash mine of the Raven Red Ash Coal Co., at Red Ash, Tazewell Co., Va.	T. K. Harnsberger	25631	1.9	A	2.9	31.8	60.3	5.0	.67	.....	.....	.....	.....	8,000	14,400
					B	1.0	32.4	61.5	5.1	.68	.....	.....	.....	.....	8,160	14,680
					C	.....	32.7	62.1	5.2	.69	.....	.....	.....	.....	8,240	14,830
					D	.....	34.5	65.5	.....	.73	.....	.....	.....	.....	8,690	15,640
Do	Composite of Nos. 25630 and 25631.	.....do	25632	2.0	A	2.9	32.0	59.4	5.73	.63	5.60	80.18	1.25	6.61	7,905	14,230
					B	.9	32.7	60.6	5.85	.64	5.49	81.80	1.28	4.94	8,065	14,520
					C	.....	33.0	61.1	5.90	.65	5.44	82.54	1.29	4.18	8,135	14,650
					D	.....	35.1	64.9	.....	.69	5.78	87.72	1.37	4.44	8,645	15,570
Aily	Prospect, Dante, Va.	C. K. Wentworth	32454	.9	A	2.6	32.2	60.8	4.40	.91	5.17	80.17	1.19	8.16	7,865	14,160
					B	1.7	32.5	61.4	4.44	.92	5.12	80.88	1.20	7.44	7,935	14,290
					C	.....	33.1	62.4	4.52	.93	5.02	82.27	1.22	6.04	8,070	14,530
					D	.....	34.6	65.4	.....	.97	5.26	86.16	1.28	6.33	8,455	15,220
Kennedy	Mine of Flatrock Coal Co., ¼ mile north of Della, Va.	T. K. Harnsberger	25367	.8	A	2.2	35.8	52.7	9.3	.82	.....	.....	.....	.....	7,465	13,440
					B	1.4	36.1	53.1	9.4	.83	.....	.....	.....	.....	7,525	13,540
					C	.....	36.6	53.9	9.5	.84	.....	.....	.....	.....	7,630	13,740
					D	.....	40.4	59.6	.....	.93	.....	.....	.....	.....	8,430	15,170
Do	.....do	.....do	25368	.4	A	1.9	35.5	53.1	9.5	.81	.....	.....	.....	.....	7,475	13,450
					B	1.5	35.6	53.3	9.6	.81	.....	.....	.....	.....	7,505	13,510
					C	.....	36.2	54.1	9.7	.83	.....	.....	.....	.....	7,615	13,710
					D	.....	40.1	59.9	.....	.92	.....	.....	.....	.....	8,435	15,180
Do	Composite of Nos. 25367 and 25368.	.....do	25369	.6	A	2.0	36.1	52.6	9.33	.83	5.21	75.37	1.17	8.09	7,470	13,450
					B	1.4	36.3	52.9	9.38	.83	5.18	75.80	1.18	7.63	7,515	13,530
					C	.....	36.8	53.7	9.52	.85	5.09	76.90	1.19	6.45	7,625	13,720
					D	.....	40.7	59.3	.....	.94	5.63	84.99	1.32	7.12	8,425	15,170
Do	Sandy Ridge mine of the Sandy Ridge Coal and Coke Co. on Lewis Creek, ½ mile south of Drill, Va.	C. M. Bauer	19528	1.8	A	3.2	33.1	57.7	6.0	.96	.....	.....	.....	.....	.....	.....
					B	1.4	33.7	58.8	6.1	.98	.....	.....	.....	.....	.....	.....
					C	.....	34.2	59.6	6.2	.99	.....	.....	.....	.....	.....	.....
					D	.....	36.4	63.6	.....	1.06	.....	.....	.....	.....	.....	.....
Do	.....do	T. K. Harnsberger	22345	3.5	A	4.7	30.8	59.4	5.14	.96	5.43	78.33	1.40	8.74	7,760	13,960
					B	1.2	31.9	61.6	5.33	1.00	5.22	81.18	1.45	5.82	8,040	14,470
					C	.....	32.3	62.3	5.39	1.01	5.15	82.17	1.47	4.81	8,140	14,650
					D	.....	34.1	65.9	.....	1.07	5.44	86.85	1.55	5.09	8,600	15,480

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Kennedy	Honaker Lumber Co. mine, at Drill, Va.	C. M. Bauer.....	19484	.8	A	2.1	32.4	58.7	6.8	1.0.	.....	.....	.....	.....	.....	.....
					B	1.3	32.6	59.2	6.9	1.02	.....	.....	.....	.....	.....	.....
					C	.....	33.1	60.0	6.9	1.03	.....	.....	.....	.....	.....	.....
					D	.....	35.5	64.5	.....	1.11	.....	.....	.....	.....	.....	.....
Do.....	Small local mine on McClure River, at Nora, Dickenson Co., ½ mile north of Open Fork.	Henry Hinds	17559	1.8	A	2.6	25.5	61.0	10.9	.70	.....	.....	.....	.....	7,470	13,440
					B	.9	25.9	62.1	11.1	.71	.....	.....	.....	.....	7,605	13,690
					C	.....	26.1	62.7	11.2	.72	.....	.....	.....	.....	7,670	13,810
					D	.....	29.4	70.6	.....	.81	.....	.....	.....	.....	8,640	15,550
Do.....	.....do	.....do	17560	1.7	A	2.6	26.0	63.2	8.2	.73	.....	.....	.....	.....	7,725	13,910
					B	.9	26.5	64.3	8.3	.74	.....	.....	.....	.....	7,860	14,150
					C	.....	26.7	64.9	8.4	.75	.....	.....	.....	.....	7,935	14,290
					D	.....	29.2	70.8	.....	.82	.....	.....	.....	.....	8,660	15,590
Do.....	Composite of Nos. 17559 and 17560.	.....do	17561	1.8	A	2.6	26.2	61.7	9.48	.74	4.75	77.60	1.57	5.86	7,575	13,640
					B	.9	26.6	62.8	9.65	.75	4.64	78.98	1.60	4.38	7,710	13,880
					C	.....	26.9	63.4	9.74	.76	4.58	79.70	1.61	3.61	7,780	14,010
					D	.....	29.8	70.2	.....	.84	5.07	88.30	1.78	4.01	8,620	15,520
Do.....	Kennedy No. 4 mine of Clinchfield Coal Corporation, Dante, Va.	Ralph W. Stone...	3947	.8	A	1.9	31.6	60.8	5.7	1.47	.....	.....	.....	.....	6,570	11,820
					B	1.1	31.8	61.4	5.7	1.48	.....	.....	.....	.....	6,620	11,920
					C	.....	32.1	62.1	5.8	1.50	.....	.....	.....	.....	6,695	12,050
					D	.....	34.1	65.9	.....	1.59	.....	.....	.....	.....	7,110	12,800
Do.....	No. 103 of the Clinchfield Coal Corp., 1 mile northwest of Dante, Va.	T. K. Harnsberger	18121	1.9	A	2.9	31.9	57.8	7.4	1.78	.....	.....	.....	.....	7,655	13,780
					B	1.0	32.5	58.9	7.6	1.81	.....	.....	.....	.....	7,800	14,040
					C	.....	32.8	59.6	7.6	1.83	.....	.....	.....	.....	7,880	14,190
					D	.....	35.5	64.5	.....	1.98	.....	.....	.....	.....	8,535	15,360
Do.....	Mine of Laurel Branch Coal Company, 1 mile west of Dante, Va.	C. K. Wentworth	32452	1.7	A	3.1	26.7	43.2	27.02	1.93	4.24	58.41	1.05	7.35	5,770	10,380
					B	1.4	27.2	43.9	27.48	1.96	4.12	59.40	1.07	5.97	5,865	10,560
					C	.....	27.5	44.6	27.88	1.99	4.02	60.27	1.08	4.76	5,950	10,710
					D	.....	38.2	61.8	.....	2.76	5.57	83.57	1.50	6.60	8,250	14,850
Do.....	Mine of Laurel Branch Coal Company, ½ mile west of Dante, Va.	.....do	32453	1.0	A	2.1	28.1	47.9	21.89	2.00	4.39	63.97	1.28	6.47	6,310	11,360
					B	1.1	28.4	48.4	22.12	2.02	4.32	64.63	1.29	5.62	6,375	11,470
					C	.....	28.7	48.9	22.36	2.04	4.25	65.35	1.31	4.69	6,445	11,600
					D	.....	37.0	63.0	.....	2.63	5.47	84.17	1.69	6.04	8,300	14,940

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Lower Banner....	No. 55 of the Clinchfield Coal Corp., Wilder, Va.	T. K. Harnsberger	18243	2.4	A	3.2	33.6	57.3	5.9	.79	.....	.....	.....	.....	7,860	14,150
					B	.8	34.5	58.7	6.0	.81	.....	.....	.....	.....	8,050	14,490
					C	.....	34.8	59.1	6.1	.82	.....	.....	.....	.....	8,115	14,600
					D	.....	37.0	63.0	.....	.87	.....	.....	.....	.....	8,640	15,550
Do.....	.....do	.....do	18244	1.6	A	2.4	34.6	57.3	5.7	.83	.....	.....	.....	.....	7,945	14,300
					B	.8	35.2	58.3	5.7	.84	.....	.....	.....	.....	8,075	14,540
					C	.....	35.5	58.7	5.8	.85	.....	.....	.....	.....	8,140	14,660
					D	.....	37.6	62.4	.....	.90	.....	.....	.....	.....	8,645	15,560
Do.....	.....do	.....do	18245	2.0	A	2.8	33.7	57.8	5.7	.78	.....	.....	.....	.....	7,920	14,260
					B	.8	34.4	59.0	5.8	.80	.....	.....	.....	.....	8,080	14,540
					C	.....	34.7	59.5	5.8	.80	.....	.....	.....	.....	8,145	14,660
					D	.....	36.8	63.2	.....	.85	.....	.....	.....	.....	8,650	15,570
Do.....	Composite of Nos. 18243, 18244, and 18245.	.....do	18246	2.0	A	2.7	33.8	57.7	5.78	.83	5.27	79.33	1.29	7.50	7,915	14,250
					B	.7	34.5	58.9	5.90	.85	5.15	80.93	1.32	5.85	8,075	14,530
					C	.....	34.8	59.3	5.94	.85	5.11	81.55	1.33	5.22	8,135	14,650
					D	.....	37.0	63.0	.....	.90	5.43	86.70	1.41	5.56	8,650	15,570
Do.....	No. 51 (called No. 2 when sampled) of the Clinchfield Coal Corp., Dante, Va.	R. W. Stone.....	4057	1.8	A	2.8	32.1	59.3	5.8	.84	.....	.....	.....	.....	.....	.....
					B	1.0	32.7	60.4	5.9	.85	.....	.....	.....	.....	.....	.....
					C	.....	33.0	61.0	6.0	.86	.....	.....	.....	.....	.....	.....
					D	.....	35.1	64.9	.....	.92	.....	.....	.....	.....	.....	.....
Do.....	No. 52 (called Clinchfield when sampled) of the Clinchfield Coal Corp., Dante, Va.	E. G. Woodruff..	10385	1.1	A	2.1	33.8	57.7	6.45	.65	5.44	78.59	1.53	7.34	7,855	14,140
					B	1.0	34.2	58.3	6.52	.66	5.38	79.46	1.55	6.43	7,940	14,290
					C	.....	34.5	58.9	6.59	.66	5.31	80.30	1.56	5.58	8,025	14,440
					D	.....	36.9	63.1	.....	.71	5.68	85.96	1.67	5.98	8,590	15,460
Do.....	No. 52 of the Clinchfield Coal Corporation, Dante, Va.	T. K. Harnsberger	18122	1.6	A	2.5	35.6	56.2	5.7	.66	.....	.....	.....	.....	7,930	14,280
					B	.9	36.1	57.2	5.8	.67	.....	.....	.....	.....	8,060	14,510
					C	.....	36.5	57.7	5.8	.68	.....	.....	.....	.....	8,135	14,640
					D	.....	38.7	61.3	.....	.72	.....	.....	.....	.....	8,640	15,550
Do.....	.....do	.....do	18123	1.1	A	2.0	35.7	54.5	7.8	.66	.....	.....	.....	.....	7,685	13,830
					B	.9	36.1	55.1	7.9	.67	.....	.....	.....	.....	7,770	13,990
					C	.....	36.4	55.6	8.0	.67	.....	.....	.....	.....	7,840	14,110
					D	.....	39.5	60.5	.....	.73	.....	.....	.....	.....	8,520	15,330

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Lower Banner....	No. 52 of the Clinchfield Coal Corporation, Dante, Va. Composite of Nos. 18122 and 18123.	T. K. Harnsberger	18124	1.4	A	2.3	35.5	55.5	6.71	.67	5.26	78.84	1.69	6.83	7,780	14,000
					B	.9	36.0	56.3	6.80	.68	5.18	79.94	1.71	5.69	7,890	14,200
					C	.....	36.3	56.8	6.87	.69	5.13	80.66	1.73	4.92	7,960	14,330
					D	.....	39.0	61.0	.....	.74	5.51	86.61	1.86	5.28	8,545	15,390
Do.....	.....do	C. K. Wentworth	32329	.5	A	1.4	36.2	56.3	6.1	.68	.....	.....	.....	.....	7,920	14,250
					B	.8	36.4	56.7	6.1	.68	.....	.....	.....	.....	7,970	14,340
					C	.....	36.7	57.1	6.2	.69	.....	.....	.....	.....	8,035	14,460
					D	.....	39.1	60.9	.....	.74	.....	.....	.....	.....	8,565	15,410
Do.....	.....do	.....do	32330	.6	A	1.4	36.6	55.7	6.3	.72	.....	.....	.....	.....	7,880	14,190
					B	.8	36.8	56.0	6.4	.72	.....	.....	.....	.....	7,930	14,270
					C	.....	37.1	56.5	6.4	.73	.....	.....	.....	.....	7,995	14,390
					D	.....	39.6	60.4	.....	.78	.....	.....	.....	.....	8,545	15,380
Do.....	Composite of Nos. 32329 and 32330.	.....do	32331	.6	A	1.4	36.2	56.2	6.20	.69	5.29	79.59	1.65	6.58	7,900	14,220
					B	.8	36.4	56.6	6.24	.68	5.25	80.09	1.66	6.08	7,950	14,310
					C	.....	36.7	57.0	6.29	.70	5.20	80.72	1.67	5.42	8,010	14,420
					D	.....	39.2	60.8	.....	.75	5.55	86.14	1.78	5.78	8,550	15,390
Do.....	Lower Banner No. 1 mine of Robert Fleming & Company, Banner, Wise Co., Va.	Albert W. Giles..	32509	1.2	A	2.3	32.9	56.7	8.1	.65	.....	.....	.....	.....	7,635	13,750
					B	1.1	33.3	57.4	8.2	.66	.....	.....	.....	.....	7,725	13,910
					C	.....	33.6	58.1	8.3	.66	.....	.....	.....	.....	7,815	14,060
					D	.....	36.7	63.3	.....	.72	.....	.....	.....	.....	8,525	15,340
Do.....	.....do	.....do	32510	.7	A	1.8	33.8	57.6	6.8	.77	.....	.....	.....	.....	7,790	14,020
					B	1.1	34.1	57.9	6.9	.78	.....	.....	.....	.....	7,845	14,120
					C	.....	34.4	58.6	7.0	.78	.....	.....	.....	.....	7,935	14,280
					D	.....	37.0	63.0	.....	.84	.....	.....	.....	.....	8,530	15,350
Do.....	Composite of Nos. 32509 and 32510.	.....do	32511	.9	A	2.2	33.3	57.1	7.45	.70	5.13	78.05	1.57	7.10	7,710	13,880
					B	1.3	33.6	57.6	7.52	.71	5.08	78.78	1.58	6.33	7,780	14,010
					C	.....	34.1	58.3	7.62	.72	5.00	79.78	1.60	5.28	7,880	14,180
					D	.....	36.9	63.1	.....	.78	5.41	86.36	1.73	5.72	8,530	15,350
Upper Banner	Mine of Yellow Poplar Lumber Co., 4 miles northwest of Prater, Dickenson Co., Va.	T. K. Harnsberger	17743	1.7	A	2.8	31.6	58.1	7.5	1.45	.....	.....	.....	.....	7,685	13,840
					B	1.1	32.2	59.1	7.6	1.47	.....	.....	.....	.....	7,815	14,070
					C	.....	32.5	59.8	7.7	1.49	.....	.....	.....	.....	7,905	14,230
					D	.....	35.2	64.8	.....	1.61	.....	.....	.....	.....	8,565	15,410

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Upper Banner	Mine of Yellow Poplar Lumber Co., 4 miles northwest of Prater, Dickenson Co., Va.	T. K. Harnsberger	17744	1.8	A	3.0	32.4	58.4	6.2	1.62	.....	.....	.....	.....	7,795	14,030
					B	1.2	33.0	59.5	6.3	1.65	.....	.....	.....	.....	7,935	14,290
					C	.....	33.4	60.2	6.4	1.67	.....	.....	.....	.....	8,030	14,460
					D	.....	35.6	64.4	.....	1.78	.....	.....	.....	.....	8,575	15,440
Do.....	No. 6 of the Clinchfield Coal Corp., at Wilder, Va.	.....do	18235	2.4	A	3.4	35.7	54.9	6.0	.55	.....	.....	.....	.....	7,760	13,970
					B	1.0	36.6	56.3	6.1	.56	.....	.....	.....	.....	7,945	14,310
					C	.....	37.0	56.8	6.2	.57	.....	.....	.....	.....	8,030	14,450
					D	.....	39.4	60.6	.....	.61	.....	.....	.....	.....	8,555	15,400
Do.....	.....do	.....do	18236	2.4	A	3.2	35.4	55.1	6.3	.59	.....	.....	.....	.....	7,760	13,970
					B	.9	36.3	56.4	6.4	.60	.....	.....	.....	.....	7,945	14,300
					C	.....	36.6	56.9	6.5	.61	.....	.....	.....	.....	8,020	14,430
					D	.....	39.1	60.9	.....	.65	.....	.....	.....	.....	8,575	15,440
Do.....	.....do	.....do	18237	2.4	A	3.3	35.1	56.9	4.7	.50	.....	.....	.....	.....	7,925	14,270
					B	.9	36.0	58.3	4.8	.51	.....	.....	.....	.....	8,115	14,610
					C	.....	36.3	58.8	4.9	.52	.....	.....	.....	.....	8,195	14,750
					D	.....	38.2	61.8	.....	.55	.....	.....	.....	.....	8,615	15,510
Do.....	Composite of Nos. 18235, 18236, and 18237.	.....do	18238	2.4	A	3.4	35.0	55.9	5.71	.55	5.37	78.72	1.37	8.28	7,820	14,080
					B	1.0	35.9	57.2	5.85	.56	5.23	80.62	1.40	6.34	8,010	14,420
					C	.....	36.3	57.8	5.91	.57	5.17	81.44	1.42	5.49	8,095	14,570
					D	.....	38.5	61.5	.....	.61	5.49	86.55	1.51	5.84	8,600	15,480
Do.....	No. 2 (called No. 3 when sampled) of the Clinchfield Coal Corp., at Dante, Va.	R. W. Stone.....	3942	1.3	A	2.4	32.4	57.9	7.3	.66	.....	.....	.....	.....	.....	.....
					B	1.1	32.8	58.7	7.4	.67	.....	.....	.....	.....	.....	.....
					C	.....	33.2	59.3	7.5	.68	.....	.....	.....	.....	.....	.....
					D	.....	35.9	64.1	.....	.74	.....	.....	.....	.....	.....	.....
Do.....	No. 3 of the Clinchfield Coal Corp., 1 mile east of Dante, Va.	E. G. Woodruff...	10887	1.4	A	2.3	35.7	55.0	7.00	.66	5.48	77.91	1.53	7.42	7,740	13,940
					B	.9	36.2	55.8	7.10	.67	5.40	79.02	1.55	6.26	7,850	14,130
					C	.....	36.5	56.3	7.16	.68	5.35	79.73	1.56	5.52	7,920	14,260
					D	.....	39.3	60.7	.....	.73	5.76	85.87	1.68	5.96	8,530	15,360
Do.....	No. 2 of the Clinchfield Coal Corp., 1¾ miles northeast of Dante, Va.	P. M. Riefkin.....	10734	1.5	A	2.3	35.2	56.2	6.3	.59	.....	.....	.....	.....	7,830	14,100
					B	.8	35.8	57.0	6.4	.60	.....	.....	.....	.....	7,950	14,310
					C	.....	36.1	57.5	6.4	.60	.....	.....	.....	.....	8,020	14,440
					D	.....	38.6	61.4	.....	.64	.....	.....	.....	.....	8,570	15,430

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Upper Banner	No. 2 of the Clinchfield Coal Corp., 1¾ miles northeast of Dante, Va.	P. M. Riefkin.....	10735	2.1	A	3.0	35.2	56.6	5.2	.59	.....	.....	.....	.....	7,860	14,150
					B	.9	35.9	57.9	5.3	.60	.....	.....	.....	.....	8,030	14,450
					C	.....	36.2	58.4	5.4	.61	.....	.....	.....	.....	8,100	14,580
					D	.....	38.3	61.7	.....	.64	.....	.....	.....	.....	8,560	15,410
Do.....	Composite of Nos. 10734 and 10735.	.....do	10736	1.8	A	2.8	34.9	56.5	5.77	.59	5.32	80.13	1.43	6.76	7,860	14,150
					B	1.0	35.6	57.5	5.88	.60	5.21	81.60	1.46	5.25	8,005	14,410
					C	.....	36.0	58.1	5.93	.61	5.15	82.41	1.47	4.43	8,085	14,550
					D	.....	38.2	61.8	.....	.65	5.47	87.60	1.56	4.72	8,590	15,460
Do.....	No. 5 of the Clinchfield Coal Corp., 1½ miles north of Dante, Va.	.....do	10737	1.4	A	2.3	35.2	57.8	4.7	.55	.....	.....	.....	.....	8,015	14,430
					B	.9	35.7	58.6	4.8	.56	.....	.....	.....	.....	8,130	14,640
					C	.....	36.0	59.1	4.9	.56	.....	.....	.....	.....	8,205	14,770
					D	.....	37.8	62.2	.....	.59	.....	.....	.....	.....	8,625	15,520
Do.....	.....do	.....do	10738	1.2	A	2.1	35.1	57.2	5.6	.56	.....	.....	.....	.....	7,930	14,280
					B	.9	35.5	57.9	5.7	.57	.....	.....	.....	.....	8,025	14,450
					C	.....	35.9	58.3	5.8	.58	.....	.....	.....	.....	8,100	14,580
					D	.....	38.1	61.9	.....	.62	.....	.....	.....	.....	8,600	15,480
Do.....	Composite of Nos. 10737 and 10738.	.....do	10739	1.3	A	2.1	35.9	56.7	5.33	.57	5.45	80.24	1.43	6.98	8,965	14,340
					B	.8	36.4	57.4	5.40	.58	5.38	81.30	1.45	5.89	8,070	14,520
					C	.....	36.7	57.9	5.44	.58	5.33	81.93	1.46	5.26	8,130	14,640
					D	.....	38.8	61.2	.....	.61	5.64	86.64	1.54	5.57	8,600	15,480
Do.....	No. 2 of the Clinchfield Coal Corp., 1¾ miles northeast of Dante, Va.	T. K. Harnsberger	18128	1.0	A	1.8	35.3	55.8	7.1	.58	.....	.....	.....	.....	7,800	14,040
					B	.8	35.7	56.3	7.2	.58	.....	.....	.....	.....	7,875	14,180
					C	.....	35.9	56.8	7.3	.59	.....	.....	.....	.....	7,945	14,300
					D	.....	38.8	61.2	.....	.64	.....	.....	.....	.....	8,565	15,420
Do.....	.....do	.....do	18129	1.4	A	2.4	36.3	55.1	6.2	.52	.....	.....	.....	.....	7,840	14,110
					B	1.0	36.8	55.9	6.3	.53	.....	.....	.....	.....	7,945	14,300
					C	.....	37.2	56.4	6.4	.53	.....	.....	.....	.....	8,025	14,450
					D	.....	39.7	60.3	.....	.57	.....	.....	.....	.....	8,570	15,430
Do.....	.....do	.....do	18130	.8	A	1.6	36.7	55.4	6.3	.58	.....	.....	.....	.....	7,870	14,170
					B	.8	37.0	55.8	6.4	.58	.....	.....	.....	.....	7,935	14,290
					C	.....	37.3	56.2	6.5	.59	.....	.....	.....	.....	8,000	14,400
					D	.....	39.9	60.1	.....	.63	.....	.....	.....	.....	8,550	15,390

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Upper Banner	Composite of Nos. 18128, 18129, and 18130.	T. K. Harnsberger	18131	1.1	A	1.8	36.2	55.5	6.53	.54	5.25	79.28	1.49	6.91	7,830	14,100
					B	.8	36.5	56.1	6.60	.55	5.18	80.12	1.51	6.04	7,915	14,250
					C	.....	36.8	56.5	6.65	.55	5.14	80.76	1.52	5.38	7,980	14,360
					D	.....	39.4	60.6	.....	.59	5.51	86.51	1.63	5.76	8,545	15,380
Do.....	Mine No. 2 of Clinchfield Coal Corporation, Dante, Va.	Albert W. Giles...	32168	1.6	A	2.7	34.8	56.2	6.3	.87	.....	.....	.....	.....	7,820	14,080
					B	1.1	35.4	57.1	6.4	.88	.....	.....	.....	.....	7,945	14,300
					C	.....	35.8	57.8	6.4	.89	.....	.....	.....	.....	8,035	14,470
					D	.....	38.3	61.7	.....	.95	.....	.....	.....	.....	8,590	15,460
Do.....	.....do	.....do	32169	1.1	A	2.2	35.3	53.4	9.1	.71	.....	.....	.....	.....	7,585	13,650
					B	1.1	35.7	54.0	9.2	.72	.....	.....	.....	.....	7,670	13,800
					C	.....	36.1	54.6	9.3	.73	.....	.....	.....	.....	7,755	13,960
					D	.....	39.8	60.2	.....	.80	.....	.....	.....	.....	8,550	15,390
Do.....	.....do	.....do	32170	1.4	A	2.5	34.0	56.2	7.3	.52	.....	.....	.....	.....	7,720	13,890
					B	1.1	34.5	57.0	7.4	.53	.....	.....	.....	.....	7,830	14,090
					C	.....	34.9	57.6	7.5	.53	.....	.....	.....	.....	7,915	14,250
					D	.....	37.7	62.3	.....	.57	.....	.....	.....	.....	8,560	15,410
Do.....	.....do	C. K. Wentworth	32171	1.1	A	2.2	36.2	55.4	6.2	.53	.....	.....	.....	.....	7,840	14,110
					B	1.1	36.6	56.0	6.3	.54	.....	.....	.....	.....	7,925	14,260
					C	.....	37.0	56.7	6.3	.54	.....	.....	.....	.....	8,015	14,420
					D	.....	39.5	60.5	.....	.58	.....	.....	.....	.....	8,555	15,400
Do.....	Composite of Nos. 32168, 32169, 32170, and 32171.	Albert W. Giles...	32172	1.3	A	2.4	34.7	55.7	7.16	.58	5.25	78.22	1.51	7.28	7,740	13,930
					B	1.1	35.1	56.5	7.25	.59	5.18	79.24	1.53	6.21	7,840	14,110
					C	.....	35.6	57.1	7.33	.59	5.11	80.13	1.55	5.29	7,925	14,270
					D	.....	38.4	61.6	.....	.64	5.51	86.47	1.67	5.71	8,555	15,400
Do.....	Mine No. 3 of Clinchfield Coal Corporation, Dante, Va.	C. K. Wentworth	32326	1.1	A	2.2	36.4	51.9	9.5	.60	.....	.....	.....	.....	7,510	13,520
					B	1.1	36.8	52.5	9.6	.61	.....	.....	.....	.....	7,590	13,660
					C	.....	37.2	53.1	9.7	.61	.....	.....	.....	.....	7,675	13,820
					D	.....	41.2	58.8	.....	.68	.....	.....	.....	.....	8,500	15,300
Do.....	.....do	.....do	32327	1.0	A	2.0	37.4	53.9	6.7	.60	.....	.....	.....	.....	7,765	13,980
					B	1.0	37.8	54.5	6.7	.61	.....	.....	.....	.....	7,845	14,120
					C	.....	38.2	55.0	6.8	.61	.....	.....	.....	.....	7,925	14,270
					D	.....	40.9	59.1	.....	.65	.....	.....	.....	.....	8,505	15,310

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Upper Banner	Composite of Nos. 32326 and 32327.	C. K. Wentworth	32328	1.0	A	2.0	37.0	53.0	8.03	.58	5.22	77.15	1.39	7.63	7,635	13,740
					B	1.0	37.4	53.5	8.11	.59	5.16	77.94	1.40	6.80	7,715	13,890
					C	.....	37.8	54.0	8.20	.59	5.09	78.75	1.42	5.95	7,795	14,030
					D	.....	41.1	58.9	.....	.64	5.54	85.78	1.55	6.49	8,490	15,280
Do.....	No. 1 mine of Robt. Fleming & Co., Barmer, Wise Co., Va.	Albert W. Giles...	32512	1.1	A	2.3	36.1	57.0	4.55	.89	5.35	79.65	1.50	8.06	7,925	14,260
					B	1.2	36.5	57.7	4.60	.90	5.29	80.52	1.52	7.17	8,010	14,420
					C	.....	36.9	58.4	4.66	.91	5.22	81.51	1.54	6.16	8,110	14,600
					D	.....	38.8	61.2	.....	.95	5.48	85.50	1.62	6.45	8,505	15,310
Do.....	Coeburn mine of the Va. Iron, Coal and Coke Co., at Toms Creek, Wise Co., Va.	J. W. Groves and W. J. von Borries	2281	1.6	A	2.7	32.4	60.4	4.5	.52	.....	.....	.....	.....	8,080	14,540
					B	1.1	33.0	61.3	4.6	.53	.....	.....	.....	.....	8,210	14,790
					C	.....	33.4	62.0	4.6	.53	.....	.....	.....	.....	8,305	14,950
					D	.....	34.9	65.1	.....	.56	.....	.....	.....	.....	8,705	15,670
Do.....	.....do	.....do	2282	1.7	A	2.9	32.0	61.0	4.1	.55	.....	.....	.....	.....	.....	.....
					B	1.2	32.5	62.1	4.2	.56	.....	.....	.....	.....	.....	.....
					C	.....	32.9	62.8	4.3	.57	.....	.....	.....	.....	.....	.....
					D	.....	34.4	65.6	.....	.60	.....	.....	.....	.....	.....	.....
Do.....	Swansea mine of Virginia Iron, Coal and Coke Co., Georgel, Wise Co., Va.	E. G. Woodruff...	10386	1.5	A	2.5	31.7	60.3	5.51	.52	5.59	79.69	1.56	7.13	7,920	14,250
					B	1.0	32.2	61.2	5.59	.53	5.50	80.90	1.58	5.90	8,040	14,470
					C	.....	32.5	61.8	5.65	.53	5.44	81.71	1.60	5.07	8,120	14,610
					D	.....	34.5	65.5	.....	.56	5.76	86.60	1.70	5.38	8,605	15,490
Do.....	No. 1 (Thelma) mine of Virginia I., C. and C. Co., Toms Creek, Wise Co., Va.	Albert W. Giles...	32404	1.8	A	2.7	34.3	56.6	6.4	.50	.....	.....	.....	.....	7,785	14,020
					B	.9	35.0	57.6	6.5	.51	.....	.....	.....	.....	7,930	14,280
					C	.....	35.3	58.1	6.6	.51	.....	.....	.....	.....	8,005	14,410
					D	.....	37.8	62.2	.....	.55	.....	.....	.....	.....	8,570	15,430
Do.....	.....do	.....do	32405	1.8	A	2.8	32.4	53.9	10.9	.56	.....	.....	.....	.....	7,340	13,220
					B	1.0	33.0	54.9	11.1	.57	.....	.....	.....	.....	7,475	13,460
					C	.....	33.4	55.4	11.2	.58	.....	.....	.....	.....	7,555	13,600
					D	.....	37.6	62.4	.....	.65	.....	.....	.....	.....	8,505	15,310
Do.....	Composite of Nos. 32404 and 32405.	.....do	32406	1.8	A	2.9	33.2	55.3	8.57	.52	5.17	76.31	1.59	7.84	7,525	13,540
					B	1.1	33.8	56.4	8.73	.53	5.06	77.71	1.62	6.35	7,660	13,790
					C	.....	34.2	57.0	8.82	.54	4.99	78.54	1.64	5.47	7,745	13,940
					D	.....	37.5	62.5	.....	.59	5.47	86.13	1.80	6.01	8,495	15,290

