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H. A. BUEHLER, DIRECTOR AND STATE GEOLOGIST.

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THE COAL DEPOSITS OF MISSOURI

BY

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Missouri Bureau of Geology and Mines,
Rolla, Mo., September 1, 1912.

To the President, Governor Herbert S. Hadley, and the Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen.—I have the honor to transmit herewith a report on the Coal Deposits of Missouri by Henry Hinds. Mr. Hinds was assisted by Mr. F. C. Greene, whose work was confined chiefly to the area underlain by the Missouri group of formations.

This volume is devoted to an economic study of the Coal deposits. Among the most important results of the investigation have been the correlation of the coals occurring in the different productive areas and the determination of the regional persistency of some of the coal beds. A number of these have been traced from the Iowa to the Kansas State lines.

The mine samples were taken, and the analyses were made according to standard methods employed by the Federal Government, and the results are therefore comparable, in every way, with the analyses of coals sampled by the Government in other fields throughout the United States.

Respectfully submitted,

H. A. BUEHLER,
Director and State Geologist.

ACKNOWLEDGMENTS.

A great amount of the information embodied in this report was derived from the writings of earlier investigators in the field, especially from the reports of the splendid pioneer work of G. C. Broadhead and his assistants and the detailed maps of some of the principal coal fields by C. F. Marbut, Arthur Winslow, and C. H. Gordon. David White contributed largely of his time and experience and, with F. C. Greene, wrote the discussion of the chemical analyses. Without the hearty co-operation of the writer's asistants, F. C. Greene, M. Albertson and M. E. Wilson, the work could hardly have been completed. Mr. Greene assisted during the entire course of both field and office work and wrote parts of the report. Finally, acknowledgments are due to the operators, miners, and citizens, who, with uniform courtesy, rendered every assistance within their power. Special thanks are tendered Mr. J. H. Bovard, member of the Board of Managers of the Bureau of Geology and Mines, for many valuable suggestions relative to the investigation, also to the officers of the Central Coal and Coke Company, the Western Coal and Mining Company and other large mining concerns, who unhesitatingly opened their drill records and mines for inspection.

INTRODUCTION.

Realizing the immense value of Missouri's coal resources to the State and to the Nation as a whole, the Missouri Bureau of Geology and Mines and the United States Geological Survey arranged, early in 1910, to make a co-operative geologic and economic survey of the Missouri coal fields. The writer was placed in charge of the project, and was assisted by F. C. Greene of the State Survey, and both field and office work were done under the supervision of David White, of the Federal Survey, and H. A. Buehler, State Geologist of Missouri. Owing to the immense area to be covered, about 24,000 square miles, it was first planned to confine work to the coal producing centers and to stratigraphic investigations in Northwest Missouri that were already in progress. With this plan in mind, Mr. Greene spent the greater part of the field season of 1910 in the Missouri group area of Northwest Missouri, while the writer visited the principal coal fields and mines of North Missouri, including those of Lafayette and Ray counties.

During the first season's work certain beds of the Des Moines group were found to be much more regular and persistent than had been supposed, and the prospects for the successful determination of the stratigraphic position of all or most of the principal coal deposits of the State were considered so good that the original scope of the survey was somewhat extended. Mr. Greene and the writer therefor spent the field season of 1911 in the region in which the Des Moines group appears at the surface, and not only visited all mines not entered in 1910, but also did more or less detailed mapping in areas that promised the most important results. In addition to other work the outcrop of the persistent limestone beds at the base of the Henrietta formation was traced diagonally across the State from Kansas to Iowa. In June M. E. Wilson joined the party and continued in the field for about two months, and during August and part of July M. Albertson also assisted. The work was completed in October by Mr. Albertson, who traced the southeastern limit of the main body of the Pennsylvanian from Saline county to the Kansas state line.

CHAPTER I.

THE PENNSYLVANIAN SERIES IN MISSOURI.*

The economic importance of the Pennsylvanian series of Missouri is due chiefly to the fact that it alone contains important coal beds. Much younger strata in southeastern Missouri include a few thin beds of lignitic coal but no bed that has justified development work on even a very small scale. The Pennsylvanian series overlies the Mississippian series and other formations that consist largely of limestone and contain no coal. Upon it lie only the unconsolidated drift deposits of clay, sand, and gravel brought in by the ice sheets of the glacial period or deposited by the abundant waters that accompanied the glacial advance and retreat.

The Pennsylvanian, aside from the drift, is the surface formation in all but the eastern edge of north Missouri and in a wide strip in the west-central part of the State. Outliers and small pockets have been found far to the east and south of the main body of these Coal Measures, and it is probable that few counties lack at least some small representative of the series. The total area of the Pennsylvanian in Missouri is 23,960 square miles.

LITHOLOGY.

The Pennsylvanian is composed of shales, sandstones, limestones, clays, and coals.

The shales are the thickest and most abundant members of the Coal Measures, being important parts of nearly every formation. The most common kind is argillaceous or clay shale, called simply shale in this report and known to drillers as "soapstone". It is usually blue when fresh and drab when weathered, though some varieties are gray or red. Black or bituminous shale is abundant, especially just above coal beds. Because of this fairly common association of coal and black shale, the latter is carefully noted by drillers. Many of the black or dark gray shales are hard and compact and notably laminated, and known to

*In this report only a very brief summary of the general stratigraphic features can be given. It is the intention to elaborate certain points in a report now in preparation by F. C. Greene and the writer.

miners as "slate", though this is a misapplication of the term. Through an increase in arenaceous content, shales become very sandy and grade into sandstone. Where much calcium carbonate is present there are formed calcareous shales that may contain considerable limestone. The lime in many black shales is concentrated along certain layers so as to form lenses or oval concretions of impure limestone, sometimes colloquially termed "niggerheads".

Sandstones are very abundant in some formations and practically absent in others. Most of them are medium-grained and not very firmly cemented, though a few are sufficiently resistant to withstand erosion almost as well as a limestone. The most common colors are yellowish-buff and reddish-brown, though some beds are nearly pure white. Sandstones are formed under unstable conditions of sedimentation and therefore the coal beds associated with them tend to be irregular in distribution and thickness.

Though composing a comparatively small part of the sediments, the limestones are the most conspicuous of all the outcropping beds because of their ability to withstand erosion. Most of the mounds and ridges of the southwestern Coal Measures area have been protected from denudation by caps of limestone, and escarpments that can be traced even into the drift-covered area of northern Missouri owe their existence to the same cause. All the Pennsylvanian limestones are fine-grained and can therefore easily be distinguished from the Mississippian limestones that underlie the Coal Measures, as most of these lower beds are coarse-grained and notably crystalline. Mississippian limestones contain a large amount of flint also, whereas there is little flint in any of the beds 300 feet or less above the base of the Coal Measures. Pennsylvanian limestones are light or bluish gray on fresh fractures, and many of them turn dark brownish-drab on exposure. Many are only a few feet thick, though some measure 20 feet or more. Even the thinnest beds, however, are remarkably persistent, preserving even minor details for great distances and serving as reliable markers for the coals. Several of the coal beds have limestone cap-rocks that are important economic factors and a great aid to the geologist.

Clays are specially abundant near the base of the Pennsylvanian in central and eastern Missouri. Every coal bed rests on a few inches to several feet of underclay. The underclays are commonly known as fire clays, but, as a matter of fact, many of them contain too many impurities to be used in the manufacture of refractory ware.

STRATIGRAPHY.

As the result of geologic work carried on in former years by Broadhead, Winslow, Marbut, and others, and by F. C. Greene and the writer in 1910 and 1911, the Pennsylvanian strata of Missouri are here

grouped into formations that correspond closely with those already noted in Kansas and to some extent in Iowa.†

PENNSYLVANIAN SERIES.

Missouri group:
- Wabaunsee formation.
- Shawnee formation.
- Douglas shale.
- Lansing formation.
- Kansas City limestone.

Des Moines group:
- Pleasanton shale.
- Henrietta formation.
- Cherokee shale.

THE DES MOINES GROUP.

The Des Moines group includes 400 to 900 feet of shales and other strata at the base of the Pennsylvanian. It includes all the commercially important coal beds and chiefly for this reason is separated in classification from the higher beds. The rocks of this group constitute the surface formation over 16,010 square miles in Missouri.

Cherokee Shale.—The lowest beds of the Des Moines group are included in the Cherokee shale. Although there are more shales than other rocks in most areas, sandstones are very abundant at the base of the formation in southwestern Missouri, and limestones constitute a large part of the total in Callaway and Audrain counties. The Cherokee includes all of the more important coal beds; in fact, with the exception of the Mulberry bed of Bates county, coal is shipped by rail from beds of no other formation.

The basal Cherokee beds were laid down upon the old land surface formed by the Mississippian series, which was exposed to atmospheric erosion for many thousands of years and reduced to almost a base level. Solution played an important part in the removal of the rocks. Large caverns and sink-holes were formed in the Mississippian limestones, yet, aside from these, the depressions made by valleys in the old land surface were not so deep as those to be seen in Missouri topography of the present day. Consequently, the advancing Cherokee sea encountered in most places only shallow depressions instead of high divides and neighboring lowlands. Naturally, however, the first deposits laid down in this sea were formed under very changeable conditions and vary greatly from place to place. It was not until several

†The reasons for the adoption of the nomenclature used and a more detailed description of the formations and their members will be included in a future publication.

hundred feet of shale, sandstone, clay, and coal were deposited that the wash from adjacent land masses decreased and deposition became slower and more uniform. The upper 100 to 180 feet of the Cherokee, the part lying above the bottom-rock of the Bevier coal horizon, are rather sharply distinguished from the lower part of the formation by the presence of several remarkably persistent coal beds, limestones, and even shales. This persistence is somewhat more marked in northern Missouri than elsewhere. The lower Cherokee is also distinguished from the upper by the absence of important limestone beds. In southern Johnson county and in Callaway and Audrain counties, the upper Cherokee includes a notable amount of limestone.

The Cherokee sea, advancing from the west or southwest, first entered Missouri between Kansas City and Forest City and stretched northeastward as a long shallow arm to and beyond Worth, Harrison and Mercer counties. The area inundated by this invasion was covered by earlier Coal Measures sediments than are to be found elsewhere in the State. In Holt county, at Forest City, the thickness of the Cherokee is 712 feet, in Buchanan county 530, in Platte 555, in Clay 460, in Jackson 430, in Livingston about 450, and in Harrison 653 feet. Between Harrison and the other counties mentioned there are no records that show the full thickness of the formation, though one from Worth county indicates that the lower Cherokee beds were deposited at least that far west. After these first deposits were laid down the sea advanced upon the old Ozark land mass lying southeast of the arm just mentioned, but it was some time before it reached Howard, Monroe, and the counties farther east. The effects of this slow advance are shown in the absence of the lowest Cherokee beds along the present eastern limit of the main body of the Coal Measures and by the reduced thickness of the formation in the following counties: Putnam 350 feet, Adair 280 to 320, Linn 260 to 310, Carroll about 340, Ray 350 to 400, Lafayette 330, Johnson 220 to 350, Cass 390, Bates 325 to 370, Henry about 230, Vernon and Barton 350, Chariton about 180, Macon 175, Randolph 180, Howard 132, Boone 130, and Callaway 85 feet. That this thinning to the east is due almost entirely to a real overlap and not to a thickening of a number of beds toward the west, as contended by Winslow,‡ is shown by the close correspondence in detail of the upper part of the Cherokee at Atchison and Leavenworth with the beds in Macon and other eastern counties. The country northwest of the first arm of the sea was not submerged for a long period, for a deep drilling at Nebraska City, Nebraska, not far from the northwest corner of Missouri, penetrated practically no Cherokee.

Henrietta Formation.—The Henrietta is distinguished from the Cherokee below it by its content of a larger amount of calcareous

‡Prelim. rept. on coal, Mo. Geol. Survey, 1891, pp. 26-32.

matter, though the division between the two formations is by no means sharp in central Missouri. As originally defined, the Henrietta was intended to include all beds between the base of the Fort Scott limestone and the top of the Pawnee limestone of Kansas. Unfortunately, however, there is an abnormal development of limestone in the upper Cherokee at the type locality of the Henrietta in Johnson county, and Marbut was led into the very natural error of including the representative of this bed in his mapping of the Henrietta in Henry, Lafayette, and Ray counties. In this report his maps are republished with revised boundaries. The Henrietta, as delineated in this report, corresponds very closely with the Appanoose formation of Iowa geologists, though the Lexington (Mystic) coal and its limestone bottom-rock are included in the Cherokee, because the Lexington and the Fort Scott "red" coal of Kansas are now known to be at the same horizon and the latter was included in the original definition of the Cherokee shale.

The Henrietta contains no workable coal except near Moundville, in Vernon county. Its economic importance rests in the fact that its limestone beds are very useful markers for the position of the coal horizons of the underlying Cherokee. Though these limestones are considerably different in character in distant localities, they are nevertheless remarkably persistent and have been traced in the field almost continuously from Kansas to Iowa.

The Henrietta thins somewhat from south to north, and in many places its highest beds have been removed by erosion, which took place in Pleasanton time. In Bates and Cass counties the Henrietta is about 100 feet thick, in Henry 75 feet, in Johnson 60 feet, in Lafayette and Ray counties about 50 feet, in Carroll, Livingston, Linn, Macon, Randolph, and Howard about 30 feet, in Sullivan, Putnam and Adair 35 to 50 feet. In counties distant from the outcrop it is often difficult to ascertain the exact thickness of the formation from drill records; it appears to be almost completely removed in a few places, and as much as 107 feet thick in one drilling, but its average is close to 50 feet.

Pleasanton Shale.—Above the Henrietta lies a formation that is in most places sharply distinguished from it in character. The Pleasanton consists almost entirely of shale and interbedded sandstone. It includes a few limestone beds, more numerous in Bates county than elsewhere, but they are comparatively inconspicuous and appear to have no great areal extent. In some localities yellow or reddish-brown sandstone constitutes the bulk of the formation. The Pleasanton contains many thin coal beds, one horizon (Ovid) near the top and another (Mulberry) near the base being fairly persistent. These coals are sufficiently thick and clean to be workable in a large way only in Bates county, though supplies for local use are obtained in Livingston, Sullivan, and other counties.

At one or more times during the deposition of the Pleasanton the sea withdrew from the earlier sediments and they were subjected to short periods of erosion. The consequent oxidation of the iron in the shales and sandstones has given them a characteristic reddish hue in certain areas. In a series of beds constituted as are those of the Pleasanton, it is difficult to decipher lines of unconformity, but where the Henrietta beds were also removed, the effect of the period of erosion is quite evident.

Some very remarkable channels were carved out in Cherokee, Henrietta, and possibly lower Pleasanton strata. One of these, known as the Moberly channel, has been traced continuously for 35 miles from east to west in Monroe, Randolph, and Chariton counties. Another, known as the Warrensburg channel, has been traced for 50 miles from south to north in Henry, Johnson and Lafayette counties. The two channels were possibly once connected with one another by way of White Rock in Carroll county, and also with other drainage lines that have been traced for short distances in many localities. These old valleys are remarkably deep and steep-sided, for though a width of more than two miles is exceptional, a depth of 150 feet or more is fairly common. They are now filled with more or less massive sandstone and shale. Fossil leaves found embedded in the channel-filling deposits are certainly Pennsylvanian in age and are Pleasanton or younger. Stratigraphic evidence points to the Pleasanton age of at least the Warrensburg and Moberly channels, though the evidence is not absolutely conclusive.

Considering the character of the sediments, the thickness of the Pleasanton is remarkably uniform. Where all of the Henrietta remains intact, the thickness is 100 to 225 feet, the average being close to 150 feet.

THE MISSOURI GROUP.

The upper part of the Pennsylvanian has been separated from the lower by Iowa and Missouri geologists in the belief that it was strongly differentiated by a greater abundance of calcareous material. It is true that the lower part of the Missouri group contains many exceptionally thick beds of limestone and that the upper part of the Des Moines group is comparatively free from them, yet there are several thick formations in the upper group that are as free from limestone as any in the lower. Nevertheless there is a well-marked faunal break between the two groups that justifies their separation, and for economic purposes the Missouri is distinguished from the Des Moines by the absence of important coal beds. Although the group contains many beds of coal, they are so thin except in Nodaway county that they hardly merit description.

The main body of the Missouri group outcrops only in northwestern Missouri, though there are small outliers as far south as Hume, in Bates county, and as far east as the Chariton river, in Adair county. About 7,950 square miles are underlain by strata belonging to the group. Owing to a dip to the north of west, the highest Pennsylvanian beds in the State occur only in its northwest corner. If calculated from outcrop observations along the Missouri river the total thickness of the Missouri group in Missouri would be about 1,200 feet. A number of the shale members thin to the northwest, however, so that the actual thickness of the group in Atchison county is probably nearer 950 feet.

Kansas City Limestone.—The lowest formation of the Missouri group contains a number of exceptionally thick limestones, with interbedded shales. The limestone at the base, the Hertha member, is 4 to 15 feet thick. Seven to 30 feet above it is a well-known 20-foot limestone member called by geologists the Bethany Falls and often known to drillers as the "spotted rock". There are other limestone beds, the best known of which is the Iola member, at the top of the formation, a bed that is 30 feet thick at Kansas City. The Kansas City limestone is 225 feet thick at Kansas City, 200 feet in Harrison county and at Leavenworth, and 165 feet near St. Joseph. In imperfect drill records all or most of the formation is reported as limestone, though the amount of shale equals or is greater than that of limestone.

Lansing Formation.—The lower half or two-thirds of the Lansing, which overlies the Kansas City limestone, consists of shale and sandstone, with limestone that is only locally important.

The top of the formation, however, is the Stanton limestone member, about 20 feet thick, and 5 to 20 feet lower is the Plattsburg limestone member, 14 to 25 feet thick. The Lansing formation is 140 feet thick in Platte county and 100 feet farther northeast, near the Iowa line.

Douglas Shale.—The Douglas is distinguished from the last two formations described by the comparatively small portion of limestone it contains. With the exception of a lenticular limestone from 2 to 22 feet thick, the lower and greater part of the formation consists of shale and sandstone, resembling in many respects the Pleasanton. It contains some thin beds of coal that are workable in a very small way in places. At the top of the formation are three conspicuous beds of limestone, known collectively as the Oread. The Douglas is 360 feet thick where it outcrops on the Missouri river, but thins to the northeast, so that it is only 250 feet thick near the Iowa state line.

Shawnee Formation.—The Shawnee is characterized by many thin limestone beds separated by thicker shales that locally contain masses of sandstone. About 200 feet below its summit is the Nodaway coal bed, the most important in the Missouri group in Missouri, and at a

higher level is the Elmo coal. The thickness of the Shawnee formation is 475 feet at its southern outcrop, but only about 350 feet near the north line of the State.

Wabaunsee Formation.—The base of this formation is the Tarkio limestone member, 7 to 10 feet thick. Above the Tarkio are 75 feet of variegated shale with some thick beds of sandstone, a few thin layers of impure limestone, and the thin Nyman coal bed at the base. These beds are the highest in the Missouri Pennsylvanian, the upper part of the Wabaunsee not being found in the State.

STRUCTURE.

In structure the Pennsylvanian of Missouri is very simple, for the rocks are nearly horizontal over moderately large areas. In northern Missouri the main feature is a low broad anticline (arch) or monocline that lies just east of the outcrop of the main body of the Missouri group from the Missouri river in Carroll county to the Iowa line in Putnam. East of this monocline the strata are essentially horizontal. On the Chariton river a dip to the south is just about equal to the gradient of the stream, so that the same horizons are exposed at the stream level in Chariton county as in Schuyler. West of the monocline, there is a dip of about 8 feet per mile a little north of west. Part of the northerly component of this dip is more apparent than real, however, as the low level of the upper part of the Missouri group in north Missouri is due more to the thinning of certain lower members than it is to post-Pennsylvanian movements. From Kansas City north to Hopkins, more than 100 miles, the northerly dip is 280 feet or about 2.7 feet per mile. From Utica, Livingston county, west to St. Joseph, the westerly dip is 7.7 feet per mile. From Princeton to Rockport, along the north line of the State, the westerly dip is 7.5 feet per mile.

South of the Missouri river the strata dip in general northwest. From Clinton to Kansas City the dip is 420 feet or 6.4 feet per mile. From Minden, Barton county, to Kansas City, the northerly component of the dip is 550 feet or about 5 feet per mile.

Superimposed upon the main structural features described above, are numerous folds that are of much more importance locally. All of these trend northwest-southeast and in places raise or lower the altitude of individual beds by 100 feet or more within short distances. The common mode of occurrence is a narrow well-marked syncline lying close to the southwest side of a rather narrow anticline. Beds commonly dip comparatively steeply to the southwest from the anticlines and more gently to the northeast. These folds, with the direction of their axes practically unchanged, can be traced for long distances across the State. One of the most notable is the Browns Station anticline in Boone county.

CHAPTER II.

THE MODE OF OCCURRENCE OF COAL IN MISSOURI.

THE COAL BEDS.

One of the surprising results of the recent geologic work in the coal area of Missouri was the determination of the remarkable regional persistency in many of the coal beds. Several beds have been traced diagonally across the state from Kansas to Iowa with hardly a break. This does not mean, of course, that the coal beds are of the same thickness and character in every locality or that every piece of land known to contain a certain coal bed or horizon can have its mineral fuel content exactly estimated. Even the most persistent coal beds, those in the upper part of the Cherokee shale, thicken and thin from place to place and are absent under large stretches of territory.

Not only were there variations in the character and density of the vegetation of the coal swamps, but parts of the coal beds have been wholly or partially removed by erosion. That beds have been removed by the streams of today that have carved valleys through them and exposed them to view is evident to everyone. Similar drainage lines were developed at two other periods of the earth's history. During Pennsylvanian time large areas were often brought close to the level of the sea and subjected to the erosive action of streams and tidal currents which removed along certain channels parts of the coal and other beds already deposited. Afterward, when the land was again inundated, these channels were filled with sand and clay, which are now consolidated into shale and sandstone. Other and more important drainage ways were developed during the period of erosion that elapsed between the close of the Pennsylvanian and the invasion of the ice sheets from the north millions of years later. In southwestern Missouri the erosion continued unchecked to the present time, but in northern Missouri the glacial ice and the waters accompanying it filled up many of the valleys with masses of sand, clay, and gravel that are still loose and incoherent and are known collectively as drift. The courses of the old valleys that had removed portions of the coal beds can be detected only by thorough drilling, for they are not shown

in the present topography. The drift has also a deterrent effect on the coal industry in that in some areas it conceals what might otherwise be good outcrops of coal beds.

COAL POCKETS.

A region occupying a broad band lying east of the main body of the Pennsylvanian and extending well up into the central Ozarks bears scattered over its surface numerous isolated Coal Measures pockets of unique character. The age of many of them is uncertain, though those bordering and underlying the main body of Coal Measures are certainly older than the more regular Pennsylvanian beds of the same districts. Deposits of this character are now known to occur in at least 35 counties, and it is probable that future geologic work will disclose many others. Pockets were formed in sink-holes or narrow valleys in Mississippian or older formations, and few are more than one acre in lateral extent. The coal they bear is predominantly cannel and in many places is remarkably thick, some deposits measuring more than 50 feet and one shaft having penetrated nearly 90 feet of coal. Some shale and clay are everywhere associated with the coal. Cannel is a compact massive coal with dull satiny luster and smooth conchoidal fracture. It is especially high in ash and always very high in volatile matter, burning readily with a bright flame that makes it popular for household use. It is an excellent gas producer and might well be more freely used for that purpose. The bituminous coal associated with the cannel in the pockets is as a rule a poor steam coal and is soft; the coal of the Stover mine in Morgan county and at a few other banks are, however, exceptions.