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Upper Banner	Cranesnest No. 1 of the Clinchfield Coal Corp., about 1½ miles northwest of Toms Creek, Wise Co., Va.	T. K. Harnsberger	18226	1.5	A	2.5	33.3	59.4	4.8	.58	.....	.....	.....	.....	8,035	14,460
					B	1.0	33.9	60.2	4.9	.59	.....	.....	.....	.....	8,160	14,680
					C	.....	34.2	60.9	4.9	.59	.....	.....	.....	.....	8,235	14,830
					D	.....	36.0	64.0	.....	.62	.....	.....	.....	.....	8,660	15,590
Do.....	.....do	.....do	18227	1.5	A	2.4	32.9	59.8	4.9	.53	.....	.....	.....	.....	8,035	14,460
					B	.9	33.4	60.7	5.0	.54	.....	.....	.....	.....	8,150	14,670
					C	.....	33.7	61.2	5.1	.54	.....	.....	.....	.....	8,225	14,810
					D	.....	35.4	64.6	.....	.57	.....	.....	.....	.....	8,665	15,600
Do.....	.....do	.....do	18228	1.4	A	2.3	32.7	59.2	5.8	.51	.....	.....	.....	.....	7,985	14,370
					B	.9	33.1	60.1	5.9	.52	.....	.....	.....	.....	8,100	14,580
					C	.....	33.5	60.6	5.9	.52	.....	.....	.....	.....	8,170	14,710
					D	.....	35.6	64.4	.....	.55	.....	.....	.....	.....	8,685	15,630
Do.....	Composite of Nos. 18226, 18227, and 18228.	.....do	18229	1.5	A	2.3	32.9	59.6	5.22	.54	5.18	80.78	1.57	6.71	8,010	14,420
					B	.8	33.4	60.5	5.30	.55	5.09	81.97	1.59	5.50	8,130	14,630
					C	.....	33.7	61.0	5.34	.55	5.05	82.67	1.61	4.78	8,200	14,760
					D	.....	35.5	64.5	.....	.58	5.33	87.33	1.70	5.06	8,660	15,590
Do.....	Caney mine of Clinchfield Coal Corporation, Toms Creek, Wise Co., Va.	Albert W. Giles...	32407	1.5	A	2.5	32.8	58.3	6.4	.52	.....	.....	.....	.....	7,825	14,080
					B	1.0	33.3	59.2	6.5	.53	.....	.....	.....	.....	7,940	14,290
					C	.....	33.6	59.8	6.6	.53	.....	.....	.....	.....	8,030	14,440
					D	.....	36.0	64.0	.....	.57	.....	.....	.....	.....	8,580	15,450
Do.....	.....do	.....do	32408	1.4	A	2.2	32.3	59.6	5.9	.59	.....	.....	.....	.....	7,865	14,160
					B	.8	32.8	60.4	6.0	.60	.....	.....	.....	.....	7,970	14,350
					C	.....	33.1	60.8	6.1	.60	.....	.....	.....	.....	8,045	14,480
					D	.....	35.2	64.8	.....	.64	.....	.....	.....	.....	8,560	15,410
Do.....	Composite of Nos. 32407 and 32408.	.....do	32409	1.4	A	2.2	32.4	59.2	6.24	.55	5.21	79.72	1.63	6.65	7,850	14,130
					B	.8	32.9	60.0	6.33	.56	5.12	80.85	1.65	5.49	7,960	14,330
					C	.....	33.1	60.5	6.38	.56	5.08	81.51	1.67	4.80	8,025	14,450
					D	.....	35.4	64.6	.....	.60	5.43	87.06	1.78	5.13	8,570	15,430

Analyses of coal samples from in and near Russell County—Contd.

Coal bed.	Name and location of mine.	Collector.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating Value.	
						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
Upper Banner	No. 6 (Lee) mine of Va. I., C. and C. Co., Toms Creek, Wise Co., Va.	Albert W. Giles...	32410	2.3	A	3.9	32.4	58.1	5.6	.48	.....	.....	.....	.....	7,760	13,970
					B	1.6	33.2	59.5	5.7	.49	.....	.....	.....	.....	7,945	14,300
					C	.....	33.7	60.5	5.8	.50	.....	.....	.....	.....	8,075	14,540
					D	.....	35.8	64.2	.....	.53	.....	.....	.....	.....	8,580	15,440
Do.....	.....do	.....do	32411	.9	A	2.0	33.1	60.4	4.5	.50	.....	.....	.....	.....	8,000	14,400
					B	1.1	33.4	60.9	4.6	.50	.....	.....	.....	.....	8,075	14,530
					C	.....	33.7	61.7	4.6	.51	.....	.....	.....	.....	8,165	14,700
					D	.....	35.4	64.6	.....	.53	.....	.....	.....	.....	8,565	15,420
Do.....	Composite of Nos. 32410 and 32411.	.....do	32412	1.6	A	2.8	33.0	59.0	5.21	.55	5.31	80.06	1.61	7.26	7,855	14,140
					B	1.2	33.6	59.9	5.30	.56	5.21	81.38	1.64	5.91	7,985	14,380
					C	.....	33.9	60.7	5.36	.57	5.14	82.40	1.66	4.87	8,085	14,560
					D	.....	35.9	64.1	.....	.60	5.43	87.06	1.75	5.16	8,545	15,380
Do.....	No. 2 (Sexton) mine of Va. I., C. and C. Co., Toms Creek, Wise Co., Va.	.....do	32413	2.1	A	3.2	30.4	52.0	14.36	.60	4.88	71.30	1.48	7.38	7,035	12,660
					B	1.1	31.1	53.1	14.67	.61	4.75	72.81	1.51	5.65	7,185	12,930
					C	.....	31.5	53.7	14.84	.62	4.67	73.66	1.53	4.68	7,270	13,080
					D	.....	36.9	63.1	.....	.73	5.48	86.50	1.80	5.49	8,535	15,360

DESCRIPTIONS OF SAMPLES ANALYZED.

32513.—Sample of coal from Burton Ford bed in the mine of the Russell Fork Coal Mining Co., 3 miles southwest of St. Paul. (Location 1.) Collected July 30, 1919, from the face of the main entry about 150 feet west of the drift mouth. This is one of the very few localities where coal in the Pennington formation is being worked in this part of southwest Virginia, hence the sample is of more than ordinary interest.[1]

25763, 25764, and 25765.—Samples of Tiller coal from the "East" mine of the Big Town Hill Creek Coal Corporation, 1½ miles west of Richlands, Tazewell Co., Virginia. Collected August 4, 1916. Sample 25763 was from room 1, off main entry, 450 feet northeast of mine mouth. Sample 25764 was cut from face of main entry 400 feet N. 30° E. of mine mouth. Sample 25765 is a composite made by mixing 25763 and 25764.[1]

18239, 18240, 18241, and 18242.—Samples of Tiller coal from Slope Mine No. 201 of the Clinchfield Coal Corporation, on Hurricane Fork of Dumps Creek, at Clinchfield Post Office (location 113). Collected November 26, 1913. Sample 18239 was from the main entry, 4,900 feet N. 30° W. of bottom of slope; sample 18240, about 1,200 feet N. 64° W. of slope and 800 feet west of main entry; and sample 18241 in a right entry about 800 feet from main entry and 2,600 feet N. 20° W. of slope. Sample 18242 is a composite made by mixing 18239, 18240, and 18241.[1]

25757, 25758, and 25759.—Samples of Jawbone coal from "West" mine of the Big Town Hill Creek Coal Corporation, 1½ miles west of Richlands, Tazewell Co., Va. Collected August 4, 1916. Sample 25757 was from face of ninth entry, off fourth right entry, 1,700 feet northwest of mine mouth; sample 25758, from face of first left entry, 1,400 feet west of mine mouth. Sample 25759 is a composite made by mixing 25757 and 25758.[1]

32276.—Sample of Jawbone coal from Mine No. 2 of the Twin City Coal Corporation at St. Paul, Wise Co., Va. Collected July 1, 1919. Sample was from main entry, 300 feet northeast of drift mouth.[1]

32277.—Sample of Jawbone coal from Mine No. 3 of the Twin City Coal Corporation at St. Paul, Wise Co., Va. Collected July 1, 1919. Sample was from main entry one-half mile northeast of drift mouth.

5217 and 5235.—Samples of Jawbone coal from the Virginia City No. 1 Mine, of Virginia City Coal Corporation, at Virginia City, Wise Co., Va.

[1] Graphic sections corresponding to these samples are given in Plate XXVI.

Collected July 26, 1907. Sample 5217 was from room 8, off the first cross entry, 2,400 feet northeast of mine mouth; sample 5235, from a breakthrough between the third and fourth cross entries, 3,200 feet northwest of mine mouth.[1]

32503, 32504, 32505, 32506, and 32507.—Samples of Jawbone coal from Virginia Iron, Coal and Coke Company's mine at Virginia City, Wise Co., Va. Collected July 28, 1919. Sample 32503 was from first cross-entry off fourth east entry; sample 32504, Room No. 1, off west cross-entry; sample 32505, Room No. 2, off second west cross-entry; sample 32506, Room No. 3, off first west cross-entry off main haulway. Sample 32507 is a composite made by mixing 32503, 32504, 32505, and 32506.[1]

25651, 25652, and 25653.—Samples of Raven coal from Mine No. 1 of the Jewell Ridge Coal Corporation, at Jewell, Tazewell Co., Va. Collected July 22, 1916. Sample 25651 was from second right entry off main entry, 1,900 feet N. 60° E. of mine mouth; sample 25652, from sixth main entry, 3,700 feet northeast of mine mouth. Sample 25653 is a composite made by mixing 25651 and 25652.[1]

25630, 25631, and 25632.—Samples of Raven coal from the Red Ash Mine of the Raven Red Ash Coal Co., at Red Ash, Tazewell Co., Va. Collected July 17, 1916. Sample 25630 was from face of air-course to tenth cross-entry, 3,000 feet northeast of No. 1 drift mouth. Sample 25631 was from face of air-course to No. 3 main entry, 2,600 feet north of No. 3 drift mouth. Sample 25632 is a composite made by mixing 25630 and 25631.[1]

32454.—Sample of Aily(?) coal from exposure in a railroad cut one-half mile west of Dante, Va. (Location 37.) Collected July 5, 1919.[1]

19528.—Sample of Kennedy coal from the Sandy Ridge Mine of the Sandy Ridge Coal & Coke Co., three-quarters of a mile south of Drill. Collected June 15, 1914. The sample was from the south drift in room off main entry, 150 feet north of mine mouth.[1]

22345.—Sample of Kennedy coal from the Sandy Ridge mine of the Sandy Ridge Coal & Coke Co., three-quarters of a mile south of Drill. (Location 148.) Collected May 25, 1915. The sample was from the north drift, 170 feet S. 70° W. of mine mouth.[1]

19484.—Sample of Kennedy coal from the Drill mine of the Honaker Lumber Co. at Drill. Collected June 5, 1914. The sample was from about 450 feet northeast of drift mouth.[1]

[1] Graphic sections corresponding to these samples are given in Plate XXVI.

17559, 17560, and 17561.—Samples of Kennedy coal from a small local drift mine, half a mile north of Nora, Dickenson Co. Collected July 12, 1913. Sample 17559 was from 300 feet east of drift mouth; and sample 17560, about 300 feet northeast of drift mouth. Sample 17561 is a composite made by mixing 17559 and 17560.[1]

18121.—Sample of Kennedy coal from Mine No. 103 of the Clinchfield Coal Corporation, 1 mile northwest of Dante, Va. Collected November 17, 1913. The sample was from the main entry, 260 feet N. 55° W. of mine mouth.[1]

32452, 32453.—Samples of Kennedy coal from mines of Laurel Branch Coal Co., which had not been worked for some months. Sample 32452 from mine one mile west of Dante, in Dickenson County, 50 feet from mine mouth. Sample 32453 from mine one-half mile west of Dante (location 38), 150 feet from mine mouth.

18243, 18244, 18245, and 18246.—Samples of Lower Banner coal from Mine No. 55 of the Clinchfield Coal Corporation at Wilder, Va. (Location 89.) Collected November 25, 1914. Sample 18243 was from 900 feet S. 60° W. of No. 3 mine mouth; sample 18244, about 2,500 feet S. 35° E. of No. 5 mine mouth; and sample 18245, about 1,300 feet N. 35° W. of No. 2 mine mouth. Sample 18246 is a composite made by mixing 18243, 18244, and 18245.[1]

4057.—Sample of Lower Banner coal from Mine No. 51 (called No. 2 when sampled) of the Clinchfield Coal Corporation at Dante, Va. Collected October 23, 1906. The sample was from Room 4 off the left entry.[1]

10385.—Sample of Lower Banner coal from Mine No. 52 (called Clinchfield when sampled) of the Clinchfield Coal Corporation at Dante, Va. (Location 40.) Collected April 30, 1910. The sample was from the main entry, 150 feet from the mine mouth.[1]

18122, 18123, and 18124.—Samples of Lower Banner coal from Mine No. 52 of the Clinchfield Coal Corporation at Dante, Va. (Location 40.) Collected November 17, 1913. Sample 18122 was cut 325 feet northeast of mouth of No. 0 drift; and sample 18123, about 1,700 feet southwest of mouth of No. 1 drift. Sample 18124 is a composite obtained by mixing 18122 and 18123.[1]

32329, 32330, 32331.—Samples of Lower Banner coal from Mine No. 52 of Clinchfield Coal Corporation, Dante, Va. (Location 40.) Collected

[1] Graphic sections corresponding to these samples are given in Plate XXVI.

July 7, 1919. Samples 32329 and 32330 both from Room 5, off right cross-entry off fourth left entry. Sample 32331 is a composite obtained by mixing 32329 and 32330.

32509, 32510, and 32511.—Samples of Lower Banner coal from Mine No. 1 of Robert Fleming and Company at Banner, Wise Co., Va. Collected July 29, 1911. Sample 32509 was from the face of main entry, 700 feet west of the drift mouth, and sample 32510 was from the main air-course entry 600 feet west of the drift mouth. Sample 32511 is a composite made by mixing 32509 and 32510.[1]

17743 and 17744.—Sample of Upper Banner coal from small local drift mine of the Yellow Poplar Lumber Co. on Slate Branch of Barts Lick Creek, Dickenson Co., 3 miles east of the mouth of Pound River. Collected September 17, 1913. Sample 17743 was from about 220 feet N. 85° E. of mine mouth.[1]

18235, 18236, 18237, and 18238.—Samples of Upper Banner coal from Mine No. 6 of the Clinchfield Coal Corporation at Wilder, Va. (Location 91.) Collected November 25, 1913. Sample 18235 was from 3,000 feet S. 71° W. of No. 1 drift; sample 18236 in Room 5, about 1,250 feet S. 35° E. of No. 3 drift; and sample 18237, about 4,000 feet S. 10° W. of No. 3 drift. Sample 18238 is a composite obtained by mixing 18235, 18236, and 18237.[1]

3942.—Sample of Upper Banner coal from Mine No. 2 (called No. 3 when sampled) of the Clinchfield Coal Corporation, 1¾ miles northeast of Dante, in Dickenson County. Collected October 4, 1906. The sample was from butt entry 6, off the main entry.[1]

10387.—Sample of Upper Banner coal from Mine No. 3 of the Clinchfield Coal Corporation at Dante, Va. (Location 45.) Collected April 30, 1910. The sample was from the fourth right entry, 1,000 feet from the mine mouth.[1]

10734, 10735, and 10736.—Samples of Upper Banner coal from Mine No. 2 of the Clinchfield Coal Corporation, 1¾ miles northeast of Dante, Va., in Dickenson County. Collected August 13, 1910. Sample 10734 was from face of butt entry, off the fourth left entry off the McClure entry; and sample 10735 in Room 16, off right entry 3, off the first entry off McClure entry. Sample 10736 is a composite made by mixing 10734 and 10735.[1]

[1] Graphic sections corresponding to these samples are given in Plate XXVI.

10737, 10738, and 10739.—Samples of Upper Banner coal from Mine No. 5 of the Clinchfield Coal Corporation, 1½ miles northeast of Dante, Va. Collected August 13, 1910. Sample 10737 was from the face of Room 14, right entry 5, off drift 9; and sample 10738, from the butt entry on left entry 9, off drift 9. Sample 10739 is a composite obtained by mixing 10737 and 10738.

18128, 18129, 18130, and 18131.—Samples of Upper Banner coal from Mine No. 2 of the Clinchfield Coal Corporation, 1¾ miles northeast of Dante, Va., in Dickenson County. Collected November 18, 1913. Sample 18128 was from 2,400 feet N. 18° W. of entrance to drift No. 3, McClure; 18129, about 2,750 feet S. 78° E. of entrance to drift No. 5, tunnel line (on Middle Fork of Lick Creek); and 18130, about 3,400 feet S. 85° E. of entrance to drift No. 1, McClure. Sample 18131 is a composite made by mixing 18128, 18129, and 18130.

32168, 32169, 32170, 32171, and 32172.—Samples of Upper Banner coal from Mine No. 2 of the Clinchfield Coal Corporation, Dante, Va. Collected June 14, 1919. Sample 32168 from point on No. 10 right cross-entry, 200 feet from main entry. Sample 32169, near Room 20 on No. 4 left cross-entry, off main entry; sample 32170 from third left air-course off No. 7 right cross-entry. Sample 32171, from Room 39, fifth left cross-entry. Sample 32172 is a composite made by mixing 32168, 32169, 32170, and 32171.[1]

32326, 32327, and 32328.—Samples of Upper Banner coal from Mine No. 3 of the Clinchfield Coal Corporation, Dante, Va. (Location 45.) Collected July 7, 1919. Sample 32326 from third right cross-entry, off main entry. Sample 32327 from Room No. 22, off fifth left cross-entry. Sample 32328, composite made by mixing 32326 and 32327.[1]

32512.—Sample of Upper Banner coal from Mine No. 1 of the Robert Fleming & Co., Banner, Wise Co., Va. Collected July 29, 1919. Sample was from the face in the main straight entry, 4,300 feet west of drift mouth.[1]

2281 and 2282.—Samples from the Coeburn mine of the Virginia Iron, Coal & Coke Co., at Toms Creek, Wise Co., Va. Collected October 7, 1905. Sample 2281 was from 17, east entry, about 3,000 feet northeast of the mine mouth; and sample 2282 in Room 3, off 11, west entry, about 2,000 feet northeast of mine mouth.[1]

[1] Graphic sections corresponding to these samples are given in Plate XXVI.

10386.—Sample of Upper Banner coal from the Swansea mine of the Virginia Iron, Coal & Coke Co., Toms Creek, Wise Co., Va. Collected April 29, 1910. The sample was from Room 21, off 17 west entry, about 2,600 feet from the outcrop.[1]

32404, 32405, and 32406.—Samples of Upper Banner coal from Mine No. 1 (Thelma) of the Virginia Iron, Coal & Coke Co., Toms Creek, Wise Co., Va. Collected July 19, 1919. Sample 32404 from east main manway, half a mile southwest of drift mouth; sample 32405 from old west main entry, near 10 cross-entry; sample 32406, composite made by mixing 32404 and 32405.[1]

18226, 18227, 18228, and 18229.—Samples of Upper Banner coal from the Cranesnest No. 1 mine of the Clinchfield Coal Corporation, about 1½ miles northwest of Toms Creek station, Wise Co. Collected November 22, 1913. Sample 18226 was from 1,500 feet southwest of mouth of main Caney entry; sample 18227, about 500 feet northeast of mouth of main Caney entry; and sample 18228, about 4,100 feet southeast of mouth of main Caney entry. The main Caney entry is on Hurricane Fork of Caney Creek, about 1½ miles northeast of the main entrance to mine. Sample 18229 is a composite made by mixing 18226, 18227, and 18228.[1]

32407, 32408, and 32409.—Samples of Upper Banner coal from the Cranesnest mine of the Clinchfield Coal Corporation, Toms Creek, Wise Co. Collected July 18, 1919. Sample 32407 was from Room B, third south Caney mine, 3 miles northeast of drift mouth. Sample 32408 was from near Room 20 off main entry, third south Caney mine, 3¼ miles northeast of drift mouth. Sample 32409 is a composite made by mixing samples 32407 and 32408.

32410, 32411, and 32412.—Samples of Upper Banner coal from the Lee mine (No. 6) of the Virginia Iron, Coal & Coke Co., at Cranesnest, 1½ miles west of Toms Creek station, Wise Co. Collected July 18, 1919. Sample 32410 was from 500 feet east of the drift mouth at the crop entry and only 50 to 60 feet from the outcrop. Sample 32411 was cut half a mile northeast of the drift mouth in second cross-entry. Sample 32412 is a composite made by mixing 32410 and 32411.

32413.—Sample of Upper Banner coal from the Sexton mine (No. 2) of the Virginia Iron, Coal & Coke Co., at Toms Creek, Wise Co., Va. Collected July 19, 1919. The sample was from 2½ miles northeast of the drift mouth in 15 west entry off main entry.[1]

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[1] Graphic sections corresponding to these samples are given in Plate XXVI.

TESTS.

GENERAL STATEMENT.

Samples of coal from two localities a short distance west of Russell County have been subjected to a series of tests in fuel testing plants of the U. S. Geological Survey to determine their value for commercial purposes. In the absence of tests of coals from points actually within Russell County the results of these tests are given below. A run-of-mine sample from the Jawbone coal bed in the Virginia City No. 1 mine, at Virginia City, Va., was used in making steaming and producer-gas tests in the plant at Norfolk, Va. It had been exposed to weathering 36 days before it was used at the testing plant. A car sample, over a 3½-inch bar screen, from the Upper Banner coal bed in the Coeburn mine of the Virginia Iron, Coal & Coke Company, at Toms Creek, Va., was tested in the St. Louis plant.

In the following tables the essential results of these tests are summarized in a manner intended to show briefly the adaptability of the coal to the uses for which it was tested. Further information regarding the types of the testing apparatus used, conditions under which the tests were made, etc., may be had by referring to the publications cited in the footnotes.

The tests emphasize the excellent qualities of coal that is essentially the same as that in Russell County. The coking tests gave especially favorable results and commercial operations have proved that high grade coke can be made from the Upper Banner coal in the southwest corner of the Clintwood quadrangle and every indication is favorable to the conclusion that the coal of Russell County is suitable for the production of excellent coke.

STEAMING TESTS.[1]

Test No. 601, Jawbone coal.—The coal burned with a medium-length flame and caked. A porous clinker formed on the dead plate and adhered to the bridge wall. Size of coal as used not recorded. Duration of test, 8 hours. Kind of grate, underfeed.

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[1] Burrows, J. S., Mine sampling and chemical analyses of coals: U. S. Geol. Survey Bull. 362, p. 9, 1907.

Breckenridge, L. P., Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905: U. S. Geol. Survey Bull. 290, p. 194-195, 1906.

Breckenridge, L. P., Kreisinger, Henry, and Ray, W. T., Steaming tests of coals and related investigations: Bureau of Mines Bull. 23, 1912.

Test No. 602, Jawbone coal.—The coal burned with a medium-length flame and caked. A small porous clinker formed on the dead plate and adhered to the bridge wall. Size of coal as used not recorded. Duration of test, 8.10 hours. Kind of grate, underfeed.

Test No. 280, Upper Banner coal.—Automatic air admission not operated; clinker and refuse easily removed from furnace. Size of coal as used: Over 1-inch, 44.7 per cent; ½-inch to 1-inch, 20.2 per cent; ¼-inch to ½-inch, 15.7 per cent; under ¼-inch, 19.4 per cent. Duration of test, 9.88 hours. Kind of grate, rocking.

Test No. 283, Upper Banner coal.—Automatic air admission was operated. A thin solid clinker adhered to the grate. Size of coal as used: Over 1-inch, 32.8 per cent; ½-inch to 1-inch, 16.5 per cent; ¼-inch to ½-inch, 15.6 per cent; under ¼-inch, 35.1 per cent. Duration of test, 10 hours. Kind of grate, rocking.

Proximate analyses of coal as used.

	Test 601	Test 602	Test 280	Test 283
Moisture	1.3	1.6	1.7	3.3
Volatile matter	28.7	28.7	33.3	32.0
Fixed carbon	54.3	53.1	60.3	60.2
Ash	15.7	16.6	4.7	4.5
Sulphur	.94	.94	.64	.56

Ultimate analyses figured on moisture-free basis.

	Test 601	Test 602	Test 280	Test 283
Carbon	71.14	70.59	82.80	82.95
Hydrogen	4.52	4.47	4.98	4.98
Oxygen	6.21	5.69	5.18	5.19
Nitrogen	1.25	1.22	1.64	1.64
Sulphur	.95	1.16	.65	.58
Ash	15.93	16.87	4.75	4.66

Summary of steaming tests.

	Test 601	Test 602	Test 280	Test 283
Heating value of coal B. t. u. per lb., dry coal	12,911	12,607	14,908	14,936
Force of draft:				
Under stack damper.....inch water..	0.39	0.35	0.42	0.37
Above fire.....do.....	.31	.23	.15	.16
Furnace temperature.....°F.....	2,336	.....	2,452	2,537
Dry coal used per sq. ft. of grate surface per hour.....pounds..	18.14	21.88	16.40	16.47
Equivalent water evaporated per sq. ft. of water heating surface per hour..lbs....	3.28	3.69	2.91	2.99
Water apparently evaporated per pound of coal as fired.....pounds..	7.70	7.07	8.14	8.18
Water evaporated from and at 212°F.: Per pound of coal as fired.....pound..	8.94	8.32	9.74	9.79
Per pound of dry coal.....do....	9.06	8.46	9.91	10.12
Per pound of combustible.....do....	10.97	10.36	10.66	10.84
Efficiency of boiler, including grate, per cent.	67.77	64.80	64.19	65.43
Boiler horse-power:				
Builder's rating.....	210	210	210	210
Developed on test.....	193.0	217.4	171.4	175.9
Analysis of ash:				
Carbon	9.93	11.26	27.88	34.47
Earthy matter.....	90.07	88.74	72.12	65.53

PRODUCER-GAS TESTS.[1]

Test No. 163, Jawbone coal.—As used, ½ to ⅔ slack. Failure of water supply made it impossible to carry this test beyond 8 hours, a period so short that the accuracy of the results is doubtful. Average B. t. u. of gas per cubic foot, about 149.

Test No. 75, Upper Banner coal.—Size as used: Over 1-inch, 51 per cent; ½-inch to 1-inch, 14 per cent; ¼-inch to ½-inch, 13 per cent; under ¼-inch, 22 per cent. Duration of test, 50 hours. Average B. t. u. of gas per cubic foot, 156.

[1] Burrows, J. S., Mine sampling and chemical analysis of coals: U. S. Geological Survey Bull. 362, p. 9, 1908.

Fernald, R. H., Preliminary report on the operation of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905: U. S. Geol. Survey Bull. 290, pp. 193-195, 1906.

Fernald, R. H., and Smith, C. D., Résumé of producer-gas investigations: Bureau of Mines Bull. 13, 1911.

Proximate analyses of coal as fired.

	Test 163	Test 75
Moisture	1.3	1.6
Volatile matter	29.7	31.7
Fixed carbon	53.6	61.8
Ash	15.4	4.9
Sulphur	1.14	.49

Analyses of gas (per cent by volume).

	Test 163	Test 75
Carbon dioxide (CO_2)	9.7	9.7
Carbon monoxide (CO)	19.7	19.3
Hydrogen (H_2)	14.5	13.8
Methane (CH_4)	2.3	3.1
Nitrogen (N_2)	53.8	54.1

Summary of producer-gas tests.

	Test 163			Test 75		
	Coal as fired.	Dry coal.	Combustible	Coal as fired	Dry coal	Combustible
Coal used in producer (lbs. per horsepower per hr.)						
Per electrical horsepower:						
Available for outside purposes.	1.23	1.22	1.03	1.21	1.18	1.13
Developed at switchboard	1.20	1.19	1.00	1.13	1.11	1.06
Per brake horsepower:						
Available for outside purposes.	1.05	1.04	.87	1.03	1.01	.96
Developed at engine	1.02	1.01	.85	.96	.95	.90
Coal used by producer plant, including fuel equivalent of auxiliary power (pounds per horsepower per hour).						
Per electrical horsepower:						
Available for outside purposes.	1.52	1.50	1.26	1.29	1.27	1.21
Developed at switchboard	1.48	1.46	1.23	1.21	1.19	1.13
Per brake horsepower:						
Available for outside purposes.	1.29	1.28	1.07	1.10	1.08	1.03
Developed at engine	1.26	1.24	1.05	1.03	1.01	.96

COKING TESTS.[1]

Two tests, Nos. 61 and 88, were made of the Upper Banner coal from Toms Creek, Va., to determine its coking properties. In test 61 the coal was finely crushed; in test 88 it was as shipped (over 3½-inch bar screen).

Summary of coking tests.

	Test 61	Test 88
Duration of test.....hours.....	45	50
Specific gravity, real.....	1.93	1.87
Specific gravity, apparent.....	1.25	1.12
Weight per cubic foot, dry.....pounds.....	77.72	69.30
Weight per cubic foot, as received (wet).....do.....	99.67	94.26
Percentage coke.....	65.00	60.00
Percentage cells.....	35.00	40.00
Six-foot drop test, percentage over 2-inch mesh:		
1	92.00	93.50
2	85.00	89.00
3	78.50	83.50
4	75.00	80.50
Weight of coal.....pounds.....	12,000	12,000
Weight of coke.....do.....	8,160	7,907
Weight of breeze.....pounds.....	240	336
Percentage coke.....	68.00	65.89
Percentage breeze.....	2.00	2.80
Total percentage yield.....	70.00	68.69

The analysis of a typical 72-hour Connellsville coke is shown in the following table as a standard for comparison. Judged by the analyses, coke made from the Upper Banner coal is as good as that from the Connellsville district.

Analysis of coal as used and resulting coke.

	Connellsville coke	Test 61		Test 88	
		Coal	Coke	Coal	
Moisture	.18	2.87	0.29	2.49	0.16
Volatile matter	.32	31.58	1.21	31.90	1.26
Fixed carbon.....	88.75	61.43	92.60	61.16	91.85
Ash	10.75	4.12	5.90	4.45	6.73
Sulphur in coke.....	.87	.56	.61	.57	.55
Sulphur in ash.....	.033		.085		.070
Phosphorus	.018		.001		.006
Specific gravity.....	1.92		1.93		1.87

[1] Belden, A. W., Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905: U. S. Geol. Survey Bull. 290, pp. 193-196, 1906.

Belden, A. W., Washing and coking tests of coal and cupola tests of coke: U. S. Geol. Survey Bull. 336, 1908.

Test 61, remarks.—Coke of light gray and silvery color; much deposited carbon; metallic ring; cell structure small; breakage good; long, large, heavy pieces; very heavy coke.

Test 88, remarks.—Coke of light gray and silvery color; much deposited carbon; metallic ring; cell structure small; breakage good; good heavy coke; decreased yield of coke and increased amount of breeze probably due to fact that coal was not crushed.

CUPOLA TESTS OF COKE.[1]

Each of the two samples of coke, made from the Upper Banner coal from Toms Creek, Va., was subjected to two cupola tests, the results of which are shown in the following table. The results of a typical test of Connellsville 72-hour coke are given in the first column, to furnish a standard for comparison.

[1] Moldenke, Richard, Washing and coking tests of coal and cupola tests of coke: U. S. Geol. Survey Bull. 336, 1908.

Summary of cupola tests.

	Connellsville Coke	Coke test 61		Coke test 88	
	Test 19	Test 33	Test 91	Test 58	Test 40
Charges (Pounds)—					
1. Coke bed	220	230	250	250	240
2. Pig iron	660	690	750	750	720
3. Scrap	220	230	250	250	240
4. Coke	53	50	45	45	48
5. Pig iron	398	390	375	375	383
6. Scrap	133	130	125	125	128
7. Coke	53	50	45	45	48
8. Pig iron	398	390	375	375	383
9. Scrap	133	130	125	125	128
10. Coke	52	50	45	45	47
11. Pig iron	397	390	375	375	382
12. Scrap	132	130	125	125	127
13. Coke	52	50	45	45	47
14. Pig iron	397	390	375	375	382
15. Scrap	132	130	125	125	127
Totals (Pounds)—					
Coke	430	430	430	430	430
Pig iron	2,250	2,250	2,250	2,250	2,250
Scrap	750	750	750	750	750
Ratio of iron to coke	7	7	7	7	7
Maximum blast pressure (oz.)	7¾	7	7	7	7
Iron poured (lbs.)	2,470	1,584	2.422	1,710	1,761
Iron melted (lbs.)	2,470	2,391	2,598	2,200	2,071
Iron recovered (lbs.)	283	255	288	636	683
Coke recovered (lbs.)	20	93	70	104	108
Melting loss (per cent)	8.2	11.80	3.80	5.46	8.20
Melting ratio (iron to coke)	6.02	7.09	7.22	6.75	6.43
Blast on at	10.57	4.03	3.30	10.23	11.14
	A. M.	P. M.	P. M.	A. M.	A. M.
Iron running	11.03	4.12	3.37	10.36	11.23
Weight and time of each ladle—					
1 lb.	175	85	132	102	64
at	11.07	4.15	3.45	10.45	11.27
2 lbs.	115	103	104	107	62
at	11.11	4.19	3.45½	10.45½	11.29
3 lbs.	185	98	111	77	80
at	11.13	4.20	3.47	10.50½	11.31
4 lbs.	150	94	135	74	62
at	11.14	4.21	3.47½	10.51	11.32
5 lbs.	220	88	92	84	72
at	11.16	4.22	3.51	10.51½	11.38
6 lbs.	150	84	110	64	75
at	11.18	4.23	3.51½	10.54	11.38½

Summary of cupola tests.

	Connellsville Coke	Coke test 61		Coke test 88	
	Test 19	Test 33	Test 91	Test 58	Test 40
Weight and time of each ladle—					
7 lbs.	225	73	151	64	95
at	11.19	4.24	3.52	10.54½	11.39
8 lbs.	155	71	94	83	55
at	11.22	4.25	3.54	10.55	11.41
9 lbs.	255	81	112	62	92
at	11.24	4.25½	3.54½	10.56	11.41½
10 lbs.	155	80	99	66	75
at	11.26	4.27	3.55	10.56½	11.42
11 lbs.	250	60	90	79	88
at	11.27	4.28	3.56	10.57	11.44
12 lbs.	125	63	99	56	76
at	11.28	4.30	3.56½	10.58	11.44½
13 lbs.	170	66	132	80	91
at	11.29	4.32	3.58	10.58½	11.45
14 lbs.	140	98	100	73	84
at	11.30	4.33	3.58½	10.59	11.46
15 lbs.	.....	51	80	50	75
at	.....	4.34	3.59	11.00½	11.46½
16 lbs.	.....	53	131	84	85
at	.....	4.35	4.01	11.01	11.48
17 lbs.	.....	54	90	59	92
at	.....	4.37	4.01½	11.02½	11.48½
18 lbs.	.....	58	142	47	36
at	.....	4.38	4.02	11.03	11.49
19 lbs.	.....	49	142	66	72
at	.....	4.39	4.04	11.03½	11.53
20 lbs.	.....	.46	.56	90	51
at	.....	4.41	4.04½	11.05	11.53½
21 lbs.	.....	27	99	48	98
at	.....	4.42	4.06	11.05½	11.54
22 lbs.	.....	37	121	103	60
at	.....	4.44	4.08	11.06	11.58
23 lbs.	.....	65	.....	64	77
at	.....	4.45	.....	11.09½	11.59½
24 lbs.	.....	.....	.....	28	44
at	.....	.....	.....	11.10	12.00
25 lbs.	.....	.....	.....	.....	.....
at	.....	.....	.....	.....	.....
Time melting (minutes)	27	29	31	24	37

Remarks:

Test 19. Iron hot.

Test 33. Iron hot and fluid; melting too fast to handle; blast off 4 minutes.

Test 91. Iron hot.

Test 58. Iron hot; blast off 5 minutes.

Test 40. Temperature of iron medium.

SUMMARY.

An examination of the analyses and tests described in the preceding pages leads to very favorable conclusions as to the purity and value of the coals themselves. The practical features and the essential working qualities of the fuels, as indicated in a limited number of steaming, coking, briqueting, producer, and foundry tests have already been quoted from the official records of the tests. These tests, which are not so numerous as is to be desired, were not in all cases conducted under favorable circumstances or with coal from the best beds, and the results, gratifying as they may be, probably do not do more than justice to either the samples submitted or the region as a whole.

Information as to the chemical composition, which discloses the purity of the coals, and as to the calorific values, i. e., the heating power of the coals as determined by standard calorimetric methods in the laboratory, is given in the accompanying table of analyses. This table, though not so large as is desirable, contains the results of analyses and calorific tests of enough cuttings taken from coal beds in widely different parts of the region to entitle it to confidence as approximately representative of the coals of the county.

From an inspection of the analyses, it will be seen that the coals are of high bituminous rank with very low moisture content; with a percentage of fixed carbon in general approximating 60 per cent; with relatively low ash, and with an exceptionally small content of sulphur. In other words, the coals are notably pure. The averages of the moisture, of the ash, of the sulphur, of the fuel ratios, and of the B. t. u.'s in the coals of the different beds are indicated in the following table:

Table of averages of analyses for different coal beds and localities in and near Russell County.

Bed and Locality	Laboratory Numbers	Air-drying loss	Form of analysis	Ash	Heating value	
					Calories	British thermal units
Tiller at Richlands	Average of 25763-4	1.8	A	8.2	7,590	13,660
Tiller at North Clinchfield	Average of 18239-40-41	1.6	A	6.4	7,830	14,090
Jawbone at Richlands	Average of 25757-8	1.2	A	11.5	7,370	13,260
Jawbone at Virginia City	Average of 5217, 5235, 32503-4-5-6.	.9	A	16.4	6,820	12,270
Raven at Jewell	Average of 25651-2	2.8	A	5.7	7,980	14,360
Raven at Red Ash	Average of 25630-31	1.9	A	5.8	7,925	14,270
Kennedy at Prater	Average of 17743-4	1.8	A	6.8	7,740	13,930
Kennedy at Nora	Average of 17559-60	1.7	A	9.5	7,600	13,680
Kennedy at Dante	Average of 3947 and 18121	1.4	A	6.6	7,115	12,810
Kennedy at Dante	Average of 32452-3	1.4	A	24.5	6,040	10,810
Kennedy at Drill	Average of 19484, 19528, 22345	2.0	A	6.0	7,880	14,180
Lower Banner at Wilder and Dante.	Average of 18243-4-5, 18122-3, 32329-30, 10385, 4057.	1.4	A	6.2	7,870	14,170
Upper Banner at Dante and Wilder.	Average of 3942, 10387, 10734-5, 10737-8, 18128-9-30, 32168-71 inclusive, 18235-6-7, 32326-7, 32168.	1.5	A	6.5	7,800	14,040
Upper Banner at Toms Creek	Average of 32404-5, 32407-8, 32410-11, 32413.	1.7	A	7.7	7,660	13,790
Upper Banner at Toms Creek	Average of 2281-2-2382, 10386	1.8	A	4.8	8,020	14,430

Analyses of representative coals of present or future competing fields for comparison with those of Russell County.[1] *(Given in "As Received" form.)*

Field	Moisture	Volatile Matter	Fixed carbon	Ash	Sulphur	Heat Value (British thermal units).
Alabama						
Birmingham district	2.4	29.1	62.6	5.9	1.0	14200
Illinois						
southern part	8.4	34.2	48.4	9.0	2.3	12030
Indiana						
entire state	11.8	36.9	43.2	8.1	2.9	11660
Kentucky						
eastern part	3.3	36.5	56.4	3.8	0.9	14040
Kentucky						
western part	8.6	36.9	45 9	8.6	3.3	12000
Maryland						
Georges Creek district	.6	18.2	71.7	9.5	1.4	13800
Ohio						
Hocking Valley	7.5	34.0	52.6	5.9	.8	12510
Pennsylvania						
Cambria County	2.8	19.9	71.1	6.2	1.2	14340
Tennessee						
Claiborne and Campbell counties	3.6	37.3	55.5	3.6	1.1	13980
Virginia						
Tazewell County	3.8	15.4	77.6	3.2	0.6	14370
Buchanan County	3.0	25.7	62.7	8.6	1.1	13770
Dickenson County	3.0	32.4	58.4	6.2	1.6	14030
Russell County	2.8	34.9	56.5	5.8	.6	14200[2]
Wise County	2.5	31.7	60.3	5.5	.5	14250
Lee County	3.4	34.4	58.8	3.4	.6	14130
Montgomery County	1.6	12.3	68.1	18.0	.5	12340
Richmond Basin	2.8	25.7	62.5	9.0	1.4	13490
West Virginia						
Fairmont district	2.9	34.5	56.9	5.7	.7	14040
Kanawha district	2.9	35.3	54.9	6.9	.8	13730
New River district	3.9	16.8	74.8	4.5	.8	14390
Thacker district	3.8	35.1	55.4	5.7	1.6	13710
Pocahontas field	3.1	17.4	75.0	4.5	.6	14570

[1] Campbell, M. R., The coal fields of the United States, General Introduction: U. S. Geol. Survey Professional Paper 100-A, 1917.

[2] Revised from a larger number of recent analyses.

COMPARISON WITH COAL OF OTHER FIELDS.

It will be seen on looking over the table giving analyses from different fields that the Russell County coals rank among the better coals of the well-known fields of the Appalachian and Interior fields. The Russell County coal is exceeded in heating value by the Pocahontas and other coals of Tazewell County, very slightly by coals of Cambria County, Pa., Wise County, Va., and the New River district in West Virginia, and equaled by the Birmingham district coals of Alabama. Of coals with higher heating value only the New River district coals are of substantially lower ash than those of Russell County. The Russell County coal is less friable than many of these higher rank coals and yields a larger proportion of lump coal or permits more satisfactory grading to sizes as the trade may demand. None of the Tennessee, Western Kentucky, Ohio, Indiana, or Illinois coals equal the Virginia coals in heating value and all these except the Tennessee and Ohio coals are higher in ash and sulphur.

Such tests as have been made indicate that the coals of Southwest Virginia are closely similar to the Connellsville coal and likely to prove of increasing value for the production of coke. A high percentage of volatile matter is much in their favor when, as is much to be hoped, future production of coke is in by-product ovens.

In summary Russell County has a large reserve of high grade fuel of the following characters: Moderately high rank bituminous coal which can be loaded on cars largely in lump form with less than 3 per cent moisture, 7 per cent of ash and .9 per cent of sulphur, and has a heating value of about 14,200 B. t. u.'s. It is well adapted for domestic use, steam production and coking, either for coke alone or for coke and by-products.

AMOUNT OF ULTIMATELY AVAILABLE COAL.

GENERAL STATEMENT.

Mining operations in Europe have shown that coal of lower grade than that in southwestern Virginia can be profitably mined from beds only 14 inches thick[1] and at depths greater than any to which it would be necessary to shaft for coal in Russell County. The tonnages in the table on page 137 therefore include beds or parts of beds in which there is 14 inches or more of minable coal but do not include thinner beds or parts of beds that could not be mined profitably, because of the position and thickness of part-

[1] Ashley, G. H., and Fisher, C. A., U. S. Geological Survey Bull. 429, 1910.

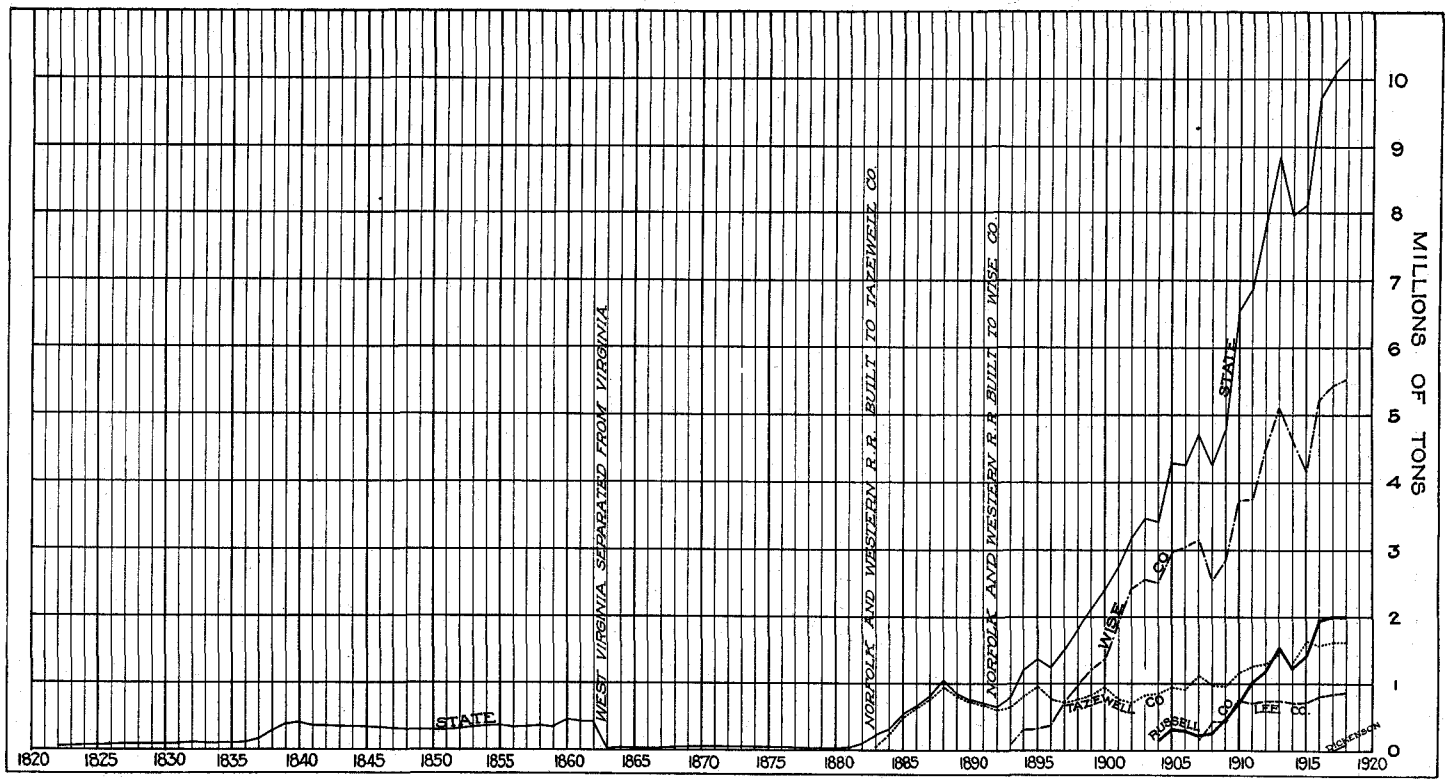


Fig. 15. Graph showing coal production in the State of Virginia, 1822 to 1918, for the entire State, and for the principal coal-producing counties.

ings. The calculations were made on a basis of 1,800 tons[1] per acre for each layer of coal 1 foot thick which is equivalent to a density of 1.315 and to a weight of 82.1 pounds for one cubic foot, following the precedent established in previous reports in this field.

Although very carefully prepared these estimates are necessarily only approximations. The figures for the lower coals of the Norton formation are most likely to be in error as little is known of the thickness of these beds. The calculated totals though large are thought to be conservative estimates. The amount of coal already mined or made unavailable for mining is very small, amounting only to 1.6 per cent of the estimated total tonnage and as it is small compared to possible errors in the estimate no attempt has been made to correct the estimate of tonnage by subtracting it.

Of the grand total of 1,009,600,000 tons only about 70 per cent would be recovered under even the most favorable mining methods now prevailing, leaving about 706,000,000 tons as a possible production. This is about equal to 15 months' consumption in the United States at the present time. Much of this coal is too thin or too far below the surface to be profitably mined and sold in competition with coal from the more cheaply mined beds now being exploited in the Appalachian coal fields. Beds that cannot be used to-day, however, are certain to be of value at some time in the future.

Amount of ultimately available coal in Russell County.

	Western part. (West of Big A Mt.)	Eastern part. (East of Big A Mt.)
Upper Banner	38,300,000	
Lower Banner	41,000,000	40,700,000
Kennedy	14,600,000	82,500,000
Raven	81,400,000	117,000,000
Jawbone	212,700,000	83,000,000
Tiller	138,800,000	83,000,000
Other coals	76,600,000	
Total for each part	603,400,000	406,200,000

Total for Russell coal field, 1,009,600,000.

MINING METHODS.

INTRODUCTION.

Space will not permit a full description of methods of mining in this report, but in the following chapter is presented a brief outline of the sub-

[1] It must be understood that this basis of 1,800 tons per acre-foot includes all of the coal in the bed and makes no allowance for waste in mining and loss of pillar coal. In using these estimates the amounts should be reduced by the percentage of loss as determined by the current practice in the field.

ject with especial reference to methods in use in Russell County. It is hoped that even this brief consideration will enable the reader to appreciate the relationship which mining methods bear to the mode of occurrence of the coal on the one hand and to the economy of production and quality of the product on the other.

GENERAL METHODS.

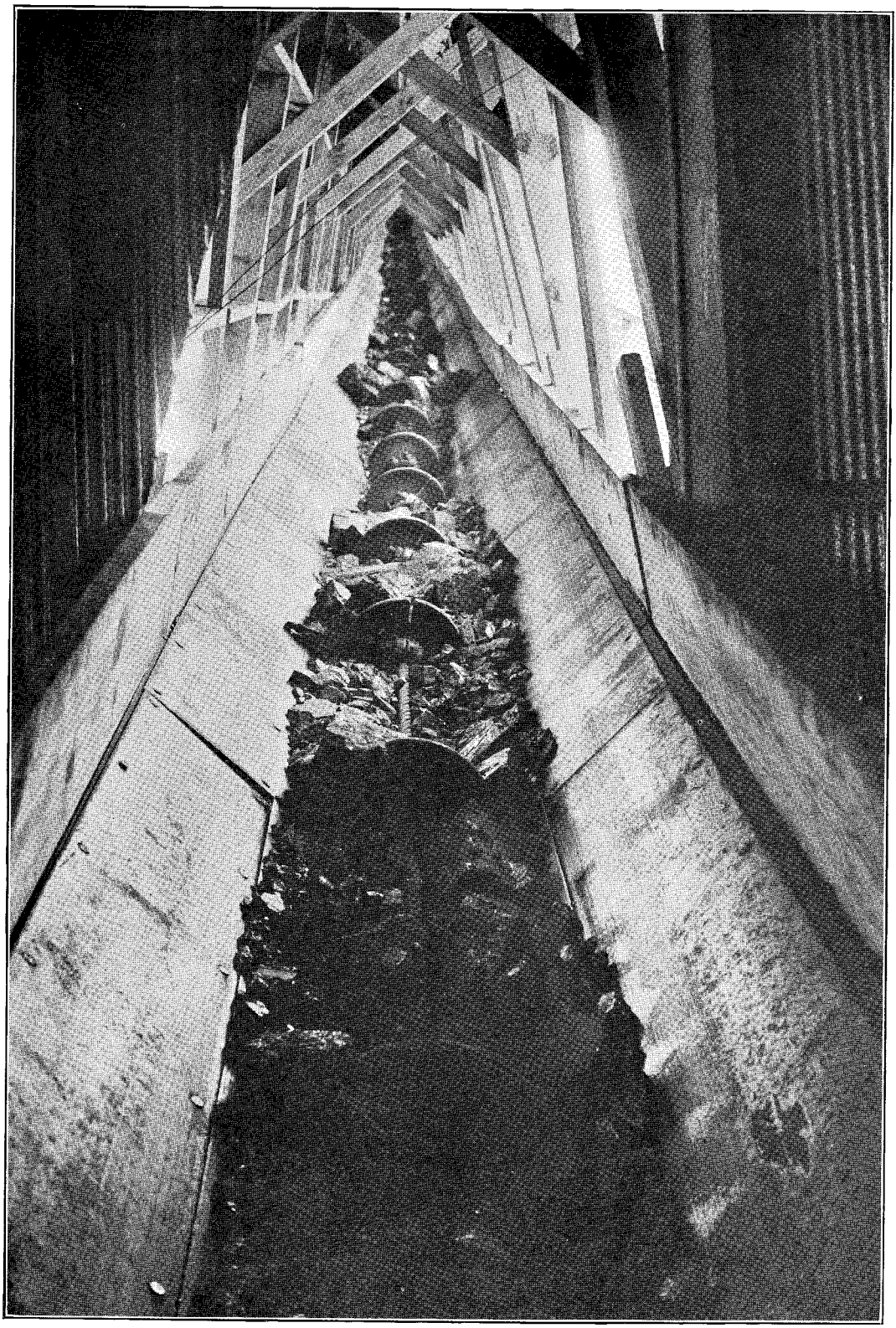
Coal is produced from two types of workings which are, first, open strippings or strip pits which are surface excavations entirely comparable to quarries and, second, underground excavations or mines. By far the larger part of the coal produced in the United States is from mines and since there are no stripping operations in Russell County only the methods involved in producing coal from mines will be considered here. The most important consideration which determines the type of the mine is the attitude of the coal bed. If the coal bed is essentially horizontal and outcrops it may be worked in a drift mine.[1] If the coal is situated at so low an elevation that it does not outcrop at an accessible locality at the surface it is reached by a rock slope[2] or a shaft.[3] If the coal is horizontal, a mine may be opened by driving entries from the bottom of the slope or shaft just as in case it outcrops at the surface. If the coal dips at a greater angle than about 5 degrees it is commonly mined by driving a slope down the dip of the bed and driving passageways, known as cross-entries, at right angles on one or both sides. These cross-entries are thus driven along the coal bed slightly to the rise and the rooms driven from them on the side which is up the rise. The chief yield of coal is from the rooms; it reaches the cross-entries by gravity, is hauled along the level to the slope where it is brought to the surface by cable haulage. All the lifting of the coal is thus concentrated at the slope where adequate facilities insure most economical handling.

At the border of the coal field are a few mines which are operating in beds which dip at considerable angles. This coal is known locally as "edge coal." These mines are all small and reach the coal by drifts driven from the outcrop. With these exceptions all the coal mined in Russell County at present is from coal beds which are essentially horizontal and with the

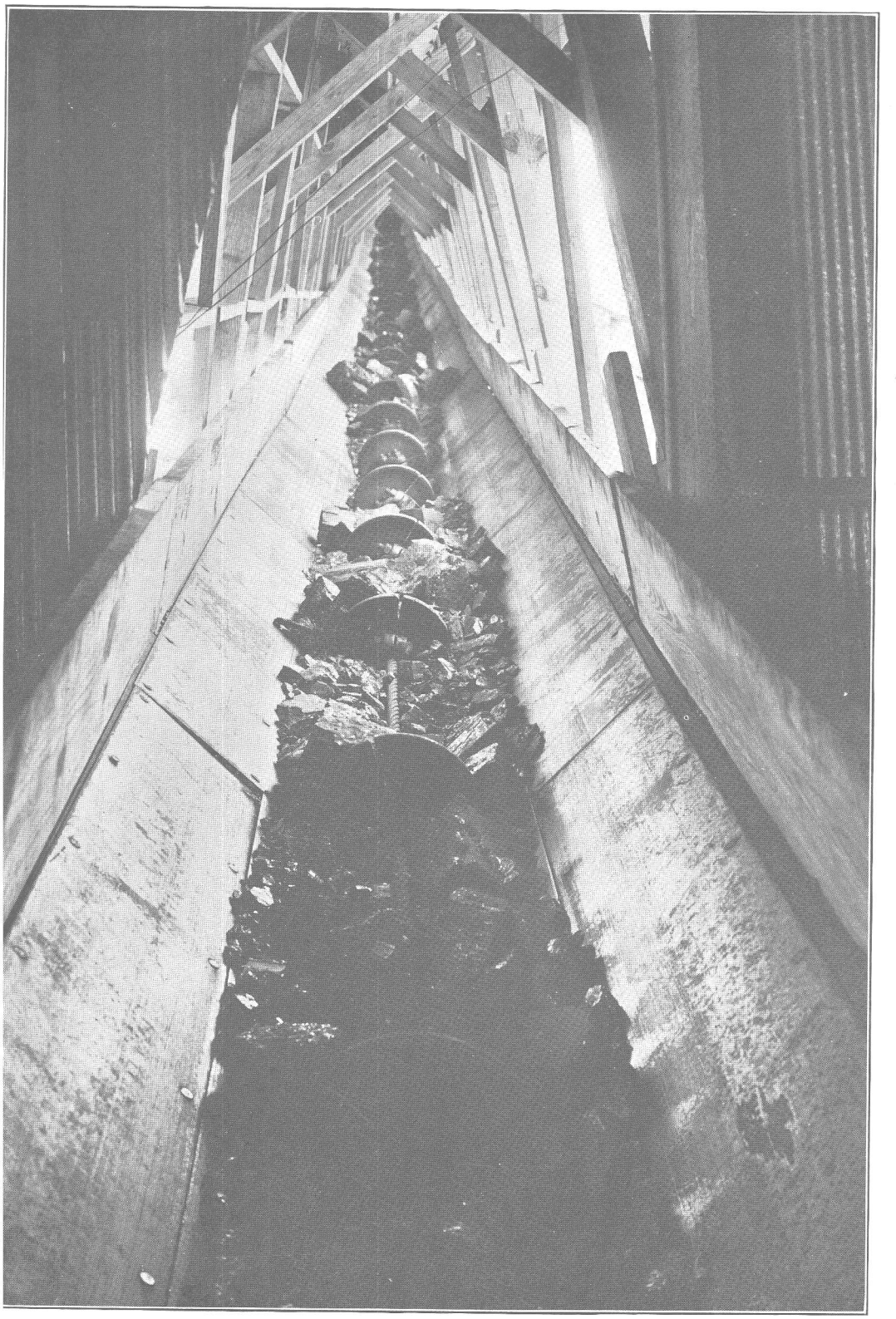
[1] A drift is a nearly horizontal passageway in the coal bed underground. A drift mine is a mine reached by such a passageway from the surface of the ground.

[2] A slope is an inclined underground passageway. A rock slope is a slope which is driven across the rock strata as opposed to an ordinary slope which follows the inclined coal bed.

[3] A shaft is a vertical or highly inclined passageway from the surface down to a place underground or between two different levels underground.



Interior of chute of retarding conveyor in use at the plant of the Harlan Coal Company at Harlan, Ky. (Photograph furnished by the Harlan Coal Company.)