False hopes have frequently been aroused by the discovery of pockets of thick coal and the field has proved a profitable one for real estate men and promoters. Strange as it may seem, experienced coal operators from Pennsylvania and other states have been among those deceived by these pockets, although their true nature was pointed out in reports of this Survey as early as 1855, and has been described in several subsequent volumes. Many of these deposits are important local supplies of fuel and may be worked with considerable profit if inexpensive equipments be used, but none of them contains sufficient coal to justify the construction of long railroad spurs or large plants An aggregate of 500,000 tons of coal in a single pocket is exceptionally large, for most of them are much smaller. In some places seams and veins of lead and zinc ore add to the value of the pocket and in others small deposits of flint clay and plastic clay are so situated that they may be burned with pocket coal mined in the vicinity. Indications by which the layman may detect the pockety nature of a coal deposit outside the main body of the Pennsylvanian are: (1) more than 6

feet of coal in one bed, (2) a large proportion of cannel, (3) dips at high angles and in various directions, and (4) outcroppings of heavy beds of limestone near and at higher elevations than the coal, especially where the dips of the limestone beds do not correspond in angle or direction with those of the deposit in question. The geologist has, of course, additional and more certain methods of identifying a pocket.

BEDS IN THE LOWER CHEROKEE SHALE.

Coal beds older than the Tebo are less persistent than those that lie stratigraphically higher and are much more variable in thickness. Many of the beds were deposited in basins a few hundred acres in extent, some are in narrow troughs, and others are fairly uniform under half a county or more. Owing to the eastern overlap of the Cherokee in north Missouri, the lowest beds are not exposed and can be found only with the drill. Consequently very little mining has been done at these horizons. In Southwest Missouri a number of beds lower than the Tebo are exposed, but few are of economic importance. Owing to the absence of reliable stratigraphic markers no attempt has been made to correlate the lowest coals in widely separated basins, though it is more than likely that many of them were contemporaneous.

The Cainesville bed lies 300 feet below the top of the Cherokee shale and 180 feet below the Bevier horizon in Harrison and Mercer counties. It contains an average of 4 feet of coal and is being utilized at a mine 500 feet deep in Cainesville. Other fairly thick beds lie below the Cainesville and constitute a valuable reserve in this part of the State. It is probable that similar deposits will be found by deep drilling farther west and southwest in the area described as first invaded by the Cherokee sea. These older coals are not likely to be found very far south or southeast of Mercer county.

At Atchison, Kansas, coal 36 inches thick was found by drilling at a depth of 1,124 feet, 325 feet below the Bevier horizon. Another coal bed, 28 inches thick, was penetrated at a depth of 1,188 feet. At Saxton, near St. Joseph, these and other lower coals are thin, but there is strong probability that thicker basins underlie certain parts of the region. At Leavenworth, Kansas, there are at a depth of 1,030 feet, or 320 feet below the Bevier, 28 inches of coal that may be in the same bed as one of these at Atchison just described. Thirty feet higher are 26 inches of coal, and there are thinner beds both above and below the two mentioned.

In Macon and Linn counties the Eureka coal bed* lies 85 to 150 feet below the Bevier bed. Drillings show at least traces of coal at this horizon in many places, but the thickness of the bed is very variable. At the only place it has been mined, west of Macon City, it

*Named by C. H. Gordon, A report on the Bevier sheet, Mo. Geol. Survey, 1893.

averaged 4 feet in thickness, but was split by a clay parting and was rather dirty.

Considerable coal has been mined at Waverly, Lafayette county, from a bed that underlies about 60 square miles and is 200 feet below the top of the Cherokee shale. It may occupy the same horizon as the Eureka bed. It is 3 to 4 feet thick at Waverly, but was not found in the drilling at Carrollton, on the opposite side of the Missouri river valley.

The Montserrat bed, in east-central Johnson county, is 120 feet below the horizon of the Bevier coal and not far from that of the Waverly. It was a large producer in the district between Montserrat and Knobnoster, where it is 7 feet and less in thickness, until it was driven from the market by cleaner coal that could be more easily mined. The Brushy Hill bed, a thinner coal 50 feet above the Montserrat, underlies the same district.

In Henry county there are two trough-shaped deposits of deep coal lying 50 feet or less below the Bevier horizon, the interval decreasing to the northeast. One of these, the Mammoth, has been mined and exhausted; the other is now being operated at Bowen, near Windsor. Near Deepwater and Clinton are irregular basins of coal at the Jordan horizon, probably 85 to 120 feet below the Bevier and about 200 feet below the top of the Cherokee. Coal 50 feet or less from the base of the Pennsylvanian and apparently at or near the Jordan horizon crops out in many places in St. Clair and Cedar counties, but is rarely more than 2 feet thick. In the northwest corner of Dade county and the northeast corner of Barton similar beds furnish local supplies of fuel for the country near Sylvania and Milford.

The Tebo† coal bed lies 15 to 50 feet below the Bevier horizon and is the lowest bed that has a limestone cap-rock. When this coal was deposited somewhat more stable conditions prevailed than during earlier Pennsylvanian time. There is some coal at this horizon in most parts of the coal area, though not everywhere in beds of workable thickness. In Linn, Grundy, Chariton, Henry and other counties, however, considerable coal is taken from it for both shipment and local use, and in many areas there are valuable reserves that will be drawn upon when other fields approach exhaustion. Slightly more than 5 per cent of the State's output now comes from the Tebo.

†A bed in Randolph and Macon counties that was called the Lower Ardmore by C. H. Gordon (A report on the Bevier sheet, Mo. Geol. Survey, 1893) has been correlated with the Tebo of Henry county. In this report the name long in use in the latter area has been used in all parts of the State.

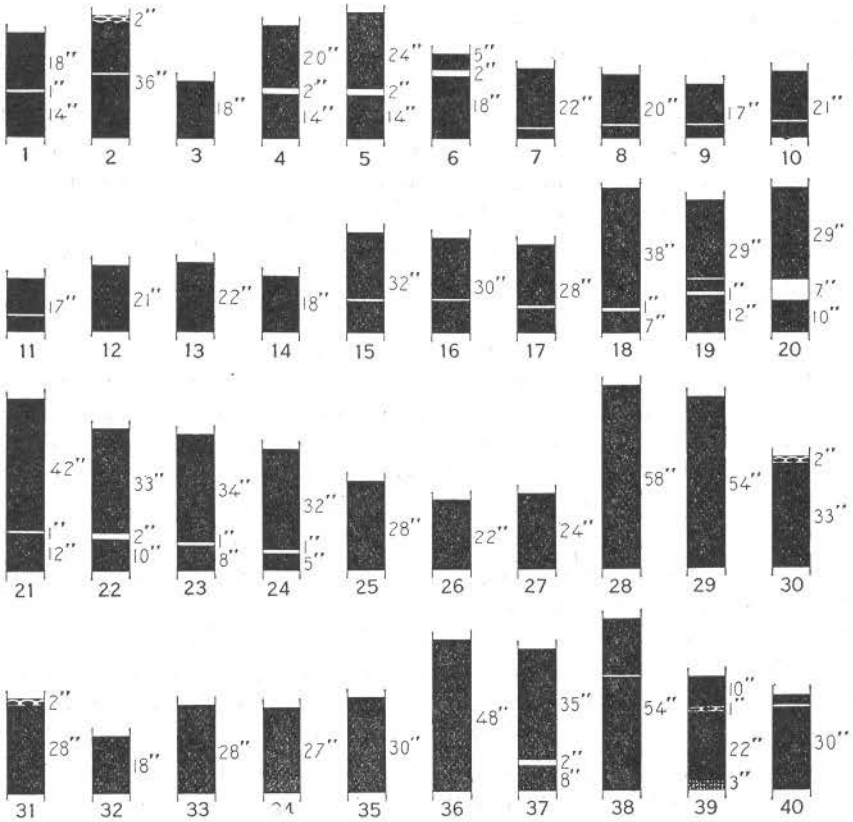

Fig. 1. Coal beds at the principal mines in Missouri.

Mulberry bed—
1. Worland.
2. Foster.
3. Chillicothe.

Lexington bed—
4. Mendota.
5. Stahl.
6. Richmond.
7. Camden.
8. Lexington.
9. Higginsville.
10. Corder.
11. Napoleon.
12. Missouri City.

Mulky bed—
13. Macon.
14. Renick.
15. Martinsburg.
16. Vandalia.
17. Perry.

Bevier bed—
18. Kirksville.
19. Novinger.
20. Milan.
21. Bevier.
22. Huntsville.
23. Higbee.
24. Columbia.
25. Fulton.
26. Leavenworth.
27. Sutherland.
28. Rich Hill.
29. New Home.
30. Minden.
31. Liberal.

Tebo bed—
32. Trenton.
33. Brookfield.
34. Marceline.
35. Lewis.

Lower beds—
36. Cainesville.
37. Waverly.
38. Windsor.
39. Deepwater.
40. Sylvania.

THE BEVIER, RICH HILL, WEIR-PITTSBURG AND BEDFORD BEDS.

The Bevier‡ is by far the most important coal horizon in Missouri. Not only does about 56% of the total coal output of the State come from it, but in nearly every part of the coal-bearing region it

‡Name given by McGee in 1888 from its occurrence at Bevier in Macon county, and employed by Gordon, Marbut, and others to designate the thick coal in the Bevier, Huntsville, and Higbee districts.

includes reserves that are still untouched. The Bevier bed carries from a few inches to six feet of coal in most counties in which the Cherokee shale outcrops and has been penetrated in many drillings and shafts in areas in which higher rocks appear at the surface. It is the bed mined extensively in Macon, Adair, Randolph, Northeast Howard, Boone and Callaway counties, at Milan in Sullivan county, and in the deep shafts at Leavenworth, Kansas, and it was formerly utilized at Randolph in Clay county. It is also mined for local trade in Chariton, Carroll, eastern Putnam, and several other counties.

The Bevier is rather easily identified, as it is the only bed that has a limestone bottom-rock and no limestone cap-rock. Over it are 10 to 40 feet of shale and sandstone which were laid down during a short period of shallow and disturbed water. The coal itself and the beds immediately below it were deposited under remarkably uniform conditions. Clay or shale partings 3 inches or less thick occupy the same positions in the coal under tens and hundreds of square miles. The Bevier bed lies 100 feet below the top of the Cherokee shale in central and northeastern Missouri, and 25 to 50 feet lower in the northwestern and west-central part of the State.

In Bates and Vernon counties there is a bed 150 to 190 feet below the top of the Cherokee which probably occupies the Bevier horizon, but as more geologic and paleobotanic work must be done before this correlation can be completely verified and as the bed has been known for years by a local name, it is called the lower Rich Hill coal bed in this report. The upper Rich Hill coal is closely associated with the lower and may be the Bedford seam. The lower Rich Hill is very irregular in thickness, having apparently been deposited in basins, and lacks the well-defined limestone bottom-rock that characterizes the Bevier bed of north Missouri.

On the western edge of Barton county is a persistent bed that is very extensively mined in Crawford and Cherokee counties, Kansas. It is undoubtedly the same as the lower Rich Hill and, consequently, very probably lies at the Bevier horizon. In conformity with the nomenclature used in the adjacent Kansas field, however, the bed is in this report termed the Weir-Pittsburg Lower. The coal is of fairly uniform thickness and lies about 180 feet below the top of the Cherokee shale.

West of the large mining districts in Macon and Randolph counties, the principal shale parting of the Bevier bed thickens so much that it is difficult to mine the coal above and below it as one bed. In Livingston and Carroll counties what is probably the upper bench of the Bevier lies about 15 feet above coal that is undoubtedly at the Bevier horizon. Because the upper bed lies so far above the lower that it is for all practical purposes a separate seam and because it may actually be an independent deposit instead of a split from the lower,

the name Bevier has been restricted to the lower bed and the name Bedford applied to the upper in this part of the State. The Bedford is of very little economic importance, except in Livingston county, being too thin for commercial mining in many districts. Some coal is found at the Bedford horizon in many drillings and a few exposures in northern and western Missouri. In Bates, Vernon, and Barton counties, the names upper Rich Hill and Weir-Pittsburg Upper have been applied to beds that may correspond to the Bedford.

THE MULKY AND SUMMIT BEDS.*

Between the Bevier coal and the top of the Cherokee shale, there are two persistent coal horizons about equally spaced from one another and from the top and bottom of the interval mentioned. Both of the beds have thin limestone cap-rocks separated from the coal by black, strongly laminated shale, and in some districts strongly resemble one another. In other areas, especially where the Bevier and Summit beds are absent or not well developed, it is very difficult to distinguish the Tebo from the Mulky.

The Mulky coal bed is rarely more than 2 feet thick, though in some fields it is as much as 3 feet. A notable peculiarity is its uniformity in character and associations over large areas in deposits that are widely separated from one another by stretches of barren territory. The Mulky is of greatest economic importance in Montgomery, Ralls, Audrain, western Macon and Randolph, Chariton, Carroll, southeastern Lafayette, and Johnson counties. In much of this area it is used only for local trade, though it could be profitably mined in many places were competition with thicker beds eliminated.

The Summit bed is about 25 feet above the Mulky in the type locality near Macon and occurs in outcrops and drillings in many parts of the State. It is less than 14 inches thick in most districts and is not considered workable in any but a very small way except in Howard and Boone counties, where, however, it is commonly less than 20 inches thick.

THE LEXINGTON BED.†

The Lexington is one of the most persistent beds in the State. In most of the region it is less than 2 feet thick and is thickest in Putnam and adjacent counties, where it bears about 3 feet of coal.

*The name Mulky was applied by Broadhead many years ago to a bed in southeastern Lafayette county and was afterward used by Winslow and other writers. In this report it replaces the name Macon City, which has been used by Gordon and Marbut to designate a bed in Macon and Randolph counties now known to occupy the same horizon as the Mulky. The name Summit was used first by McGee and afterward by Gordon and Marbut to designate the bed next higher than the Macon City in Macon and Randolph counties.

†So named by Broadhead in 1873 from its occurrence near Lexington. The name was also used by Winslow in 1892 and Marbut in 1898 in detailed reports on Lafayette and Ray counties.

Except in Macon county and the region south and southeast of it, outcrops and drill records show at least a few inches of coal at the Lexington horizon in nearly all parts of the State in which it occurs. Nearly 30 per cent of the State's total production comes from this bed, by far the greater part from Lafayette and Ray counties and most of the remainder from Putnam and Adair counties.

The Lexington bed lies at or within a few feet of the top of the Cherokee shale. Much limestone is associated with it, for its cap-rock is the lowest limestone of the Henrietta formation, and in north Missouri it has also a well-developed limestone bottom-rock. It is the same bed stratigraphically as the Fort Scott red coal of Kansas and the Mystic coal bed that is economically so important in Appanoose and Wayne counties, Iowa.

BEDS IN THE PLEASANTON SHALE.

Coal beds are exposed in many places along the outcrop of the Pleasanton shale and appear in a number of drill records that have penetrated the formation, but most of these are so thin as to be of very little economic importance. The two most persistent coal horizons are near the top and bottom, respectively, of the formation. The upper, named the Ovid by Marbut, has been mined only in northeastern Sullivan county and only for local use in that locality. The lower, called the Mulberry by Broadhead,‡ is sufficiently thick to be workable only in Bates county, where it is slightly less than 3 feet thick and is mined both for local use and for shipment. Aside from the two districts just mentioned, Pleasanton coals are not known to be utilized in Missouri at any but a few small farm diggings.

BEDS IN THE MISSOURI GROUP.

There are streaks and thin beds of coal in several of the formations of the Missouri group, but very few that can be utilized. Those in the Douglas shale are too thin or too impure in Missouri, though more serviceable in parts of Kansas. The Wabaunsee and Shawnee formations also contain several thin beds of coal, among them the Nyman bed in the Wabaunsee, and the Elmo and Nodaway in the Shawnee. Only the Nodaway is as much as 14 inches thick in more than very small areas and it is economically important only in Nodaway county, where it averages 16 inches thick in places and furnishes considerable coal for local consumption. In Iowa a somewhat larger fuel supply is derived from this bed.

‡Rept. for 1873-1874, Mo. Geol. Survey, pp. 155-178.

THE COAL FIELDS.

One of the most important questions regarding the coal of the western interior region is the westward extension of coal-bearing deposits in Kansas, Nebraska, southwestern Iowa, and northwestern Missouri. Until recently it was the opinion of many geologists that the region in which there are rocks of Missouri group age in northwestern Missouri and southwestern Iowa was very doubtful coal territory. It was realized that the thin beds of the Missouri group might be locally workable, as in Nodaway county, Missouri, and Page county, Iowa, but it was thought that the thicker coal beds of the Cherokee formation were probably absent. Drilling at Clarinda, Iowa, and more especially at Leon* have shown that parts of the doubtful Iowa territory may contain workable coal beds. Still more satisfactory have been the results of drilling in northwestern Missouri. At Cainesville, in Harrison county, and Princeton, in Mercer county, the Cherokee shale is exceptionally thick and contains a considerable amount of coal. Drilling just completed in Worth county shows similar conditions, though not quite so much coal. Drillings in Nodaway, Atchison, and Andrew counties were not carried sufficiently deep to explore the more important coal horizons in the lower Cherokee, but one at Forest City, Holt county, showed that the Cherokee was very thick and contained considerable coal, though not in thick beds. There can be little doubt that the region east and south of that just mentioned is potential coal territory, though only a few drillings have been carried to the base of the Coal Measures. The results of drillings and mining operations at Saxton, Atchison and Leavenworth are particularly gratifying. Indeed, the only part of the Pennsylvanian area of the State about which there is much doubt is the extreme northwest corner, where the Cherokee shale may be largely or entirely lacking. Even there, however, the Nodaway and other beds of the Missouri group are locally workable.

In connection with the future coal development of northwestern Missouri, the fact should not be overlooked that coal beds more than 3 feet thick are probably as rare in that region as in the more thoroughly explored parts of the State. In every part of Missouri, however, coal horizons are less than 2,000 feet below the surface and the possibility of profitably mining beds of moderate thickness at even greater depths has been thoroughly proven in this and other countries.† At Atchison, Kansas, a shaft has been sunk and some mining done at a depth of 1,170 feet, and at Leavenworth a 22-inch coal bed

*Hinds, Henry, Coal deposits of Iowa, Iowa Geol. Survey, Vol. XIX, 1909, pp. 247-253.

†Fisher, C. A., Depth and minimum thickness of coal beds as limiting factors in the valuation of coal lands, Bull. U. S. Geol. Survey, No. 424, 1909, pp. 48-64.

at a depth of 720 feet has furnished large supplies of fuel for many years. Under the present rather depressed state of the coal market in the western interior field it is a question whether the expense of

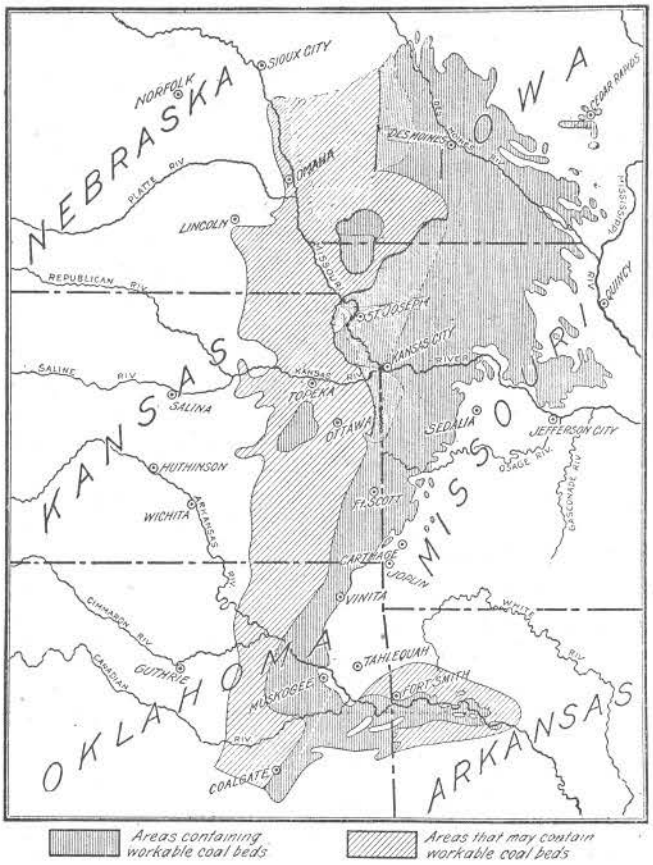

Fig. 2. Map of the Western Interior Coal Fields.

prospecting and opening deep-lying coal deposits of moderate thickness would be justified, but with the better conditions that the near future is certain to bring forth, the immense coal resources of northwestern Missouri will become important.

Although practically all the Pennsylvania area of Missouri is coal-bearing and although mining on at least a small scale is carried on in nearly all of the region in which the Des Moines group appears at the surface, yet certain fields are distinguished by the fact that they have been proved to contain exceptionally thick or easily mined coal deposits and have been developed by comparatively large mines. Only those areas in which there are shipping mines that contain coal deposits similar and contiguous to those at such mines are shown on the accompanying map (Pl. III) and described in the following discus-

sion. Examination of the detailed county reports in this volume will show that other parts of the State that have received relatively little attention from operators contain deposits equal in value to those that are now extensively mined.

THE BEVIER FIELD.

The Bevier is one of the most important fields in Missouri, for it contains the Bevier coal, a fairly thick bed of wide areal extent, and produces about 27 per cent of the State's output of coal. In a broad sense the part of this bed that is workable under present conditions is bounded on the north by the Hannibal & St. Joseph branch of the Burlington system, on the east by the Wabash railroad from Macon City to Renick and thence by an imaginary line south to Rucker and southeast to Browns Station and Fulton, on the west and south by Mussel fork and an imaginary line passing through Salisbury, Yates, Burton, Harrisburg, Columbia and Carrington. By no means all the land within this area is underlain by the Bevier bed, for the coal has been cut out by a channel of Pennsylvanian age in central Randolph county and by pre-glacial erosion in many places, notably between Middle fork and the Chariton in Macon county and between East and Middle forks in parts of Randolph. The west side of the northern part of the field is seriously affected in places by a thickening of a clay and sandstone parting.

The northern part of this field, the Ardmore district in Macon county, is the most important, both because a greater quantity of coal is mined there than in any other single district in the State and because the coal is slightly thicker than it is farther south. The average thickness of the bed is 4½ feet, though it is in places one or two feet above or below this average. A clay band averaging 2 inches in thickness splits the coal about one foot from its base. Locally this band becomes hard and arenaceous and thickens so much as to become somewhat troublesome. At Lingo, where a detached area of the Bevier bed was formerly mined, this thickening of the clay band was especially notable. The roof of the Bevier bed in the Ardmore district is a sandy shale or a sandstone, changing abruptly from one to the other. The sandstone makes a firm roof, but has a tendency to cut down into the coal so as to make its thickness variable. The shale roof is fairly stable when proper precautions are taken.

One other bed, the Mulky coal, is of present economic importance near and east of the Wabash railroad, where the Bevier bed is thin. It lies 12 to 30 feet above the Bevier and is about 2 feet thick. It is mined on a fairly large scale in and near Macon City, where it is of excellent quality and possesses a very strong roof. Other coal beds occur, but are not now mined.

The Huntsville district of the Bevier field occupies the northwest quarter of Randolph county, west and north of the Wabash railroad, and the adjoining edge of Chariton county as far west as Salisbury. The Bevier bed is slightly thinner here than in the Ardmore district, averaging 3½ to 4 feet, but is otherwise similar. The principal mining centers are Huntsville and Kimberly. Mining at Salisbury has not proved very profitable because of the thickening of the clay parting in the Bevier bed at that point. The Mulky coal is not mined within the limits of this district, though local trade is supplied from the same or a very similar bed at points near the Missouri, Kansas and Texas railroad between Moberly and Paris.

The Higbee district of the Bevier field lies in south-central Randolph county, west of the Wabash railroad, and the northeast corner of Howard county. It is separated from the Huntsville district by a channel of Pennsylvanian age in which the coal is cut out by sandstone and shale. The Bevier bed has been opened by shipping mines at and near Higbee, Yates, Elliott, Renick and Russell, and averages 3½ feet in thickness with the usual thin clay band in its lower half. The roof is not quite so strong as in the northern districts, being an argillaceous shale that requires careful attention. The Mulky coal is mined at Renick, where it is 18 inches thick and has an excellent roof of firm black shale overlain by a limestone cap-rock.