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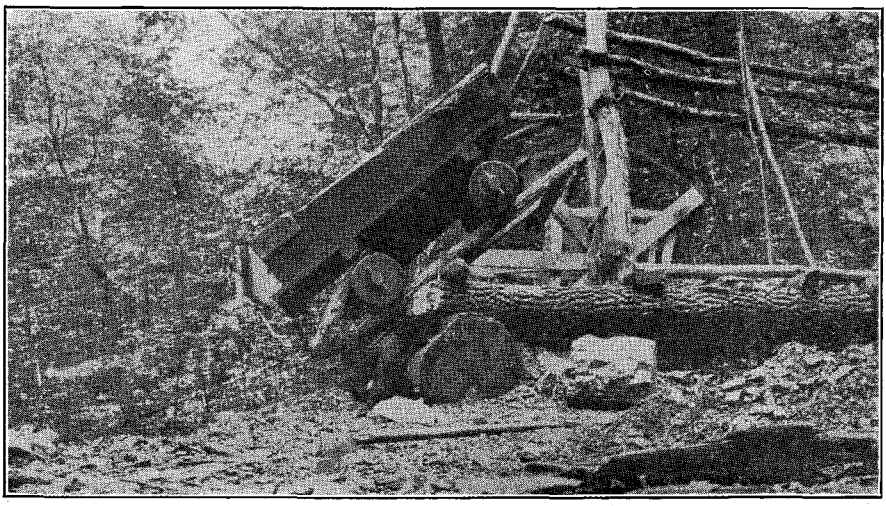
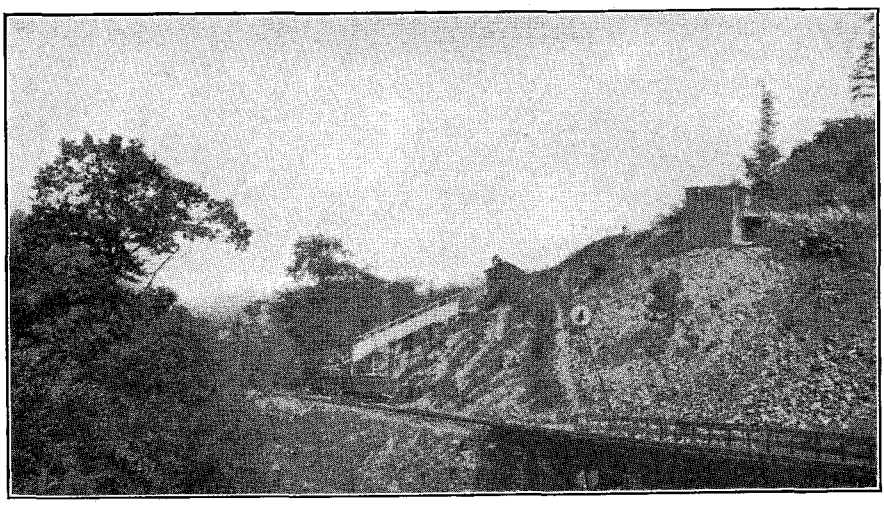
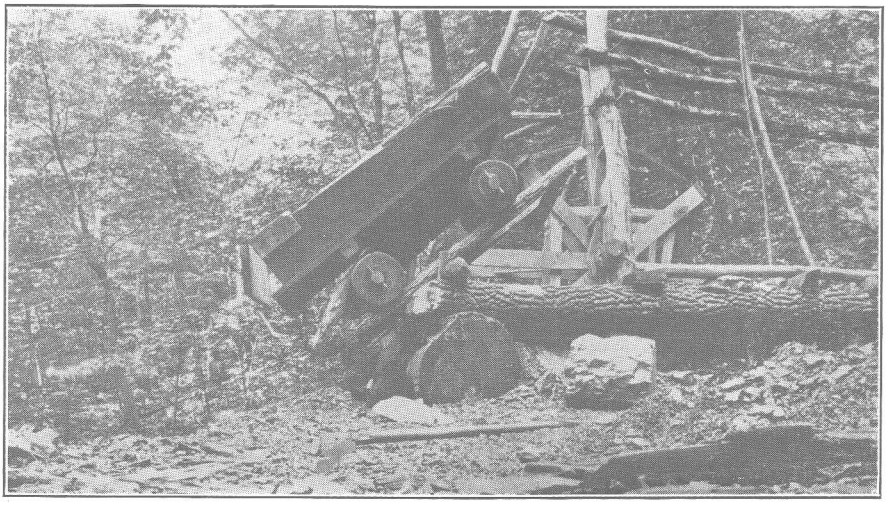


(A) View of simple improvised tipple used at many local mines. Note the wooden axles, wheels, and track and the utilization of the fork of a tree at the end of the tipple proper to check the car as it is thrown forward in dumping. As a study in evolution compare this simple though effective arrangement with the highly specialized modern tipples shown below.



(B) Tipple and loading track of the Hamlin Coal Company at Hamlin, Va.



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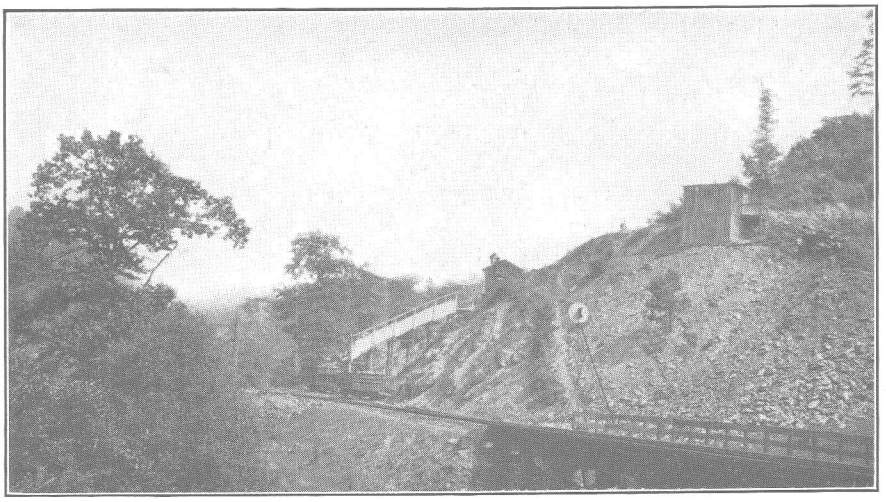


(B) Tipple and loading track of the Hamlin Coal Company at Hamlin, Va.

single exception of Mine No. 201 of the Clinchfield Coal Corporation at Clinchfield is from coal beds which outcrop at the surface. The greater part of the coal mining in Russell coal field is therefore carried on in drift mines and to this type of mine chief consideration will be given below.

In the production of coal from such mines two general methods are used, the longwall method and the room-and-pillar method. In the longwall method the coal is mined from one continuous face and the roof is allowed to fall as the work progresses. The roof pressure or squeeze aids in bringing the coal down after it has been undercut. The longwall method is largely used abroad but to comparatively slight extent in the United States and not at all in Russell coal field.

The room-and-pillar method in its simplest form consists in driving a series of rooms on one or both sides of a passageway known as an entry. The rooms are driven commonly at uniform distances apart and frequently but not always at right angles to the entry. Sixty feet is a common distance between the centers of successive rooms. The room is begun as a narrow passageway or neck about ten feet wide which is driven some ten or fifteen feet before it is widened out commonly on one side only to a half or two-thirds of the distance between rooms. There is thus left a nearly continuous wall or rib of coal standing adjacent to the entry which is broken only by the narrow necks of the rooms. (See figure 16.) This is for adequate safety in the support of the roof over the entry which is an important passageway and must usually be occupied for some time. The length of the rooms is usually fixed by the distance between successive entries, the ends of the rooms being stopped at such a distance as to leave adequate support for the roof over the next entry. A certain amount of coal is derived, of course, from the various passageways or entries as they are driven, but the principal yield of coal during the active period of operation of the mine is from the rooms. As only a limited amount of coal can be produced from one room during each day, increase of output is achieved only by increasing the number of rooms available for mining. Driving the necessary entries from which to open additional rooms is a slow process, as only a limited number of men or a limited amount of machinery can be concentrated at the face of the entry to work effectively. It will readily be seen from the foregoing that it is not possible to increase at short notice the output of a coal mine as the coal is produced under conditions differing radically from many other industries in which it is necessary only to hire more men to increase the output.

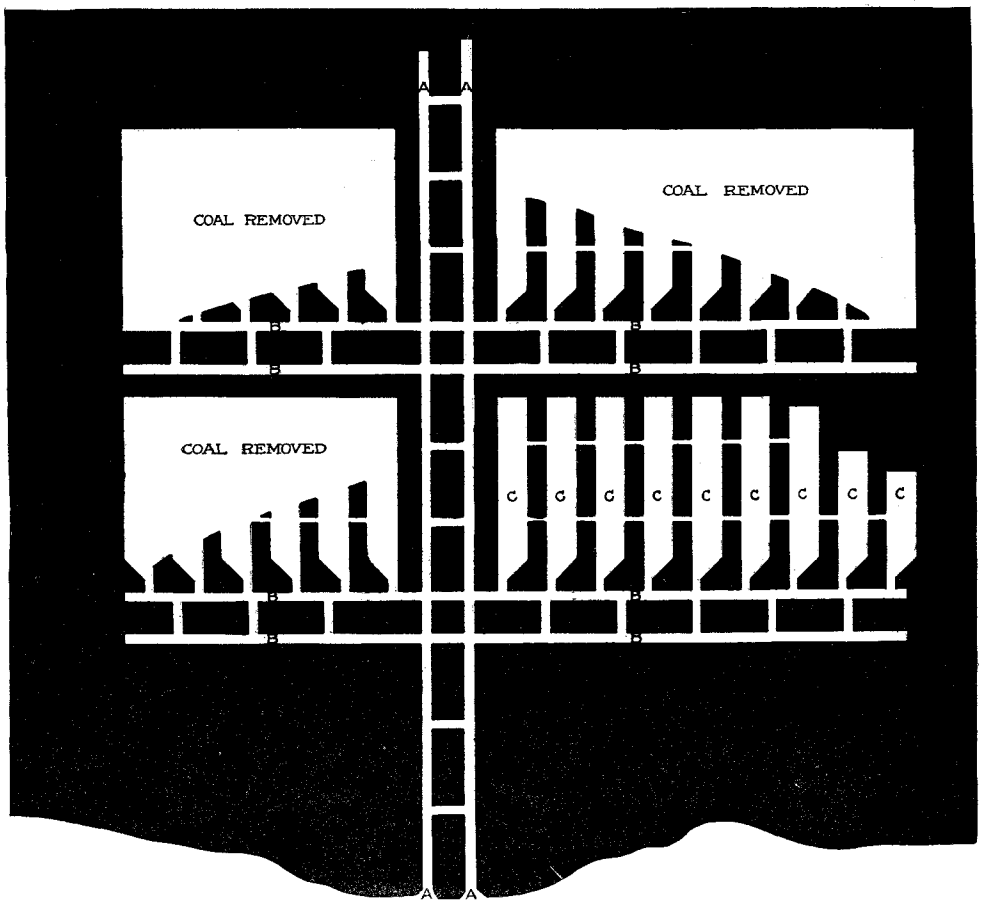


Fig. 16. Diagram of coal mine showing room and pillar method of mining coal.

AA—Main entries; BB—Cross entries; CC—Rooms.

In the larger mines the plan is much more complicated than the simple one of entries and rooms described above, but is based on the same essential features and differs only in the addition of more passageways parallel to the original entry and air-course. In some very large mines there are as many as seven parallel entries which constitute the main haulway and along each of which traffic is specialized with one or more, for outgoing loaded cars and others for ingoing empty cars and so forth. The entry from which the rooms are driven may be in a small mine, the main entry from the mine mouth or, as in most of the larger mines, is one of many cross-entries driven at intervals from the main entry or haulway to the mine mouth. The mine mouth is preferably located at the lowest point of the coal bed on the property so as to afford natural drainage and gravity haul. When this is not possible because other conditions such as access to the railroad, need for sufficient height at the tipple, etc., control the location of the mine mouth at some other than the lowest point of the bed it may be necessary to free the deeper parts of the mine from water by pumping. As mentioned above when it is planned to produce a considerable amount of coal from extensive workings the rooms are driven from cross-entries which are in turn driven from the main entry. As the greater part of the output is from the faces of the rooms the orientation of the various entries is generally planned so that the rooms are driven in a direction at right angles to the trend of the more prominent of the two cleavages which are commonly present in bituminous coal. This cleavage is commonly called the face cleavage and bounds the working faces of the rooms. As this cleavage is developed throughout the entire mass of the coal the driving of the rooms against this cleavage greatly favors economy of production, the coal being separated with a minimum of explosive along the line of this cross cleavage. The other cleavage which is usually less perfectly developed is called the butt cleavage and is commonly nearly at right angles with the face cleavage. It usually bounds the sides of the rooms, and the faces of the cross-entries. Ideally the main entry is driven against the face cleavage, the cross-entries against the butt cleavage from one or both sides of the main entry depending on the dip of the coal bed and the shape and extent of the property and the rooms in turn driven against the face cleavage. If the coal has an appreciable dip across the cross-entries the rooms are driven on the side which is up the rise as empty cars are more readily placed up the grade than full cars hauled up grade in gathering them for hauling. If the coal is nearly horizontal, rooms may be driven from both sides of the cross-entry though this plan is not common. When the coal is nearly horizontal the directions of the cleavages commonly

control the layout of the mine resulting in a practically if not exactly rectangular plan throughout. As the dip becomes greater, however, it begins to control the layout until in slope mines where the dip of the coal is more than about 5 or 6 degrees it is entirely dominant. At intermediate angles of 3 or 4 degrees the rooms may be driven against the face cleavage and the cross-entries horizontally along the strike of the coal resulting in various angles between the rooms and the cross-entries, depending on the local relation between the cleavages and the dip of the coal, though this angle is rarely less than 45 degrees.

All the mine openings which are of permanent character must usually be supported by suitable timbers. This proceedure is demanded both for safety and efficiency in maintaining the various entries. When a mine is being opened and the various entries and rooms driven there is left in the pillars between the rooms and in the ribs adjacent to the entries a large part of the original coal, from 50 to 80 per cent in different plans and policies of mining. This coal which is left in place serves to support the overlying rock. If the rock immediately overlying the coal is a strong, compact rock capable of spanning adequately the spaces across the widest rooms and the amount of coal left in the pillars is great enough there may be little need of timbering. These conditions are rarely realized and nearly all states in which coal is mined have enacted laws requiring adequate timbering and systematic inspection by state officers to insure their fulfillment.

The stresses which come to bear on mine timbers are two in number. The first or major pressure is due to the weight of all the overlying rock from the mine opening to the surface. It is very great, amounting to about 8 tons to the square foot per 100 feet of overlying strata, and cannot be successfully resisted by wood timbers. Only solid masonry or concrete will suffice to withstand this pressure which is often called squeeze. The other stress is the minor pressure which is caused by the weight of the softer or more readily disintegrated rock, commonly soft shale called draw slate, which immediately overlies the coal in many places. This varies from a few inches to a number of feet in thickness and must either be removed until a strong roof rock is reached or it must be supported by timbers. The minor pressure may amount to as much as 3 or 4 tons to the square foot, but is not commonly more than 500 pounds.

Mine timbers perform two functions in connection with the stresses described above. When the coal in the pillars and ribs is inadequate to support the major pressure or squeeze timbers properly set give warning by their buckling, splitting and other signs of failure. As the collapse of the

pillars and fall of the roof rarely takes place suddenly but may be anticipated by inspection of timbers and pillars danger to miners and property from this source may be very largely reduced by careful attention to these details. The second and most apparent function of the mine timbers is the support of the minor pressure of the "draw slate" and other loose rock. The number and size of timbers depends on the character of the roof; a weak roof requires closer spacing of moderate sized timbers whereas a strong roof is properly supported by heavy timbers placed farther apart. The rooms are not so carefully timbered as the entries but only so as to insure the safety of the miner while they are being worked. The entries as permanent passageways should be thoroughly supported. At mine mouths, along main entries, at places where shops or other equipment must be placed underground concrete or structural steel or both have been found very satisfactory for support of the roof especially where pressures are great or openings must be maintained for long periods of time. In fact, though the first cost is greater, the ultimate cost of maintenance has in many cases been found to be less than with wood.

Two methods prevail in the loosening of the coal at the faces of the rooms, blasting after under-cutting and blasting without under-cutting. The latter method, known as shooting off the solid, though practised to some extent in the smaller and less progressive mines, is not to be recommended because it produces a greater amount of dust which is likely to become a serious fire and explosion hazard and also because it yields a product consisting of a greater amount of fine coal and less lump coal and therefore commanding a lower price on the market. In the latter method the coal is undercut by hand labor with a pick or by a cutting machine. In the past much coal has been undercut by hand but the greater part of the undercutting of to-day is done by machines of which there are several types. For undercutting coal in situations similar to those obtaining in most of Russell coal field, where the coal is nearly horizontal, lies under a good roof, and is comparatively free from pyrite balls, there is little doubt that the chain breast machine is the most satisfactory type. This machine consists of a low bed mounted on wheels and carrying a motor. From the bed extends a bar 5 or 6 feet in length around which an endless chain carrying cutting teeth runs in a horizontal plane. Means are provided for advancing the bar as the chain cuts a channel under the coal and the machine is steadied by a jack screw which is set against the roof. These machines are arranged to travel under their own power from place to place in the mine and the cutting is usually done at night by a special crew of machine men. In

the morning the miner who is responsible for each room bores two or more holes with an auger, tamps the powder or other explosive in the holes and fires them. After the coal has been blasted down it is loaded on the mine cars. Any shale partings or shale from loose parts of the roof is loaded on "rock" cars to be hauled to the "slate dump" or "gobbed," i. e., disposed in worked-out parts of the mine. After the coal is loaded on mine cars, which vary in capacity from 1 to 5 tons depending chiefly on the thickness of the coal bed and consequent height of the rooms and entries, it is hauled to the mine mouth and thence to the tipple. In many small local mines coal is loaded into small cars which are pushed by the miners to the tipple. In other mines haulage is by mules or, in mines where the roof is very low, by Shetland ponies. All these methods give way in the larger mines where distances are greater and quantities handled are large to some form of electric locomotive haulage. In some mines mules are used for the local gathering of the cars into trains and the motors used on the main haul to the mine mouth. Mine locomotives, commonly called motors, are of several types, trolley motors which require an overhead wire, reel motors which carry a lead wire which is automatically wound and unwound on a spring reel as the motor retreats or advances from the source of the driving current, storage battery motors and so-called crab locomotives which carry a drum and cable and haul to themselves cars situated beyond the limit of the trolley wire. The motors and other inside machinery are commonly operated on an E. M. F. of 275 volts. This voltage though carried on bare wires at the height of a man's head and not one to be treated lightly or to invite carelessness is not a serious menace to mine workers. Serious burns or deaths occur only in rare instances where well grounded, usually wet contacts have permitted a very heavy current to pass through the body of the victim. In some localities locomotives operated by compressed air or gasoline locomotives are used in mine haulage but are not used in Russell coal field so far as the writer knows.

All extensive mines have to be ventilated to provide fresh air for the workers and at the same time to remove the products of combustion and the gases given off by the coal. At some of the smaller mines a stack is erected at the air-course mouth at the base of which a fire is built. The ascending warm air creates a draft which is fed by air from within the mine and a circulation is thus started which ventilates the mine. Such measures are quite inadequate for larger mines which must be ventilated by powerful fans located at the air-course mouth and commonly at intermediate points within the mine as needed. The proper circulation of the air and its car-

riage to all parts of the mine are insured by controlling it at various points by tight doors. These are made automatic in many mines so that they open at the approach of a train or "trip" as the trains are called in common parlance at the mines. The mines of Russell coal field are comparatively free from mine gases and the ventilation needs are only those of an adequate supply of fresh air for breathing.

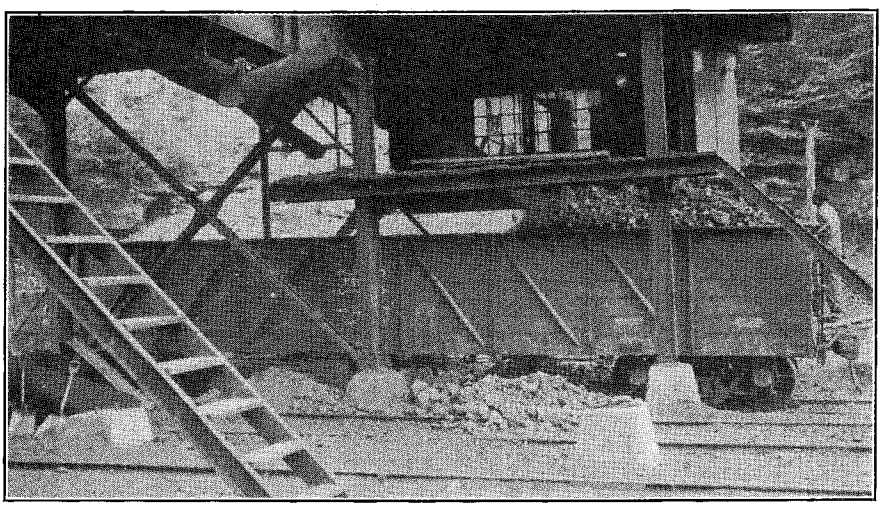
The absence of gas in the Russell coal field mines simplifies the lighting problem also and with one exception open acetylene lights are used in all the mines of the field. At Clinchfield is a slight amount of mine gas and electric storage battery lights are used by the miners. At all of the mines where electric current is available electric lights are used to considerable extent along the permanent ways.

The tipple includes equipment for dumping the coal from the mine cars, preparing it and loading it on wagons or railroad cars. The simplest form of tipple is that used at many small local mines. It consists of a short section of track at the end of the mine track which is arranged to tilt forward with the mine car on it and discharge the load into a simple chute leading to the wagon or railroad car. The mine car is caught by upturned rails or other stops as it rolls onto the tilting section of track and its momentum assists in tipping it over to the required angle. After dumping the empty car is thrown back to a horizontal position and run back to the face. At some tipples the mine cars discharge into a large storage bin built at the angle of a chute and from which coal is drawn off into wagons or cars at the bottom, thus rendering the mining and dumping of coal to some extent independent of the irregularities of haulage away from the mine. When the height of the mine mouth above the railroad or road is great the coal acquires a high velocity in sliding down a simple chute and is broken up excessively. This reduces the market price paid and it is more economical in the long run to install some kind of conveyor and avoid the excessive breakage. These are of several sorts. One of the simplest is the so-called self-acting which consists of two cars running up and down an inclined track and attached to the two ends of a cable in such a way that when one is at the top the other is at the bottom, the cable being passed over a pulley or drum at the top. As the loaded car is the down-travelling car in every case and is more than capable of pulling the empty car up the incline no power is required and the speed may be controlled and racing avoided by brakes applied to the drum. This kind of conveyor is limited in capacity as its operation is intermittent. In some cases the mine cars are run down

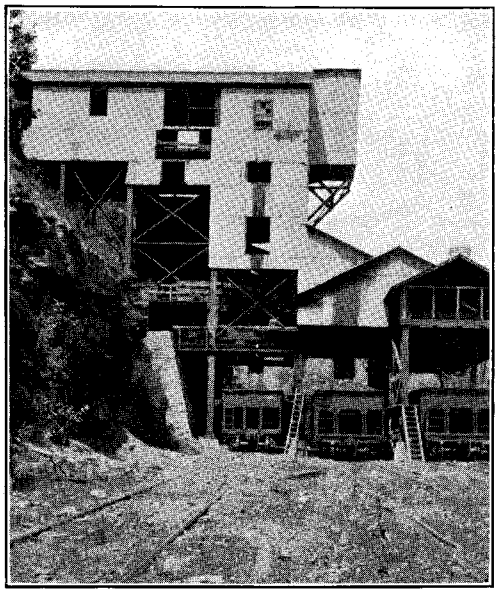
the incline and up again either one at a time or in strings of two or three and in others they are dumped into larger cars that are used on the incline and are permanently attached to the cable.

Where the output is large and warrants the larger investment an endless chain retarding conveyor is probably the most efficient means of getting the coal from the mine level to the tipple level where the difference in elevation is great. This consists of a steel-lined chute in which fits and runs an endless bucket chain. The best angle of inclination is probably one on which the coal will just a little more than slide and thus assists in driving the conveyor chain and is in turn prevented from acquiring any considerable velocity. Such a conveyor delivers to the preparing screens a continuous supply of coal as long as it is available at the top and with a minimum of breakage.

The preparation of the coal includes cleaning and sizing of the product. It is usually crushed when it is to be made into coke and in some cases also for the purpose of removing impurities. However, when the coal is sufficiently free from impurities the process of mining and handling is designed to avoid excessive breakage because the larger sizes of lump coal command a higher market price than the smaller sizes or run-of-mine coal. There are a number of different arrangements of sizing screens. A simpler arrangement is that in which the chute over which the coal passes is perforated with several sets of holes, the smaller being at the top and larger ones successively toward the bottom. The angle necessary to pass the coal over such a screen, however, gives the coal a considerable velocity and results in some breakage. This difficulty is obviated in various types of shaker screens in which the coal is moved over the screens and passed from screen to screen with a to-and-fro shaker motion. The motion, in the case of an inclined screen, may be simple to-and-fro agitation but coal is passed over horizontal screens by the use of an asymetrical motion with a more abrupt halt at one end than at the other. The screens are commonly adjustable so as to set for different sizing limits and any or all of them may be covered so that the coal may be shipped as run-of-mine coal in case the consumer so specifies. In order to provide sufficient slope for the different screens where four sizes are shipped a tipple height of 30 to 35 feet from loading track to mine track is required and where possible coal beds are opened at this height above the railroad avoiding additional expense of installing and operating a conveyor. Loading tracks are commonly built with a grade of about 1½ per cent from above and under the tipple. On such a grade cars will run by gravity under the tipple in loading and need only be placed by the loco-



(A) Loading run-of-mine coal at the No. 2 tipple of the Clinchfield Coal Corpopation, Dante, Va.



(B) Tipple serving mine No. 3 of the Clinchfield Coal Corporation at Dante, Va. The car at the right is receiving the largest size of lump coal; i. e., that which has passed over all the screens, the middle car a smaller size of lump coal, and the car at the left is being loaded with slack coal.

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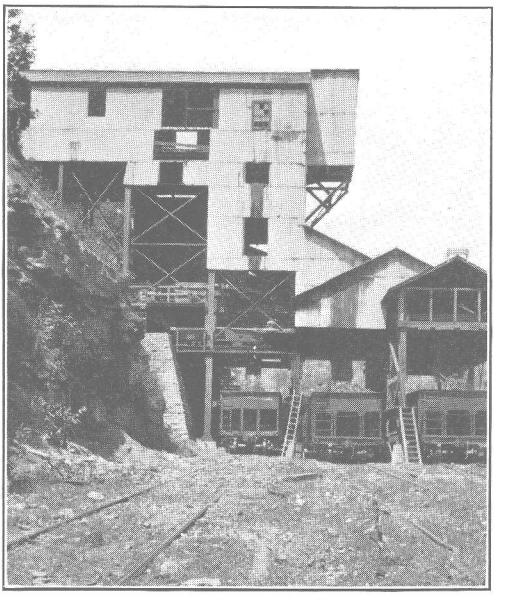

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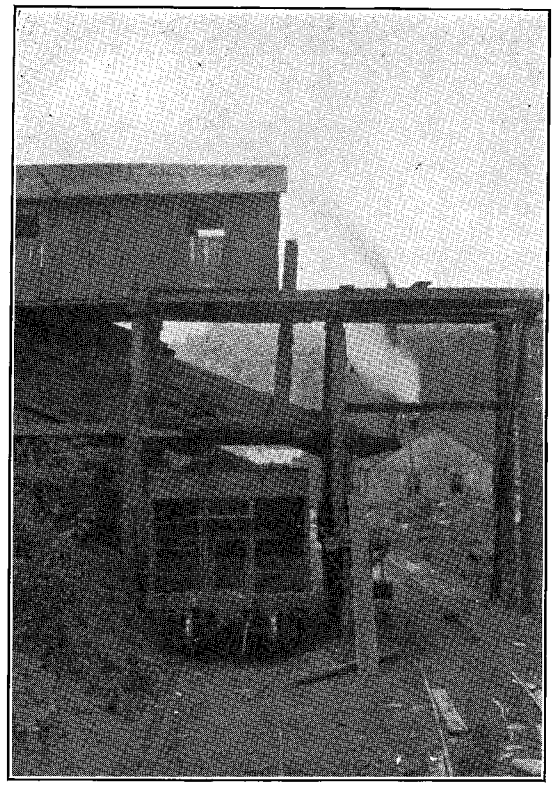
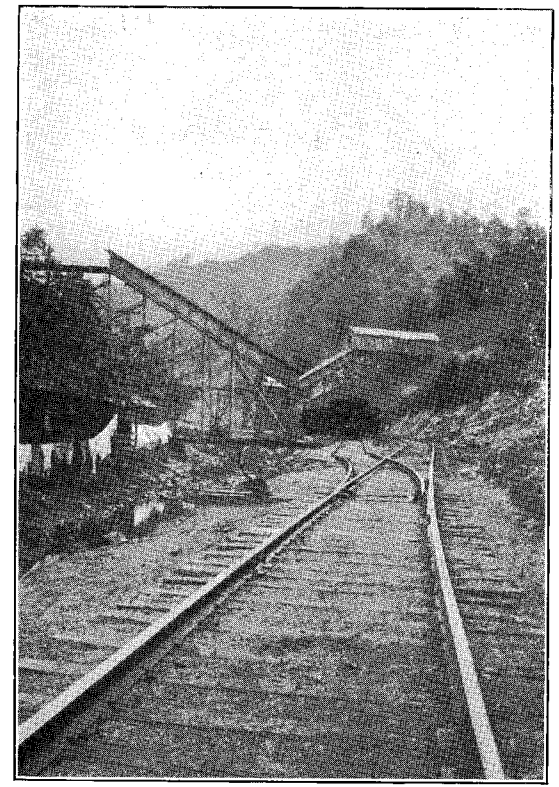
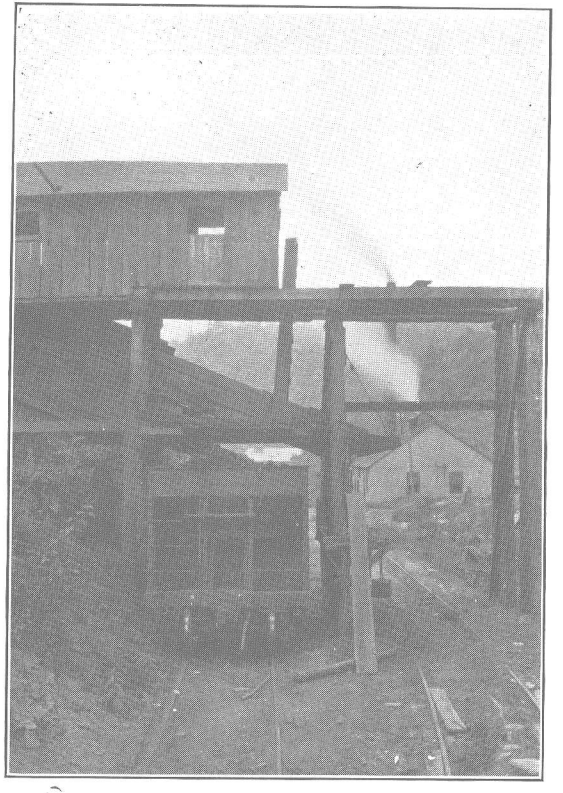


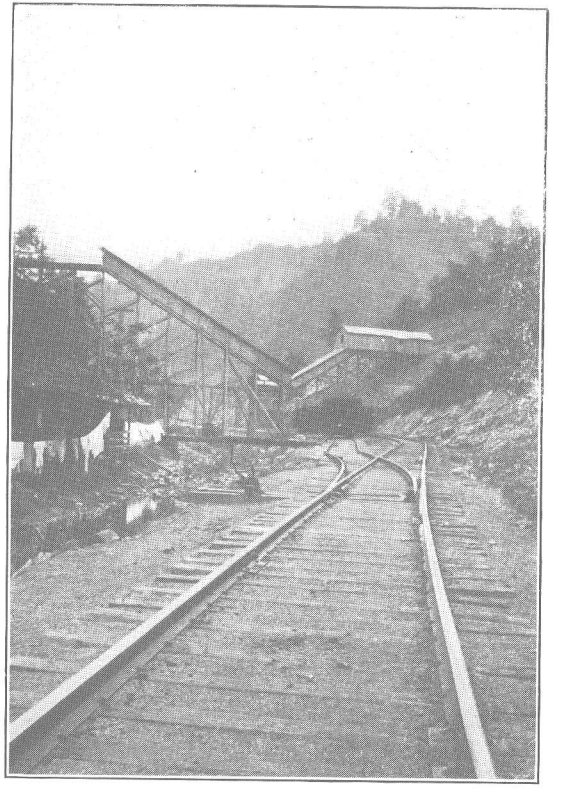
(A) Tipple of the Flatrock Coal Company showing power house in the background. Flatrock, Va.



(B) Small company tipples crossing Lewis Creek two miles south of Drill, Va.



(A) Tipple of the Flatrock Coal Company showing power house in the background. Flatrock, Va.



(B) Small company tipples crossing Lewis Creek two miles south of Drill, Va.

motive on the siding above the tipple. Commonly they are controlled by hand braking while passing under the tipple in loading but a more efficient method is to lower them under the tipple by a cable which can be controlled and paid out by the same workman who operates the loading chute. The number of loading sidings is determined by the number of sizes of coal shipped, one size being delivered to the cars on each track. The length of tracks depends on the daily output of the mine, room for cars to handle a day's output being essential and for two days' output being very desirable to compensate for irregularities in car supply.

In some coal fields washing is resorted to extensively to remove the impurities from the coal. This process is based on the difference in density between the coal and most of the impurities, the latter being heavier. Various types of machines are used in washing, all of which may be designated as hydraulic classifiers, and which depend for their operation on the different rates of settling of lighter and heavier materials in water. There is no coal prepared by washing in Russell coal field at the present time and details of the method will not be discussed here.

Certain of the more salient principles and methods of coal production as exemplified in Russell coal field have been described above. There is another class of problems which confronts the larger producers of coal in most coal fields and which, though not concerned with the technologic side of coal production, is of equal importance. This is the problem of housing the miners and other workmen. At most of the larger operations in the Russell coal field the mining companies have undertaken the entire problem of providing houses, schools, churches, hospital facilities, and amusement places. Stores conducted by the companies and commonly called commissaries sell food, clothing, and a wide range of other commodities, transactions commonly being carried on largely by means of coupon books known as script books. Most of the towns in this coal field of rugged topography are of necessity located in narrow valleys where there is very little flat land and careful planning has been necessary to secure room for the housing of the mining population. Though the corporation method of town control with its long rows of miners' houses, company store and seemingly excessive company jurisdiction in various matters is not theoretically ideal there is no doubt that, under the circumstances and considering the situation and concentration of a population largely foreign born, the towns are more orderly, have better sanitation, better educational and amusement facilities, and are more satisfactory to live in than they would be if developed and controlled under individual initiative. Many of the companies have pro-

vided educational opportunities and encouragements, ball parks, hospital equipment and moving picture theatres at considerable expense and there is little doubt that the investment has been profitable to the mine operator and mine worker as well.

METHODS AND EQUIPMENT IN USE IN SOME OF THE MINES OF RUSSELL COUNTY COAL FIELD.

The Burton Ford mine of the Russell Fork Coal Mining Company is a slope mine and is developed in a coal bed of rather irregular dip which averages about 15 degrees. The coal is hauled up the slope by drum and cable driven by a steam engine. It is shipped as run-of-mine coal and loaded directly from mine cars to railroad cars on the main line of the Carolina, Clinchfield and Ohio Railroad at Burton Ford station. A few houses have been built for miners and a general store is operated by the company.

The Litton Coal Company was just opening up a new mine on the Tiller coal bed north of Hamlin at the time of the writer's visit in July, 1920. The mine was being developed as a slope mine on coal having a dip of about 20 degrees. Production at that time was about 50 tons daily but was increasing. The coal was shipped as run-of-mine and loaded on cars on the Carolina, Clinchfield and Ohio Railroad only a few yards from the mine mouth.

A few rods from the mine mentioned above the Hamlin Coal Company is producing about 50 tons of coal per day from a drift mine on the east side of the valley of Lick Creek about one-half mile north of Hamlin. The product is shipped as run-of-mine coal over the Carolina, Clinchfield and Ohio Railroad.

At Dante near the head of Lick Creek are located mines No. 2, 3, 5, and 52 of the Clinchfield Coal Corporation. All of these mines are drift mines with natural drainage and no gas. They have an aggregate capacity of slightly more than 3,000 tons daily, all of which is undercut by chain-breast machines. All haulage is by electric motors of the trolley type and the mines are lighted by electricity. Mines No. 2 and 5 are served by a retarding conveyor and steel tipple located on the middle fork of Lick Creek. The tipple is equipped with shaker screens so as to load four sizes of coal, 6-inch, 4-inch, and 2-inch lump and slack through the 2-inch screen. Mine No. 52 is served by a wooden tipple on the north side of the right fork of Lick Creek. Mine No. 3 is served by a tipple of steel and shaker screens similar to that at the Nos. 2 and 5 mines. Coal from mines No. 52 and No. 3 reaches the main line of the Carolina, Clinchfield and Ohio Railroad over

a switchback railroad of standard guage of about one mile in length. A short spur of the same railroad affords outlet for the coal from mines Nos. 2 and 5. About 750 workmen are employed and the company has built upwards of 500 houses. There is a large general store, a drug store, a bath house, a theatre, 5 schools and 5 churches at Dante.

Mines Nos. 6 and 55 of the Clinchfield Coal Corporation at Wilder are drift mines with natural drainage. No gas is encountered in these mines which have a daily joint capacity of about 2,400 tons. The coal is undercut by electric chain-breast cutting machines and is hauled by electric motors. It is handled at a wood and steel tipple which is equipped to ship four sizes of coal as enumerated for the tipple at Dante. The coal is shipped over an 8-mile spur of the Carolina, Clinchfield and Ohio Railroad to the Clinch Valley division of the Norfolk and Western Railroad at Carbo. The company employs about 450 men at Wilder and owns 230 houses. There are one church, two schools, and a theatre at this town.

The Clinchfield Coal Corporation operates a slope mine at Clinchfield which has a capacity of about 400 tons daily. The coal is reached by a rock slope and the mine is developed from the foot of the slope in a horizontal coal bed in which the coal is undercut by electric cutting machines and hauled by electric motor to the foot of the slope. There is a small amount of gas in this mine and electric safety lights are used by the miners. The tipple is of steel and equipped to size the coal as at the other mines of the Clinchfield Coal Corporation. The coal is loaded on cars on a branch of the Carolina, Clinchfield and Ohio Railroad and reaches the Clinch Valley division of the Norfolk and Western Railroad at Carbo, 4 miles away. About 150 workmen are employed at this town and the company has built 140 houses, 2 churches, and 2 schools.

The Banner-Raven Coal Company operates two drift mines on the east side of Lewis Creek. Mine No. 1 is about one mile north of Drill and mine No. 2 is about two miles north of the same town. In mine No. 1 the coal was shot from the solid in July, 1920, but plans had been made for undercutting in the near future. Black powder is used in blasting and the coal is hauled by storage battery motor to the tipple where it is loaded in two sizes, 4-inch lump and slack. The tipple is located on the branch railroad of the Honaker Lumber Company which connects with the Clinch Valley division of the Norfolk and Western Railroad. At mine No. 2 coal is shot from the solid with black powder and hauled by mules to the tipple where it is shipped as run-of-mine over the branch railroad mentioned above. It is planned to replace the mule haulage with storage battery motor haulage in

the near future. The output of mine No. 1 is about 300 tons daily and that of mine No. 2 about 100 tons. The company employs about 40 miners in the two mines.

The Garden Coal Company operates three mines near Drill, mine No. 1 in the Kennedy coal bed about one mile north of the town, mine No. 2 just above mine No. 1 in the Lower Banner, and mine No. 3 in the Lower Banner about three-fourths mile north of mine No. 1. In all of these mines the coal is shot from the solid with black powder and hauled by mules to the tipple, which is in each case located on the branch railroad of the Honaker Lumber Company. The company expects to introduce machine cutting very shortly. The coal from each of these mines is shipped as run-of-mine and the output is about 100 tons daily at each. A total of 60 miners is employed.

At the Camilla mine about one mile south of Drill on the east side of Lewis Creek an output of about 50 tons daily is shot from the solid and hauled by mules. The tipple is located on the Honaker Lumber Company Railroad and the mine furnishes employment to 10 miners.

On the west side of Lewis Creek and just south of the above mentioned mine is the Lewis Creek Banner mine. The output from this mine is about 125 tons daily which is shot from the solid with black powder. Haulage is by mules and the product is shipped over the Honaker Lumber Company Railroad as run-of-mine coal. In July, 1920, 22 miners were employed at this mine.

At the mine of the Tarkiln Coal Company a quarter of a mile north of Flatrock on the west side of Lewis Creek, 20 miners are employed with an output of 90 tons daily. The coal is shot from the solid and hauled by mules. Black powder is the explosive used and the coal is shipped as run-of-mine. Plans are under way to establish a power plant and electrify the mine.

The Flatrock Coal Company mine near the mouth of Flatrock Creek has a daily output of about 50 tons of coal which is undercut by machine and hauled by electric trolley motor. Black powder is used as the explosive. Nineteen miners are employed and the product is shipped over the Honaker Lumber Company Railroad as run-of-mine coal. The company owns 14 houses in Flatrock and has plans for considerable further development in the near future.

THE FORESTS OF RUSSELL COUNTY, VIRGINIA

By J. W. O'Byrne.

LOCATION AND AREA.

Russell County is centrally located in what is known as "Southwest Virginia," being separated by Washington and Scott counties from Tennessee on the south, by Wise, Dickenson, and Buchanan counties from Kentucky on the west, and by Tazewell County from West Virginia on the north. It is roughly rectangular, with the long axis along Clinch River in a southwesterly direction and the long sides following Clinch Mountain on the southeast and Sandy Ridge on the northwest. It is approximately 15 miles wide and 34 miles long, containing 496 square miles, or 316,440 acres.

TOPOGRAPHY AND DRAINAGE.

The county lies in one of the main valleys of the Alleghany Mountains, with a range in elevation of from 1,400 feet above sea level in Clinch Valley to 3,735 feet on the top of Big A Mountain on the north boundary, and 4,550 feet on the top of Whiterock Mountain in the southeast corner. The mountains throughout the county have steep slopes, becoming almost precipitous in the coal measures and along Clinch Mountain. North of Clinch River and Maiden Spring Creek the valleys are generally narrow, with very little cleared area. South of Clinch River and Maiden Spring Creek the valleys are generally broad and rolling, with extensive areas well suited to agriculture. The ridge-tops are almost uniformly narrow, amounting to little more than peaks in the large majority of cases, especially in the coal-bearing portions.

Clinch River drains 78 per cent of the total area, including all of the northern and central portions of the county. Copper and Moccasin creeks, running parallel to and between Clinch River and Clinch Mountain, drain about 19 per cent or 94 square miles, in the southwest corner, while the remaining 3 per cent, lying in the extreme southeast corner, is drained by Tumbling Creek, a tributary of the North Fork of Holston River. All of these streams are a part of the Tennessee River system and find their outlet in the Gulf of Mexico, through the Tennessee and Mississippi rivers.

POPULATION.

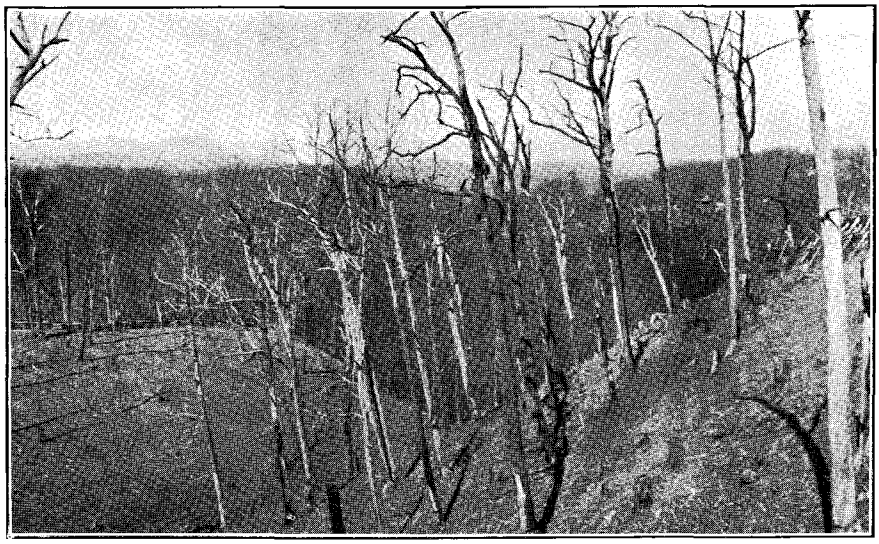
Preliminary announcements by the Bureau of the Census for 1920 give Russell County a population of 26,786, as compared with 23,474 in 1910 and 18,031 in 1900. Most of the increase has taken place in Castlewood, Cleveland, and New Garden districts, indicating that it is largely the result of increased mining activities in these sections.

TRANSPORTATION FACILITIES.

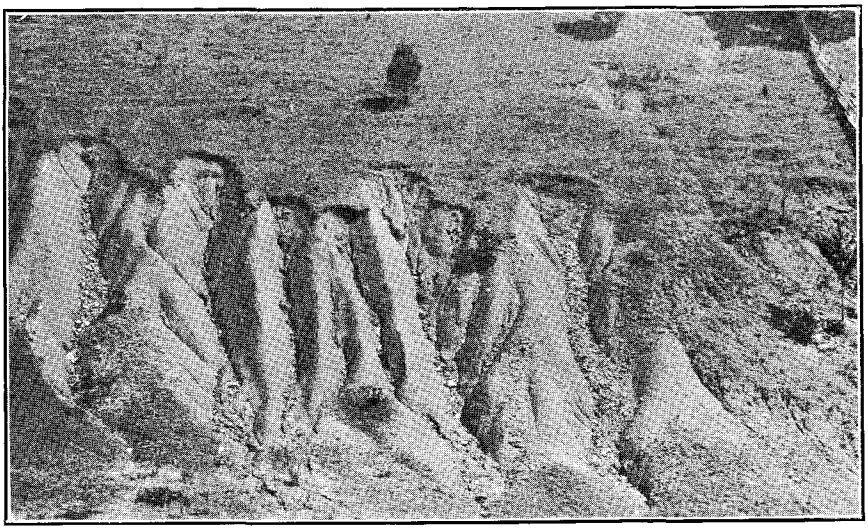
The Clinch Valley Division of the Norfolk & Western Railroad crosses the county from northeast to southwest, with branch roads from Honaker to Drill and from Honaker to Blackford. The Carolina, Clinchfield & Ohio enters the west end of the county along Clinch River and leaves it by way of Lick Creek. This road also maintains a branch in Dumps Creek, with trackage rights over the Norfolk & Western from Carbo to St. Paul, giving an outlet to Wilder and other camps in Dumps Creek. Other small roads connect various camps with the Norfolk & Western, but are not chartered as common carriers. Good macadam roads are quite common throughout the limestone and grazing portions of the county, but north of Clinch River the only good roads are those connecting the larger camps with railroad points. Most of the cross-country travel is by automobile, except in the mountains, where horseback riding is the rule.

CHIEF INDUSTRIES.

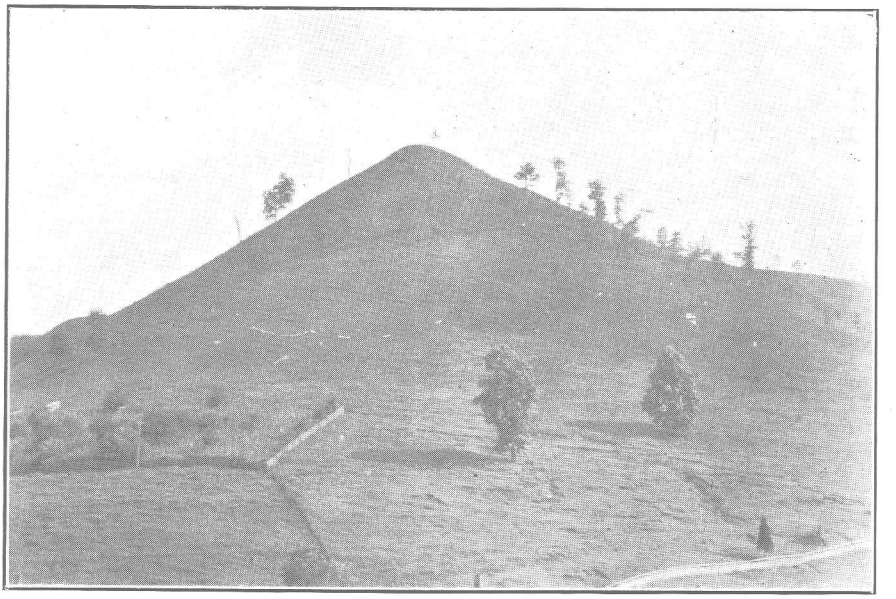
Considering the county as a whole, agriculture is the leading industry, with coal-mining second, and lumbering a poor third. A distinction must be made between the "limestone" and the "coal-bearing rocks" sections of the county. The limestone section, roughly speaking, is all that portion of the county lying south of Clinch River and Maiden Spring Creek. Here the soil is of good depth and fertility, and bluegrass, the principal native grass, thrives unusually well, even on the steep slopes of the larger hills and mountains. The "coal-bearing rocks" section lies north of this section, and includes not only that portion actually underlain with coal, but other land of similar formation lying between the coal-bearing area and the "limestone" country. The soil here is loose, much less fertile than in the limestone sections, and bluegrass does not thrive or produce a sod, so that erosion ("washing") is a serious problem whenever the timber is removed from the steep slopes.



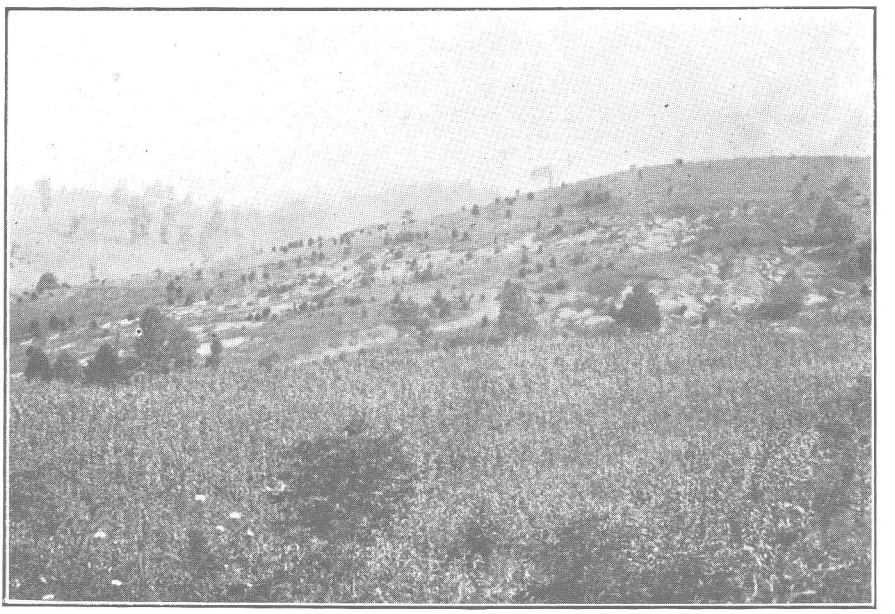
(A) Method of land-clearing in "coal-bearing rocks" section. Trees killed by girdling 3 years ago.



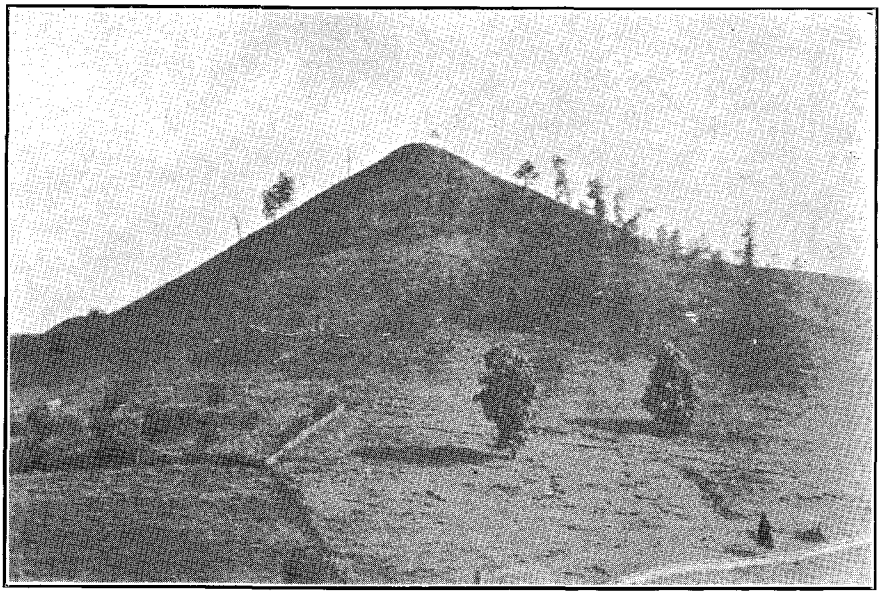
(B) Typical example of erosion following clearing in "coal-bearing rocks" section. Such fields usually have to be abandoned within 7 years after clearing.



(A) Steep slope cleared for grazing in the "limestone" section. Illustrates lack of erosion in this section.



(B) Erosion over large area in "coal-bearing rocks" section which should never have been cleared. Slopes not nearly as steep as in (A) above.



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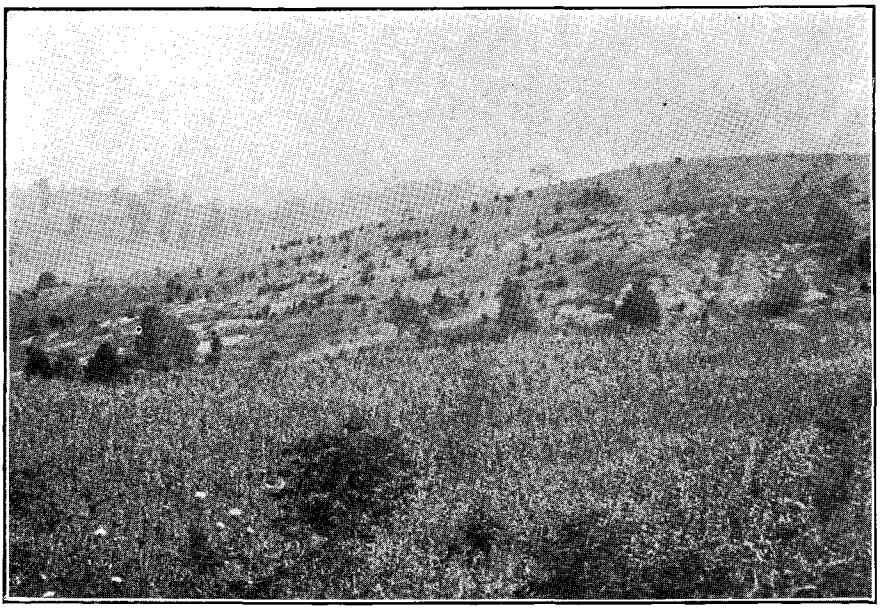

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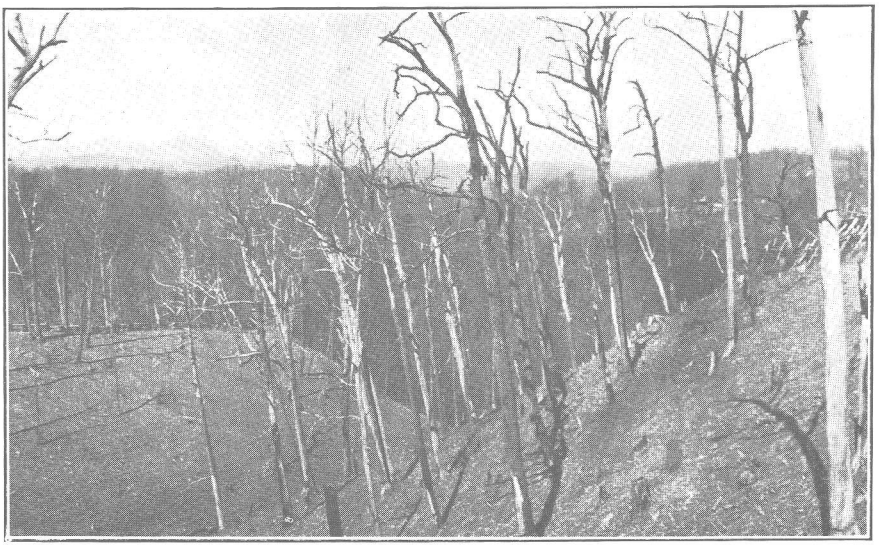

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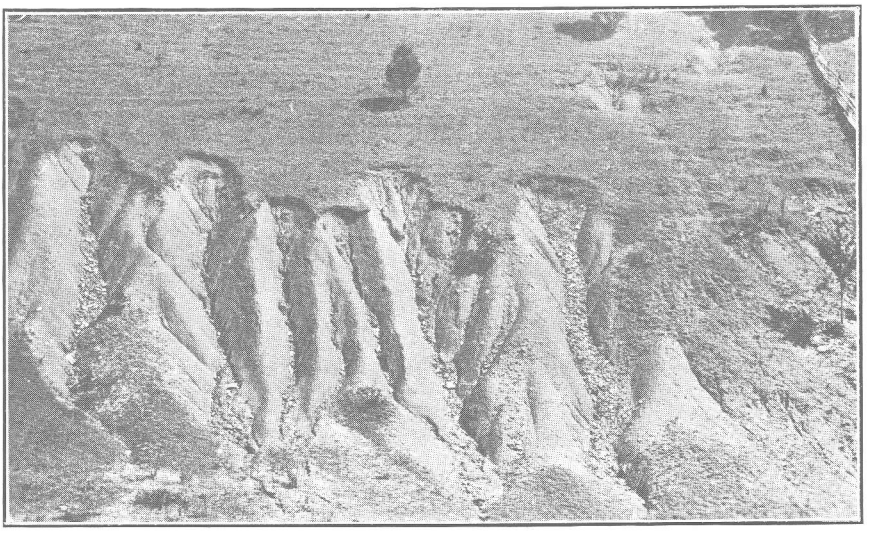


(B) Typical example of erosion following clearing in "coal-bearing rocks" section. Such fields usually have to be abandoned within 7 years after clearing.

In the "limestone" or "bluegrass" section, agriculture, especially cattle-raising and feeding, is the most important industry. Throughout most of the area lumbering operations are confined to small portable mills operating in small bodies of timber which the owners desire to have cleared off as fast as they become marketable, in order that the land may be seeded down to bluegrass. Lumbering, therefore, now a very poor second, is doomed to play a continually decreasing part in the activities of this portion of the county. For this reason the timberland conditions described and discussed hereafter should be regarded as applying primarily to that portion designated above as the "coal-bearing rocks" section.

In the "coal-bearing rocks" section, coal-mining is the leading industry, with large camps at Dante and Wilder. Other mines are being opened or operated in other sections, hence coal-mining is destined to be of increasing importance. Lumbering is also an important industry in this section. and with proper attention to the fundamental principles of forestry should remain so indefinitely. Agriculture is carried on to a limited extent but is rarely if ever the sole means of livelihood.

There are no wood-using industries in the county, except the mines, which use considerable quantities of mine-props and structural timbers.

LAND OWNERSHIP.

The two largest holdings in the county contain approximately 22,000 and 8,000 acres respectively. The former is made up largely of farming and grazing land, while the latter is the property of a coal company. In both instances the acreage held in Russell County is only a portion of the total area controlled and operated by the respective companies. In the mineral section there are a few other holdings of considerable size, ranging from 300 to 1,100 acres, but the average unit of ownership, exclusive of the large holdings mentioned above, is about 75 acres. In the "limestone" section the holdings run considerably larger, there being, aside from the 22,000 acres mentioned above, upward of 35 holdings ranging from 300 to 3,000 acres each, with an average size, exclusive of the very large and very small tracts, of about 120 acres.

FOREST TREES OF COMMERCIAL IMPORTANCE IN THE "COAL-BEARING ROCKS" SECTION.

The forest trees of commercial importance in the "coal-bearing rocks" section of the county, arranged approximately in the order of their economic importance, are as follows:

Common Name.	*Scientific Name.*
White oak	*Quercus alba.*
Tulip (yellow) poplar	*Liriodendron tulipifera.*
Chestnut	*Castanea dentata.*
Chestnut (rock) oak	*Quercus prinus.*
Red oak (northern)	*Quercus rubra.*
Hemlock	*Tsuga canadensis.*
Black oak	*Quercus velutina.*
Hard maple (sugar tree)	*Acer saccharum.*
Cucumber	*Magnolia acuminata.*
Basswood (linden or lin)	*Tilia Americana.*
Beech	*Fagus Americana.*
Buckeye	*Aesculus glabra.*
Sweet birch	*Betula lenta.*
Black gum	*Nyssa sylvatica.*
White ash	*Fraxinus Americana.*
Scarlet oak	*Quercus coccinia.*
Red (soft) maple	*Acer rubrum.*
Hickory (shagbark)	*Hicoria ovata.*
Bitternut (hickory)	*Hicoria minima.*
Red birch (water birch)	*Betula nigra.*
Black walnut	*Juglans nigra.*
Sycamore	*Platanus occidentalis.*
Butternut	*Juglans cineria.*
Elm	*Ulmus Americana.*
Red cedar	*Juniperus Virginiana.*
Shortleaf pine	*Pinus echinata.*
Pitch pine	*Pinus rigida*
Scrub pine	*Pinus Virginia.*

FOREST TYPES.