The Columbia district of the Bevier field is the continuation to the southeast of the Higbee district. The Bevier coal, averaging 3½ feet in thickness, underlies the divides in the northwest quarter of Boone county. Mining for local trade is prosecuted near Harrisburg, Rucker and other points, and in a slightly more extensive manner near Columbia. Mining conditions are much the same as in the Higbee district, yet the Boone county area has not received the attention it merits. Improvement in railway facilities may give an impetus to the coal mining industry. Another coal (Summit), about 2 feet thick and 40 feet higher than the Bevier, underlies the higher lands of the district, while an 18-inch bed (Tebo) lies, at least locally, a short distance below the Bevier.

The Fulton district of the Bevier field occupies east-central Callaway county. The only important coal bed is the Bevier, here irregular in thickness but averaging about 30 inches. The shale roof is poor except where it is strengthened somewhat by a thin cap-rock of impure limestone. It is mined rather extensively near Fulton, where the product is consumed locally by the clay plants and the State institutions, and in smaller quantities at Younger, Stephens Store, Millersburg, Carrington, and other places.

THE LEXINGTON FIELD.

The Lexington coal field equals the Bevier field in output, in spite of the fact that its only coal bed averages little more than 20 inches in thickness. This coal, the Lexington bed, is a favorite for domestic use, can be mined very economically, and is located near large centers of fuel consumption. The roof of the coal is a strong limestone, in many localities separated from the coal by a thin stratum of firm black shale ("slate") that can be conveniently taken down to make the requisite height along the face and used to build gob walls.

The Richmond district includes that portion of the Lexington field that lies north of the Missouri river bottoms; viz., all of Ray county, except perhaps its northeast corner, and at least southeastern Clay and southern Caldwell counties. It may also include northern Caldwell county, for the Lexington bed was once mined at Hamilton, where, however, it was not in very good condition. In the greater part of the Richmond district the coal lies in two benches with limestone resting on the coal, thus:

	Feet.	*Inches*
Limestone	5	....
COAL, pyritiferous (top coal)	....	5
Clay	....	2
COAL, clean (bottom coal)	1	6

This type of bed is found at and near Richmond, Vibbard, and Knoxville. In places, notably between Swanwick and Richmond and near Lakeview, the top bench is irregular or lacking and more rarely the upper portion of the bottom bench is absent. When traced from Richmond to Camden the top coal gradually disappears, its place being taken by black shale. At Camden, Fleming, Orrick, and Missouri City, the following is the average section:

	Feet.	*Inches.*
Limestone	7	....
Shale, black ("slate")	....	10
COAL	1	9

There is a vast amount of coal in the Richmond district still untouched.

The Higginsville district of the Lexington field includes all of Lafayette county except the eastern and the southern edges. In the southeast corner, however, there is a lower coal called the Mulky bed, much like the Lexington bed in thickness and character; and at Waverly, in the northeast corner of the county, there is a large basin of still lower coal that is 4 feet thick and has a roof of thick shale. The Lexington bed was cut out and replaced by sandstone and shale in an ancient channel, several miles broad, that lies between Lexington and Dover and extends thence southward to beyond Higginsville; and it has been removed more recently from the valleys of the larger creeks. East of Lexington the coal is the same as at Richmond, being

in two benches. At Dover the coal is as at Lakeview, in two benches but subject to rather abrupt and irregular thinnings. South and west of Lexington, where the most extensive mining is conducted, the coal bed is the same as at Camden, though the black shale between the coal and the limestone is a few inches thicker. Westward and southward from Wellington and southward from Lexington the thickness of coal decreases gradually, so that at Napoleon it is only 17 inches and at Mayview only 16 inches. Northwest and southwest of Odessa there is only from 10 to 16 inches of coal. Near Higginsville the coal is of the Camden type, but is only from 14 to 18 inches thick. The excellence of mining conditions, however, the attractive condition in which the coal reaches the market, and the advantageous location of the town as regards shipping facilities have caused extensive mining to be prosecuted near it. Near Corder the thickness of the coal averages 21 inches, though somewhat decreased locally by "horsebacks". North and south of Corder there is a considerable area of coal land practically untouched.

THE NOVINGER FIELD.

The Novinger field is the third in importance in Missouri, producing 15 per cent of the State's coal output. As now known, it embraces the northwest quarter of Adair county, reaching its fullest development in the neighborhood of the Iowa & St. Louis railroad between Youngstown and Connelsville, where the coal worked is reached by slopes and shafts. It is probable that future prospecting will reveal important basins of coal between the Novinger and Bevier fields, for in both areas the Bevier bed is utilized and is much the same in one as in the other. The average section of the Bevier at Novinger and Connelsville is:

	Feet.	*Inches.*
Shale	....	....
COAL	2	1
Clay	....	½
COAL	....	4
Clay	....	1
COAL	1	....
Total coal	3	5

This coal is excellent for steaming purposes, is very hard, and is somewhat dirty at top and bottom. The shale roof requires rather careful attention. The long-wall method of mining is being introduced as an experiment; its success would mean that a great impetus would be given to mining in this and similar fields. East of Novinger, near Kirksville, the shale over the coal is replaced by a sandstone that has a very uneven undersurface, cutting down badly into the coal in rolls. Under Kirksville itself, the Bevier bed is so thin as to be unworkable. West of Novinger, at Danforth, the coal is split by a troublesome "bench-rock," which thickens farther west. At Stahl

the upper bench of the Bevier is 30 inches thick and is separated from the lower bench by 9 feet of shale. At Dewey, a short distance west of Stahl, the Bevier was abandoned after a short attempt to mine it. At Milan, still farther west, the two benches of the Bevier are so close together that both have been mined together, though with difficulty. No prospecting has been done between Dewey and Milan and it is possible that the "bench-rock" is locally thinner in this territory than is generally supposed.

A coal bed (Tebo) that is about 24 inches thick lies about 55 feet below the Bevier bed, but no coal has yet been taken from it. The bed now mined at Stahl (Lexington) lies about 100 feet above the Bevier bed and will be mentioned under the next heading.

THE MENDOTA FIELD.

The Mendota field includes the eastern half of Putnam county, the northwest corners of Schuyler and Adair counties, and the northeast quarter of Sullivan county. In this field there is a vast area of undeveloped coal land, the value of which is scarcely realized, for only 2 per cent of the total output of the State comes from it. The coal present constitutes the southern extension of the bed termed the Mystic coal in reports of the Iowa Geological Survey, a bed that produces, near Mystic, Centerville, Cincinnati and Seymour, nearly one-fifth of Iowa's large coal output. This bed is now known to be the same as the Lexington of the Lexington field in Missouri. There are numerous small country mines in many localities in the Mendota field, but shipping mines are confined to Mendota, Unionville, Stahl, and Coal City. The following average sections show the thickness of the coal and the nature of the overlying strata in the different districts:

AT MENDOTA AND UNIONVILLE.

	Feet.	*Inches.*
Limestone ("cap-rock")	1	6
Shale, drab ("clod")	....	8
Shale, black ("slate")	1	1
COAL	1	8
Clay parting ("mud-band")	....	2
COAL	1	....
Clay parting	....	1
COAL ("Dutchman")	....	1
Total coal	2	9

AT STAHL.

	Feet.	*Inches.*
Limestone ("cap-rock")	2	....
Shale, drab ("clod")	1	....
Shale, black ("slate")	1	....
COAL	2	....
Clay ("mud-band")	....	2
COAL	....	10
Clay parting	....	½
COAL ("Dutchman")	....	1
Total coal	2	11

AT COAL CITY.

	Feet.	Inches.
Limestone ("cap-rock")	1	6
Shale, soft ("clod")	....	10
Shale, black ("slate")	1	....
COAL	1	8
Clay ("mud-band")	....	2
COAL	1	1
Clay parting	....	1
COAL	....	3
Total coal	3	....

THE LEAVENWORTH FIELD.

Although no coal is being taken from shafts in the Missouri portion of the Leavenworth field, a large part of the product of the Leavenworth, Kansas, shafts, about 250,000 tons annually, is actually mined in Missouri. These shafts are about 720 feet deep and have for many years mined the Bevier bed, which is only 22 inches thick and contains no regular clay or shale partings. The roof is in most places a fairly strong shale. Formerly the same bed was mined at Randolph, near Kansas City, in Clay county, and at the Brush creek shaft, a short distance south of Kansas City. Owing to several discouraging factors these mines have been abandoned, although the coal mined had much the same thickness as at Leavenworth. At Atchison, Kansas, the Bevier was reached at a depth of 799 feet and found to be 22 inches thick. At Saxton, near St. Joseph, 21 inches of coal at the Bevier horizon was penetrated by the drill at a depth of 645 feet. At Stewartsville, about 20 miles east of St. Joseph, the same bed was 23 inches thick. All the evidence at hand points to the existence of a remarkably persistent bed at the Bevier horizon under Platte, Buchanan, and parts of Clinton, Clay and Jackson counties. Though this bed may be too thin and too far below the surface to be profitably mined at present, the success of the Leavenworth mines shows the commercial value of the deposit where market conditions are exceptionally good.

In addition to the Bevier there are other coal beds in the Leavenworth field, most of them stratigraphically lower than the Bevier and more irregular in thickness. At Atchison some attempt has been made to mine a 36-inch bed at a depth of 1,170 feet. The probabilities are strong that several deep-lying basins of at least 4-foot coal will be discovered in the Leavenworth field. In the drilling at Atchison there were 101 inches of coal in beds more than 14 inches thick, at Saxton 110 inches, at Leavenworth 108 inches, and at Randolph 50 inches. No other reliable drillings in the field have penetrated to the bottom of the Coal Measures.

At Forest City, in Holt county, a deep core drilling showed the Bevier to be only 15 inches thick and other coal beds also thin. The

Bevier bed may be workable a considerable distance east of the area mapped, for at Richmond a drilling showed it to be 18 inches thick and at Hamilton it is 19 inches thick and is mined in a shaft nearly 500 feet deep.

THE RICH HILL AND MINDEN FIELDS.

Rich Hill was until recently the center of some of the most active mining in the State, but the exhaustion of the thicker basins of coal has resulted in the withdrawal of all the larger operators. One large mine is now working at New Home, west of Rich Hill, and several smaller mines are effecting the depletion of the territory south of the city, in Bates county and the adjacent parts of Vernon. The bed mined is the lower Rich Hill and probably lies at the same stratigraphic horizon as the Bevier. Its characteristics are, however, quite different from those of the Bevier in north Missouri, for it lies in barren areas. Only coal that is 3 to 6 feet thick is mined, thinner deposits being left in the ground or used by basins, separated from one another by small operators. The upper Rich Hill bed, which lies a few feet above the lower and is rarely more than 18 inches thick, is also utilized where the lower bed is stripped. As a consequence of remarkable dips that cause the coal to vary tens of feet in altitude within short distances, operations are conducted from moderately deep shafts on prairie lands adjacent to strippings.

Prospecting thoroughly prosecuted for a radius of several miles from Rich Hill has failed to open up new fields, except one at New Home. There is little doubt, however, that other basins similar to those at Rich Hill remain undiscovered beneath the upland areas of both Bates and Vernon counties. One such basin has long been known at Moundville, where three small mines now obtain supplies from a deposit that contains as much as 50 inches or more of coal in places, but is so split by clay partings that only part of it can be recovered.

Along the western edge of Barton county, near and north of Minden, and in an outlier at Liberal, mining is done on a large scale from a bed that is stratigraphically the same as that at Rich Hill, but is much more regular in thickness. Only about 23 square miles are included in this field in Barton county, the remainder being in Cherokee and Crawford counties, Kansas, where the bed mined is known as the Weir-Pittsburg Lower. This bed is an excellent steam coal, has a fairly strong shale roof, and averages about 30 inches in thickness. Although much of the more easily mined coal has already been extracted by stripping and shafting operations, the Missouri portion of the field still produces more than 200,000 tons annually.

THE MARCELINE FIELD.

The Marceline field occupies the southeast quarter of Linn county and the adjoining northern edge of Chariton county, and produces 4 per cent of the State's coal output. Coal is mined rather extensively at Marceline and for local needs at Bucklin, Brookfield, and Rothville. At least three beds of coal are known to underlie this field, only the Tebo being utilized to any great extent. At Rothville the Mulky is mined on a small scale, and a fourth bed, said to be 32 inches thick, is reported to lie about 70 feet below the Tebo in several places. The Tebo is reached at Bucklin by a shaft 228 feet deep and at Marceline by three shafts respectively 130, 190 and 212 feet deep. It is slightly irregular in thickness, being affected by "rolls" in the roof and the floor, and averages about 29 inches. The roof is a shale of fair strength. The field is commercially important because it is the only producer of coal along the line of the Atchison, Topeka & Santa Fe railway between Carrollton and Clark county.

THE VANDALIA FIELD.

The Vandalia field is perhaps better known for its fire clays than for its mineral fuel, yet it contains a coal bed, probably the Mulky, that is also important. This coal bed is mined, though in rather a small way, at and near Perry, Vandalia, Farber, Laddonia, Martinsburg, and Wellsville. It underlies the southwest corner of Ralls county, the extreme southeast corner of Monroe, the vicinity of Wellsville in Montgomery, and all of Audrain county east of an imaginary line drawn up the South fork of Salt river to Mexico and thence southeastward. The Mulky is of good quality locally, but contains numerous patches of poor coal where "slips" and "clay seams" are numerous. The roof over the bed is a hard, blue-back shale ("slate"), which is lithified in places and bears ovoid concretionary boulders of impure limestone. Near Perry the coal is reached by drifts and shallow shafts and in the remainder of the field by shafts 110 feet or less in depth. Where normal the coal is remarkably uniform in thickness and averages:

	Inches.
COAL	20
Pyrite	¼
COAL	10

THE FOSTER FIELD.

The Mulberry coal is mined for local use and by small shipping mines in the western half of Bates county. Where mined near Worland, Foster, Sprague and Hume, it averages 30 to 36 inches in thickness. Farther north it is more variable and is thin in places. The

roof is normally a thick shale, though in northwestern Bates county there is locally a limestone cap-rock. The field produces about 50,000 tons of coal annually. There are other coal beds, not utilized, beneath the Mulberry.

THE JORDAN FIELD.

The Jordan field occupies the south-central part of Henry county and much of northwest St. Clair county, though mining on a large scale is confined to the vicinity of Clinton and Deepwater. In the chief mining area the coal mined, the Jordan bed, was deposited very irregularly and lies in basins or lenses. The average thickness of the coal is about 3 feet where mined. The roof is a shale of variable composition that contains well-known fossil-plant floras. The field formerly yielded a larger output than it does at present, as the thicker basins have been exhausted. It is possible that the coal mined in small local drifts and slopes near Lowry, Monegaw Springs, Johnson City, and elsewhere in St. Clair county, is not the Jordan, though it is in many respects similar.

THE LEWIS FIELD.

The Lewis field includes the typical Tebo coal in northern and western Henry, west-central Bates, and northwest St. Clair counties, being divided into two parts by the valley of Grand river. The Tebo is fairly persistent and has a uniform thickness of 24 to 30 inches. It has a strong limestone cap-rock separated from coal by 2 or 3 feet of black, strongly laminated shale. This field uses the longwall system of mining and is the only large one south of the Lexington that does so. In the greater part of it only a local trade is supplied, but some coal is shipped from northwest of Clinton and more from the vicinity of Lewis. The same coal is found in Johnson county, but is not much mined.

OTHER FIELDS.

In addition to the fields described above, there are a number of smaller ones from which coal is shipped, as well as a great number in which coal is mined only for the local trade. The shipping areas will be very briefly enumerated, as more detailed accounts may be found in the county reports.

The most important recent discovery was the finding of much coal in drillings at Cainesville, Harrison county, and Princeton, Mercer county. Drill records at the former town show an average of more than 10 feet of coal distributed among several beds. One of the best equipped mines in the State has been opened in a 4-foot bed that lies 480 feet below the surface. Drillings near Princeton also reveal large

amounts of coal at fairly deep horizons, though the value of the principal bed is slightly impaired by a shale parting. There are immense and hitherto unknown coal resources in this part of the State, and we may look for a rapid development of the coal industry.

In the early days of coal mining large shipping plants operated near Montserrat, in Johnson county, where the Montserrat bed was locally 7 feet thick, but not very clean. There are several higher coals in Johnson county that are 3 feet and less thick, yet very little coal is shipped. At Chilhowee, in the southern part of the county, two shafts 223 feet deep were operated until recently. The coal mined was 52 inches thick, but split into two benches by 3 or 4 feet of clay. A drilling near Chilhowee shows the presence of other coal beds. At Sutherland coal is occasionally shipped from a two-foot bed at the Bevier horizon.

A few miles northwest of Windsor there is a remarkable trough-shaped coal deposit 6 feet and less thick, and closely associated with another thick bed that cannot be utilized. Although it is only a question of a comparatively short time before this trough shall have been exhausted, it is now producing more than 200,000 tons a year from shafts of moderate depth. A similar deposit was mined out near Lewis and others will probably be discovered as soon as systematic and thorough drilling is undertaken.

At Sylvania, in northwest Dade county, there is a field from which small quantities of coal are hauled and shipped, though it is many miles from a railroad. The coal underlies only the higher lands and is about 30 inches thick. A similar deposit is mined locally in the northeast corner of Barton county and adjacent parts of Vernon and St. Clair counties.

A little coal is shipped from some of the thick coal pockets in Moniteau and Cole counties, though the total output is not important.

CHAPTER III.

THE COAL INDUSTRY IN MISSOURI.

PRODUCTION AND MARKET CONDITIONS.

So far as known Missouri was the first state west of the Mississippi to produce coal. In 1840 the output was 9,972 short tons, according to the census report of that year, and it is probable that mining began at an earlier date. At first mining appears to have been confined to the Missouri river counties, because of the early settlement of the region, cheap transportation by water, and the fact that the coal outcropped in many river bluffs where it could be mined by drifting and utilized by the many steamboats then plying on the great stream. With the coming of railroads conditions were changed, but for many years mining was largely confined to regions in which the coal outcropped. Later increased demand caused the sinking of shafts in the more level districts, adjacent to those in which drifting was done, and finally deep-lying beds were exploited to some extent.

Until 1874, when it was surpassed by Iowa, Missouri held first place among states west of the Mississippi as a coal producer. More recently a few other western States have also registered a production greater than that of Missouri. The following table shows the production of coal in the United States in 1911, by states:

COAL PRODUCTION OF THE UNITED STATES IN 1911.

	Quantity.	Value.
Alabama	15,021,421	$19,079,949
Arkansas	2,106,789	3,396,849
California and Alaska	11,647	13,297
Colorado	10,157,383	14,747,764
Georgia	165,330	246,448
Idaho	1,821	4,872
Illinois	53,679,118	59,503,278
Indiana	14,201,355	15,326,808
Iowa	7,331,648	12,663,507
Kansas	6,254,228	9,645,572
Kentucky	13,706,839	13,617,217
Maryland	4,685,795	5,197,066

COAL PRODUCTION OF THE UNITED STATES IN 1911—Continued.

State or Territory.	Quantity.	Value.
Michigan	$1,476,074	$2,633,803
Missouri	3,760,607	6,431,066
Montana	2,976,358	5,342,168
New Mexico	3,148,158	4,525,925
North Dakota	502,628	720,489
Ohio	30,759,986	31,810,123
Oklahoma	3,074,242	6,291,494
Oregon	46,661	108,033
Pennsylvania bituminous	144,721,303	146,311,930
Tennessee	6,433,156	7,209,734
Texas	1,974,593	3,273,288
Utah	2,513,175	4,248,666
Virginia	6,864,667	6,254,804
Washington	3,572,815	8,174,170
West Virginia	59,831,580	53,670,515
Wyoming	6,744,864	10,508,863
Total bituminous	405,724,241	$450,957,698
Pennsylvania anthracite	90,464,067	174,952,415
Grand totals	496,188,308	$625,910,113

E. W. Parker, of the U. S. Geological Survey, summarizes the present status of the industry as follows:

Even if the coal mining industry were free from the biennial wage troubles, the prospects for any marked increase in the production of coal in Missouri are not favorable. Surrounded as it is by other coal-producing states—Iowa on the north, Illinois and Kentucky on the east, and Arkansas, Oklahoma and Kansas on the south and west—the output of the Missouri mines is restricted to comparatively local markets. Moreover, the larger cities of the State which are near the boundary lines draw their fuel supplies from other fields. St. Louis secures its fuel from the more accessible fields of Southastern Illinois, and Kansas City depends to a large extent upon Arkansas, Kansas, and Oklahoma for coal. But a more potential factor in limiting the demand for Missouri coal in the last few years has been the notable increase in the production of petroleum and natural gas in the mid-continent field of Kansas and Oklahoma. Natural gas from Eastern Kansas is now piped to Kansas City, St. Joseph and Joplin, Mo., and to Atchison, Leavenworth and other cities in Kansas. Oil from the same district and from Northern Oklahoma is being extensively used as fuel for manufacturing purposes in Kansas City and other cities contiguous to the Missouri coal fields, and as long as these more desirable fuels are available the demand for Missouri coal is not likely to increase materially. The interruptions to their regular supplies of fuel caused by the biyearly conflicts between coal operators and their miners has created a tendency on the part of manufacturers to substitute oil and gas for coal.*

*Mineral Resources U. S. for 1910, U. S. Geol. Survey, 1911, p. 151.

Although prospects for the immediate future are not particularly bright, it seems certain that conditions will materially improve within a few years. It is only a question of time before the output of cheap oil from the southwestern fields will greatly diminish, and a shortage in the supply of natural gas has already been felt by consumers in western Missouri. Missouri contains a wealth of easily available coal, but it lies in beds commonly 4 feet or less in thickness, and, consequently, cannot be mined as cheaply as the thicker beds of neighboring states. As soon as Illinois and other competing states are forced to obtain their coal from thinner deposits than those now utilized, Missouri's industry will receive an immediate impetus, for Kansas City and St. Louis alone consume three times as much coal as is now produced in the State.

PRODUCTION OF COAL IN MISSOURI FROM 1840 TO 1910, IN SHORT TONS.†

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840.....	9,972	1859....	260,000	1878....	1,608,000	1897....	2,665,626
1841.....	12,000	1860....	280,000	1879....	1,008,000	1898....	2,688,321
1842.....	15,000	1861....	300,000	1880....	844,304	1899....	3,025,814
1843.....	25,000	1862....	320,000	1881....	1,960,000	1900....	3,540,103
1844.....	35,000	1863....	360,000	1882....	2,240,000	1901....	3,802,088
1845.....	50,000	1864....	375,000	1883....	2,520,000	1902....	3,890,154
1846.....	68,000	1865....	420,000	1884....	2,800,000	1903....	4,238,586
1847.....	80,000	1866....	450,000	1885....	3,080,000	1904....	4,168,308
1848.....	85,000	1867....	500,000	1886....	1,800,000	1905....	3,983,378
1849.....	90,000	1868....	541,000	1887....	3,209,916	1906....	3,758,008
1850.....	100,000	1869....	550,000	1888....	3,909,967	1907....	3,997,936
1851.....	125,000	1870....	621,930	1889....	2,557,823	1908....	3,317,315
1852.....	140,000	1871....	725,060	1890....	2,735,221	1909....	3,756,530
1853.....	160,000	1872....	784,000	1891....	2,674,606	1910....	2,982,433
1854.....	175,000	1873....	784,000	1892....	2,733,949		
1855.....	185,000	1874....	789,680	1893....	2,897,442	Total..	107,674,384
1856.....	200,000	1875....	840,000	1894....	2,245,039		
1857.....	220,000	1876....	1,008,000	1895....	2,372,393		
1858.....	240,000	1877....	1,068,000	1896....	2,331,542		

†Mineral Resources U. S. for 1910, U. S. Geol. Survey, 1911, p. 154. Figures for recent years differ slightly from those furnished by the State Mine Inspectors.

The total value of all coal mined in the State is estimated to be more than $200,000,000.

Of the 114 counties in the State, 50 have produced more or less coal and several others have, at various times, mined very small amounts. Statistics for early years are very incomplete and unsatisfactory. The first year of which anything is known of the production by counties is 1860, when the Federal census report credits Cooper with 1,040 tons and Schuyler with 2,840 tons. No other counties were reported. At the ends of the next two decades the census reports were much more complete, as shown in the following table:

PRODUCTION AND VALUE IN 1870 AND 1880.