Four distinct forest types are recognizable:

(1) "Ridge" type.
(2) "Slope" type.
(3) "Cove" type.
(4) "Bottom" type.

As the names imply, these types correspond to the various main divisions of the topography. These types are, however, considerably modified by exposure to direct sunlight and air currents, and all four types are found to occur farther down the slopes on the southerly exposures than on the north-

erly exposures. The composition of the stands also varies considerably with the exposure, but lacks consistent or characteristic differences such as are necessary for further division into types.

The "ridge" type occurs on the tops of the main ridges and spurs and for a short distance down each side, especially on the southern exposures. The characteristic tree of this type is the chestnut oak, which, frequently, especially where the soil is unusually shallow or dry, occurs in pure stands. Chestnut is the most common tree found in mixture, but as a rule it occurs only on the deeper, moister soils and less exposed situations. Other species frequently found in this type are scarlet oak, white oak, hickory, black locust, and pitch pine, while on the saddles and upper north slopes, basswood, maple, gum, and northern red oak frequently occur.

The typical tree-form for the "ridge" type is small, crooked, and much branched. On the poorest, rockiest sites the chestnut oak is of such poor form and size as to be unmerchantable except for cordwood or mine-props. Over most of the area, however, it reaches an average size of 20 inches D. B. H. (diameter, outside bark, at breast height) and a height of 50 feet. One log per tree is about the best that can be expected from this type.

Fires have done considerable damage in this type, due to the open character of the stands and their exposure to wind and sun, which dry out the fallen leaves and other debris while the more protected slopes are still moist or even wet.

The "ridge" type is a relatively unimportant one from a timber production point of view. The ridges are so narrow that they can be considered as having no "top," and, together with the upper slopes on which the same general type of growth occurs, make up less than 10 per cent of the total area. The timber also is generally quite inferior, both in size and quality.

The "slope" type is the most important type recognized, occupying 60 per cent of the forest area. It occupies all of the slopes and benches except the upper slopes of southern exposure, which support the "ridge" type of growth, and the lower slopes of northern exposure, where it merges into the bottom type.

White oak is the characteristic and most valuable tree in this type. It reaches its best development on the lower benches with northern exposure. Chestnut also attains its greatest value in this type and in many places far outnumbers the white oak. It is, however, much more subject to various defects, and seldom equals in size or value the white oaks with which it associates.

The other associated species vary greatly with the exposure and the amount of direct sunlight and moisture. On slopes and benches with a southerly exposure, chestnut oak, scarlet oak, black oak, and hickory are those most commonly found, while on the northerly exposures red oak, poplar, beech, maple, buckeye, cucumber, basswood, ash, sweet birch, and black gum are common. Walnut formerly occurred frequently in this type but is now seldom seen.

The stand varies considerably with the exposure, averaging two or three times as heavy on north slopes as on the more open and dryer south slopes. The individual trees are also larger and better developed on the north slopes.

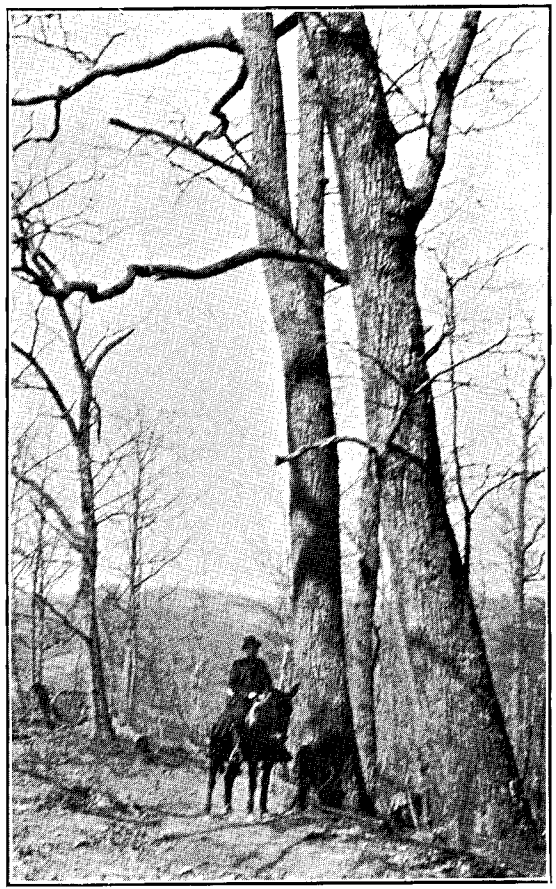
The "cove" type, while small, occupying probably not over 15 per cent of the forested area, contained in the virgin growth, and still contains, the most valuable if not actually the heaviest stands. It is confined to the ravines near the smaller streams, and the coves which usually occur near their heads. As in the case of the "slope" type, exposure to the direct rays of the sun, and, probably to a somewhat less extent, exposure to the wind, greatly influence the composition and general thriftiness of this type.

Tulip (yellow) poplar is the characteristic and most important tree in this type. In size, beauty, and rate of growth, it stands without a peer, and it is exceeded only by some of the choicer cabinet-woods in value. It reaches its best development near the heads of coves with a northerly exposure, where trees from five to eight feet in diameter and from 150 to 200 feet tall were formerly numerous and are still occasionally found. Tulip poplar occasionally formed the bulk of the original stands in the coves draining north. As a rule, however, it did not make up more than 30 per cent of the total.

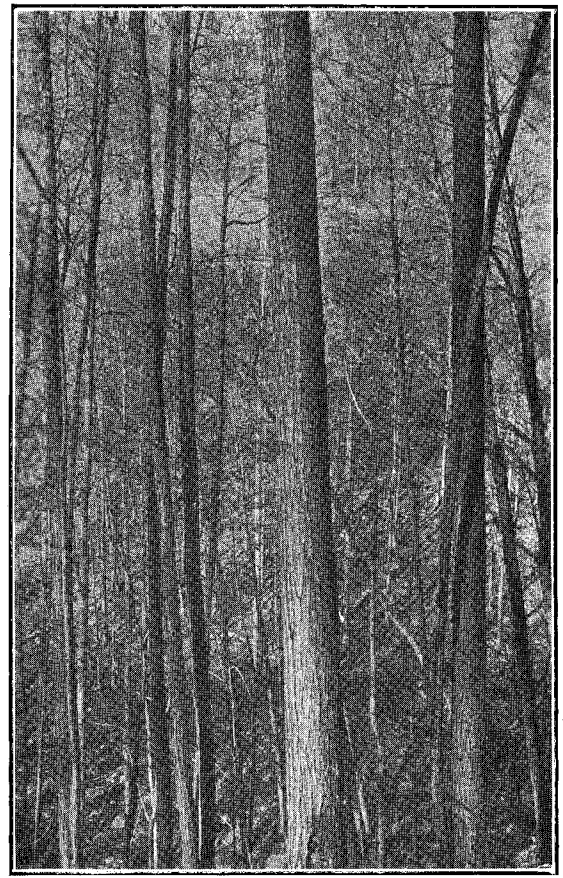
Basswood, northern red oak, white oak, maple, white ash, buckeye, and cucumber are usually associated with tulip poplar in coves draining north, with chestnut and chestnut oak coming in toward the tops of the ridges, and hemlock lower down near the main stream bottoms. In coves draining south tulip poplar is largely replaced by white oak, the undergrowth is less dense, the stand lighter, and in many respects the growth more nearly resembles the slope type than the typical "cove" type found on the northerly exposures.

The "bottom" type covers the usually narrow bottom-lands of the main valleys, and the lower slopes adjacent, especially those on the south side of the streams.

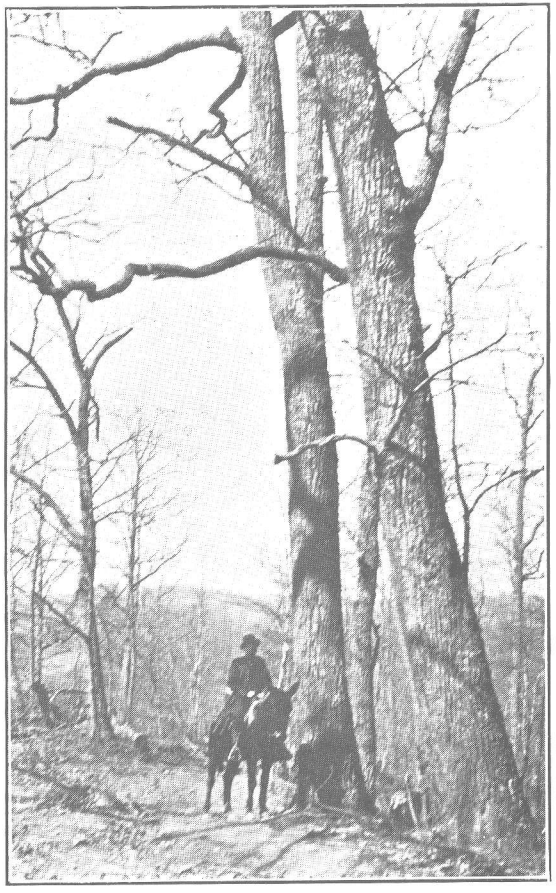
Hemlock is the characteristic and most important tree. It frequently occurs in pure stands over considerable areas. These are the heaviest stands of timber now found in the county. Associated with hemlock in the "bot-



(A) Chestnut oaks, or rock oaks, near a ridge top. The form of the trees varies greatly with their location.



(B) Thrifty stand of second-growth chestnut. Note the fire-scar near the base.



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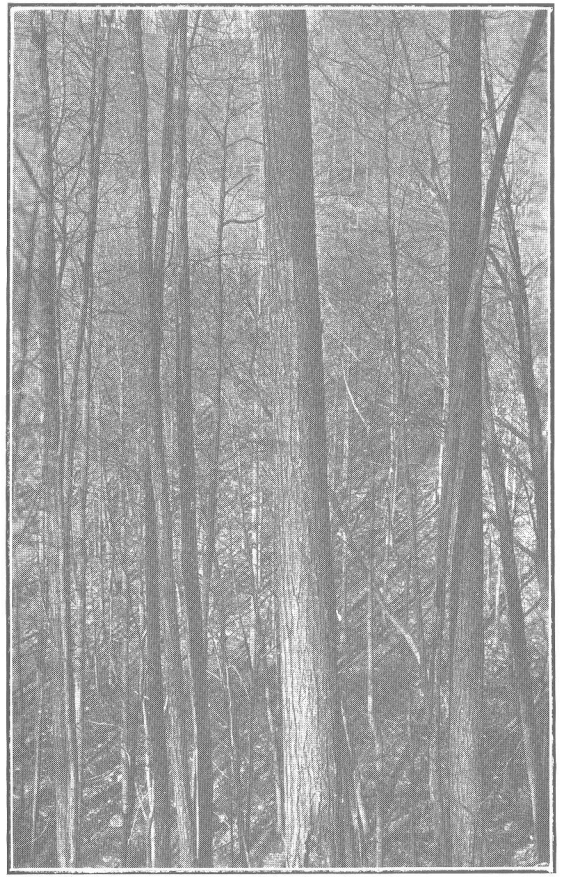
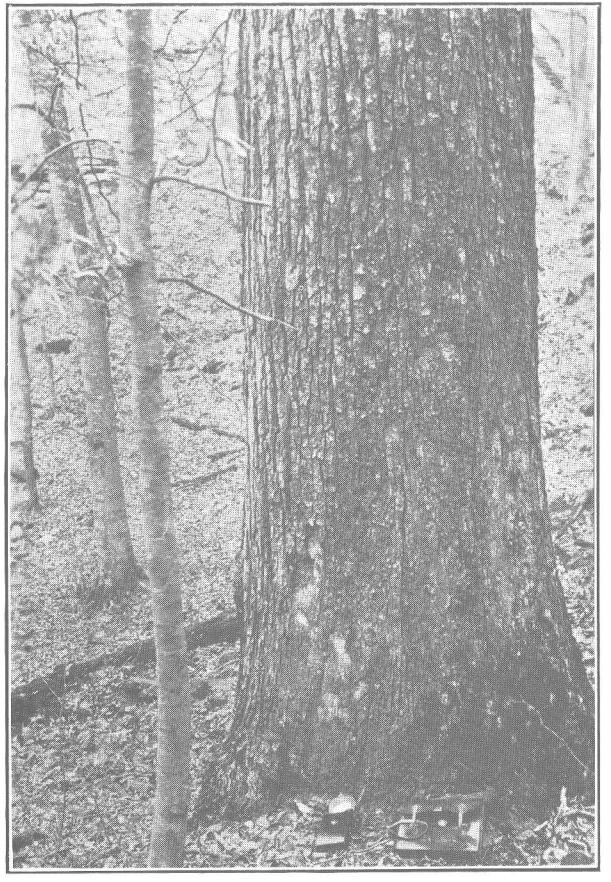


(B) Thrifty stand of second-growth chestnut. Note the fire-scar near the base.

(A) Yellow poplar, about 55 inches in diameter at breast height, containing about 6 M. board feet. Such trees were abundant originally, but are very scarce now.

(B) Young stand, principally poplar, where the larger poplars were cut out 20 years ago. Illustrates that the early cuttings did not ruin the forests.



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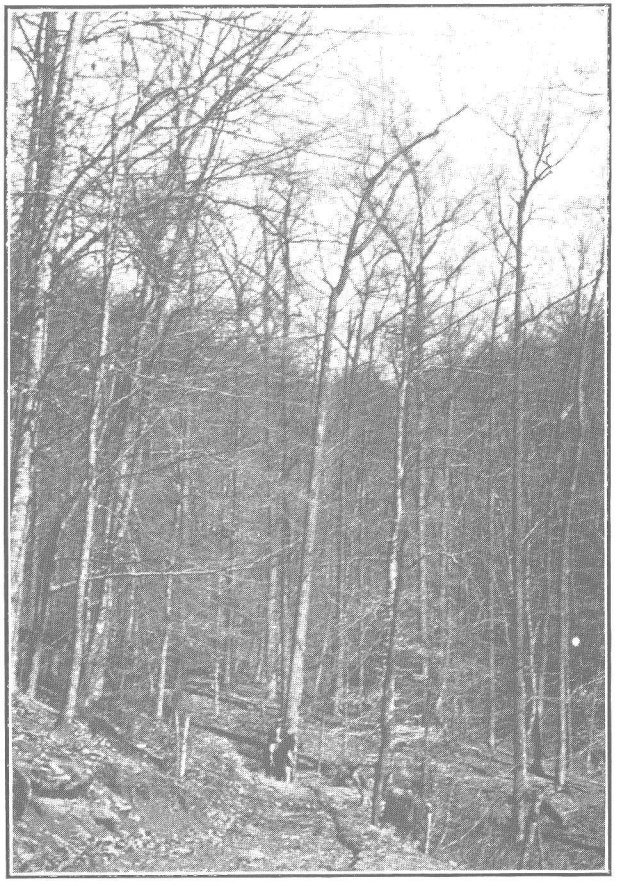


(B) Young stand, principally poplar, where the larger poplars were cut out 20 years ago. Illustrates that the early cuttings did not ruin the forests.

tom" type are soft maple, beech, river birch, black gum, and cucumber. Rhododendron forms dense, almost impenetrable thickets under the trees, casting a shade which keeps the ground so wet as to make fires almost unheard of, but which also excludes reproduction, except on rotten logs and stumps and in occasional small openings.

CLASSIFICATION OF THE FORESTS AND AN ESTIMATE OF THE TOTAL STAND IN THE "COAL-BEARING ROCKS" SECTION.

Of the 317,440 acres in the county, about 40 per cent, or 126,976 acres, comprise that part of the county known as the "coal-bearing rocks" section. This section may be divided into the following classes, in accordance with the present stand of timber (Sept., 1920):

(1) Land on which there is now sufficient timber to justify a sawmill operation. 74,916 acres, or 59 per cent of the "coal-bearing rocks" section.

(2) Land on which the timber has been so severely culled or burned, or so recently cut, as to make it impractical to attempt saw-milling. 29,204 acres, or 23 per cent of the "coal-bearing rocks" section.

(3) Cleared land. 22,856 acres, or 18 per cent of the "coal-bearing rocks" section.

(1) *Forests in which saw-milling is a possibility.*—The stand in these forests varies from 1,200 feet B. M. per acre on areas cut over as recently as 12 or 15 years ago to 7,000 feet per acre on areas from which only the better poplar and white oak have been removed. Small areas of hemlock occasionally run as heavy as 15 M. feet per acre, but since these stands occur only as narrow strips in the valley bottoms, where the only practical method of operating is to log them in conjunction with the adjacent slope timber, these heavy stands have been averaged in with the lighter ones described above. Taking this class of forests as a whole, 4,500 board feet per acre is probably a fair average, giving a total of approximately 337,122 M. feet now available for saw-milling in the "coal-bearing rocks" portion of the county.

(2) *Forests which are too lightly timbered for saw-milling.*—This class of forests includes areas recently cut over by saw-mill operations, burned areas, and areas once cleared for farming, but worn out, abandoned, and now seeding up to a more or less indifferent stand of young growth. Where the cutting was done prior to 10 or 12 years ago, when the price of lumber did not warrant the handling of the smaller trees and less valuable species,

and fires have been kept out, stands of 1,500 or 2,000 board feet per acre are occasionally encountered. The great bulk of this class of forest, however, runs from nothing to 1,000 board feet per acre, with an average stand of probably 350 feet per acre.

(3) *Cleared land.*—This class includes all lands now used for camps, farming and grazing, and abandoned lands not yet seeded up to tree growth. Under present practices the amount of this class of land tends to increase, as steep slopes are being cleared. They "wear out" in from five to seven years, due to "washing" and continuous cropping, and are abandoned, but the forest only reëstablishes itself on them slowly.

The total estimated stand of timber in the "coal-bearing rocks" section, in bodies of large enough size to constitute practicable saw-mill operations, is about 337 million board feet, or its equivalent in other products. This is not claimed to be more than an approximate figure. It does not include the ties, props, cordwood, etc., available from stands too scattered or too small to make saw-milling operations in them feasible. Nor does it include any estimate for the "limestone" section of the county. Good enough maps and other facilities were not available when the study was made to make an estimate of the stand in the "limestone" section feasible.

HISTORY OF LUMBERING.

Here again we find the two sections of the county strongly contrasted. In the "limestone" section the great bulk of the area was cleared before there was sufficient demand for lumber to justify the expense of transportating even the choicest material to market, and the usual practice was to pile up the logs and brush into huge piles and burn them. As market conditions improved, a portion of the better material, principally the walnut and the choicest poplar, was hauled by wagon across Clinch Mountain to Abingdon and other railroad points in Washington County. With the building of the Clinch Valley branch of the Norfolk & Western Railroad, some 30 years ago, numerous small saw-mills came in, which cut and shipped lumber, but the long-established industry of cutting and shipping logs continues to the present time.

In the "coal-bearing rocks" section cutting on a large scale began at a much later date, very little having been done prior to the construction of the railroad. Such clearing as was done prior to this time was confined to the narrow valley bottoms and to small isolated patches on the slopes. On the steep slopes the clearing was usually accomplished by girdling the larger

trees and allowing them to stand while crops were grown between the dead trees. Such patches were frequently "worn out" and abandoned before the dead trees had decayed sufficiently to fall.

Following the building of the railroad through the county the mountain timber was cut heavily, all of the walnut and the best of the poplar and white oak and the more accessible hemlock being removed and either cut into lumber by portable mills, hewn square, or shipped in the log. As timber became more valuable the cutting became heavier, until at present practically everything down to 12 inches inside the bark at the stump is removed. An exception to this general statement took place in Lewis Creek, where a logging railroad to supply the three-band mill at Honaker was constructed. This mill, with a capacity of about 100,000 board feet per day, has cut most of its timber in Dickenson and Buchanan counties, but in its earliest operations it cut up the logs from some 2,000 acres in Lewis Creek. This cutting was much closer than that done by the small circular mills operating in the adjacent territory.

Russell County lies within the so-called "poplar belt," and originally contained heavy stands of the well-known "yellow poplar" of the timber trade. In these stands poplar was one of the dominant species and ran as heavy as 1,500 or 2,000 board feet per acre over extensive areas. There are still a few tracts containing the original poplar, the largest being at the headwaters of Dumps and Sword creeks, but altogether these do not total over 1,100 acres.

Prior to 1914 hewn railroad ties and export timbers made up a considerable portion of the cut. The tie business consisted largely of a combination of a mule and a small boy. The mule has now been sold and the small boy has gone to town to drive an automobile. The export timbers were of two kinds: Large white oak logs hewn square, running from 12 to 30 inches on each face and up to 40 feet long, and sawn white or chestnut oak car-stock, of the following dimensions: 3½″ x 12″, 10′ to 15′ long, 5″ x 12″, 12′ 8″ and 16′ long, and 5½″ x 12″, 8′ and 16′ long. During recent years the amount of car-stock has averaged about 1,000,000 board feet per year, but the market is very quiet at present (Sept., 1920), due to the prevailing high prices and the rate of exchange on foreign money, unfavorable to the foreign importer.

PRESENT METHODS OF LUMBERING.

Logging and manufacturing practices have not changed materially from those used many years ago, except that there is now much closer utilization,

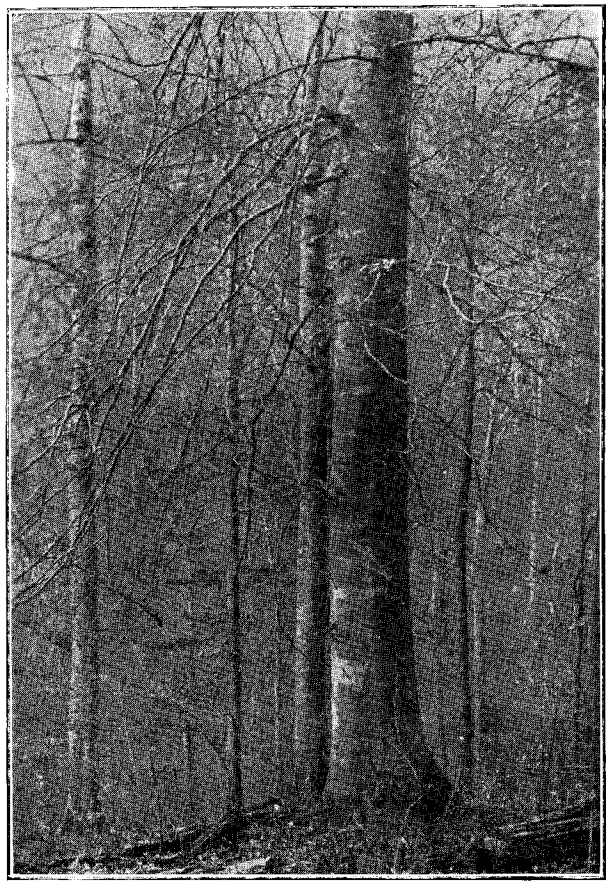
both as regards sizes and species, than formerly. The only large mill operating in the county is located at Honaker. This is a three-band mill with a rated capacity of 100,000 board feet per day. Its timber, however, all comes from Dickenson and Buchanan counties, by means of the company's own logging-roads to Drill and from there over the Lewis Creek Branch of the Norfolk & Western. As an offset to this, however, there is another large operation at the head of Tumbling Creek in the extreme southeastern corner of the county, where about an equal amount of timber is cut for manufacture at Clinchburg, in Washington County. A modern, single-band mill of about 30,000 board feet daily capacity is under construction on Dumps Creek, with which it is planned to cut out a large part of the Dumps Creek timber. There are, in addition to these, 26 circular mills scattered over the county, with outputs varying from 2,000,000 feet per year down to negligible amounts. Some of them are small rigs doing only custom sawing. Of these 26 circular mills, 9 are scattered throughout the "coal-bearing rocks" portion of the county, while 17, including all of those doing custom work, are located in the "limestone" section.

Logging is largely done by day labor. The logs are commonly "bruted" down the steep slopes to side draws or valleys, where they are fastened together by grabs into "runs" of from 3 to 6 logs. They are then dragged to the mill, or, in the case of long hauls, to a tramroad in the main valley bottom, where they are loaded on small cars and then hauled to the mill.

Timber is usually purchased by the "boundary" (tract), or by the acre, but occasionally by the tree or by the thousand board feet. The latter, however, is the basis for all selling, as when selling is done on any other basis both parties to the agreement are, or should be, in possession of estimates giving the approximate number of feet of each species in the tract.

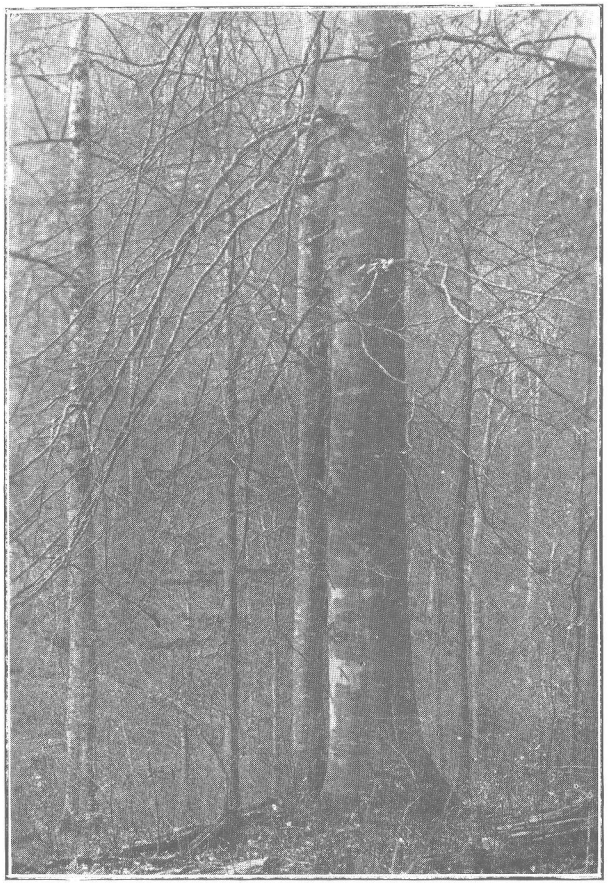
A minimum diameter is customarily specified below which no trees are to be cut. At present this minimum is usually 12″ inside the bark on the stump. Ten years ago 18″ was the customary limit, which left the remaining stand in immeasurably better condition, both from the standpoint of reproduction on the area and the future growth of remaining trees.

A definite period is usually specified for the removal of all the timber included in the contract of sale. The length of this period varies with the size of the contemplated operation and with the products to be obtained. Most sales now made are for periods of 10 years or less.



(A) Beech, a rather common species in moist situations.

(B) Hemlock, occasionally found in dense stands. Note the undergrowth of rhododendron.



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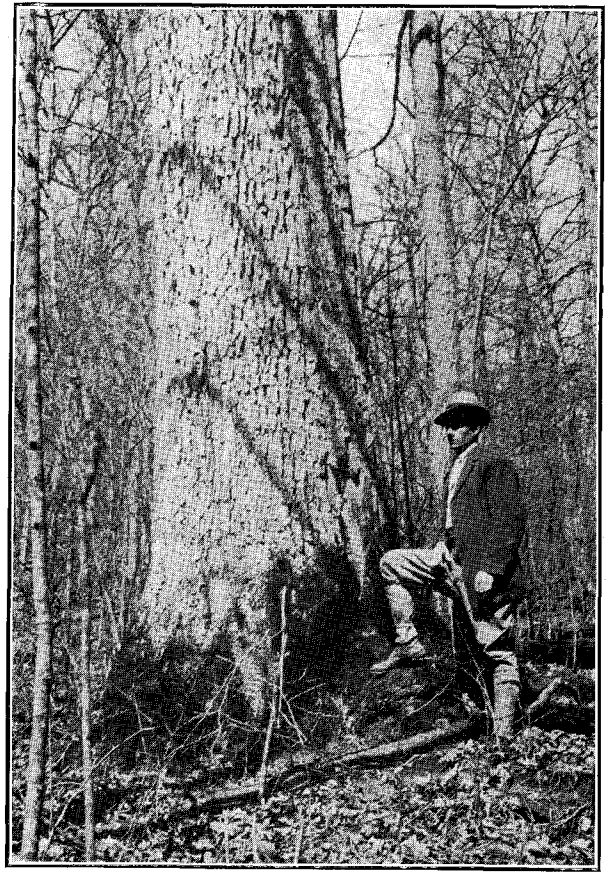
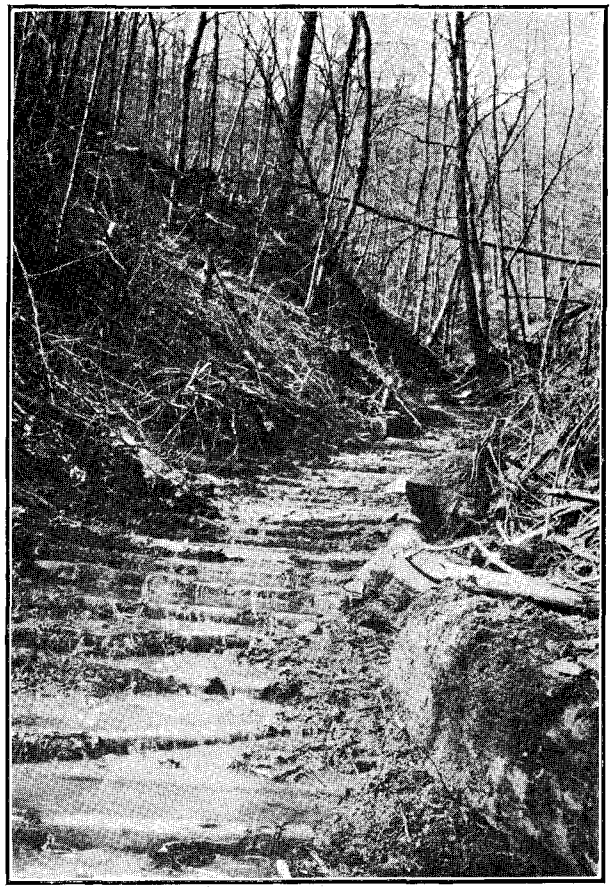
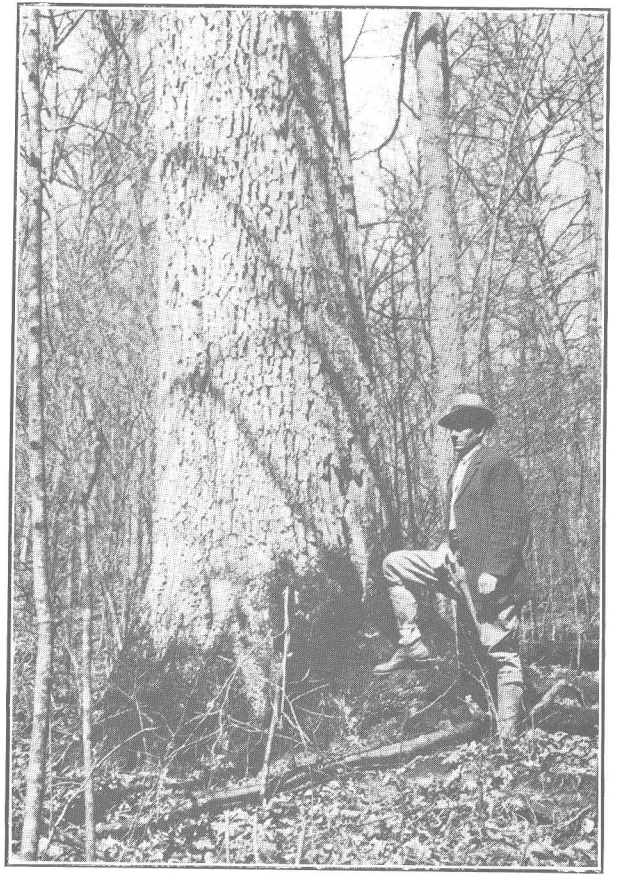


(A) White oak, original growth.