County.	1870.		1880.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Adair	.....	.....	4,464	$9,220
Audrain	1,200	$2,700	1,174	2,348
Barton	.....	.....	23,501	27,763
Bates	1,923	6,250	308,545	425,215
Boone	1,380	7,090	400	1,000
Callaway	2,450	9,640	951	1,826
Carroll	.....	.....	2,030	5,060
Cass	.....	.....	388	582
Cedar	.....	.....	140	337
Chariton	.....	.....	606	2,410
Cole	1,357	5,320	910	2,800
Cooper	3,000	12,000	8,352	18,204
Dade	.....	.....	1,865	3,225
Henry	900	2,800	56,904	104,319
Johnson	8,000	24,000	6,910	18,300
Lafayette	.....	.....	77,326	132,235
Lincoln	.....	.....	285	626
Linn	2,100	7,140	325	975
Livingston	600	3,700	2,060	6,380
Macon	75,282	212,000	155,520	302,522
Moniteau	1,000	3,000	990	1,778
Monroe	.....	.....	1,175	2,350
Montgomery	.....	.....	2,300	4,725
Nodaway	.....	.....	2,660	7,754
Platte	.....	.....	20	40
Putnam	.....	.....	15,100	19,775
Ralls	.....	.....	200	800
Randolph	27,200	82,250	120,078	233,362
Ray	43,846	132,295	29,480	79,225
St. Charles	5,400	23,435	5,900	19,100
St. Louis	444,642	1,473,000	1,375	2,759
Saline	.....	.....	8,727	19,174
Schuyler	1,400	4,000	30	45
Sullivan	.....	.....	1,600	3,750
Vernon	.....	.....	2,193	4,441
Warren	250	800	.....	.....
Totals	621,930	$2,011,420	844,304	$1,464,425

From 1882 to 1889 incomplete reports of the production of some counties are given in the county and State Mine Inspectors' reports.

PRODUCTION FROM 1882 TO 1889, INCLUSIVE, IN SHORT TONS.

County.	1882.	1883.	1884.	1885.	1886.	1887.	1889.
Adair							16,532
Audrain						91,100	22,298
Barton					46,480	118,103	122,664
Bates	1,040,000	720,000		495,735	537,300	956,345	729,633
Boone							9,944
Caldwell						26,000	26,074
Callaway							12,633
Carroll						8,000	2,439
Cedar							2,070
Chariton							1,951
Cooper						7,000	1,027
Dade							2,290
Grundy						32,306	18,000
Henry	76,000		877,800			178,372	210,376
Howard							1,100
Jasper							720
Johnson					26,530	8,910	12,803
Lafayette					216,000	315,078	320,448
Linn						650	2,136
Livingston							1,381
Macon	239,920	250,000	507,578	250,000	214,149	568,832	223,660
Monroe							222
Montgomery							10,003
Morgan							496
Nodaway							7,758
Putnam	255,000	29,840				105,000	75,877
Ralls							562
Randolph	150,000	109,376	165,000	218,076	151,962	249,470	184,609
Ray		150,000	175,000	88,984	144,514	180,880	207,829
St. Clair							6,880
Saline							832
Schuyler							770
Shelby							275
Sullivan							805
Vernon					74,800	19,950	13,313

In 1889 the State Mine Inspectors began to collect complete statistics on production. The following table shows the output from 1890 to 1910:

RANK AND PRODUCTION OF EACH COUNTY FOR THE LAST TWENTY-ONE YEARS.*

Counties.	Rank	1890.	Rank	1891.	Rank	1892.	Rank	1893.	Rank	1894.	Rank	1895.	Rank	1896.	Rank	1897.	Rank	1898.	Rank	1899.
Bates	1	671,373	1	726,273	2	659,924	2	627,514	4	291,271	3	252,231	2	375,300	2	410,304	3	343,878	2	441,983
Macon	2	457,896	2	454,029	1	685,335	1	788,563	1	511,566	1	539,120	1	519,649	1	490,601	1	720,999	1	739,293
Ray	3	387,346	4	282,247	5	272,948	4	319,405	6	196,852	6	150,998	6	149,083	6	157,652	6	215,348	6	252,683
Lafayette	4	329,845	3	352,603	3	347,600	3	371,928	2	296,931	2	256,761	3	307,286	3	284,448	2	347,857	3	392,608
Randolph	5	245,898	5	224,758	4	297,011	6	219,762	5	209,656	5	218,774	5	230,194	5	243,012	4	314,842	4	354,830
Henry	6	127,281	6	144,139	6	137,258	8	125,962	8	84,473	9	99,058	9	78,551	8	76,023	10	68,261	9	81,373
Putnam	7	91,584	7	123,526	7	134,984	7	145,641	7	119,832	7	111,572	8	85,032	7	101,330	7	121,952	7	126,673
Barton	8	65,097	9	63,026	9	108,784	9	61,301	10	55,767	10	76,242	12	37,570	9	70,554	8	104,233	11	67,844
Vernon	9	33,292	8	64,303	8	119,036	5	234,376	3	297,599	4	237,965	4	303,886	4	281,894	5	252,134	5	298,382
Grundy	10	23,593	10	28,983	13	28,670	12	35,770	12	35,000	12	37,200	10	41,000	11	35,402	12	39,974	13	39,633
Audrain	11	22,813	14	19,569	12	29,792	11	42,262	11	43,910	11	40,918	11	37,611	12	35,167	14	36,498	12	40,759
Boone	12	21,302	12	23,577	14	21,058	14	25,602	17	19,038	14	21,090	15	20,428	18	14,127	16	16,780	14	29,665
Callaway	13	18,355	16	15,581	15	16,551	15	23,961	13	23,223	15	18,771	14	22,182	15	20,152	15	21,281	17	22,356
Caldwell	14	17,074	13	22,661	10	38,333	13	29,020	14	22,869	16	17,876	16	19,780	16	20,000	13	23,000	15	28,000
Adair	15	14,840	15	17,110	17	14,820	16	20,957	15	20,744	13	24,540	13	23,510	13	27,078	11	62,215	8	104,868
Montgomery	16	14,744	17	13,124	16	16,039	17	15,923	19	12,175	18	10,900	18	10,736	17	15,200	26	2,740	27	2,670
Linn	17	13,403	11	28,036	11	35,588	10	48,302	9	71,807	8	100,179	7	92,022	10	67,895	9	83,041	10	72,081
Johnson	18	13,187	18	10,530	18	10,485	18	12,101	18	15,427	19	8,873	24	3,961	23	2,870	21	4,318	23	4,710
Clay	19	5,036	19	8,289	....	.....	19	7,139	16	19,371	23	4,000	20	6,500	19	9,000	30	1,500	20	8,000
Howard	20	4,000	....	.....	....	.....	....	.....	....	.....	25	3,460	25	3,220	25	2,240	....	.....	35	456
Cooper	21	1,594	24	2,200	24	3,666	23	2,892	26	2,639	27	2,492	31	750	34	250	36	514	36	320
Dade	22	1,400	22	3,402	20	6,881	20	6,695	27	2,327	22	5,066	22	4,570	23	2,980	20	4,495	22	4,930
Livingston	23	1,100	33	200	29	1,000	30	1,000	32	800	33	1,050	29	1,155	31	1,468	27	1,817	34	800
Ralls	24	675	29	614	32	280	25	2,160	23	4,400	20	8,489	19	9,644	20	7,843	18	7,768	18	16,014
Saline	25	660	20	7,981	22	4,440	26	1,865	29	1,875	24	3,682	32	432	32	1,281	35	740	32	1,320
Schuyler	26	300	32	280	30	766	32	962	24	3,556	30	1,620	26	2,440	28	2,022	25	2,921	21	5,304
Morgan	27	240	35	36	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	31	1,440	....	.....
Chariton	28	120	27	1,170	25	2,312	28	1,136	34	185	28	1,859	33	355	29	1,573	24	3,488	24	4,517
Monroe	29	108	36	12	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	28	1,810	33	960
Miller	30	87	34	130	33	127	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Shelby	31	40	37	8	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
St. Clair	....	.....	21	3,866	21	5,405	21	6,517	22	5,337	21	5,487	23	4,058	21	5,452	23	3,596	25	4,210
Nodaway	....	.....	23	2,222	26	1,850	24	2,548	25	2,984	29	1,802	21	6,065	24	2,769	33	1,000	29	2,350
Cole	....	.....	25	2,000	27	1,548	27	1,200	28	2,000	32	1,120	....	.....	22	3,794	22	3,704	19	8,600
Cedar	....	.....	26	1,264	23	4,181	33	890	33	730	31	1,590	28	1,863	27	2,178	32	1,244	30	2,116
Jasper	....	.....	28	633	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Sullivan	....	.....	30	560	19	8,800	31	1,000	21	6,600	34	1,000	....	.....	....	.....	....	.....	....	.....
Moniteau	....	.....	31	476	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Pettis	....	.....	....	.....	31	433	34	181	30	1,738	....	.....	....	.....	30	1,470	19	5,400	26	3,200
Carroll	....	.....	....	.....	28	1,380	29	1,088	31	920	26	2,664	27	2,304	26	2,225	34	803	28	2,397
Jackson	....	.....	....	.....	....	.....	22	4,819	20	6,720	17	14,632	17	18,000	14	21,028	17	15,000	16	27,125
Cass	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	30	1,000	33	1,206	29	1,558	31	1,321
Harrison	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Total tons		2,437,399		2,650,018		3,017,285		3,190,442		2,383,322		2,283,081		2,420,147		2,429,388		2,838,152		3,191,811

*From 23rd and 24th Reports, Bureau of Mines, Mining and Mine Inspection of Missouri, 1909 and 1910.

RANK AND PRODUCTION OF EACH COUNTY FOR THE LAST TWENTY-ONE YEARS—Continued.

Counties.	Rank	1900.	Rank	1901.	Rank	1902.	Rank	1903.	Rank	1904.	Rank	1905.	Rank	1906.	Rank	1907.	Rank	1908.	Rank	1909.	Rank	1910.
Bates	3	363,577	4	347,047	4	359,061	7	176,877	8	152,495	9	178,246	8	160,014	9	166,512	7	136,531	10	117,674	10	69,600
Macon	1	595,297	1	1,025,213	1	1,198,133	1	1,119,646	1	899,963	1	817,093	1	782,948	1	1,159,233	1	851,130	1	816,306	1	610,166
Ray	5	248,591	6	264,900	6	280,162	5	356,424	5	225,485	5	226,369	5	280,156	4	349,180	4	294,230	4	301,383	4	232,971
Lafayette	2	377,892	2	439,217	2	539,612	2	539,612	2	713,677	3	705,917	2	648,015	2	712,981	2	571,908	2	724,110	2	559,426
Randolph	4	303,133	3	432,655	3	432,655	3	605,716	4	578,895	4	544,118	4	342,497	11	97,702	15	31,266	7	205,909	6	207,067
Henry	9	129,902	10	103,267	10	91,612	10	87,203	10	113,987	10	132,619	10	122,718	8	166,928	5	216,152	5	279,754	5	209,526
Putnam	10	106,203	9	139,456	9	125,543	9	114,008	12	70,118	12	84,240	11	102,973	13	58,999	10	54,505	11	51,770	11	60,645
Barton	8	141,520	7	183,983	8	200,433	6	185,257	6	199,973	8	196,175	6	267,344	7	191,106	9	103,765	6	217,001	7	168,459
Vernon	6	229,343	8	164,972	7	207,126	8	175,221	7	173,571	6	206,772	9	155,427	6	221,194	11	52,197	15	31,472	14	24,032
Grundy	13	42,371	13	42,361	12	34,936	14	25,563	19	13,647	36	500	23	7,990	22	11,040	18	10,822	18	9,869	18	12,640
Audrain	12	43,530	12	44,066	13	33,435	12	39,009	13	42,578	13	52,434	14	39,940	18	25,463	14	31,391	13	33,336	12	34,546
Boone	17	19,179	16	21,549	15	23,609	15	22,216	14	35,865	14	39,152	17	28,132	16	35,495	16	26,842	16	19,726	16	18,651
Callaway	18	15,120	15	21,562	14	24,483	13	28,882	17	19,754	15	37,645	15	39,660	17	34,748	12	50,719	14	32,491	13	34,278
Caldwell	14	26,000	18	19,021	18	11,853	18	11,485	20	11,866	18	15,000	22	11,419	21	11,656	19	10,800	19	7,815	21	7,300
Adair	7	181,577	5	347,047	5	312,403	4	516,267	3	658,558	2	708,388	3	428,037	3	584,371	3	568,446	3	564,328	3	250,230
Montgomery	29	2,670	28	1,680	26	2,400	27	2,880	26	2,371	24	4,000	31	1,840	29	2,990	29	1,382	24	2,828	28	1,500
Linn	11	81,130	11	85,459	11	79,221	11	64,206	11	102,205	11	91,593	12	97,879	10	124,068	8	104,240	9	132,810	9	86,774
Johnson	20	8,455	20	9,695	19	8,500	25	3,847	23	4,139	17	32,221	18	23,853	12	66,403	20	7,888	21	6,556	20	7,360
Clay	19	12,800	19	16,681	20	8,052	17	18,000	15	32,400	16	34,317	13	42,002	14	40,590	13	37,786	12	44,500	15	22,994
Howard	24	2,944	24	3,685	22	4,350	20	9,051	25	2,694	20	11,954	20	14,949	20	13,456	21	7,438	33	611	31	664
Cooper	32	1,000	33	1,265	33	945	34	315	35	500	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Dade	28	2,350	21	5,393	21	5,180	22	8,260	27	2,286	31	1,646	28	2,151	34	1,912	23	4,654	22	5,592	24	4,436
Livingston	23	3,813	34	1,177	34	800	29	2,068	30	1,539	26	2,810	29	2,150	33	2,270	30	1,010	32	735	30	725
Ralls	15	20,956	14	25,238	17	20,150	16	18,085	18	16,902	19	14,961	19	17,073	19	16,768	17	14,415	17	15,237	17	17,658
Saline	34	500	35	942	36	205	....	.....	....	.....	33	1,410	32	900	35	845	36	150	35	100	....	.....
Schuyler	21	4,253	23	3,800	23	3,373	19	9,077	16	21,860	22	5,292	30	2,094	24	4,840	26	2,425	26	2,300	26	1,943
Morgan	35	300	29	1,674	35	446	23	4,183	21	4,200	32	1,500	35	600	30	2,640	27	1,683	28	1,680	....	.....
Chariton	25	2,940	30	1,447	27	2,025	33	956	32	625	21	10,651	16	29,044	15	36,474	31	879	31	1,007	29	925
Monroe	33	822	31	1,445	29	1,980	28	2,451	28	1,682	35	730	....	.....	....	.....	33	800	34	450	32	600
Miller	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Shelby	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
St. Clair	22	3,892	22	4,539	24	3,139	24	3,963	31	1,229	27	2,559	21	13,220	32	2,360	32	812	29	1,360	27	1,500
Nodaway	27	2,371	26	2,000	30	1,590	....	.....	....	.....	28	2,063	33	731	37	120	....	.....	....	.....	....	.....
Cole	....	.....	25	2,280	32	1,045	32	1,440	29	1,600	23	5,080	27	2,720	31	2,401	34	500	25	2,466	25	3,100
Cedar	31	1,095	27	1,730	25	3,107	31	1,554	36	330	37	408	....	.....	....	.....	35	165	....	.....	34	185
Jasper	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Sullivan	....	.....	....	.....	....	.....	....	.....	....	.....	30	1,666	....	.....	28	3,000	24	3,263	23	4,972	22	7,200
Moniteau	....	.....	36	480	37	143	....	.....	34	576	34	1,146	24	3,550	25	3,552	25	3,100	27	1,792	....	.....
Pettis	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Carroll	30	1,575	32	1,430	28	1,985	30	1,570	33	604	38	164	34	717	23	4,850	28	1,581	30	1,210	33	560
Jackson	16	20,900	17	20,000	16	21,000	21	8,500	24	3,348	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....
Cass	26	2,745	....	.....	31	1,350	26	3,316	22	4,173	29	1,882	25	3,422	26	3,400	22	5,340	20	7,500	19	9,938
Platte	....	.....	....	.....	....	.....	....	.....	9	126,217	7	205,535	7	210,197	5	259,849	6	190,306	8	204,098	8	136,934
Benton	....	.....	....	.....	....	.....	....	.....	....	.....	25	3,700	26	3,297	27	3,106	....	.....	....	.....	....	.....
Lewis	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	36	210	37	123	....	.....	....	.....
Harrison	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	23	4,700
Total tons...		2,995,022		3,810,767		4,063,572		4,265,328		4,241,912		4,381,956		3,889,659		4,355,494		3,400,644		3,850,748		2,809,215

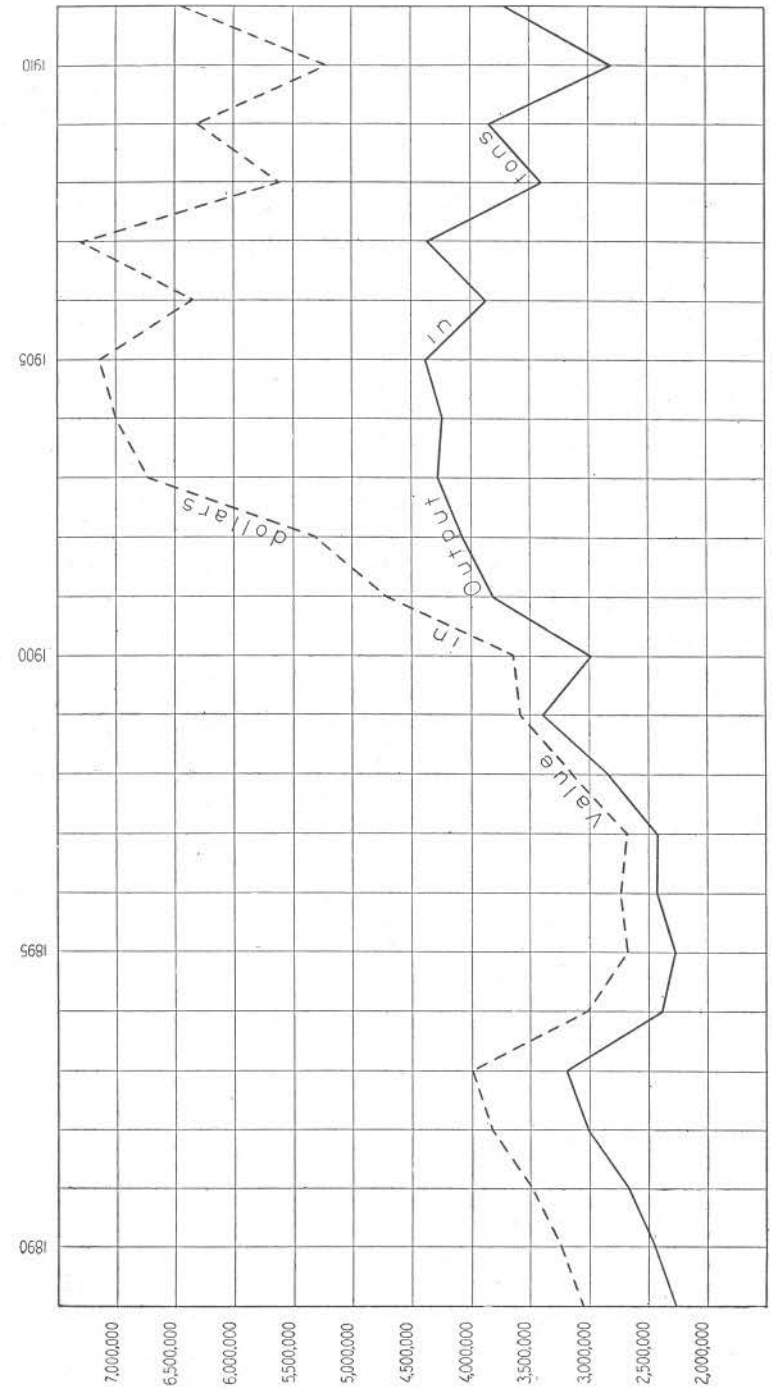

Fig. 3. Amount and Value of Missouri's Coal Output since 1889.

THE VALUE OF COAL LANDS.

There is a constant tendency on the part of farmers and other land owners to underestimate the value of the mineral fuel in the ground beneath them. The coal under many farms is worth much more than the surface, yet the writer was much impressed by the fact that many property holders had paid little or no attention to the wealth concealed beneath the ground. In pricing the lands of the public domain the U. S. Geological Survey estimates that one acre of ordinary bituminous coal one foot thick contains 1800 tons of coal and that all beds not less than 14 inches thick and not more than 3000 feet below the surface are workable. In Missouri no coal beds are as much as 3000 feet deep and many beds of 14 inches or less are mined. All of the 1800 tons per acre-foot cannot be recovered. Under the best systems of longwall mining more than 1500 tons per acre can be obtained. In room and pillar mining, as commonly practiced in many fields, as little as 1000 tons is recovered. The proportion of Missouri coal mined on the longwall plan is increasing from year to year, however, and in time room and pillar mining will become the exception rather than the rule.

The proper determination of the value of coal lands depends on a large number of factors, many of them variable. The character and thickness of the coal beds and the rocks immediately above and below them, their accessibility, their dip, the amount of water that may enter the proposed mines, and many other factors must be considered. One of the most important of all considerations is the marketability of the product as determined by competition with coal from the same and other fields and with other fuels, by the distance to large centers of consumption, by railroad facilities, and by other factors. Another is the cost of labor as regulated by the miner's unions and the law of supply and demand.

Coal in the ground is generally bought by one of two methods—by royalties and by outright purchase with or without the surface rights. Royalties are of course variable, but average about 5 cents a ton where operations are large and 1 cent a bushel or 25 cents a ton where only a local trade is supplied by small mines. With a royalty of 5 cents a ton the return for every foot of coal in the bed mined, assuming a recovery of 1300 tons per acre-foot, is $65.00 an acre. The actual value to the land owner will, however, depend on the rate at which the coal is mined, as he is receiving no interest or other return upon his investment until royalty payments are made. Many contracts therefore restrict within certain definite limits the time allowed for the completion of mining. When coal is purchased outright the

amount paid per acre-foot is considerably less than when royalties are paid. The reason for this is explained by G. H. Ashley as follows:*

In general, the sale price of coal land must necessarily be less than the gross royalty income that the same land would bring at the prevailing royalties. In the first place, the net royalty income derived by the lessor may be quite different from the gross income. There is the cost of collection, and possibly of inspection, which may amount to 5 to 10 per cent or more of the gross income. In the second place, the operator who buys his coal land rather than leases it must pay interest and taxes on it from the time of the purchase until the coal has been mined out. These should be computed on the average length of time each acre is carried. If mining is started immediately after purchase and is continued regularly for twenty years, the average time of carrying the coal will be ten years. The first cost of the land may be increased one-half to three times or more, the increase depending on the rate of interest, so that a tract of land bought for $100 an acre may have actually cost $150 to $300 or more an acre by the time the coal is mined. In other words, an acre of land that, when mined ten years hence, would yield $500 in royalties would be worth today, if interest is 5 per cent and taxes are left out of account, $314; with interest at 7 per cent it would be worth today $253; at 10 per cent only $108. Taxes would still further decrease these amounts. If twenty years be taken as the life of the average active mine, the first acre of coal will be mined out the first year, the last acre the twentieth year, and the average acre in ten years. On a tract of land, therefore, that, it is confidently estimated, will be mined out within twenty years the purchase value can hardly be more than one-half the estimated royalty value. If that value be again cut in half on the possibility that the estimated tonnage may be too large, the buyer is made doubly secure. It may therefore be confidently said that where the conditions are favorable to the almost immediate development of a piece of coal land, its purchase value may be estimated at from one-fifth to one-half its estimated royalty value.

The above brief summary shows the great importance of the coal resources of a district. A man who owns 40 acres of land containing a 3-foot bed of coal will receive for it under average conditions about $7,400, provided he is paid a royalty of 5 cents a ton. He will, moreover, still retain full ownership of the surface. Should he elect to sell his coal rights for a lump sum, his profits would be about the same, for, although he would receive less per acre, he would be in a position to invest the purchase money at once and would be free from all anxiety concerning the fortunes of the mines.

THE TOTAL ORIGINAL TONNAGE.