(B) Poles set in stream-bed to facilitate hauling of logs.



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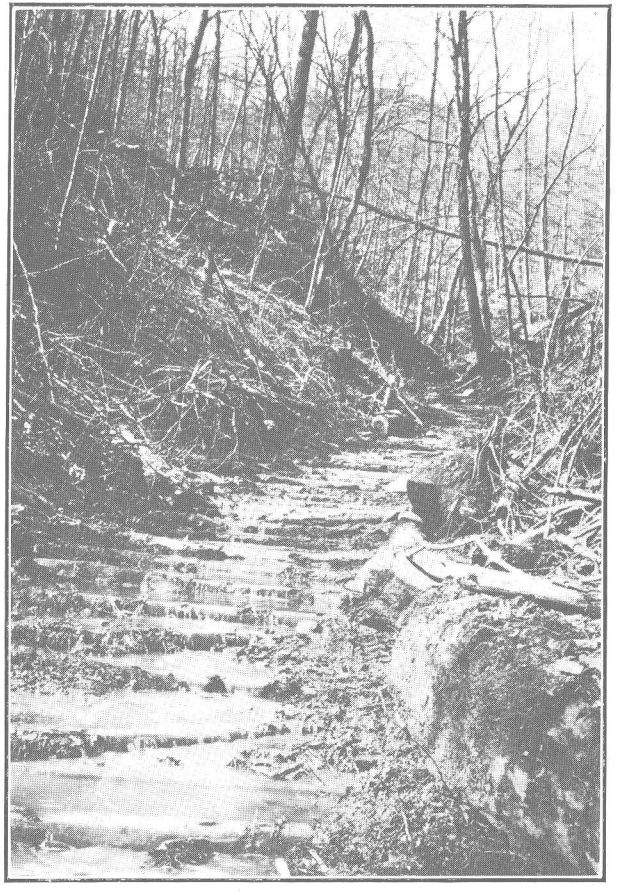


(B) Poles set in stream-bed to facilitate hauling of logs.

Classification of Sawmills.[a]

Total amount cut.	Number of mills. "Limestone" Section.	Number of mills. "Coal-bearing rocks" Section.
15,000,000 board feet		1 [b]
3,000,000-5,000,000 board feet		1 [c]
1,000,000-2,000,000 " "	2	2
500,000-1,000,000 " "	3	2
100,000-1,000,000 " "	3	2
Less than 100,000 " "	12	

TANNIN EXTRACT.

Chestnut wood is extensively used for the extraction of tannin. The same is true of the bark of hemlock and chestnut oak. Chestnut wood for this purpose is sold by the "cord," a cord in this instance meaning a stack of 5-foot wood 8 feet long and 4 feet high, containing 160 cubic feet instead of 128 cubic feet in a standard cord. Wood for this purpose may be cut from the tops of trees which are cut for lumber, or from dead or defective trees. In actual practice, however, the two operations are seldom carried on together. Usually the entire tree is cut into extract wood, where that is the product desired. Hemlock and chestnut oak bark for "extract" is usually spoken of as being sold by the "cord," the term "cord" here meaning 2,240 lbs., as it is usually weighed instead of measured. Very few of the sawmills make any effort to get out bark, for several reasons: (1) Shortage of labor (the average mill man considering himself fortunate to get enough men to run his mill); (2) the short season during which the bark will "slip" (usually from the middle of April until the last of May), and the loss due to the checking of logs peeled during this period and left to be sawed later; (3) the heavy expense of getting the bark off the slopes, which are usually too steep to permit a wagon to be driven to the place where the bark is peeled; and (4) the unsatisfactory results when a separate contract for the bark is let (requiring more supervision to see that no cutting is done in places where it is impractical to get out the logs than the sale-value of the product justifies).

The nearest market for extract wood and bark is at St. Paul, (in Wise County, just at the edge of Russell County), where a plant using about 30,000 "cords" per year is located. During the past year about 600 "cords"

[a] Does not include mill located at Clinchburg, Washington County, whose timber is cut in the Clinch Mountains.

[b] Cuts timber from Buchanan County.

[c] Mill under construction will begin operations about Jan. 1, 1921.

of chestnut wood and 400 "cords" of bark were received at this plant from various points in Russell County, most of it being delivered direct to the plant by wagon. The present price for chestnut wood (Sept. 1920) is about $10.00 per cord delivered at the plant or $9.00 per cord F. O. B. cars. Bark (of both species) brings about 1 cent per pound, or $22.40 per "cord."

MINE PROPS AND MINE TIES.

All species are used for these purposes. The props and ties are usually cut on the operator's own property. The props are cut various lengths, depending on the thickness of the coal seam. Small timber is used in the round, while larger pieces are split. Mine ties are flattened on two sides, and may or may not be peeled. Because of excessive weight or the difficulty of splitting them, hickory, beech, black gum and maple are not cut in many operations, especially the larger trees. This is apt to result in the area being seeded up to these less desirable species.

MARKETS FOR LUMBER.

Most of the lumber cut in the county is shipped to outside points to be further manufactured. The principal markets are railroads, mines, and large dealers who supply material for furniture factories (oak and poplar), automobile bodies (hard maple and poplar), coffins and caskets (chestnut, wormy chestnut preferred), phonograph cases, and innumerable other uses.

STUMPAGE VALUES.

Prior to 20 years ago much of the best timber in the county was sold for little more than the cost of getting it out. First walnut, then the best poplar, and finally the best white oak, were cut out in this way. Next to walnut, poplar was for many years the most valuable wood. White oak then came up to at least an equal value. During the last few years high prices have prevailed, but at the present time they are down somewhat. In actual practice timber is worth "what you can get for it." The following values, however, appear to be a fair average for timber up to four miles from a shipping point:

Species.	*Value per M. ft. B. M. on the stump, (Sept., 1920).*
White oak	$8.00 to $10.00
Yellow poplar	8.00 to 10.00
Red oak (water oak)	7.00 to 8.00
Hard maple	4.00 to 5.00
Chestnut	3.00
Hemlock	3.00
Beech, birch, buckeye, etc.	1.00 to 2.00

Recent sales, when all species are included, have brought prices that figure about $5.00 per thousand, log scale.

Large poplar, when sound and suitable for veneer-making, usually commands a premium price. The writer was reliably informed of three such poplar trees which scaled 15,900 feet, that brought $1,590.00 on the stump six miles from the railroad, and of another sale (near Bluefield, W. Va.) in which 2,000 poplar trees, 24 inches in diameter and up, and containing not less than 24 feet of log length, brought a flat rate of $25.00 each.

DEFECTS AND GRADES OF LEADING SPECIES.

Yellow poplar, having a thin bark, is severely injured by even light fires. Such fires kill a portion of the bark and expose the wood to the action of various wood-rotting fungi. Once started the rot spreads rapidly, frequently "culling" the entire tree. Otherwise poplar is remarkably free from defect, has a long clean bole, and about 60 per cent of the lumber from the logs actually taken to the mill is of the grades known as No. 1 common and better.

White and chestnut oaks are both subject to attack by a small grub locally termed "Flag worm." It works throughout the heartwood of the tree, leaving a small hole about 1/10 inch in diameter, running across the grain. In the sawed lumber this hole shows a streak of yellow or light brown stain extending with the grain of the wood in both directions for a distance of about 1½ inches, which when surfaced becomes very noticeable, seriously injuring the lumber for natural finish. These two oaks, which are usually marketed together as white oak, are generally free from decay, and 40 or 50 per cent of the lumber cut from them is of the grade known as No. 1 common or better.

Red and black oaks are subject to the attack of a "flatheaded borer," also the grub of a beetle, which makes an oval-shaped hole ½ or ¾ of an inch in diameter the long way and ¼ of an inch across. These holes, however, are not nearly as numerous as the smaller holes in both white oak and chestnut, which fact, together with the good form of the trees and their freedom from rot, results in a yield of a very high percentage of lumber of the upper grades, averaging almost 75 per cent No. 1 common and better for red oak and 60 per cent for black oak.

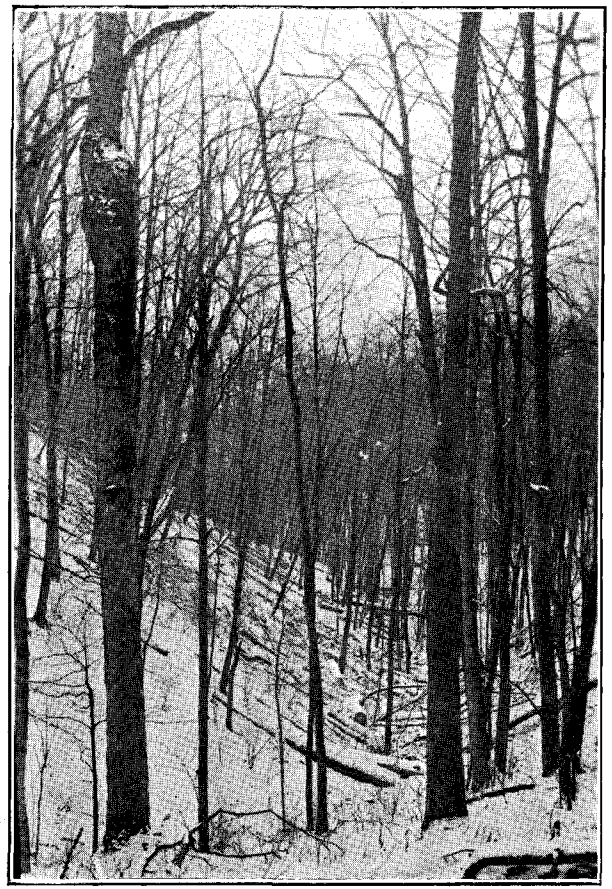
Chestnut is very subject to attack by still another grub which leaves a hole somewhat larger than the "Flag worm" but without the accompanying stain. Lumber with this defect is so common that it has been recognized by lumbermen as a separate grade. For certain uses, notably foundation for

veneering, this "wormy" or "pin-hole" chestnut is preferred, hence on the whole the "worminess" is not regarded as a very serious defect. Chestnut is, however, very subject to rot, does not have as clear a bole as many associated species, and is subject to severe windshake. Its yield of No. 1 common and better lumber is not over 25 per cent.

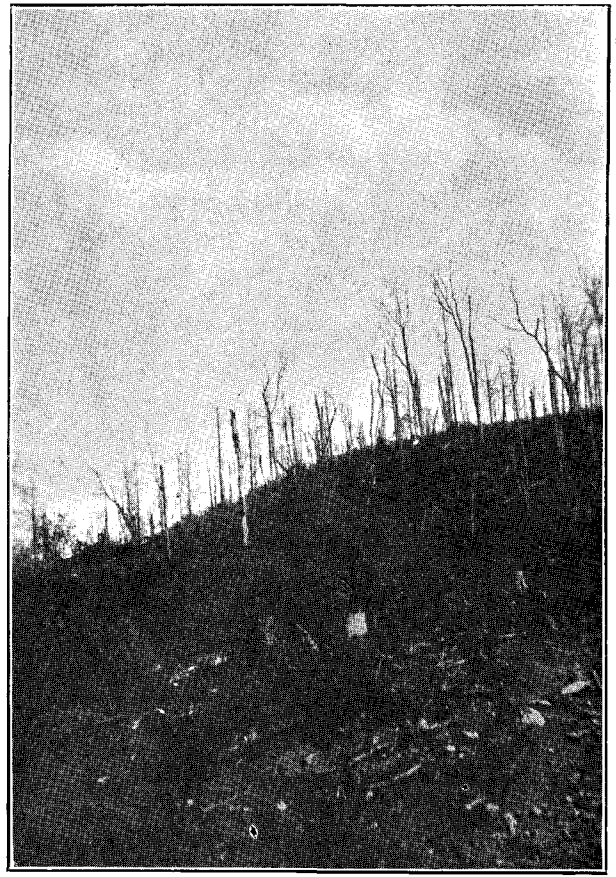
FOREST FIRES.

In the more open portions of Russell County, where the forests are in relatively small bodies, forest fires are not a serious menace. Ordinary care on the part of the owners of such woods should suffice to keep them reasonably safe, and even should a fire start, with the aid of neighbors control should not be difficult, or at the worst the fire can easily be confined to the one woodlot. In the more heavily timbered mountain country the situation is more difficult. Fires have swept over large areas repeatedly and still do a tremendous amount of damage. Such fires usually kill all young growth in their path, burn up the leaf-litter and humus, and, by exposing the soil to wind and sun, which dry it out, make the re-establishment of a valuable stand increasingly difficult with each burning. On dry situations and during extended periods of dry weather, mature trees are frequently killed outright, while those that are not killed are usually so scorched near the ground that the bark peals off, exposing the wood to insect attack and the action of the wood-rotting fungi which are responsible for most of the cull logs and cull lumber. The loss from this latter source alone amounts to not less than $5.00 per acre of average mountain timber.

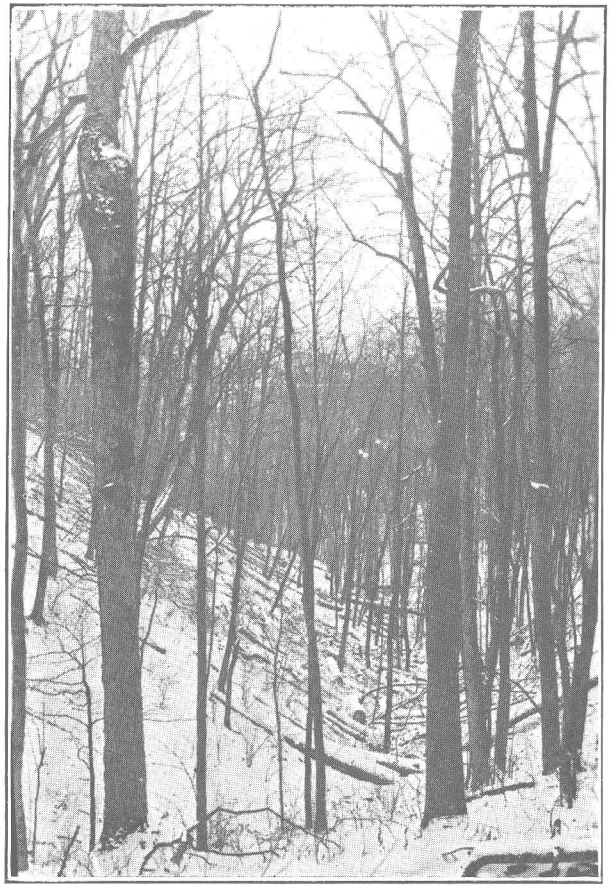
During the period of development, when land was being cleared for cultivation and there was little or no market for forest products, small attention was paid to fire unless it threatened improvements. This attitude unfortunately became a habit of thought which persisted long after the conditions which gave rise to it had ceased to exist, and it is only in recent years that even the more progressive people have realized the loss they have been suffering through these repeated burnings and have come to recognize the need of taking steps to prevent them. To meet this need, a coöperative protection organization, under the direction of the Virginia State Forester, has been developed, whereby the Federal and State Governments, coöperating with the various counties or large land owners, employ wardens or patrolmen whose duty it is to prevent forest fires, as far as possible, extinguish those which do occur, and enforce the state laws pertaining to forest-fires and their prevention. Such an organization has been in operation over almost all of Dickenson County and a part of Wise County for several years,



(A) "Cove" type, from which the poplar was cut 20 years ago and other species are being cut now.



(B) A stand that has just been cut-over and burned. No trees of any value remaining. Compare this with results of earlier cuttings as shown in (A).



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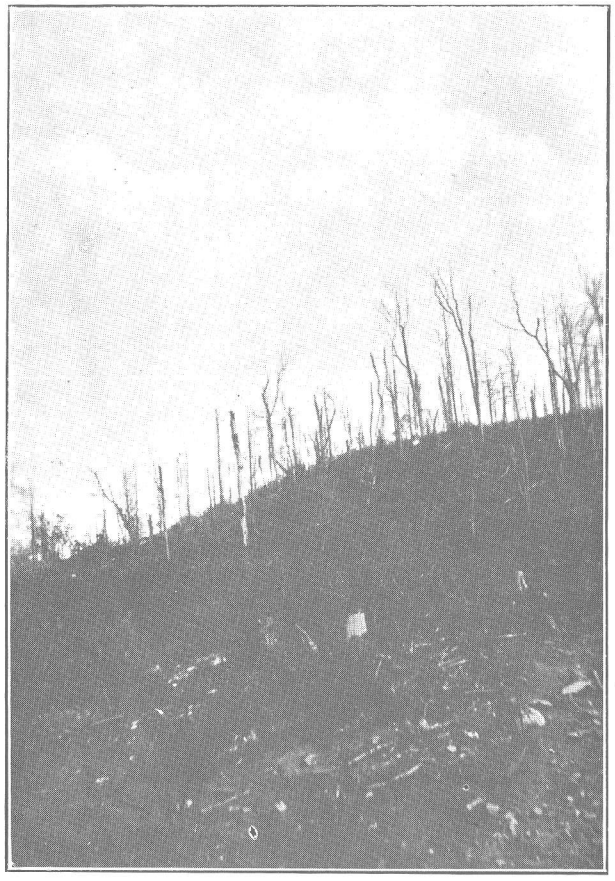

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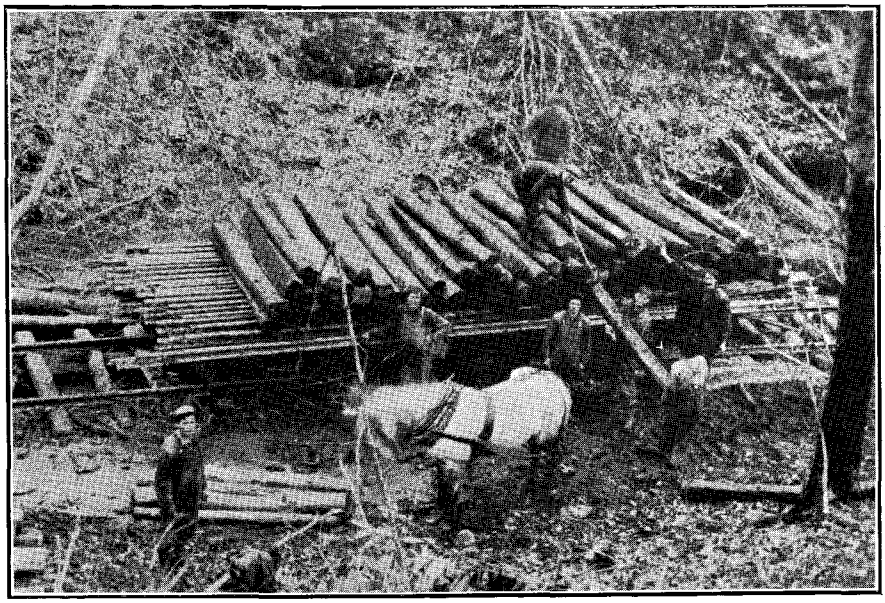
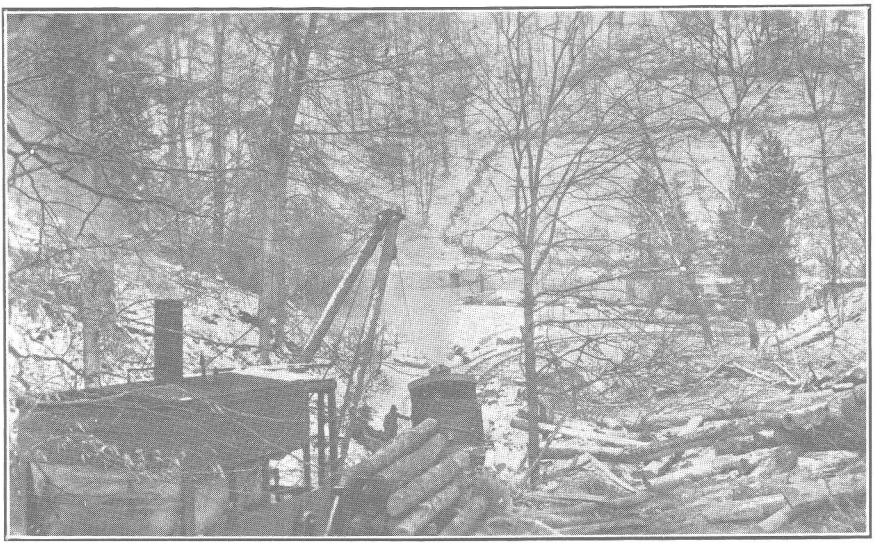
(A) Log-loader, logging railroad, etc.



(B) Tearing up rails and ties of logging railroad. Illustrates the migratory character of the lumber industry as at present conducted. When the lumber industry moves on, the prosperity of the region goes with it.



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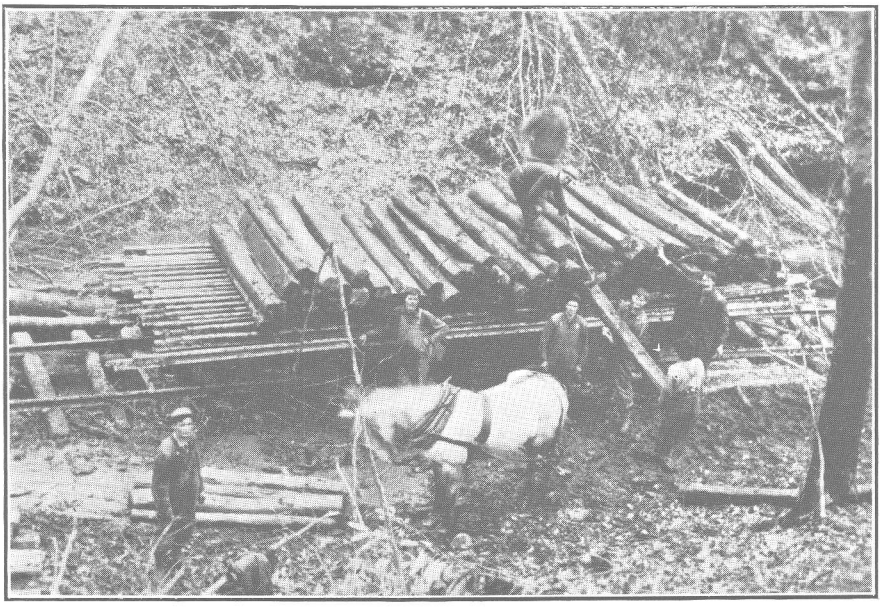

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and has proven very successful. Buchanan County, through action by its Board of Supervisors, has recently availed itself of the opportunity to start fire-protection work in the Fall of 1920.

It is doubtful if most timberland owners realize to what an extent the state laws afford protection to them and their holdings. Not only is provision made for the punishment of violators of the fire laws, but specific precautions are required, which, if enforced, will greatly reduce the hazard of fires getting started. Especial attention is called to Section 546, Code 1919, which requires the operator of any engine or boiler, in or near forest or brush land, to provide appliances to prevent the escape of sparks from ash-pans, fire-boxes and smoke-stacks, and to Section 546-a, Code 1919, Acts 1920, Chapter 416, which requires all mills operating in or near forest or brush land to clean up the premises for a distance of at least fifty yards in all directions from any fire maintained in connection with the operation of the mill. Owners of timberland are likely to suffer serious loss in case these requirements are disregarded, and are in the best position to keep check on conditions.

For the convenience of those interested, the State Forester has compiled and issued a leaflet entitled "Forest Fire Laws of Virginia." A copy of this leaflet will be sent free of charge to any one on application.

The State Forester will be glad to assist any county, any group of citizens, or any individual who desires to protect timberland from fire, and will coöperate to the limit of funds available in financing the undertaking. Any one interested should communicate with the State Forester, Charlottesville, Va.

THE FUTURE OF THE FORESTS.

The limestone section of Russell County is, and in all probability will remain, a farming and stock-raising country. Much of the land now bearing timber will probably be cleared in the near future and seeded to bluegrass. Farmers will find it to their advantage, however, to retain a small part of their land in timber for the production of wood-products for use in constructing and maintaining improvements about the farm. These woodlots, occupying, as they do, valuable land, should be intensively cared for in order that they may produce to their maximum capacities. This care should include:

(1) Absolute exclusion of all fires; in order that the soil may be kept rich and moist by the natural leaf-litter and that seedlings in abundance may be on the ground fully established and ready to take the places of any trees removed.

(2) The exclusion of stock; since stock browse off the seedlings and sprouts, trample the ground hard, and thin out the undergrowth which is necessary to prevent the wind blowing away or piling up the fallen leaves and to protect the soil from the drying effect of the wind.

(3) Good judgment in the cutting of timber. By carefully considering the future stand and removing only mature, defective, or dead trees of the more valuable species, and using the less valuable ones such as soft maple, beech, sycamore, elm, etc., whenever possible, and to as small size as may be feasible, the percentage of the more valuable species and therefore the value of the tract will be steadily increased.

The virgin stands in the "limestone" section of Russell County averaged three times more timber per acre than those in the "coal-bearing rocks" section. The stands were denser, the trees were taller and larger, and the timber was less wormy. Under the more careful handling which these fine stands justify, future tree crops in the "limestone" section should show a still more favorable ratio.

In the "coal-bearing rocks" section conditions are entirely different. Bluegrass is not native and does not thrive; the soil, derived from sandstone and shale, is loose, and not only "washes" badly on the steep slopes but is torn up by trampling stock, even when covered with a fairly good stand of grass. In this section only the stream-bottoms and the more moderate slopes should be cleared, while the rest should be kept permanently timbered and so managed as to yield the maximum amount of high-grade material in the shortest possible rotations.

The rapid rise in lumber prices during the last few years is familiar to all. Whether or not they have been higher than conditions have warranted, and whether or not stumpage owners have received their fair share of this increased value, are questions beyond the scope of this report, There is no doubt, however, that the diminishing supply of accessible standing timber everywhere has been an important factor in this rise, and to consider the possibility of lumber prices dropping back to where they were prior to 1914, for any extended period, is little less than folly. Standing timber is by every process of reasoning bound to become more valuable as the remaining stands are further exploited.

THE NECESSITY OF MORE CONSERVATIVE CUTTING.

Aside from any consideration of the general market, there is sure to be a good local market for material of all sizes in the development of the coal resources of Russell and adjoining counties. It has been said by mining-

experts that there is not an acre of surface underlain with coal in the Southern Appalachian soft-coal field which now bears or has ever borne a sufficiently heavy stand of timber to furnish the various timbers needed in mining the same acre of coal. Whether this opinion is literally true or not, it indicates the need of a large amount of wood products in soft-coal mining. The following figures were supplied by one of the largest coal operators in Southwest Virginia. They represent one year's run and are probably typical.

Coal mined	2,800,000 tons
Area mined	267 acres
Total timber used (props, ties, brattice lumber, concrete forms and such construction as is directly chargeable to the actual mine equipment)	4,770,000 ft. B. M.
Coal mined per acre	10,490 tons
Timber used per acre	17,865 ft. B. M.
Props used per acre	621 props
Average area of timberland required to mine one acre of coal	[a] 3.02 acres
Average stand on timberland used	5,916 ft. B. M.

When it is considered that the above figures represent the development of only one seam and that most of the mineral land of Russell County has from three to five such seams, the tremendous amount of timber which will have to be secured from some source is apparent. Mining props are already being shipped into the Pocahontas fields from points 75 to 100 miles distant, with the fields less than half developed. As other fields are developed or extended the same or a worse timber shortage will become general, and the getting out of mine props and timbers will develop into a well-recognized and, if properly handled, permanent and profitable industry.

Much of the cutting done up to 15 years ago, in which only the best poplar and white oak were removed, amounted to a "selective" system of cutting, in that only the largest trees of the stand were removed. An examination of such areas shows cucumber and poplar forming a large proportion of the young timber. Where the cutting was heavier, removing practically all of the more valuable species but leaving the less desirable ones, such as beech, maple, gum, and hickory, to seed up the ground, these undesirable species have taken possession of the area and the outlook for a valuable stand for the next cut is very poor. Had these less desirable species been utilized to as small a diameter as the other species and a few scattering

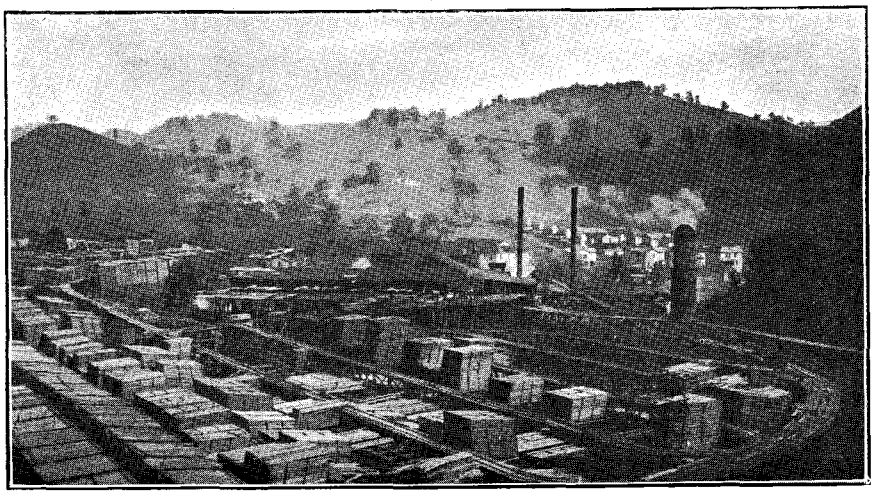
[a] This land had been culled over for saw-logs several years prior to the operation for mine timber, but for that reason is all the more typical of conditions obtaining in Russell County.

seed-trees of the more valuable species been left to supply seed, the present stand would have contained an even larger percentage of the better species. Under the conditions prevailing at the time much of this former cutting was done, close utilization of inferior species, was in most cases, impracticable, and no one can be censured for the resulting poor stands. These conditions have now changed, however, and especially where mine-props can be marketed, the inferior species should be used to as low a diameter as is possible, while sufficient seed-trees of the more valuable species should be left to completely re-seed the area. The number of such seed-trees should be varied to meet local conditions. Prolific and light-seeded species, such as poplar, ash, maple, hemlock, birch, and the pines, will seed a much larger area than the heavier-seeded oaks, chestnut, etc., and this fact should be taken into consideration. As a general rule, two or three moderate-sized trees per acre should be sufficient. Fires must be kept out. Even with the most careless cutting some sort of tree-growth will come in if fires are kept out, but if periodic fires are to follow logging operations, care in cutting and the leaving of seed trees will be wasted effort. Such fires kill or ruin all young growth, destroy the fertility of the soil, and make the establishment of a new stand of any value very difficult or even impossible for many years.