Any estimate of the total amount of coal in the ground before mining began must necessarily be only approximate and in some districts little better than a guess. It is believed, however, that the estimates contained in the following table, based as they are upon the

*The value of coal land, Bull. U. S. Geol. Survey No. 424, 1910, p. 13. This article contains much useful information concerning the value of coal land in the United States.

best available evidence, are of value. Estimates are given in more detail in the county reports and are made on the basis of 1800 tons per acre-foot, beds or parts of beds less than 14 inches thick not being included:

TOTAL ORIGINAL TONNAGE.

County.	Tons.	County.	Tons.
Adair	2,263,628,000	Jasper	100,000,000
Andrew	1,209,600,000	Johnson	5,460,000,000
Atchison	411,840,000	Lafayette	877,440,000
Audrain	1,320,000,000	Linn	2,190,080,000
Barton	464,256,000	Livingston	1,532,160,000
Bates	3,989,760,000	Macon	2,985,888,000
Boone	846,706,000	Mercer	4,329,600,000
Buchanan	4,203,360,000	Monroe	288,450,000
Caldwell	1,260,380,000	Montgomery	315,560,000
Callaway	450,928,000	Nodaway	914,720,000
Carroll	1,000,000,000	Pettis	300,000,000
Cass	2,460,672,000	Platte	3,384,960,000
Cedar	170,312,000	Putnam	4,296,192,000
Chariton	2,168,000,000	Ralls	44,000,000
Clark	200,000,000	Randolph	2,020,664,000
Clay	1,953,600,000	Ray	1,098,240,000
Clinton	1,521,216,000	St. Clair	602,880,000
Dade	33,880,000	St. Louis	70,846,000
Daviess	2,752,704,000	Saline	337,120,000
DeKalb	1,209,600,000	Schuyler	337,920,000
Gentry	1,280,496,000	Scotland	20,000,000
Grundy	1,416,960,000	Sullivan	2,971,128,000
Harrison	3,363,840,000	Vernon	1,257,408,000
Henry	1,832,720,000	Worth	1,140,480,000
Holt	823,200,000	Other counties	500,000,000
Howard	1,280,690,000		
Jackson	2,097,792,000	Total for State	79,362,016,000

Of this total about 110,000,000 tons, or less than one-fifth of 1 per cent, have been mined and utilized and perhaps 50,000,000 tons more rendered unfit for use by mining operations, leaving in the ground 79,343,514,000 tons. In actual mining practice not more than 60 per cent, or 47,702,108,400 tons, will be recovered, even under the most ideal market and labor conditions.

CHAPTER IV.

DETAILED DESCRIPTION BY COUNTIES.

ADAIR COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....493,807 TONS.

Adair ranks third among the producing counties of the State, and is easily entitled to that position by her coal resources. There are not many other Missouri fields in which coal beds three to four feet in thickness are as accessible. Although it is only within the last two decades that operations have been conducted on a large scale, four large companies now own mines near Connelsville and Novinger and ship coal to St. Joseph, Mo., and Omaha, and other points in Nebraska. Market and labor conditions are not of the best, however, and it appears that the producing capacity of the mines now exceeds the profitable demand. The change from room and pillar to longwall mining, now in its experimental stages at Novinger, bids fair to change conditions for the better, provided that a suitable wage scale can be arranged with the miners.

Several formations are represented in the county. The comparatively thick limestone beds at the base of the Missouri group, described more fully in the report on Sullivan county, may be found in isolated patches on the hills bordering the Chariton river in the southern part of the county. Below these is the Pleasanton, in some places consisting largely of shale and in others of sandstone or a mixture of shale and sandstone. The Pleasanton is about 120 to 160 feet in thickness and occurs chiefly south of the Quincy, Omaha and Kansas City railroad.

The next lower formation is the Henrietta, which consists of about 30 to 50 feet of thin alternating beds of limestone and shale, as shown in the Danforth and other records published farther along in this chapter. This formation contains a greater proportion of limestone than any other assemblage of strata of equal thickness below the Missouri group, and is consequently a useful marker for the position of the coal beds. It outcrops on all the higher lands near the main streams west of the

*The geology of Adair county was first described by G. C. Broadhead: Mo. Geol. Survey, 1873-1874, pp. 242-256. The writer is unable to agree with his general section, pp. 222-226. Winslow very briefly described former mines: Mo. Geo. Survey, 1891, pp. 59-62.

Wabash railroad. Below it is the Cherokee, composed of shale and sandstone with a few thin limestones. Only the upper 100 feet are exposed within the county, but the total thickness found in the few drill records that have penetrated the entire formation ranges from 280 to more than 335 feet. The thickness of the Cherokee varies, not only because of changes in its constituent beds, but also because of the uneven upper surface of the Mississippian limestone upon which it rests. The Mississippian consists of heavy beds of a flinty limestone that is well known to drillers, as its top marks the lower limit of coal.

The highest coal beds lie at several horizons in the Pleasanton shale, especially at one about 30 feet from its top. Comparatively little is known about these deposits and so far they have not proved to be of importance, though one bed southeast of Youngstown is 30 inches thick and has been mined. Pleasanton coals appear to be of inferior quality and sufficiently thick to be workable at present only in small areas.

The highest important coal is the Lexington, which lies a few feet below the base of the Henrietta formation. In the northwest corner of the county it is a remarkably regular bed about 33 inches thick, with a limestone cap and sump rocks that simplify its mining. It is a superior domestic fuel, the same as that so extensively mined at Unionville, Mendota, Coal City, Centerville, Mystic, and other points north and northwest. In Adair county it is mined by a shipping plant at Stahl and by local drifts on Spring and Shuteye creeks. Although the coal is in many places traversed by numerous clay veins and the roof weakened by fractures and drift channels, it is certain that a bed so easily reached from the main valleys will be much more extensively utilized in the future. One of the remarkable features of this bed is the persistent occurrence in it of two very regular and thin clay partings.

East of R. 17 W. the Lexington coal thins so as to become unworkable. Near Connelsville and Novinger it measures 15 inches or less; farther south, along the Chariton and near Kirksville, it is represented only by black shale or a few inches of coal; in the eastern half of the county it is thin or absent and most of the rocks near its horizon have been removed by pre-glacial erosion.

About 50 feet below the Lexington horizon is that of the Summit coal, locally known as the "slate vein." In Adair county the Summit consists only of slaty shale and a few inches of coal, but, with the thin limestone just above and below it, serves as a good marker for the lower coals. From 85 to 100 feet below the Lexington horizon is the Bevier coal bed, the one mined in the Bevier-Ardmore districts of Macon county and farther south. Along both sides of the Chariton river, from near the Schuyler county line to Youngstown, the Bevier is a fair steam coal three to four feet thick. Like the Lexington bed, it contains two clay partings, the lower being the thicker and more persistent. The bed is

hard and contains impurities consisting of iron pyrites ("sulphur") and some clay. The underclay rests on limestone and is several feet thick, but, because of the dryness of the mines, gives comparatively

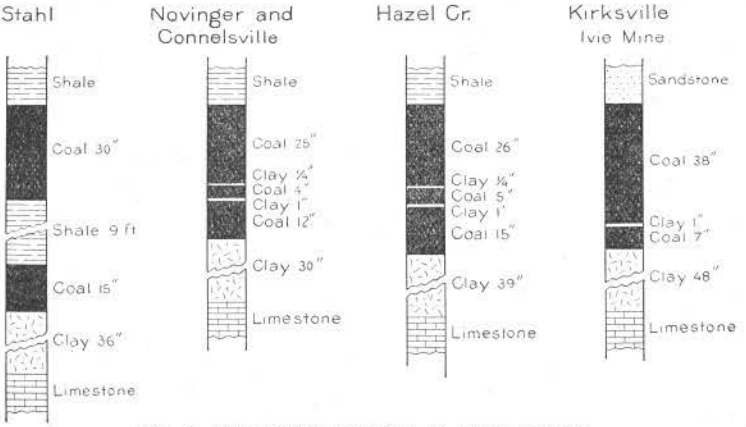

Fig. 4. The Bevier coal bed in Adair County.

little trouble. In the better districts, near Connelsville and Novinger, the roof is a thick shale overlain by sandstone. East of the Chariton the sandstone comes down close to or next the coal and in many areas cuts out the upper bench. This difficulty was encountered in mines on Rye and Big creeks and in the Star mine on the west side of Kirksville, though at the Ivie mine and other places the lower surface of the sandstone is even and the full thickness of the coal is present. About two miles northwest of Novinger, near Danforth, the lower clay parting thickens so as to be a serious detriment in mining. At Stahl there is nine feet of clay and shale between the two benches of coal, so that only the upper one can be recovered. At Milan, in Sullivan county, the two benches approach each other closely, showing that the thickening of the parting at Stahl may be more or less local, and not one that continues to increase to the west. It is not known whether the Bevier coal bed is of workable thickness in the southwestern part of the county. Unless the material just above the coal horizon is a sandstone with irregular base, as at the Star mine, there must be large productive areas in the region.

From 45 to 65 feet below the Bevier bed is the Tebo coal, a bed very regularly two feet in thickness. It has been found in drillings at Stahl, Novinger, and Kirksville, and observations in neighboring counties lead to the belief that it extends much farther south. As it lies too low to crop out and no shafts have been sunk to it, little can be said about its quality or the ease with which it could be mined. The few drillings that have penetrated below the Tebo have reported no lower coal that is workable. If lower beds exist, they lie in basins of more or less restricted extent.

As to what lies east of the Wabash railroad, little is known. The country is so covered with loose surface material that no outcrops of the solid rocks are to be seen. It seems probable that the drift is so deep in most of this region as to have replaced much of the Coal Measures. The deep well at Kirksville penetrated 170 feet of drift, borings 12 miles northeast of the city, 175 feet; and one at Green Top, 201 feet. In the drilling last named, six inches of coal were found at 206 feet and operations stopped in sandstone and shale at 235 feet.

The structure in Adair county is governed by an anticline or arch, whose highest points lie along a line trending northwest-southeast and passing through Putnam and Schuyler counties. From the north county line to Connelsville the Bevier bed lies a few feet above river level. At Novinger it is below the stream and nearly 80 feet lower than at the county line. At Youngstown and Yarrow it is about 50 feet below the Chariton. The southerly component of the southwesterly dip is therefore slightly greater than the fall of the stream. From Connelsville to Novinger and from Shuteye creek to Stahl the dip is exceptionally great.

The following table shows the quantity of coal in beds or parts of beds more than 14 inches thick, computed to run 1,800 tons of coal per acre-foot. Of the original tonnage considerably less than 1 per cent has been mined and utilized:

TOTAL ORIGINAL TONNAGE OF ADAIR COUNTY.

Thickness of beds (in inches).	Tons of coal.
T. 64 N., R. 16 W.—	
Bevier 36, Tebo 18	62,208,000
T. 64 N., R. 17 W.—	
Lexington 34, Bevier 28, Tebo 24	138,816,000
T. 63 N., R. 16 W.—	
Bevier 38, Tebo 24	212,976,000
T. 63 N., R. 17 W.—	
Lexington 30, Bevier 30, Tebo 24	278,784,000
T. 62 N., R. 16 W.—	
Bevier 36, Tebo 24	207,360,000
T. 62 N., R. 17 W., and T. 61 N., Rs. 16 and 17 W.—	
All beds (conjectural)	466,560,000
Ts. 61-64 N., inclusive, R. 15 W.—	
All beds (conjectural)	606,720,000
Ts. 61-64 N., inclusive, R. 14 W.—	
All beds (conjectural)	290,204,000
Total	2,263,628,000

DETAILED MENTION.

Stahl.—Both the Lexington and Bevier beds have been mined by shipping mines at Stahl, though operations are now confined to the upper bed. The Consolidated Stahl Coal Company has two drifts near the town,

No. 2 (N. W. ¼ S. W. ¼ Sec. 2) is a small mine that is not yet in full operation. No. 1 (N. E. ¼ N. E. ¼ Sec. 3), however, has worked out 120 acres and shipped a considerable product over a spur from Stahl. A haulage motor and two undercutting machines obtain power from an electric plant at the mine. The room and pillar system was formerly used, but the longwall system, now employed, is much better adapted to this bed and produces only six per cent of slack. The coal is excellent for domestic use, and has a vertical jointing that produces a semi-block coal. The roof, which is supported by a limestone cap-rock, is strong. In parts of the mine a tough drift clay containing pebbles and boulders cuts out the regular roof and has caused much trouble; it does not cut into the coal, however, and with proper care can be supported. In places small fissures occur in the cap-rock and clay seams run at high angles through the coal. Where the bed is normal the conditions for mining are excellent. The thickness of the bed, which lies 50 feet above the depot at Stahl, and the characteristic clay partings are shown in the accompanying figure:

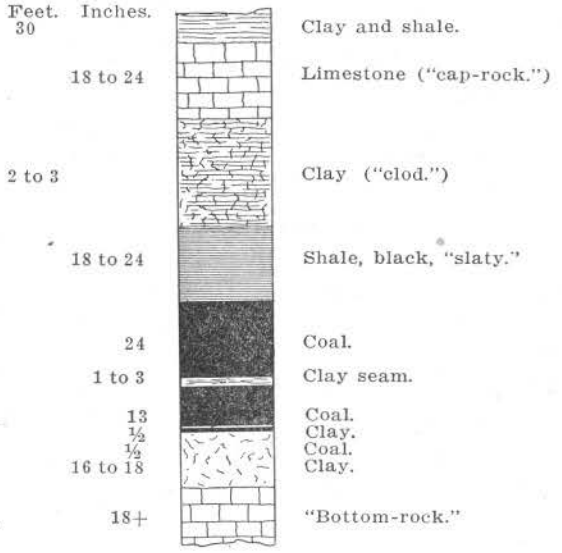

FIG. 5. The Lexington coal bed at Stahl.

In 1897 a shaft was sunk at the Stahl depot to the Bevier coal, which lies about 100 feet below the Lexington bed. The thin parting seen in the Bevier at Novinger is nine feet thick at Stahl, so that only the upper bench of 30 inches was mined, and was soon abandoned. It may be that this mine would have been more of a success if longwall instead of room and pillar working had been used.

SHAFT AND DRILLING NEAR STAHL DEPOT.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Surface material	1	....	1	....
2.	Limestone, bluish gray	1	6	2	6
3.	Shale, black, rotten ("slate vein")	1	....	3	6
4.	Clay	5	....	8	6
5.	Limestone, blue gray	1	2	9	8
6.	Shale, dark blue, with limestone concretions	39	....	48	8
7.	COAL (Bevier, upper bench)	2	6	51	2
8.	Clay, or sandy shale	9	....	60	2
9.	COAL (Bevier, lower bench)	1	3	61	5
10.	Clay	3	....	64	5
11.	Limestone (bottom of shaft)	4	....	68	5
12.	Shale	4	5	72	10
13.	Limestone	1	3	74	1
14.	Shale and limestone, alternating	36	8	110	9
15.	COAL (Tebo)	2	....	112	9
16.	Clay	1	....	113	9
17.	Limestone	8	....	121	9
18.	COAL and clay, mixed	3	6	125	3
19.	Clay	2	....	127	3
20.	Limestone	5	7	132	10
21.	Shale	48	....	180	10
22.	Sandstone	4	....	184	10
23.	Shale, black	4	....	188	10
24.	Sandstone	19	....	207	10
25.	Shale, "slaty," and a little COAL	29	....	236	10
26.	Limestone	9	....	245	10
27.	Shale, "slaty"	49	....	294	10

Shafts were sunk at Dewey, one and one-half miles west of Stahl on the railroad, but the Lexington bed was considered too "faulty" to be worked and the Bevier too thin, so that the camp was soon abandoned. The Lexington coal outcrops in the valley of Spring creek to the Sullivan county line and beyond, and in that of Shuteye creek and its tributaries north and northwest of Stahl. The bed lies at a higher elevation on Shuteye than on Spring creek, indicating a dip to the southwest. Three miles northwest of Stahl is the Karl Maiwald local mine (N. W. ¼ Sec. 28, T. 64 N., R. 17 W.), where the thickness of the coal and partings is almost identically the same as at the Stahl drift, though "slips," drift channels, and other hindrances to mining are less common. There are eight inches of black "slaty" shale and six of clay between the clay and the limestone cap. As in other parts of the district, the whole cap-rock is formed by three or four limestone beds, two feet or less thick, separated from one another by shale beds of nearly the same thickness. In minor details these overlying strata vary within short distances. Below the coal there are 18 inches of clay to a limestone sump-rock. One mile southwest the Lexington is intermittently worked:

LEXINGTON BED AT DUDLEY'S MINE (N. E. ¼ N. E. ¼ SEC. 32, T. 64 N., R. 17 W.).

	Inches.
COAL	27
Clay	1½
COAL	10
Clay	½
COAL	1½

Here there are eight inches of "slaty" shale that comes down with the coal and two feet of clay and shale to the limestone cap-rocks. The underclay is two feet thick to the sump-rock. Mining conditions are said to be good. Near Shuteye creek, above Shibleys Point, are the small drifts of G. W. Young and A. Walker (S. E. ¼ Sec. 21, T. 64 N., R. 17 W.). The bed mined is the same as at Dudley's, except that the upper bench of coal is 22 inches. The overlying "slaty" shale is five inches, and the "clod" between it and the cap-rock eight inches. The mines are 40 feet, more or less, above the bottom lands of the creek. Mining conditions are fairly good; small "clay slips" are numerous and injure the roof, though not the coal. The Lexington bed outcrops down Shuteye to beyond Shibleys Point, preserving its characteristics with remarkable fidelity.

Small drifts have been worked south of Stahl but are now abandoned. The coal is of excellent quality and in greater part has a strong roof, but the bed is "faulty" in places.

BLUFF ON TURKEY CREEK, TWO MILES SOUTH OF STAHL.

		Feet.	*Inches.*
1.	Limestone, in one bed	....	8
2.	Shale, light	....	5
3.	Limestone, with thin partings	1	1
4.	Shale, light gray	1	6
5.	Shale, black, "slaty" at base	1	....
6.	COAL, 21 inches Clay, 3 " COAL, 14 " (Lexington)	3	2
7.	Clay	1	11
8.	Limestone	2	4
9.	Shale and sandstone, alternating	6	8
10.	Sandstone, yellowish brown	10	....

Danforth.—Several shafts were formerly operated near Danforth, an old camp two miles northwest of Novinger. West and north of Danforth the main clay parting of the Bevier bed was very sandy and thickened to as much as 12 inches in places, causing work to be abandoned. The "bench rock" evidently thickens still more toward the northwest, as shown in the old shaft at Stahl. The mines at and a half mile south of Danforth found the coal much the same as at Novinger, but were also abandoned before all the available coal had been extracted. The following record, made near the mine south of Danforth, gives an excellent summary of the rocks above the coal:

DANFORTH RECORD (N. E. ¼ S. W. ¼ SEC. 30, T. 63 N., R. 16 W.).

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Surface material	5	....	5	....
Henrietta formation—					
2.	Limestone	2	....	7	....
3.	Clay	....	6	7	6
4.	Limestone	2	6	10	....

DANFORTH RECORD (N. E. ¼ S. W. ¼ SEC. 30, T. 63 N., R. 16 W.).

		Thickness. Feet.	Thickness. Inches.	Depth. Feet.	Depth. Inches.
Cherokee shale—					
5.	"Slaty" shale, COAL (Lexington), and clay	7	....	17	....
6.	Limestone	2	8	19	8
7.	Clay	....	6	20	2
8.	Limestone	....	2	20	4
9.	Shale	....	2	20	6
10.	Sandstone	3	1	23	7
11.	Shale	21	4	44	11
12.	Limestone	....	8	45	7
13.	Shale, black, "slaty," with "bat" at base	2	....	47	7
14.	COAL (Summit)	....	6	48	1
15.	Clay and shale	11	2	59	3
16.	Limestone	2	6	61	9
17.	Shale, gray, "slaty"	5	7	67	4
18.	Limestone	4	7	71	11
19.	Shale, gray, "slaty"	35	8	107	7
20.	"Bat"	4	....	111	7
21.	COAL (Bevier), 1½-inch clay seam 1 ft. from base	3	7	115	2
22.	Clay	1	5	116	7

Novinger.—The town of Novinger owes its present size and prosperity entirely to the large coal mining industry that has developed in its vicinity within recent years. All except one of the mines are large and fairly well equipped with steam hoisting apparatus and other machinery. Motor haulage is not yet in use.

NOVINGER MINES, 1910.

Name.	Location (T. 63 N., R. 16 W.).	Depth of shaft.
Kansas City Midland No. 2	S. W. ¼ S. W. ¼ Sec. 16	146
Kansas City Midland No. 3	S. W. ¼ N. W. ¼ Sec. 21	95
Rombauer No. 2	N. E. ¼ N. E. ¼ Sec. 29	75
Rombauer No. 3	S. W. ¼ N. E. ¼ Sec. 17	82
Rombauer No. 4	N. W. ¼ N. W. ¼ Sec. 20	92
Great Northern No. 1	N. W. ¼ N. E. ¼ Sec. 20	85
Great Northern No. 21	S. E. ¼ N. W. ¼ Sec. 6 (T. 62, R. 16)	137
Great Northern No. 23	N. E. ¼ S. E. ¼ Sec. 32	65
Manufacturers No. 50	S. E. ¼ N. W. ¼ Sec. 32	74
Artic	S. E. ¼ S. E. ¼ Sec. 29	43

In addition to these two shafts, Great Northern No. 31 (N. W. ¼ S. E. ¼ Sec. 4, T. 62 N., R. 16 W.) and No. 22 (N. E. ¼ S. E. ¼ Sec. 6, T. 62 N., R. 16 W.), are equipped with top works, but are not producing. All of these mines and old mines in the same district have exhausted the coal under more than 1,500 acres. The product is shipped to points west, especially to the large cities along the Missouri river.

The bed mined at Novinger is the Bevier and is a fairly good steam coal. It is harder than the Lexington and is not so well adapted to domestic use. The thickness of the bed varies from 30 to 50 inches, but

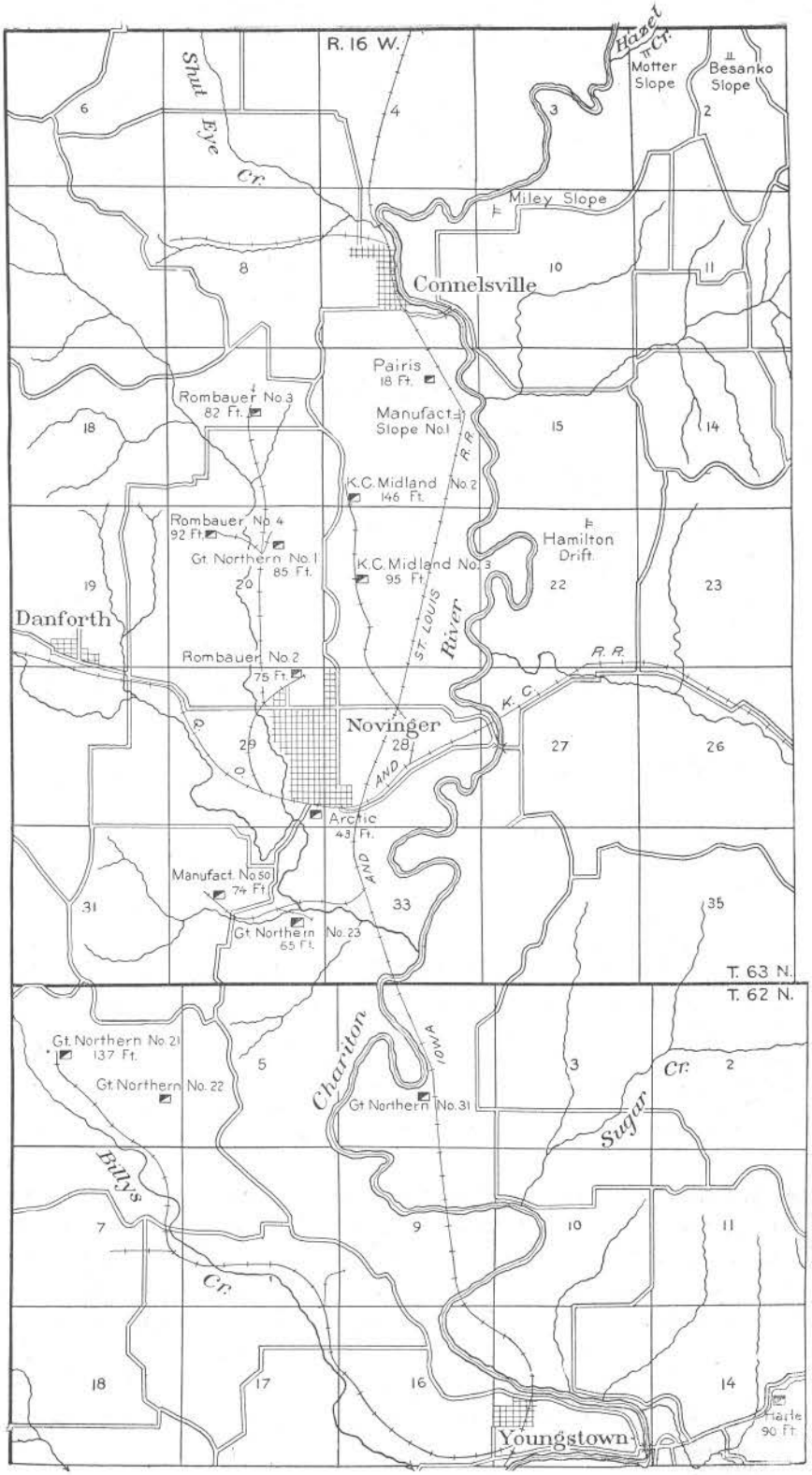

Fig. 6. Map of Connelsville-Novinger Coal Fields.

in general is very uniform. Measurements made in the mines both north and south of Novinger are remarkably similar and average as follows:

	Inches.
COAL	25
Clay	¼
COAL	4
Clay	1
COAL	12

The upper bench of coal contains some "bright sulphur" in horizontal streaks and lenses near the top and a streak of "bone" at the bottom; the middle bench is bright and clean; the lower is in many places very dirty, containing pockets of "brown sulphur," a mixture of coal, clay and iron pyrites. The clay bands are hard and stick to the coal, being detrimental to economical mining. The upper band is absent in places. The lower clay band is commonly ½ to 1½ inches thick, but in the northwest workings of Rombauer No. 3 is 3 to 15 inches, resembling that found in some of the Danforth mines. Some rolls in the roof cut out part of the upper coal and vertical clay veins traverse all or part of the entire bed here and there. The coal appears to be somewhat more free from foreign material south than north of Novinger.

Over the coal is a dark shale, "slaty" and containing considerable calcareous matter at the base. It is brittle and, as a mine roof, needs careful attention. In places a very thin layer of very carbonaceous, friable shale ("bat") bearing pyritized shells lies on the coal. After the roof stands for a short time large quantities of white crystals gather on it and fall to the floor in heaps like snow. These are erroneously known as "saltpeter" to the miners, but are in reality melanterite (hydrous ferrous sulphate). Under the coal is an irregular bed of clay, in most places two to three feet thick, which rests on a limestone of about the same thickness. As the mines are notably dry, this clay remains hard and rarely "heaves." Up to a short time ago the room and pillar system of mining was universally employed, but an experiment is being made in Rombauer Nos. 3 and 4 with longwall. As the coal is harder than the roof, holes are drilled about eight inches from the top of the bed and a device known as the hydraulic cartridge is placed in them to force down the coal. The bed parts along a line connecting the holes and along the clay bands, yielding a large proportion of lump. The top coal is then easily taken down. Owing to the nature of the roof, props must be kept close to the face and gob walls must be carefully constructed along the haulage ways. In spite of the difficulties encountered and the expense of operating the hydraulic cartridge, the longwall plan bids fair to be successful and to revolutionize methods of mining in this and similar fields.

On the east side of the Chariton, northeast of Novinger, numerous small abandoned openings occur in the Bevier bed, which lies 10 feet above the bottom lands. In places there are three feet of black shale over 24 inches of coal and under the massive sandstone that lies at varying distances above the coal near Novinger. At the J. A. Hamilton local drift (N. W. ¼ N. E. ¼ Sec. 22, T. 63 N., R. 16 W.), operated by L. M. Dixon, the sandstone lies on the coal and, because of its rolling under surface, cuts out much of the bed and causes it to vary from 10 to 36 inches in thickness. The two clay partings are in the positions occupied by them in the shipping mines, the upper one-fourth inch thick, and the lower six inches. It is reported that in mines once operated at Frye, half way between Novinger and Kirksville, the coal bed was 32 inches thick, and only 18 inches not far distant. Evidently the thickness of the coal is very unreliable in this district.

The Lexington coal bed thins to the east between Stahl and Novinger, so that near the latter town it is less than 14 inches thick in places. Higher rocks are well exposed on the road near Manufacturers No. 50 and Great Northern No. 23.

OUTCROP ONE MILE SOUTH OF NOVINGER (N. E. ¼ S. W. ¼ Sec. 32, T. 63 N., R. 16 W.).

		Feet.	*Inches.*
Henrietta formation—			
1.	Limestone, light gray, massive (top of Henrietta?)	1	6
2.	Shale, with fragmentary limestone six feet from top	18	....
3.	Limestone, brown, conglomeratic	....	8
4.	Shale, light gray	1	....
5.	Limestone, buff, four-inch shale band in center	1	6
6.	Shale, sandy and calcareous	3	....
7.	Limestone	1	8
Cherokee shale—			
8.	Shale, light above, dark below	1	4
9.	COAL, 11 inches Clay, ¼ inch COAL, 3 inches (Lexington)	1	2
10.	Clay and shale	2	....
11.	Limestone, buff, upper surface rough	2	10
12.	Sandy shale and sandstone	20	....
	To Bevier coal bed in neighboring shafts	72	....

It is reported that there is in the Bevier district a very persistent coal bed of 24 to 30 inches (Tebo) about 55 feet below the Bevier horizon. No attempt has been made to develop it.

Connelsville.—The Manufacturers Coal and Coke Company formerly operated several shipping mines within a radius of a mile from Connelsville, though at present only No. 1 is open. This is less than one mile south of town (S. E. ¼ N. E. ¼ Sec. 16) and is a slope to the Bevier bed, which lies at about the level of the river bottoms. The average thickness of the three benches and of the clay partings is the same as that given for the average in the Novinger district. Except at the top, the coal is fairly clean. The roof is a dark gray shale. Room and pillar is the method of working and cable haulage is used on the slope. J. P.

Pairis operates a local slope and horse-whim shaft between No. 1 and Connelsville (N. E. ¼ N. E. ¼ Sec. 16). The upper bench of coal is 27 inches, the middle 5, and the lower 11; the upper and lower clay partings are one-fourth and one inch, respectively. The following record of the abandoned mine one mile west of Connelsville was furnished by James Stroup:

SHAFT RECORD OF MANUFACTURERS NO. 7 (S. W. ¼ N. W. ¼ SEC. 5, T. 63 N., R. 16 W.).

		Thickness. Feet.	Thickness. Inches.	Depth. Feet.	Depth. Inches.
1.	Drift clay, yellow	15	....	15	....
2.	Limestone	....	6	15	6
3.	Shale, blue, "slaty" (horizon of Summit coal)	5	....	20	6
4.	Clay	4	....	24	6
5.	Limestone	2	6	27	....
6.	Clay (shale?)	30	....	57	....
7.	Limestone	1	2	58	2
8.	Shale	22	....	80	2
9.	COAL, 30 inches Clay, 1 inch COAL, 12 inches (Bevier)	3	7	83	9
10.	Clay	4	....	87	9
11.	Limestone	2	....	89	9

On the east side of the Chariton small local mines have been operated for many years. One mile east of Connelsville (N. W. ¼ N. W. ¼ Sec. 10) is the short slope of J. H. Miley, operated by James Ray, where the Bevier lies a few feet below the bottoms. The upper bench of coal is 25 inches, the middle 3½, and the lower 10; the upper clay parting is one-fourth and the lower one-half inch. The bottom coal contains considerable "brown sulphur" and the top of the upper shows "light sulphur." In working room and pillar the upper eight inches of coal is not thrown by the shots.

Near the mouth of Hazel creek the Bevier lies at about the level of the river bottoms, and is mined in short slopes by Neff and Lee on land of N. Motter (N. W. ¼ N. W. ¼ Sec. 2, T. 63 N., R. 16 W.) and by F. Lomberger on land of R. Besanko (N. W. ¼ N. E. ¼ Sec. 2). The coal is the same as at Manufacturers No. 1, except that the lower bench is 15 inches thick. The roof is shale, at least 10 feet thick, and not very strong. The floor is 30 to 48 inches of hard clay resting on limestone, below which is at least 15 feet of shaly sandstone. The "slate vein," or Summit coal, is 55 feet above the Bevier and only one inch thick. With its black "slaty" shale and thin limestone capping it is a useful marker for the thicker bed. The Hazel creek district will at some future time be an important producer.

On the north edge of the county the Bevier is thinner than farther south. In Putam county, near the Adair line, drifts have been opened in 26 inches of coal that lies a few feet above the railroad and is probably one bench of the Bevier.

Kirksville.—The Bevier bed is found west of Kirksville at a level nearly 40 feet lower than at the Novinger depot. Two mines are now supplying the city and surrounding country with coal from this bed. One mile west of the city limits (near center section 7) is the I. M. Ivie shaft, 138 feet deep. The bed worked is much like that at Novinger, but the roof is a strong sandstone with an even and regular surface. The bed is fairly clean and "clays" are rare. The plan of working is room and pillar, the coal being undercut before being shot.

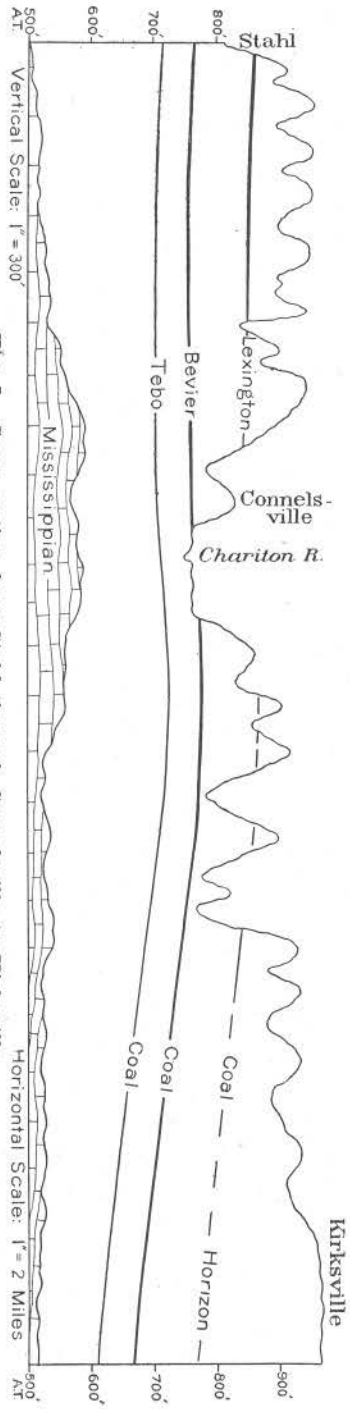

Fig. 7. Cross-section from Stahl through Connelsville to Kirksville.

BEVIER BED AT IVIE MINE.

	Inches.
Sandstone	....
COAL	33
Clay, with pyrite, not persistent	½
COAL	5
Clay, with pyrite, persistent	1
COAL	7
Clay, taken up in roads	48
Limestone	....

One mile east, near the city limits (N. W. ¼ N. E. ¼ Sec. 8), are the well-built top works of the Star Coal Company. One of the few electric hoists in this part of the United States is used to raise coal 236 feet from the Bevier bed. The roof consists of 38 feet of blue, even-grained sandstone with an uneven lower surface that cuts down into the upper coal and causes the thickness of the entire bed to vary from 12 to 33 inches, its average thickness being two feet. The mine is new, however, and work is being carried westward to a point where drilling has shown the existence of coal similar to that at the Ivie mine. In the main entries most of the underclay, which is 46 inches thick, is taken up.

The Pleasanton and much of the Henrietta formations have been removed by preglacial erosion in most of the dis-

trict west of Kirksville, but exposures of the Henrietta in Big creek near the Ivie mine and of the Pleasanton shale not far distant furnish useful guides to the position of the coals, as no similar association of beds occurs at any other exposed horizons. This and other evidence shows that there is little or no coal at the Lexington horizon in this district.

EXPOSURES IN BIG CREEK (SEC. 7, T. 62 N., R. 15 W.)

	Feet.	Inches
Henrietta formation—		
1. Limestone, gray, irregularly bedded	4	6
2. Shale, gray, calcareous	....	8
3. Limestone, in one bed	....	8
4. Shale, gray, with calcareous nodules	2	....
5. Limestone, drab, irregularly bedded	1	4
Cherokee shale—		
6. Shale, green, dark streak in center (horizon of Lexington coal)	....	5
7. Limestone, rough on top, shale partings	1	6

PART OF PLEASANTON SHALE, IN ROAD (S. W. ¼ SEC. 7, T. 62 N., R. 15 W.).

	Feet.
1. Shale, red	10
2. Shale, sandy, and sandstone	20
3. Shale, green (base of Pleasanton)	10
4. Limestone, gray, irregularly bedded	3

The connection between the Henrietta beds, the Bevier coal, and the coal (Tebo) occurring persistently 50 to 65 feet below the Bevier is shown in the following drill record:

DRILLING ONE MILE NORTH OF IVIE MINE (N. W. ¼ S. E. ¼ SEC. 6, T. 62 N., R. 15 W.).

	Thickness.		Depth.	
	Feet.	Inches.	Feet.	Inches.
Drift clay	103	....	103	....
Henrietta formation—				
Limestone	3	....	106	....
Shale, calcareous	4	....	110	....
Limestone	8	....	118	....
Cherokee shale—				
Shale, dark	1	....	119	....
COAL (Lexington)	....	4	119	4
Clay	1	6	120	10
Shale, calcareous	1	2	122	....
Limestone	3	....	125	....
Shale, sandy	25	....	150	....
Shale, light	8	....	158	....
Shale, black, "slaty" (horizon of Summit coal)	4	....	162	....
Shale, dark at top, light at bottom	9	....	171	....
Limestone	3	....	174	....
Shale, light	4	....	178	....
Sandstone	21	....	199	....
Shale, sandy	10	....	209	....
Sandstone	1	9	210	9
COAL, 36 inches Shale, 1 inch (Bevier) COAL, 8 inches	3	9	214	6
Clay	4	....	218	6
Shale, sandy	39	6	258	....
Shale, light	15	2	273	2
COAL (Tebo)	2	1	275	3
Clay	1	9	277	....

As shown in the deep well at Kirksville,* only shale and sandstone were found below the Tebo coal, and the top of the Mississippian, the lower limit of coal, was reached at 450 feet, or about 180 feet below the Bevier. In this record the Bevier appears as 18 inches thick, and the Tebo 24 inches. In 12 drill records made within three miles of the west side of Kirksville (Sec. 31, T. 63 N., R. 15 W.; Secs. 5, 6 and 8, T. 62 N., R. 15 W.; Sec. 2, T. 62 N., R. 16 W.), the Bevier is 21 to 44 inches thick, and averages 32 inches. In half of these the roof is a sandstone and in half shale. Five of the borings were carried down to the Tebo coal and found that it is 20 to 29 inches thick and averages 24, and that its roof is thick sandy shale. This lower bed appears to be very regular and could be easily adapted to longwall working. Most of the records show that the lower beds of the Henrietta formation are the highest rocks beneath the drift, though on the west the latter is deeper and cuts down as far as the Summit horizon. At the Star hoisting shaft the drift is 140 feet deep; at the Kirksville deep well, 170 feet; and 1½ miles northwest of the Q., O. & K. C. depot, 190 feet. From such scant information as is available it appears probable that the drift is still deeper in the region east of the Wabash railroad, and has for the greater part replaced the Bevier and possibly the Tebo coals.

Youngstown.—From Novinger to Youngstown the rocks dip to the south slightly more than the fall of the river. One mile east of Youngstown excellent exposures show 87 feet of Pleasanton sandstone and shale, 32 feet of the thin limestone and shale beds of the Henrietta formation, and 45 of the Cherokee. The slaty shale of the Summit coal horizon lies only a few feet above river level, indicating that the Bevier coal lies about 50 feet below the stream. The Bevier coal is mined on Big creek, two miles east of Youngstown (S. E. ¼ Sec. 14, T. 62 N., R. 16 W.), by W. A. Harle. The product is sold locally to the wagon trade and is hauled to Kirksville. The top of the shaft is at the level of the base of the Henrietta formation, and reaches the coal at 86 feet. Over the coal is one foot of slaty shale overlaid by nearly 40 feet of sandstone that has an uneven lower surface and in places cuts the coal down to as little as 10 inches. Where the full thickness is present, the bed is much the same as in the Novinger district. The upper bench is 31 inches or less, the middle 4, and the lower 10. The lower bench is somewhat dirty. The upper clay parting is one-fourth and the lower three-fourths of an inch. The underclay rests on limestone and is six to seven feet thick.

Two miles southeast of Youngstown there is a coal bed in the upper part of the Pleasanton shale at the horizon that bears workable coal in several places in Sullivan county. Little is known as to the areal extent of this bed.

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*Shepard, E. M.: Water Supply Paper No. 195, U. S. Geol. Survey, 1907, p. 55.

EXPOSURES SOUTHEAST OF YOUNGSTOWN (N. E. ¼ N. E. ¼ SEC. 27, T. 62 N., R. 16 W.)

		Feet.
1.	Limestone (base of Missouri group)	....
2.	Concealed (top of Pleasanton) about	25
3.	Shale, black	3
4.	COAL, reported thickness	2½
5.	Concealed	10
6.	Sandstone	42
7.	Shale, black	1
8.	Shale, red at base	35
9.	Limestone (top of Henrietta)	3½

Yarrow.—At Yarrow the horizon of the Bevier bed lies within 40 or 50 feet of the river level. What thickness of coal there is at that horizon is not known, though it is highly probable that workable coal exists in patches at least. Four miles south of Yarrow, near the Macon county line (Sec. 33, T. 61 N., R. 16 W.), one foot of coal is said to have been found at 54 feet (Bevier?) and 44 inches at 108 feet (Tebo?), though some doubt exists as to the accuracy of the drilling.

Millard.—Little is known about the rocks concealed beneath the heavy drift cover in the southeastern quarter of Adair county. The following core-drill record, kindly furnished by H. L. Miller, gives a clue to the nature of part of the Coal Measures in that region. The correlation of the coals and other beds shown cannot be undertaken at this time.

DRILLING SOUTHWEST OF MILLARD (N. E. ¼ S. W. ¼ SEC. 20, T. 61 N., R. 15 W.)

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift clay	24	....	24	....
Shale, light, soft	43	....	67	....
Shale, sandy at top	15	....	82	....
Sandstone	11	....	93	....
Shale, sandy	9	....	102	....
"Conglomerate rock"	2	....	104	....
Shale, sandy	23	6	127	6
COAL	3	....	130	6
Clay	1	....	131	6
Shale, sandy	20	6	152	....
Shale, dark	2	....	154	....
Shale, sandy	38	6	192	6
COAL	1	8	194	2
Clay	1	10	196	....
Shale, light, sandy	12	....	208	....
Shale, various colors	2	....	210	....
Shale, calcareous	9	....	219	....
Sandstone, soft	3	....	222	....
Shale, blue, calcareous	6	....	228	....
Limestone, soft	2	....	230	....

ANDREW COUNTY.*

The surface formations of Andrew county are the Shawnee and the upper part of the Douglas. The latter bears thin seams of coal in places, but none over one foot in thickness. No workable coal is known to outcrop within the county. In small areas in Missouri and larger ones in Kansas, the Douglas carries some coal beds that are more than fourteen inches thick, but they are of small areal extent and the coal is commonly of inferior quality. Drillings to a depth of 175 feet near Wyeth and to 370 feet at Savannah failed to find coal.

No drillings have explored the important coal horizons of the Des Moines group in order to demonstrate the presence of workable coal. The deep drilling at Forest City reached the Bevier bed, one of the most important of these horizons, at a depth of 1,039 feet, or 844 feet below the base of an important series of limestones known as the Oread. The Oread lies at the top of the Douglas formation (see state geologic map) and outcrops conspicuously along the Missouri, 102, Platte and lower Nodaway rivers, along Niagara creek, and west to Union Star. It may therefore be used as a guide to the depth of the coal beds found in the Forest City and Saxton drillings (see reports on Holt and Buchanan counties). In the northwestern portion of the county, especially along the Nodaway river, the most prominent of the outcropping limestones is the Deer Creek, which lies about 150 feet above the Oread.

As an aggregate of 29 inches of coal in beds of 14 inches or more was found in the Forest City drilling, and 110 inches in that at Saxton, a very moderate estimate of the aggregate in the deep-lying beds of Andrew county would be an average of 30 inches under the entire area, or 1,209,600,000 tons.

ATCHISON COUNTY.*

Two thin seams of coal outcrop in this county, both of which have been worked in a small way. The surface formations are the Wabaunsee and Shawnee and the depth to the principal coal horizons of the Des Moines group is greater than in any other county. No drillings have penetrated formations lower than the Lawrence shale and the occurrence of coal below that is purely hypothetical. If the deep drilling at Nebraska City, Nebraska, is correctly interpreted, the center of the

*A report on the geology of Andrew county, by G. C. Broadhead, is contained in the report of the Missouri Geol. Survey for 1873-74, pp. 301-311, and a few sections along the Missouri river are given in the report for 1872, pt. 2, pp. 124-126.

*The geology of Atchison county is described by G. C. Broadhead: Report on iron ores and coal fields, 1872: Mo. Geol. Survey, pt. 2, 1873, pp. 376-387. The coal is mentioned by Arthur Winslow, Prelim. report on coal, Mo. Geol. Survey, 1891, pp. 101-102.

Pennsylvanian basin of deposition lay southeast of Atchison county. At Nebraska City the Pennsylvanian appears to be only 1,050 feet thick, or but slightly greater than the estimated thickness of the Missouri group in this region. The Cherokee shale, which is the chief coal-bearing formation and lies at the base of the Coal Measures, is probably absent, therefore, at least in the northwestern part of the county.

The two surface coals are the Nyman and the Elmo, the latter about 120 feet below the former. Neither bed exceeds one foot in thickness, so far as observed, and neither would be of importance in regions nearer producing coal fields. The Nyman coal is exposed at intervals along the Missouri bluff from near the State line to Big Tarkio and up that stream nearly to Fairfax, where it has been replaced by drift. It has been prospected about four miles south of Rockport, on the farm of John Whitham (N. E. ¼ Sec. 22, T. 64 N., R. 41 W.), where the following were measured:

		Feet.	*Inches.*
1.	Limestone, including 9-inch parting in middle	3	11
2.	Shale	....	6
3.	COAL (Nyman)	....	8
4.	Clay	....	2

In connection with the question of a possible local thickening of this coal, there should be mentioned the Honey Creek coal mine,† southeast of Peru, Nebraska (N. W. ¼ N. W. ¼ Sec. 36, T. 6 N., R. 15 E. A seam about 33 inches thick has been opened by a drift at this place and over 1,000 tons of coal mined. The coal occurs at a level, which suggests its correlation with the Nyman bed, though it is said to be overlain by shale, and the Nyman seam, wherever seen, has but a few inches of shale between the coal and limestone cap-rock.

The Elmo coal outcrops only in the eastern part of the county and has been found only on Manly branch, where it is very thin. About 120 feet below it is the Nodaway seam, a coal that does not outcrop in the county, but has been found by drilling at a number of places in and near Atchison county. It is being mined at Coin, Iowa, where its average thickness is about 16 inches. North of Corning, near the south line of the county, the Nodaway is reported 150 feet deep and 16 inches thick. At Nebraska City, Neb., a seam of coal correlated with the Nodaway is reported 15 inches thick at a depth of 199 feet.‡ The Nodaway coal may be the seam at 357 feet in the following drill record:

†Described in detail by R. V. Pepperberg, Pub. Neb. Geol. Survey, vol. 3, pt. 10, 1910, pp. 275-307.

‡Meek, F. B., Final Report on Nebraska, etc., U. S. Geol. Survey, 1872, pp. 105-106.