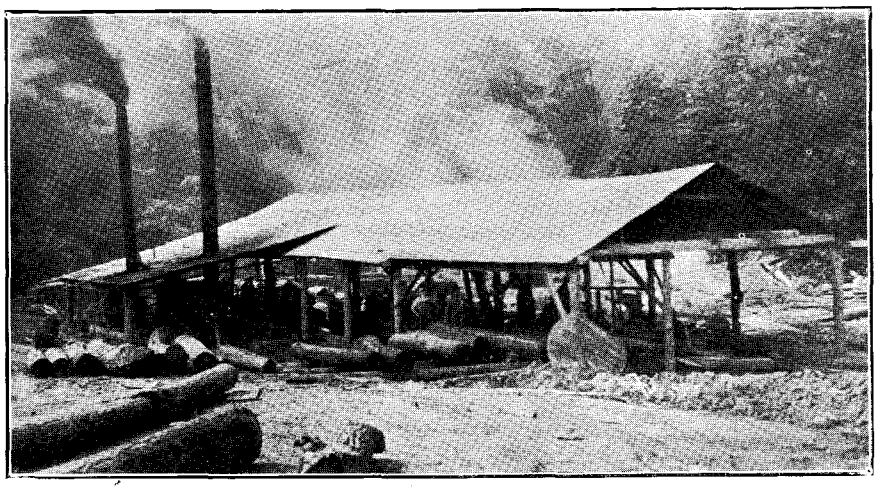
Poplar, northern red oak ("water oak"), and white oak are the most valuable species and the ones holding out the greatest promise. Poplar reproduces and grows well on north slopes and coves and should be encouraged wherever possible. Northern red oak does best on the "dark soils" of northern slopes, and while not so valuable a wood for many uses as white oak, it grows much more rapidly, and produces a larger percentage of the upper grades of lumber. It should, therefore, be favored wherever found. White oak reproduces well on all but the extremely wet or dry sites, and is the next most valuable species to grow. It does well over a larger area than poplar or northern red oak, and should be the dominant species in future stands.

Chestnut oak is a good seeder and sprouter and will take care of itself if fires are kept out. It will probably always be one of the most important species, especially on the ridge-tops and dry upper slopes, situations to which it is well adapted. The value of its bark is an important point in its favor. It does not grow as rapidly as poplar and northern red oak on favorable sites.

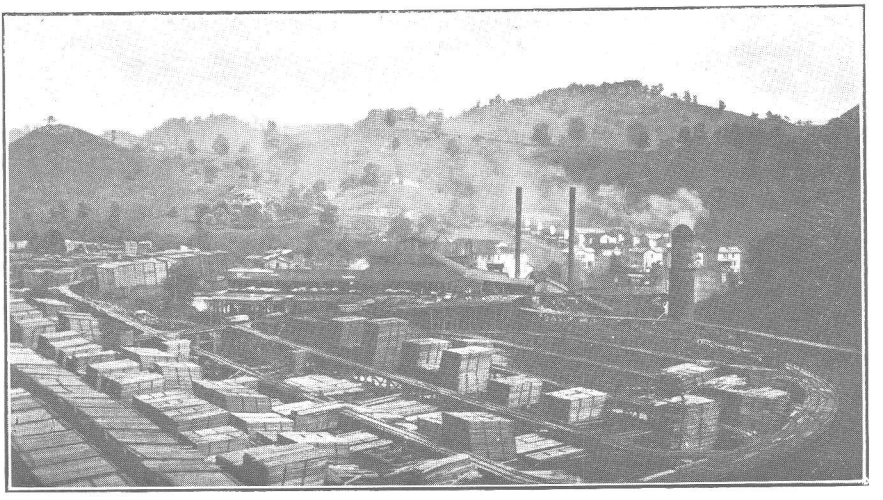
Chestnut is a valuable tree, of rapid growth, and a prolific sprouter, but is subject to the attack of the chestnut bark disease or "blight." This disease is caused by a fungus growth attacking the inner bark, which in time kills the tree by girdling it. Sprouts springing up from the stump are repeatedly



(A) Saw-mill and lumber-yards of the White Oak Lumber Co., at Honaker. A triple-band mill, with a capacity rated at 100,000 board feet per day. Its timber all comes from Dickenson and Buchanan counties.



(B) Typical small portable saw-mill. Such mills are numerous in the county.



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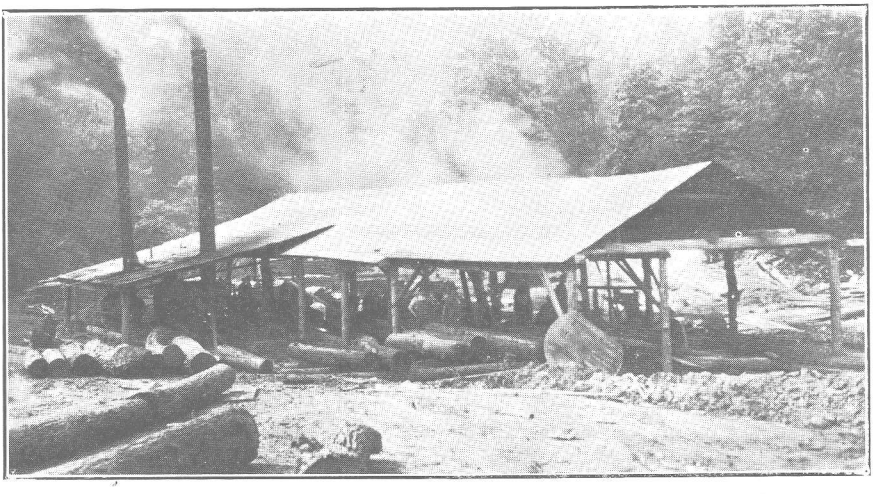

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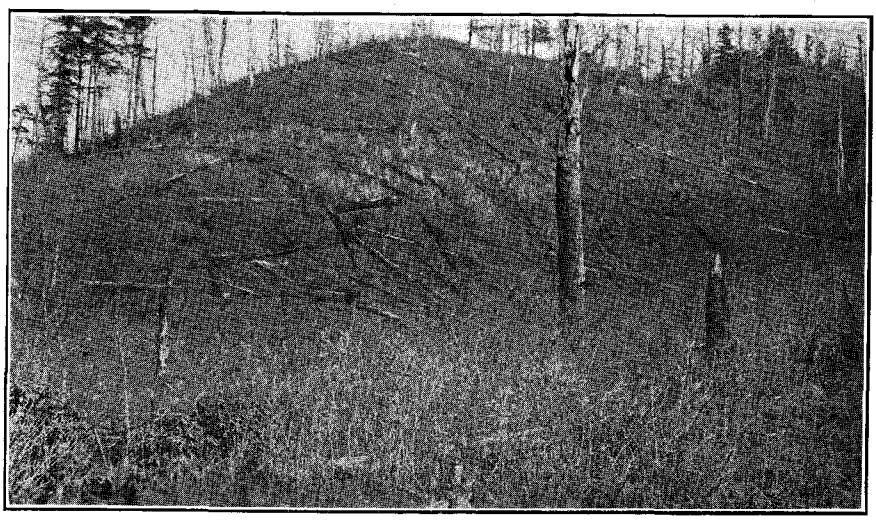
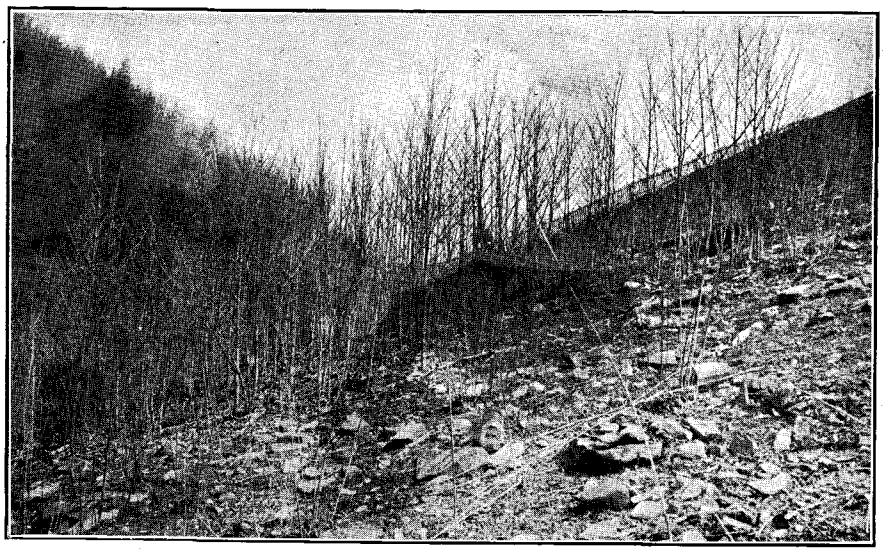
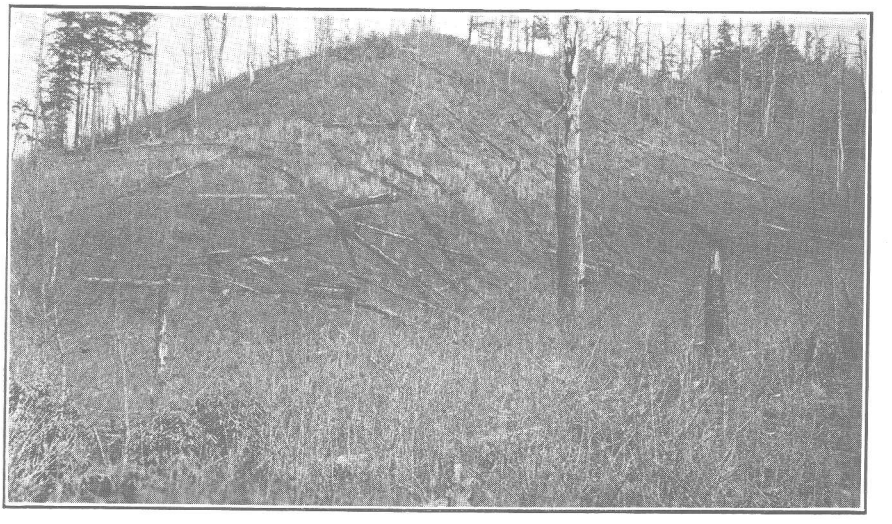


(A) Recently lumbered and burned. Left fork of Mudlick Creek. Underlain with coal, but no props with which to mine the coal.



(B) An abandoned field seeding up with yellow poplar from nearby seed-trees. Such land should never have been cleared.



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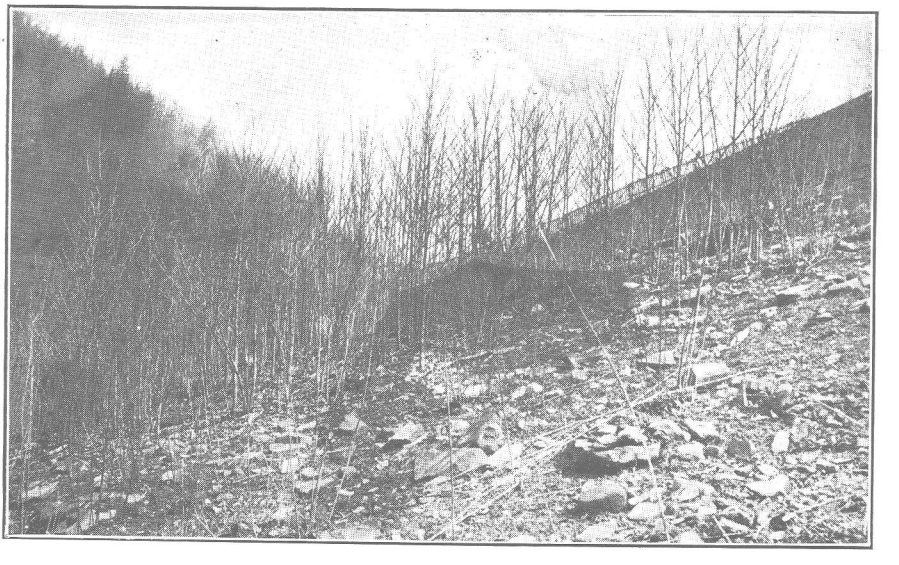

(B) An abandoned field seeding up with yellow poplar from nearby seed-trees. Such land should never have been cleared.

attacked and killed until the sprouting power of the stump is exhausted. In this manner all of the chestnut has been killed over large areas in the north and it appears to be only a question of time until practically all the chestnut is gone. No reports of the disease have been received from Russell County, but it has been found in Giles, Pulaski, and Grayson counties in Virginia, and in several places in the Blue Ridge Mountains section of North Carolina. It is supposed that the disease is spread by the spores sticking to the feet of birds and insects, and by the wind, and when once started in a new locality its spread is rapid. For this reason no effort should be made to secure chestnut in the young stands.

Hemlock will grow in very dense stands, making a high yield per acre. Both its wood and its bark are useful. Its great disadvantage is its typically slow growth.

Hemlock requires a moist, shaded situation, both for growth and reproduction. Its seedlings will start and thrive under shade so dense that no other native tree can endure it. Seedlings starting in fairly open situations will thrive, and grow more rapdly than in dense shade, but large trees which have been growing in heavy shade are apt to die if suddenly opened up to sunlight and air currents. The best chance to secure young growth of this species seems to be to leave a few trees occurring on the outskirts of the stand which have become hardened to the exposure, and depend on their light, winged, seeds being scattered over the area to be re-seeded. Black walnut, basswood, cucumber, and ash, and to a less extent, sugar maple, black oak, locust, and hickory, should also be considered as valuable trees for future timber production, and should be encouraged by leaving occasional seed-trees and thrifty young trees, which, though merchantable at present down to twelve inches across the stump, are making their most rapid growth, and are therefore more valuable as growing-stock than for what could be cut from them now.

Beech, buckeye, scarlet oak, soft maple, black gum, sycamore, and other undesirable species should be cut and utilized to as small a diameter as possible, as their slow rate of growth, excessive weight, or inferior wood make them distinctly "undesirable citizens" whenever better species can be secured.

Most of the contracts now in force provide for a twelve-inch diameter-limit. In open stands, where seedlings have had an opportunity to start, this leaves a good stand of young growth, but this limit is entirely too low in heavier and more mature stands. It would be much better practice to raise this limit to 16 or even 18 inches for the more valuable species, and require

the less desirable ones to be cut to as small sizes as can be used. Such a practice would obviously increase the percentage of the more valuable species in the next cut.

An exception must be made to the recommended diameter limit of 16 inches in the case of stands in which the use of this limit would leave practically no thrifty trees below 16 inches in diameter. Openings should never be made larger than half an acre in area. To avoid this an occasional seed-tree should be left. There should be left at least two or three seed-trees per acre, well distributed through any openings. These seed-trees should be of the best species—poplar, oak, basswood, cucumber, or ash—but need not be large, valuable trees. They should be only average-sized trees, with well-developed crowns, capable of scattering numerous seeds and of living until the next cut.

These precautions must be supplemented by adequate protection from fire. With proper protection and the application of sound forestry principles the future forests of Russell County will be productive, and timber for the development of the extensive coal resources of the county will be available. Without these precautions timber of value cannot be grown.

SUMMARY.

(1) *Location and area.*—Russell County is situated in the southwestern part of Virginia. It is roughly about 34 miles long and 15 miles wide, and contains about 496 square miles, or about 316,440 acres.

(2) *Topography and drainage.*—The county lies within the Allegheny Mountains at altitudes of between 1400 and 4550 feet. In the "coal-measures" the slopes are steep and the valleys narrow, while in the balance of the county, the "limestone" section, the slopes of the high mountains are steep but the valleys between them are broad and rolling. The county is well-drained. It comprises part of the headwaters of Clinch River and other small streams tributary to the North Fork of Holston River, which is tributary to Tennessee River.

(3) *Transportation facilities.*—The Clinch Valley Division of the Norfolk and Western Railroad traverses the county from one end to the other. The Carolina, Clinchfield & Ohio Railroad also passes through a part of the county at its extreme western edge. There are other short roads or branches connecting with mining-camps, but most of them are not common

carriers. There are many miles of good macadam roads in the "limestone" section, but in the "coal-measures" only short stretches connecting mining-camps with railroads.

(4) *Chief industries.*—The county is not thickly settled, but prosperous. The most important industries are agriculture, coal-mining, and lumbering. The "limestone" section is particularly adapted to grazing, because of the bluegrass. This is not true of the "coal-measures." Coal-mining is increasing.

(5) *Land ownership.*—There is one tract of about 22,000 acres, which is part of a much larger property extending into other counties. This is largely farming and grazing land. There is one tract of about 8,000 acres belonging to a coal company. There are a few others containing from 1,000 to 3,000 acres, but, except for these, the average holding is of about 100 acres.

(6) *The forest trees of commercial importance.*—The most important trees are white oak and tulip poplar. Others are chestnut, chestnut oak, northern red oak ("water oak"), hemlock, black oak, and hard maple.

(7) *Forest types.*—The forests may be divided into four types—ridge, slope, cove, and bottom—the occurrence of each being indicated by its name. There are characteristic species composing each type.

(8) *Classification of the forests of the "coal-bearing rocks" section.*—This section comprises about 40 per cent of the area of the county. Of this section about 59 per cent bears forests heavy enough for saw-milling, with an acreage yield of about 4,500 board feet per acre, or its equivalent; about 23 per cent bears forests so severely culled or burned or so recently cut-over that there is no possibility of saw-milling in them at present (their average estimated stand being about 350 board feet); and the remaining 18 per cent is cleared land. No estimates made for the "limestone" section.

(9) *Estimated stand of timber in the "coal-bearing rocks" section.*—In this section, the "merchantable" forests (those in which saw-milling would be feasible), are estimated to contain about 337 million board feet, or the equivalent in other products. This does not include material too small for lumber, or scattered stands and trees. No estimate made for the "limestone" section.

(10) *History of lumbering.*—Before the construction of the Clinch Valley branch of the Norfolk & Western Railroad, about 30 years ago, some

of the best logs, principally walnut and poplar, were hauled by wagon to Abingdon. After the construction of the railroad many small mills came in, and more recently one large mill.

(11) *Present methods of lumbering.*—There is now much closer utilization than formerly, both as regards species and sizes. Cutting is still largely done by small circular-saw mills, of which there are 26 in the county, but there are also one 3-band mill and one 1-band mill. There is also a considerable production of tannin extract (from bark and wood), and mine-props and ties. Most of the lumber and timbers produced are shipped outside of the county.

(12) *Stumpage values.*—Stumpage values are in general as follows. (Sept. 1920): White oak and yellow poplar, $8.00 or $10.00 per M. feet; northern red oak, $7.00 or $8.00; hard maple, $4.00 or $5.00; chestnut and hemlock, $3.00; beech, birch, hickory, etc., $1.00 or $2.00; a general average, all species, about $5.00 per M., log scale. These values are for timber within 4 miles of a shipping point. There have lately been occasional sales of exceptionally high-grade poplar at very much higher prices. Chestnut extract-wood is bringing about $10.00 per cord delivered at the plant or $9.00 F. O. B. cars, and bark about $22.40 per "cord" or "ton."

(13) *Forest-fires.*—In the part of the county where the forests are in rather small bodies they can be protected from fire by the owners, but where the forests are in large bodies fires have burned repeatedly and done tremendous damage, and are still doing so. Under these conditions organization for fire-protection is necessary, as is done in Dickenson and other neighboring counties, under the direction of the State Forester, in coöperation with the U. S. Forest Service and with local people, either large landowners or County Supervisors.

(14) *The future of the forests.*—In the "limestone" section of the county the present forest area will probably be still somewhat further reduced by clearing for grazing. The permanent forest land here can easily be made continually productive by conservative cutting and protection from forest fires and excessively heavy grazing. In this part of the county erosion is not a problem, but in the "coal-measures" only a very small per cent of the land should ever be cleared, because of the steepness of the slopes, the fact that bluegrass does not thrive, and the excessive "washing" after a few years of cultivation. Here the forests must be maintained in a productive condi-

tion, both as a protection to the land itself and as a source of supply of material needed in mining the coal. Protection from forest fires and conservative cutting are of supreme importance.

(15) *Necessity of more conservative cutting.*—The rough character of the land classifies a very large percentage of the "coal-measures" and part of the "limestone" section of the county as permanent forest land. The conditions are favorable for rapid growth of the most valuable species, but unless fires are prevented and unless cutting is done in such a way as to protect and favor the thrifty small trees, the supply of timber will not be sufficient when the coal resources of the county are developed. The present customary diameter limit of 12 inches on the stump is too low for the valuable species. They should be cut to not less than 16 inches. Furthermore, no openings larger than one-half acre in extent should be made. If necessary to avoid such openings, two or three carefully selected seed-trees per acre should be left.

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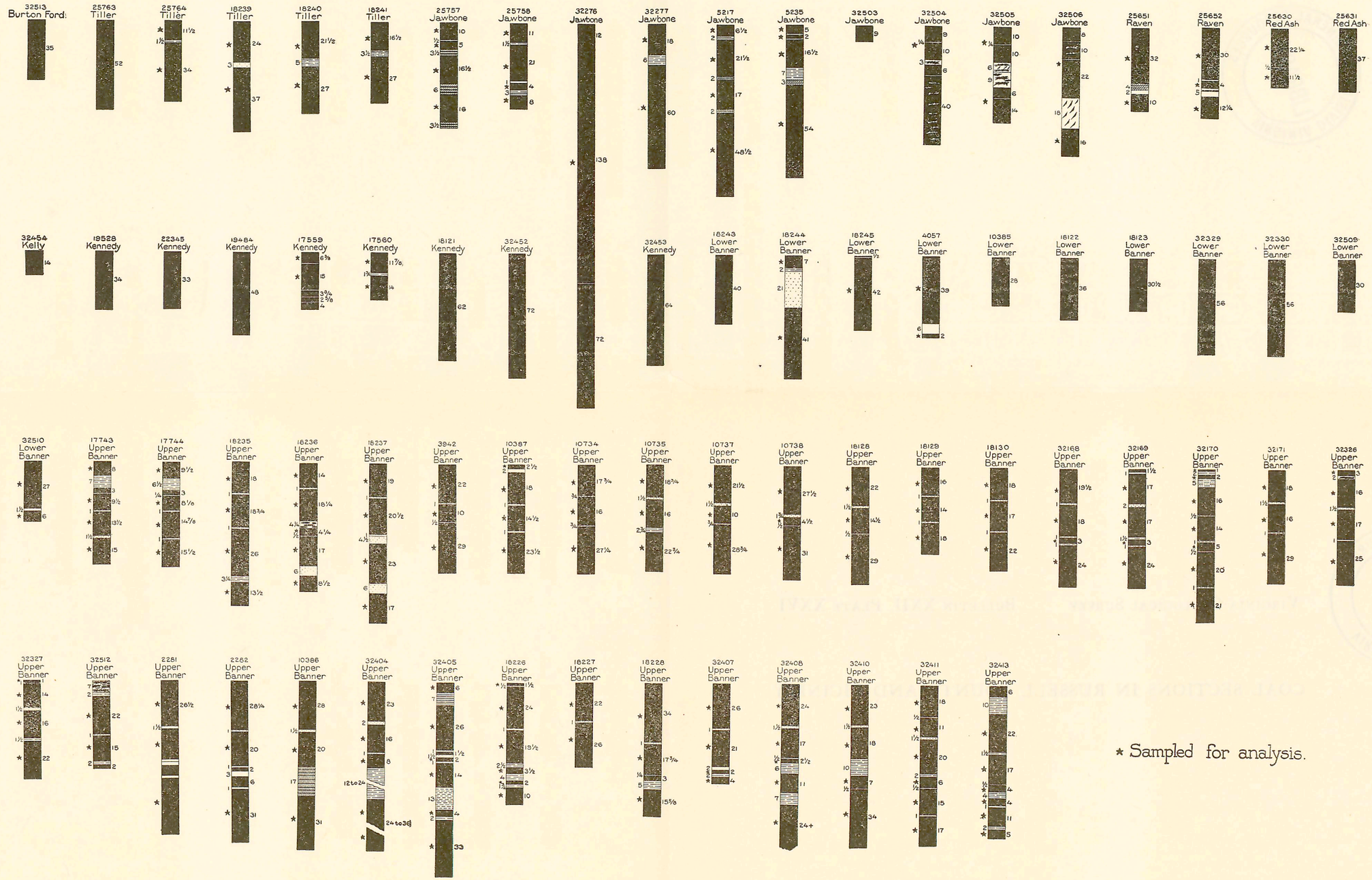
COAL SECTIONS IN RUSSELL COUNTY AND VICINITY

Numbers at top of sections correspond with numbers in the table of analyses



★ Sampled for analysis.

TOPOGRAPHIC MAP

OF THE

COAL-BEARING PART OF

RUSSELL COUNTY

AND ADJACENT AREA ON THE NORTH

VIRGINIA

PREPARED BY

VIRGINIA GEOLOGICAL SURVEY

THOMAS LEONARD WATSON, DIRECTOR

IN COOPERATION WITH

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

SURVEYED IN 1913 - 1921

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

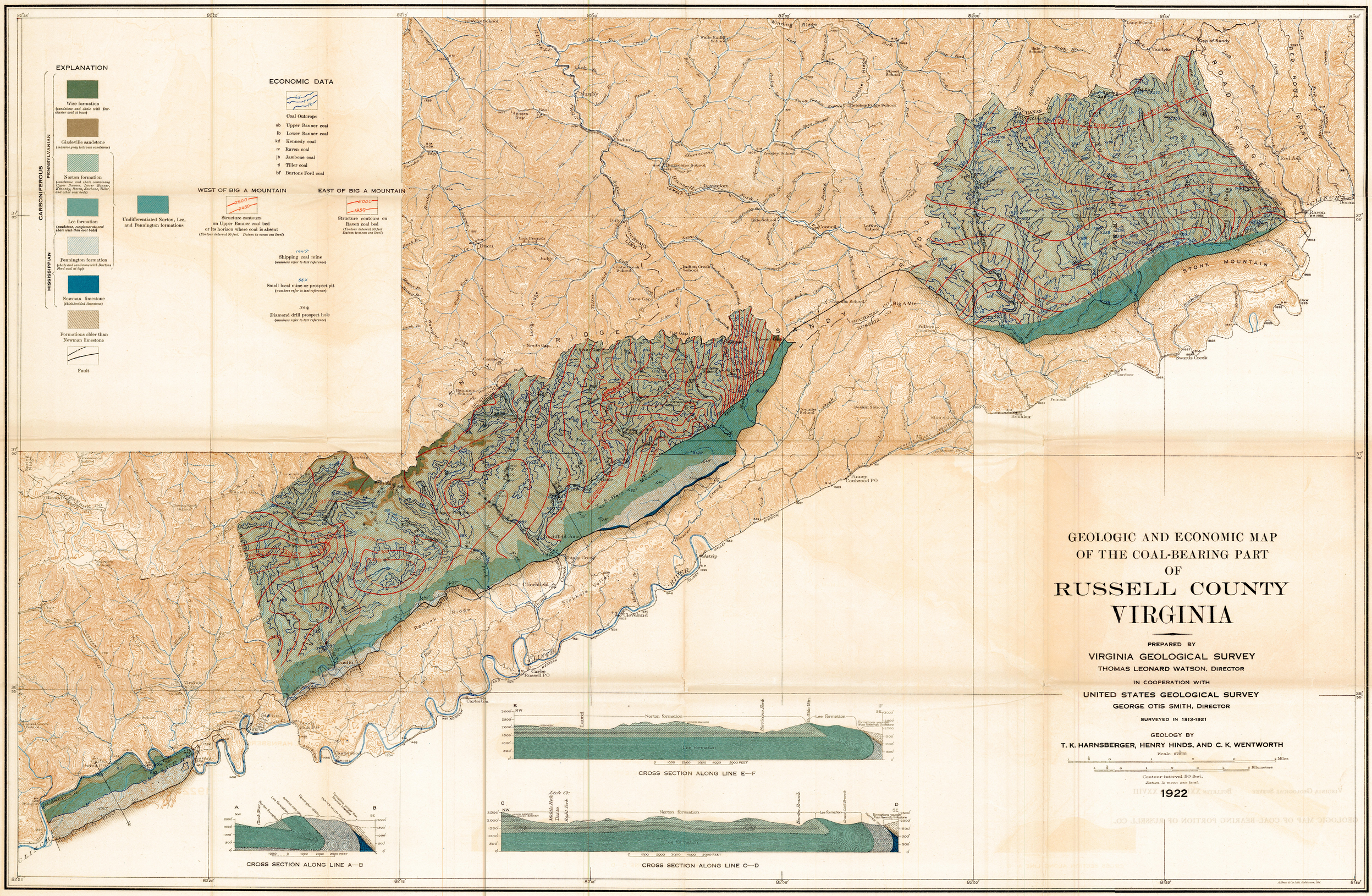
1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 50 feet.

Datum is mean sea level.

1922

A. HOEN & CO. BALTIMORE, MD.



GEOLOGIC AND ECONOMIC MAP OF THE COAL-BEARING PART OF RUSSELL COUNTY VIRGINIA

PREPARED BY

VIRGINIA GEOLOGICAL SURVEY

THOMAS LEONARD WATSON, DIRECTOR

IN COOPERATION WITH

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

SURVEYED IN 1913-1921

GEOLOGY BY

T. K. HARNSBERGER, HENRY HINDS, AND C. K. WENTWORTH

1922