RECORD OF DRILLING AT ROCKPORT.

	Thickness. Feet.	Inches.	Depth. Feet.	Inches.
Soil and clay	98	....	98	....
Sand and gravel	42	....	140	....
Gravel and sand, with abundance of water	3	....	143	....
Clay, blue	25	....	168	....
Limestone	3	....	171	....
Shale, gray	2	....	173	....
Limestone, sandstone and 5 inches of coal	3	....	176	....
Shale, dark colored	110	....	286	....
Limestone, gray	4	....	290	....
Shale	58	....	348	....
Limestone, dark colored	9	....	357	....
"COAL fault"	1	....	358	....
Shale	20	....	378	....
Limestone	21	....	399	....
Shale, black, "slaty"	3	....	402	....
Shale	88	....	490	....
Limestone (Oread), light gray	60	....	550	....
Shale, black, "slaty"	4	....	554	....
Shale, light colored	19	....	573	....
Shale, red	11	....	584	....
Shale, dark colored	40	....	624	....
Limestone, show of water	6	....	630	....
COAL (reported excellent quality)	2	3	632	3
Shale	46	5	678	8

The coal at 630 feet is probably the Atchison seam, which occurs in the Lawrence shale in many places in Missouri and Kansas. The thickness given above is greater than at any other place known and is probably local. So far as known this is the deepest drilling in Atchison county of which there is any record. Across the river at Brownville, Nebraska, the following record is reported:**

DRILLING AT BROWNVILLE, NEB.

		Thickness. Feet.	Inches.	Depth. Feet.	Inches.
1.	Shales, lime and sandstone	93	....	93	....
2.	COAL	....	8	93	8
3.	Shales and limestone	148	4	242	....
4.	COAL	1	2	243	2
5.	Shales, lime and sandstone	132	10	376	....
6.	COAL	....	10	376	10
7.	Limestone and shale	444	2	821	....
8.	COAL	2	6	823	6
9.	Shales, lime and sandstone	177	6	1,001	....

The drilling was begun at an altitude of 919 feet above sea level, indicating that the coal at 242 feet may be the Nodaway seam.

If only deposits 14 inches or more in thickness be considered and the doubtful possibility of deeper coals be disregarded, the following approximate estimate is obtained:

TOTAL ORIGINAL TONNAGE OF ATCHISON COUNTY.

Bed.	Average thickness.	Area.	Tonnage.
Nodaway	15 inches	250 sq. mi.	360,000,000 tons.
Atchison seam	15 inches	36 sq. mi.	51,840,000 tons.
Total			411,840,000 tons.

**Hicks, L. E., Proc. Am. Assoc. Adv. Sci., vol. 35, 1886, pp. 217-218.

AUDRAIN COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....38,736 TONS.

Nearly all of Audrain county is underlain by a thin veneer of Pennsylvanian Coal Measures bearing beds of coal less than three feet in thickness. The central portion of the region is a level plain forming the divide between the Mississippi and Missouri river drainages, and covered so effectually by 50 feet and more of drift as to conceal the coal-bearing rocks in all but the larger valleys. Structurally the eastern half of the county is simple, the rocks lying nearly flat when the territory is considered as a whole, though minor undulations have local effect and strata at Rush Hill and Laddonia are at higher altitudes than in the region farther east and south. The structure in the western half of the county is more complicated, because of the presence of several anticlines with axes probably trending northwest and southeast parallel to the Browns station anticline of Boone county. Outcrops are rare in this region and wells are so shallow as to yield little information concerning the stratigraphy. All of these factors, combined with the absence of strongly individualized beds where exposures do occur, make the work of the geologist very difficult.

Aside from a few scattered country mines operated for local trade, mining is confined to the eastern part of the county, and shipping mines to Vandalia, Farber and Martinsburg. Nearly all of the territory east of Mexico and extending into Ralls and Montgomery counties is underlain by a remarkably persistent and uniform bed of coal about 30 inches thick and characterized by a very thin pyrite band in its lower part. The value of this bed is greatly impaired by small "slips" and by rolls in the floor and roof, though in places it is of excellent quality and can be easily worked on the longwall plan of mining; the only system in vogue in any of the mines of the county. The coal seam is correlated with the Mulky on the basis of observations made in tracing beds in Monroe county on the north and Callaway on the south,† though it is possible that this conclusion is erroneous. Twenty feet higher is another coal bed that is very irregular and is eroded away in the northern part of the field.

Near Mexico and on Davis fork and its tributaries are thin coal beds that are not utilized and do not justify development on any but a very small scale. Their exact stratigraphic position was not definitely

*The topography of the county is shown on the Moberly and Mexico atlas sheets of the Topographic Atlas of the United States, published by the U. S. Geol. Survey. Earlier coal mines were briefly described by Arthur Winslow, A preliminary report on coal: Mo. Geol. Survey, 1891, pp. 80-82, and clays and shales by H. A. Wheeler, Clay deposits: Idem, vol. XI, pp. 270, 295, 307, 366, et al.

†Correlations of beds in this region will be more fully discussed in a report on the Pennsylvanian of Missouri, now being prepared.

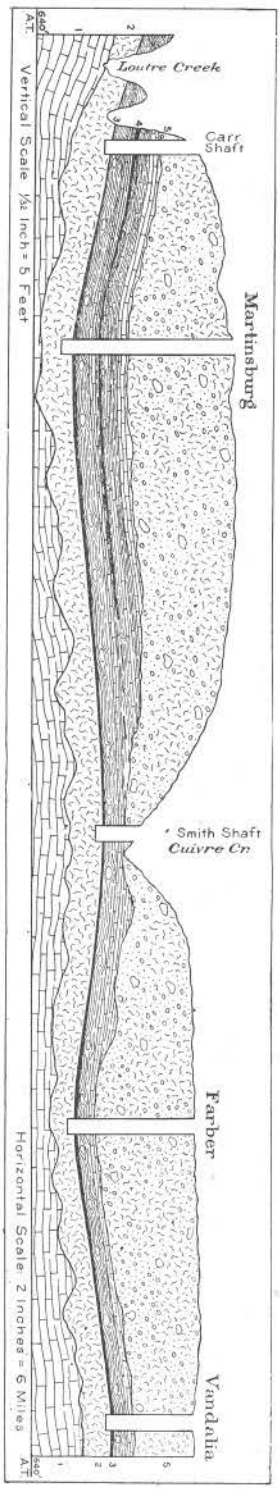

Fig. 8. Cross-section through Martinsburg and Vandalia. (1) Mississippian limestone. (2) Basal fire clays of Pennsylvanian. (3) Mulky coal. (4) Summit coal. (5) Glacial drift.

determined, though it is known that they lie not far from the base of the Pennsylvanian. East and north of Centralia is a thirty-inch coal bed of excellent quality and easily mined. This district deserves more attention from mining men than it has received, both for this bed and for others that may underlie it. The surface coal is probably the Summit, though it also resembles the Mulky and to a slight extent the Tebo. The finding near Thompson of a coal bed apparently corresponding stratigraphically to the Bevier is mentioned in the following pages. The drilling which revealed this thick bed was made for water, not for coal; but the report of the strata penetrated corresponds so closely to the stratigraphic section southwest of Centralia that it deserves attention.

So far as depth from the surface is concerned, the base of the Coal Measures is in about the same position at Mexico (110 feet), Farber (120 feet) and Vandalia (95 feet). At Martinsburg it is 165 feet, on the C. F. Clark farm, two miles north of Thompson, 100 feet, and on the J. W. Smith farm, 3½ miles southeast of Mexico, 140 feet, from the surface. In all parts of the county the lowest Pennsylvanian bed is a light-colored fire clay from 10 to 40 feet thick.

The total original coal supply of Audrain county, excluding beds or parts of beds less than 14 inches thick, may be roughly estimated at 1,220,000,000 tons. Of this amount approximately 1,030,000 tons have been mined since 1879, and about 50,000 in earlier years, a total of less than one-tenth of one per cent of the original content.

DETAILED MENTION.

Vandalia.—Both coal and fire clay have been mined at Vandalia for many years,

and three shafts are now developing the Mulky bed. These are (1) Standard Coal Co., hoisting 73 feet by horse-gin in the northwest corner of town, (2) Mississippi Glass Co. with a 70-foot shaft and steam power plant on the west edge of town, and (3) Audrain Coal Co. with steam hoisting equipment and shaft 82 feet deep two miles southwest of town (S. W. ¼ S. E. ¼ Sec. 12, T. 52 N., R. 6 W.). The Mississippi Glass Co. and the Audrain Coal Co. ship over the Chicago and Alton railroad, on which they are located, although the company first named consumes most of its product at its own brick plant. At the shaft of this company fire clay lying below the coal is mined by the room and pillar method, the coal being removed by the longwall method as at all other mines in the county.

The Mulky coal is bright and of medium hardness. It contains abundant gypsum and calcite films and plates in vertical joints and pyrite in thin streaks. The bed is, in part, excellent, but many of the working faces are much affected by small faults ("slips") and by rolls of clay in the bottom and of rock and shale in the top. Where "slips" occur, the amount of clay and "sulphur" in the coal is large, and the roof is not everywhere firm. Elsewhere the roof is good except for the "niggerheads" that lie in the laminated shale; they are a source of danger to the men, and also, in places, project downward so as to cut out part of the upper bench of coal. From 5 inches to 2½ feet of "draw slate" comes down with the coal and about 2 inches sticks to the coal.

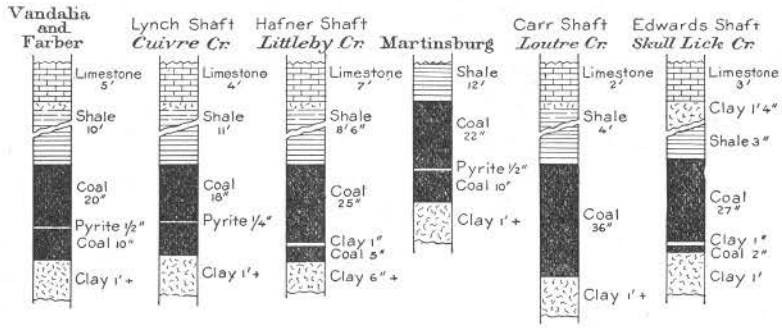

Fig. 9. Audrain County coal beds.

STRATIGRAPHIC SECTION AT VANDALIA.

		Feet.
1.	Soil and drift clay, thickness variable, average about	50
2.	Limestone, gray; irregularly bedded above, more massive below; average about.	5
3.	Shale, drab and clayey above, black and "slaty" below; "slaty" portion in part lithified and bearing oval "niggerhead" clay-iron-stone concretions of all sizes up to 100 lbs. or more in weight	10
4.	COAL, 20 inches, Clay, with much pyrite, ½ inch COAL, 10 inches,	2½
5.	Clay, light green; stigmaria roots in upper part; thickness variable, average	7
6.	Clay, white; somewhat silicious; contains scattered concretionary bouiders of ferruginous limestone; mined for fireclay; thickness variable, average about.	20
7.	Mississippian limestone	

Farber.—On the railroad at the west edge of Farber the Lawder and Peterson Coal Co. operates an old shaft 100 feet deep. The coal and associated strata are almost identical with those at Vandalia. In parts of the mine one-half or more of the face is greatly injured by "slips" and "rolls." Electric mining machines were formerly used but have been abandoned. The product is sold locally and to the railroad.

Laddonia.—At Laddonia shafts 45 feet and less in depth were sunk in 1893 and subsequent years to a 26-inch coal bed, but were abandoned because of poor roof and much water. South of Laddonia and Farber, in the valley of Cuivre creek, several small shafts are worked with gin hoists for the country trade. Three mines were in operation in 1910: (1) James Lynch (N. E. ¼ N. W. ¼ Sec. 17, T. 51 N., R. 6 W.), shaft 45 feet; (2) J. A. Smith (N. W. ¼ N. E. ¼ Sec. 17, T. 51 N., R. 6 W.), shaft 35 feet; and (3) H. Hammett (S. W. ¼ S. E. ¼ Sec. 22, T. 51 N., R. 6 W.), shaft 32 feet. Other shafts were located at other points on Cuivre creek and also on Hickory creek. The coal bed has the same characteristics as at Vandalia, and the associated strata are also the same, as shown in the Lynch shaft.

		Feet
1.	Limestone	4
2.	Shale, gray, soft above, harder below	7
3.	Shale, black, "slaty," with "niggerheads"	4
4.	COAL, 18 inches, Clay, containing pyrite, ½ inch COAL, 10 inches,	2½
5.	Fire clay, with boulders of concretionary limestone	10

Rush Hill.—Reports of drilling done at Rush Hill are rather vague, but it is stated that 30 inches of coal was found 1½ miles west of town, and none half a mile east of the depot. These reports need verification. About 2½ miles northwest of the town a few shallow country shafts were once worked, but are now abandoned. Seven miles northwest of Rush Hill (N. W. ¼ S. W. ¼ Sec. 14, T. 52 N., R. 8 W.) is the well-known Hafner mine, a shaft 35 feet deep to the Mulky coal bed in the valley of Littleby creek. Horse power is used for hoisting and the product is sold locally. "Slips" are plentiful, but less so than at Farber and Vandalia.

HAFNER SHAFT, NORTHWEST OF RUSH HILL.

		Feet.	Inches.
1.	Shale, drab, clayey	2	....
2.	Limestone	7	....
3.	Shale, drab, clayey	2	6
4.	Shale, black, in part lithified and with calcareous concretions	6	....
5.	COAL, 25 inches, Clay, pyritiferous, 1 inch COAL, 5 inches,	2	7
6.	Clay	....	....

In the hillside near the shaft six feet of gray limestone is exposed just above the level of the above section, and less than one mile down

the creek Mississippian limestone outcrops not far below the level of the coal.

Martinsburg.—The Martinsburg Coal Co. operates a shipping mine beside the Wabash railroad on the west side of the town; the shaft being 136 feet deep to the Mulky coal. This seam has here all the characteristics it possesses at Vandalia, although the upper bench is about two inches thicker. The "draw slate" is about one foot thick, "slips" with a throw of 18 inches or less are plentiful, and some of the "niggerheads" are two feet in length. The working face is about 650 feet south and west of the shaft.

An attempt was made to work the Summit coal, which lies 20 feet above the Mulky, but it was found to be of great irregularity in the under surface of the "niggerhead" roof. The coal ranged from a thin film to a bed four feet thick and was given up as too unreliable to work. A thin streak of coal lies still higher. The mine sump penetrates 10 feet of bouldery clay lying beneath the Mulky coal.

The Summit coal is worked by the W. C. Carr country mine 3½ miles southwest of Martinsburg (S. E. ¼ S. W. ¼ Sec. 28, T. 50 N., R. 7 W.) from a gin shaft 52 feet deep. The roof is black laminated shale filled with oval limestone "niggerheads" that project downward into the coal in such a manner as to make its thickness vary from 2½ to 4 feet. The coal is of good quality and contains only a moderate amount of sulphur chiefly in vertical streaks of pyrite.

The Summit bed has been opened by small drifts at one or two points near the head of a small branch one mile north of Carr's, but under much of the district the seam is too thin to be utilized. The Mulky coal also is thin in this area, as shown in the following section compounded from shaft and outcrop observations in the neighborhood:

		Feet.
1.	Limestone, irregularly bedded	7
2.	Shale, with lenticles of limestone	6
3.	Limestone, yellowish brown, dark blue when fresh, compact and massive	2
4.	Shale, black, very hard and calcareous below, softer above	4
5.	COAL (Summit) average thickness where worked	3
6.	Clay, with limestone boulders in lower part, thickness very variable	3
7.	Limestone, light gray and nodular on top, dark blue and massive below	2½
8.	Shale, dark drab	10
9.	Shale, bluish black	2
10.	COAL (Mulky)	¾
11.	Clay, blue	2
12.	Shale, yellow	2
13.	Limestone, nodular	1+
14.	Interval, probably very small and all shale	....
15.	Shale, light drab, hard	4
16.	Shale, dark blue	2
17.	Clay, drab above, white below	20
18.	Mississippian limestone	....

Dips are irregular and outcrops not very good, so that the connections between component parts of the above section may not be perfect. Numbers 1 to 7 were measured in the Carr shaft and in a

cut bank up a neighboring branch, 8 to 13 in outcrops in the creek close to the Carr mine, and 14 to 18 one-half mile south of the mine. Other outcrops seem to confirm the compounded section.

Mexico.—Feeble attempts have been made from time to time to mine coal at and near Mexico, though none of them were continued for a long period. The most promising bed discovered was a four-foot coal with soft shale roof, found at the bottom of a 42-foot shaft one mile east of Mexico. Little could be learned of the extent and nature of the bed. For a time a coal 4 to 16 inches thick was mined in connection with the fire clay deposits that are so extensively developed at Mexico* and occupy the same stratigraphic position as at Vandalia. Small drifts have been intermittently worked on Davis (Henry's) fork both west and north of the city, but in many places the bed exposed is too variable in thickness and quality to make mining profitable. As previously stated, the stratigraphic position of this seam is doubtful. Where the railroads cross Davis fork, 1½ miles west of Mexico, the following section appears:

		Feet.	*Inches.*
1.	Limestone, bluish gray, irregularly bedded, nodular on top	4	....
2.	Shale	3	6
3.	Limestone, blue, weathers drab, one-half inch clay parting in upper portion	1	....
4.	Shale, dark drab	1	3
5.	Shale, black, "slaty"	1	5
6.	COAL	2	2
7.	Shale, poorly exposed, about	6	....
8.	Limestone, light gray, nodular, exposed	1	....
9.	Concealed	26	....
10.	Limestone, dark blue, weathers bluish gray, nodular, in creek bed	2	....

Coal is reported to have been found below creek level when the bridge piers were sunk. The upper portion of the above section is exposed at many points up Davis fork, down stream to its junction with Beaver Dam creek and in Beaver Dam east and southeast of Mexico. The Mississippian outcrops in South fork from near Mexico to the Monroe county line.

Molino.—South of Molino, near South fork (S. W. ¼ Sec. 25, T. 52 N., R. 9 W.), a small country drift is operated and the following section is exposed at the mine:

		Feet.	*Inches.*
1.	Limestone, dark blue when fresh, yellowish brown when weathered, compact, fossiliferous	....	10
2.	Shale, black and "slaty" below, lighter above	8	....
3.	Limestone, weathers yellowish brown, somewhat irregularly bedded	1	....
4.	Concealed	8	....
5.	Limestone, light blue with dark blue spots	1	6
6.	Shale, dark drab above, black and "slaty" next coal, a fair mine roof	8	....
7.	COAL	2	4

Many rolls in the roof decrease the thickness of the coal in parts of the mine and considerable sulphur in the form of vertical pyritic

*For a description of the fire clay deposits see Wheeler, H. A., Clay deposits: Mo. Geol. Survey, vol. XI, p. 290.

streaks lessens its value. A short distance below the coal is a band of light gray limestone, one foot thick; and farther down the small branch is nearly 30 feet of white clay resting on Mississippi limestone and flint just above the level of South fork. On the west side of South fork the Mississipian appears about 50 feet higher than at the mine and outcrops well up in the hills at Molino. About one mile northeast of the drift, where some mining has been undertaken, there is only six feet of shale between the coal and its cap-rock and the coal is said to be from 28 to 30 inches thick.

Thompson.—In the valley of Davis (Henry's) fork and the lower courses of Mays fork and Possum Run, south and southwest of Thompson, two coal beds have been worked very slightly by short drifts, though nothing has been done recently. Both beds are very irregular in thickness, ranging from 1 to 24 inches where outcropping and from 16 to 36 inches where mined. One mile south of Thompson, near the bridge over Davis fork, is the following exposure:

		Feet.	*Inches.*
1.	Limestone, blue, nodular	3	....
2.	Concealed	8	....
3.	Limestone, drab, compact, in two layers	1	4
4.	Clay	1	....
5.	Shale, black, "slaty"	2	....
6.	Concealed, probably shale and a thin coal bed	12	....
7.	Shale, black, "slaty"	2	....
8.	COAL	1	4
9.	Clay	1+	....

Between this bridge and the one next above numbers 4 to 8 are better exposed in Davis fork and small tributaries on the south, the dip being sharply to the northeast:

		Feet.	*Inches.*
1.	Shale, light drab	3	....
2.	Limestone, drab, blue when fresh, in two layers	1	2
3.	Clay	....	10
4.	Shale, black, "slaty"	3	....
5.	COAL, dirty	....	6
6.	Clay	2	....

The following section was obtained by compounding exposures along the lower part of Mays creek. In the upper part of Mays creek and South (Henry's) fork an anticline brings the Mississippian to the surface:

		Feet.	*Inches.*
1.	Limestone, light blue when fresh, weathers yellowish brown, compact, heavy-bedded, fossiliferous	2	....
2.	Shale, dark blue and "slaty" below	4	....
3.	COAL, with 1-inch clay seam 2 inches from bottom	1	6
4.	Clay	2	....
5.	Shale, in large part bluish black	4	....
6.	Limestone, light gray, in part slightly nodular	1	2
7.	Clay, with concretionary limestone layers	3	....
8.	Shale, dark blue, "slaty"	3	6
9.	COAL, streak	....	4
10.	Clay, drab	4	....

		Feet.	Inches.
11.	Limestone, concretionary layer	....	4
12.	Shale, drab	1	6
13.	Conglomerate, very small pebbles in firm limestone matrix	....	4
14.	Clay	2	....
15.	Limestone, light gray, nodular on top	1	6
16.	Concealed, probably clay, approximately	20	....
17.	Mississippian chert	....	....

The principal mine of western Audrain county is that on the land of J. P. Edwards on Skull Lick creek, five miles east of Centralia (N. W. ¼ S. W. ¼ Sec. 9, T. 51 N., R. 10 W.). Here Mr. J. T. Bell operates a shaft 35 feet deep to a bed that greatly resembles the Summit, hoisting by horse-power, and selling the product locally and in Centralia. If this is the Summit, probably the Mulky bed is absent here, the succession of strata corresponding with that in Boone county. This district includes one of the best portions of the county's coal reserves, the mine roof being good and with only a gently undulating lower surface, "slips" few, and "sulphur" moderate in quantity. The coal is hard and bright, with pyrite in fine vertical streaks and gypsum and calcite in films on the joint planes. It has been successfully mined with machines. In small mines once operated in the neighborhood "niggerheads" in the roof gave much trouble. The section exposed in the shaft and in Skull Lick creek is:

		Feet.	Inches.
1.	Shale, sandy	5	....
2.	Limestone, bluish gray, compact, fossiliferous, laminated at base	3	....
3.	Clay, soft	1	4
4.	Shale, black, not blocky, small concretions of pyritiferous shale	3	....
5.	COAL, 27 inches Clay, 1 inch COAL, 2 inches	2	6
6.	Clay	3	....
7.	Limestone, buff, nodular	1+	....

Portions of the above section outcrop elsewhere on Skull Lick and Little Skull Lick creeks. At the county line due east of Centralia, the same coal bed, two feet thick, was once mined by the Centralia Coal Co., but is said to have been abandoned because of the amount of water present. Mr. Bell reports that a recent drilling for water near the railroad, west of Thompson, penetrated the Mulky bed at 32 feet and a second coal seam four feet thick, at 70 feet, or 38 feet below the Mulky. Under the Mulky was a two-foot sump-rock, then soft shale, becoming harder at the base, to the second coal bed; below the second was four feet of very hard rock, then slate to 250 feet, where water was found at the top of another hard rock. It will be seen that the second coal bed corresponds closely in stratigraphic relationships to the Bevier and that the great thickness of shale below it fills an old valley eroded in the Mississippian limestone before the deposition of the Coal Measures. In Mays creek no thick coal outcrops and the Mississippian is at higher levels.

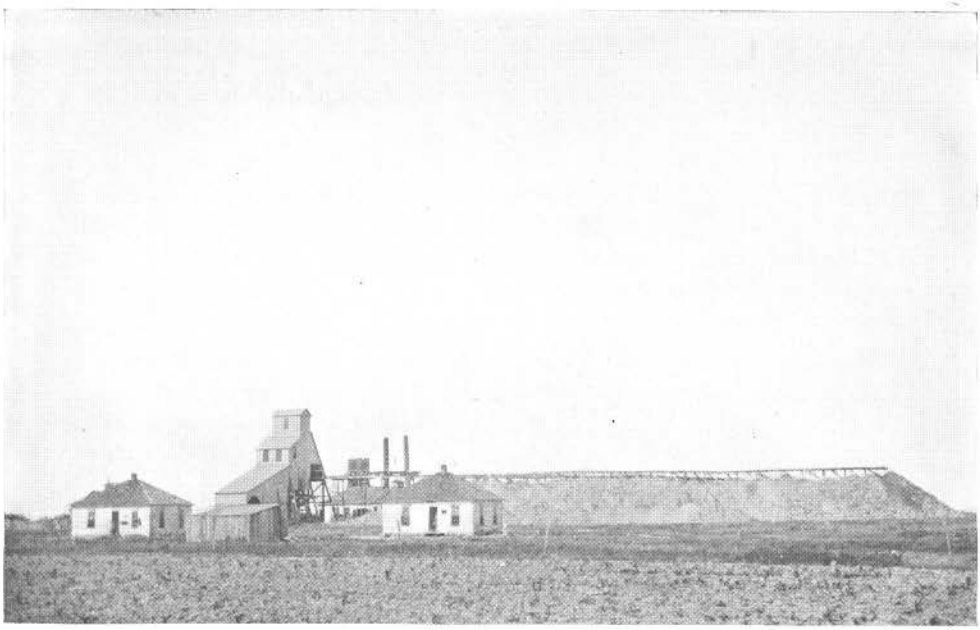

Fig. 1. Western Coal and Mining Co., Mine No. 17, Minden, Mo.

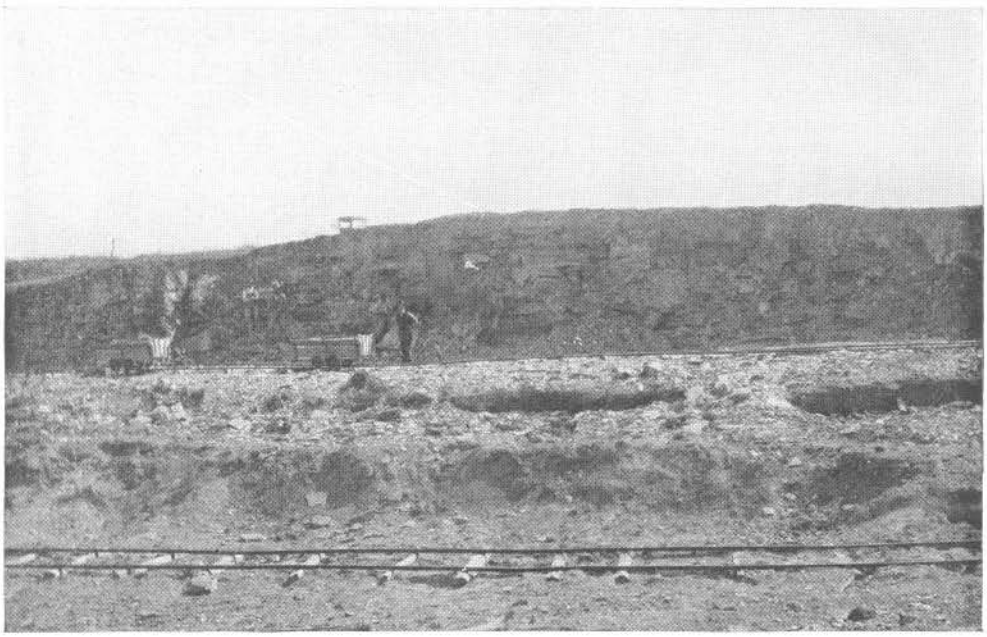

Fig. 2. Clay pit at Oskaloosa, showing fire clay, coal, and overlying shale.

What is probably the Summit section outcrops at intervals on the upper part of Goodwater creek for several miles, exposures being very poor. In Sec. 22, T. 52 N., R. 11 W., coal formerly stripped is reported at 30 inches. In the N. W. ¼ Sec. 34, two miles north of Centralia, are five abandoned country shafts 30 to 42 feet in depth that penetrated the following:

		Feet.	Inches.
1.	Limestone	3	....
2.	Shale, black, "siaty"	3	....
3.	COAL	2	2
4.	Clay	1+	....

BARTON COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....192,250 TONS.

Mining on a large scale has been confined to the western edge of the county near Minden, Mulberry (Kansas), Ardath, and Liberal, but small strip-pits and mines are operated for local trade near Oskaloosa, Liberal, Lamar, Nashville and Boston and in the northeast corner of the county.

There are about 500 square miles of Coal Measures in the county, belonging chiefly to the Cherokee shale. The overlying Henrietta formation is found capping only one small mound near Verdella (Hannon). The Mississipian limestone, below the top of which there is no coal, outcrops in the southeast quarter of the county, in Horse creek near Newport and in the northeastern corner of the county. Because of a general dip of the strata to the west and northwest, the thickness of the Coal Measures is greatest in the northwestern part of the region. The Cherokee is nearly 350 feet thick, though the upper 100 feet of the formation occur only on one or two mounds.

The highest coal bed, stratigraphically, is found on Round Mound, southeast of Hannon, and is 70 feet below the top of the Cherokee shale. It is 18 inches thick and underlies only 2 or 3 acres. About 45 feet below this bed is one 20 inches thick, known in Kansas as the Weir-Pittsburg Upper.† This has been found in only one small mound southeast of Mulberry, though it may outcrop under a cover of debris in a mound near Oskaloosa.

The most important coal bed is the one known in Kansas as the Weir-Pittsburg Lower. In Missouri it occupies a strip only one-half to 3 miles wide next to the State line extending from a point just south of Minden to Oskaloosa, and several outliers near Liberal. In-

†Univ. Geol. Survey, Kansas, vol. III, p. 151, 1898.

*The geology of Barton county is described by G. C. Broadhead, Rept. for 1873-1874; Mo. Geol. Survey, 1874, pp. 97-118. The coal is mentioned by Arthur Winslow, Prelim. report on coal: Mo. Geol. Survey, 1891, pp. 161-165. The topography is shown on the Fort Scott, Nevada, Carthage and Joplin sheets of the U. S. Geol. Survey.

vestigations made by F. C. Greene near Mulberry indicate that this bed lies 180 feet below the limestones at the base of the Henrietta formation and that it corresponds very closely to the lower Rich Hill bed of Bates and Vernon counties, and, consequently, with the Bevier of more northern parts of the State. In this area it is about 30 inches thick and is an extension of the bed that supplies most of the Kansas production. It furnishes a good steam coal of high calorific value. Pyrite appears in thin streaks, particularly near the middle of the bed and there is some white gypsum scale. The coal is brittle and shoots almost too easily, much slack being produced by the universal practice of shooting off the solid. Not more than 60 per cent of the coal in the ground reaches a market. On top of the coal are 2 to 3 inches of shaly coal, above which is a blue shale that is fairly firm and stable at the base, but is weaker above. Few timbers are used in the mines, the practice being to allow the roof to arch itself. One of the most striking features of the coal bed is the presence of numerous "horsebacks," "rolls," and "slips." "Slips" are small, the maximum change of level reported being 30 inches. The "rolls" in the roof are not serious and cut out only a small amount of coal. "Horsebacks," however, are numerous. In this part of the field the term is commonly applied to vertical or highly inclined veins of clay which average about 3 feet in width and in places are as much as 700 feet in length. Where they traverse the coal they have jagged and irregular edges. They commonly extend upward into the roof shale, weakening it, and in places may be recognized at the surface as much as 25 feet above the coal bed.

Between the Weir-Pittsburg Lower and Upper there are one or more thin coal beds of no economic importance. Between the thick coal and the base of the Coal Measures are 150 to 200 feet of sandstone with interbedded shale. In this interval there are many coal beds, but in many areas all of them are too thin to be mined. Beds 12 to 18 inches thick are, however, utilized locally in the southwestern, central, and eastern parts of the county. In the northeast corner there is an important field of 2-foot coal that lies about 50 feet from the base of the Cherokee. This deposit is described in the detailed report on the Milford district. It is a notable fact that this workable coal was found in one of the few parts of Barton where there are deep valleys and complete outcrops. It may be that similar beds underlie portions of the rolling prairie that constitutes most of the surface in this territory. The country is not thickly settled and little drilling or well-digging has been done.

The Weir-Pittsburg Lower underlies about 23 square miles and averages 30 inches in thickness. Its total original tonnage was, therefore, 66,240,000 tons, though much of the best coal has already been

mined or spoiled. The quantity of coal in beds higher than the Weir-Pittsburg Lower is so small as to be negligible. The Milford district contains about 18 square miles of 22-inch coal, or 38,016,000 tons. In other districts the lower coals are thinner and less regular and it can only be roughly estimated that, not including beds less than 14 inches thick, there is an average of 15 inches in one-half of the Coal Measures area, or 360,000,000 tons. The total original tonnage of the county is therefore 464,256,000 tons.

DETAILED MENTION.

Oskaloosa.—At the plant of the Premier Fire Clay and Products Co. (S. E. ¼ Sec. 7, T. 33 N., R. 33 W.), are several strippings and small slopes in coal averaging 31 inches in thickness; probably the Weir-Pittsburg Lower. The roof is 16 feet of shale, blue at bottom and light gray at top. Under the coal is 5 feet of fireclay. North of this place the coal apparently thins. On Big Drywood, east and southeast of town, there is no coal of importance, red sandstone being the rock most commonly exposed.

Ardath.—The Calhoun Coal Co. has a 40-foot shaft at Ardath, hoisting by steam power and shipping the product. The Weir-Pittsburg Lower is reported 31 inches thick. One mile south is the shaft of the Imperial Coal Co., where coal is hoisted 30 feet from the same bed and shipped. The coal bed averages 32 inches and bears two thin "sulphur bands" between which shots are placed. Over the coal is 30 feet of shale that is blue and firm at base and is capped with 2 feet of sandstone. Dips are irregular and in places steep. The same bed has been stripped on lower ground on three sides of the shaft and also in a dry branch 1½ miles east, where it is 2 to 3 feet thick. Broadhead states that a boring 150 feet deep in the latter locality (N. E. ¼ N. E. ¼ Sec. 29, T. 33 N., R. 33 W.) was nearly all in sandstone.

Mulberry (Kansas).—From the outcrops just mentioned southward to a line drawn east from Mulberry there is no workable coal, though south of that line the country is dotted with strip-pits and dumps from workings in the Weir-Pittsburg Lower. Between Mulberry and Vernon the coal, because of its general westerly dip, underlies only a strip about a mile wide on the western border of the State. It was formerly mined extensively, but only the following small mines were found in operation in 1911: (1) H. L. Bevan, drift, center Sec. 18, T. 32 N., R. 33 W., coal 31 inches, roof 10 feet of blue shale capped with 6 inches of coal; (2) Black Diamond, shaft 28 feet, S. W. ¼ S. E. ¼ Sec. 18, coal 32 to 37 inches, roof 26 feet of shale capped with sandstone, floor 5 feet soft clay; (3) W. B. Leslie, slope, S. E. ¼ S. E. ¼ Sec. 19, coal 35 inches, roof hard blue shale.

On a conspicuous mound southeast of Mulberry (S. E. ¼ Sec. 7), is a stripping 65 feet above the thick coal. The section is:

	Feet.	Inches.
Sandstone, yellow to reddish-brown, top of mound	2	....
Shale, light drab	6	....
Shale, bluish-black, hard	2	8
COAL (Weir-Pittsburg Upper)	1	8

Minden.—The Weir-Pittsburg Lower underlies a strip about 3 miles wide on the west edge of the State at Minden, dipping to the west, and south of Minden, to the northwest. Several mines with steam hoists and modern equipment ship a considerable output. The coal is 30 to 37 inches thick, and has the characteristics already described. The roof is a hard blue shale that grades into lighter and softer material above. The following section illustrates the general character of the overlying rocks:

SHAFT AT WEIR COAL CO., MINE NO. 18.

	Feet.	Inches
Shale	28	....
COAL	....	6
Clay	1	....
Shale, light	10	....
Shale, blue, somewhat "slaty"	9	....
COAL (Weir-Pittsburg Lower)	2	9
Clay, more than	3	....

The following mines were found in operation: (1) Pullen and Sons, shaft 42 feet, S. W. ¼ S. W. ¼ Sec. 28, T. 32 N., R. 33 W., coal 30 inches; (2) Chapman Coal Co., small slope a few rods south of Pullen's, coal 30 inches; (3) Western Coal and Mining Co., Mine No. 17, shaft 68 feet, S. W. ¼ S. W. ¼ Sec. 30, coal 34 inches; (4) Weir Coal Co., Mine No. 18, shaft 48 feet, on western edge of Minden, coal 33 inches; (5) Midway Coal and Mining Co., Mine No. 8, shaft 45 feet, N. W. ¼ Sec. 7, T. 31 N., R. 33 W., coal 37 feet. The thick coal is stripped near the Midway mine and has been removed by recent erosion a short distance east and south. Its most southern appearance is at the top of a low mound about 3 miles south of the Midway shaft (S. E. ¼ S. W. ¼ Sec. 30).

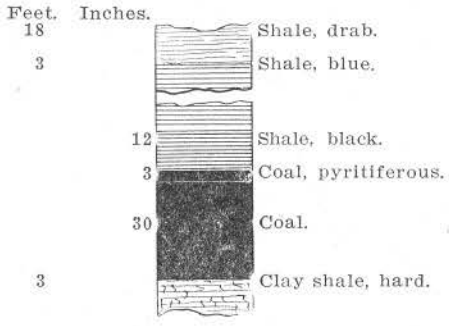

FIG. 10. The Weir-Pittsburg Lower coal bed at Minden.

Liberal.—On the low ridges west and southeast of Liberal (Secs. 2, 11, 12, 13, and 24 of T. 32 N., R. 33 W., and Secs. 18 and 30 of T. 32 N., R. 32 W.), the Weir-Pittsburg Lower has been stripped in many places, chiefly on a small scale. The coal area comprises little more than 4 square miles. The bed mined is 26 to 30 inches thick, in addition to a few inches of very coaly shale ("rash") at the top. The roof is formed by 6 feet of hard blue shale that grades upward into lighter and softer shale. Over the shale is sandstone and in places it lies directly on the coal or, along ancient channels, even replaces all or part of that valuable deposit. Dips are small and irregular, though in general beds rise to the south. The only mine with railroad connection is that of W. Lavery on the west side of Liberal (N. ½ Sec. 11), where the coal is 29 inches thick and is locally overlain with sandstone. Small strip pits and drifts are: (1) S. W. ¼ S. E. ¼ Sec. 2, coal 26 inches, roof 12 feet of shale; (2) S. W. ¼ Sec. 11, coal 30 inches, roof 8 feet of sandstone; (3) S. E. ¼ S. E. ¼ Sec. 11, coal 14 inches, roof sandstone; (4) N. W. ¼ N. W. ¼ Sec. 12, coal 28 inches, roof 19 feet of shale used at clay plant; (5) S. E. ¼ N. W. ¼ Sec. 13, coal 24 to 30 inches, roof 7 feet of shale and sandstone; (6) N. W. ¼ N. E. ¼ Sec. 24, coal 23 inches, roof 5 feet of sandy shale and sandstone; (7) S. E. ¼ N. E. ¼ Sec. 24, coal 30 inches, roof 7 feet of shale; (8) N. E. ¼ S. W. ¼ Sec. 18, coal 27 inches, roof 15 feet of shale; (9) N. E. ¼ N. E. ¼ Sec. 30, coal 24 inches, roof 8 feet of shale; (10) S. E. ¼ N. E. ¼ Sec. 30, coal 24 inches, roof 5 feet of shale under 4 of sandstone. No workable coal is known for many miles south of those enumerated, the rocks exposed being chiefly sandstone.

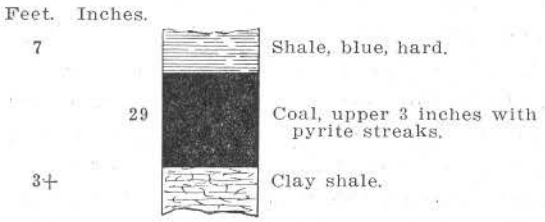

FIG. 11. The Weir-Pittsburg Lower coal bed at Liberal.

Fourteen feet of shale is being removed by A. B. Petgen from the top of a small mound one mile northwest of Liberal (N. E. ¼ S. E. ¼ Sec. 34) in order to obtain the Weir-Pittsburg Lower. The coal bed is 26 inches thick. Two miles northeast of town (S. W. ¼ S. W. ¼ Sec. 30) are 17 inches of coal overlain with blue, thinly laminated shale. This bed lies about 50 feet below the horizon of the thick coal, and a similar deposit outcrops a mile or less down East Drywood. In a drilling near Liberal, begun 50 feet below the level of the Weir-

Pittsburg Lower and continued to the depth of 135 feet, eight coal beds were penetrated, but none were more than one foot thick.

Nearly 4 miles northeast of Liberal there is a long mound covering less than one square mile. Around its base the Weir-Pittsburg Lower outcrops and is mined at the drifts of J. J. Martin on land of E. Coles (N. E. ¼ S. W. ¼ Sec. 29) and S. F. Christian on land of C. J. Cameron (N. E. ¼ N. E. ¼ Sec. 29). The following was measured on the road which crosses the mound:

	Feet.	*Inches.*
Sandstone, just below top of mound, more than	10	....
Shale, light, sandy, with ferruginous concretions	21	....
Sandstone	1	....
Shale	....	8
COAL	....	8
Shale, light-colored	12	....
Shale, dark blue, a good roof	6	....
COAL (Weir-Pittsburg Lower)	2	....

Not quite 2 miles north of this mound, near Verdella (N. W. ¼ S. E. ¼ Sec. 16, T. 33 N., R. 32 W.), is Round Mound. Its top is covered with limestone fragments derived from the beds at the base of the Henrietta formation. Seventy feet lower is the following, dipping 10° northwest:

	Feet.
Sandstone	2
Shale, light, sandy	5
Shale, dark blue, firm	2
COAL	1½
Shale and a little sandstone	20

Nashville.—Along Little North fork, in the southwestern part of the county, the principal outcrops are the sandstones and interbedded shales lying near the base of the Coal Measures. Thin beds of coal appear in many places, but most of them are less than 14 inches thick. The thickest coal outcrop noted by Broadhead was one of 16 inches.

Lamar.—Only thin coal beds lying at stratigraphic levels lower than those on the Weir-Pittsburg beds have been found near Lamar. These are mined on a small scale for local trade on North fork, west and south of the city, on McCollum creek, and at a few scattered localities. One mile west of Lamar (N. E. ¼ Sec. 26 and N. W. ¼ Sec. 25), two beds are exposed near some small drifts and strip-pits, as follows:

	Feet.	*Inches.*
Sandstone, red, ferruginous	1	....
COAL	....	10
Shale, yellowish-drab at top, bluish-gray at bottom	8	....
COAL	1	1
Clay, very hard	....	....

One-half mile south of Lamar, on McCollum creek, the same two beds are stripped, the upper 11 inches and the lower 12 to 16 inches thick, both beds having shale roofs. The thickest coal bed noted in this part of the county was 6 miles east of Lamar (N. W. ¼ N. E. ¼ Sec. 30,

T. 32 N., R. 29 W.), where 32 inches was stripped in the creek. At other places on the same property what may be the same bed is only 13 to 16 inches thick.

Boston.—Near Boston, as near Lamar, the only coal is in the thin beds in the lower Cherokee. Fuel is obtained for local use at many places where the bed stripped is less than 14 inches thick. In a few places beds 14 to 18 inches thick are exposed and utilized, but the coal deposits of the district cannot be considered of more than local importance.

Newport.—Mississipian limestone appears in Horse creek near Newport, and the coal beds at the base of the Coal Measures in the vicinity are thin. Two miles northwest, in the bluffs of Horse creek (N. E. ¼ Sec. 8), are the Cole and Beaver drifts in 14 inches of excellent coal. The roof is a strong sandstone and 3 feet of underclay is taken up in the entries. Similar coal beds are occasionally utilized elsewhere in the northwest corner of T. 32 N., R. 29 W., and probably underlie the divides.

Milford.—For half a mile south of the Milford bridge there is a line of old drifts in coal commonly 21 inches thick and overlain with sandstone. The only drift in operation was that of A. A. Johnson (N. W. ¼ S. W. ¼ Sec. 29, T. 33 N., R. 29 W.), where there were measured:

	Feet.	*Inches.*
Sandstone	4	....
Shale, sandy, with thin sandstone layers	10	....
COAL, fair quality, very thin streaks of shale and mother coal in places	1	8
Shale, carbonaceous	....	4
Clay, soft	1	....

The principal mining district in eastern Barton county is 4 miles east of Milford, where a number of small mines supply a large territory with its mineral fuel. The bed mined lies only a short distance above the base of the Coal Measures and contains 21 to 24 inches of coal. Near the middle of the bed is a persistent parting of shale or bony coal 2 to 4 inches thick, and other thinner and non-persistent partings make the bed rather dirty in places. Fine films of calcite and gypsum may be seen in the joints. At the bottom of the bed is 2 to 8 inches of dirty coal and carbonaceous shale, below which is an underclay that is sufficiently hard to prevent excessive heaving. In some of the mines sandstone forms the roof; in others the sandstone is separated from the coal by a few feet of shale or of alternating layers of shale and sandstone. The few props required are readily obtained in the forested ravines. The coal outcrops low down in sharp valleys, and dips slightly to the west. Mines found in operation were: (1) R. E. Cackley, drift, N. W. ¼ S. W. ¼ Sec. 26, T. 33 N., R. 29 W.; (2) Spencer and Faubion, drift, S. W. ¼ S. W. ¼ Sec. 26; (3) A. C.

Ritchie, drift, N. E. ¼ S. W. ¼ Sec. 26; (4) R. M. Perry, slope, S. W. ¼ S. E. ¼ Sec. 26; (5) C. T. Stone, drift, N. E. ¼ N. W. ¼ Sec. 26; (6) R. P. Stout, slope, S. W. ¼ N. W. ¼ Sec. 27; (7) G. W. Rector, drift, S. E. ¼ S. W. ¼ Sec. 23. The bed is typically developed at the Ritchie drift, as follows:

	Feet.	*Inches.*
Sandstone, shale partings	5	....
Shale, bluish-gray, sandy	4	....
COAL	....	9
Shale	....	2
COAL	1	3
Shale, carbonaceous	....	8
Clay, soft at top, hard below	2	6

Three miles northeast of Milford the bed just mentioned outcrops low down in narrow valleys. At an old drift (S. W. ¼ S. E. ¼ Sec. 16, T. 33 N., R. 29 W.), the persistent shale parting is 20 to 36 inches thick, the coal above it being 13 inches and that below 12 inches thick. Over the coal is 16 feet of sandstone that is massive at top and thin-bedded at bottom. At the Bass and Faubion drifts (N. W. ¼ Sec. 21), the bed mined is perhaps not the same. It contains 20 inches of coal without partings and bony at top. Here, too, 7 feet of thin-bedded, yellowish-white sandstone lies on the coal.

Coal has been found farther northwest, but that it lies near the lower limit of coal is shown by outcroppings of the Mississipian limestone in the extreme northeast corner of the county. In the N. W. ¼ S. E. ¼ Sec. 10 is coal in two benches separated by about 18 inches of shale. The upper bench is 13 inches thick and the lower reported to be 10 inches. The roof is a firm sandstone. Little coal has been found north of this, but farther west (S. E. ¼ S. E. ¼ Sec. 11) is an old drift in coal reported to be the same as that just described. Mr. W. M. Lloyd, the owner of this property, reports finding the following by drilling in the creek bottom below the level of the drift:

	Feet.	*Inches.*
Alluvium	8	....
COAL	1	2
Shale	2	....
COAL	2	....
Shale	3	....
COAL, not penetrated	....	....

BATES COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....188,923 TONS.

For many years Bates county produced more coal than any other in the State. As far back as 1892, however, it was surpassed by Macon, and since then its output has steadily decreased. The decline of the

*The geology of Bates county is described by G. C. Broadhead, Rept. for 1873-1874: Mo. Geol. Survey, pp. 155-178. The coal is mentioned by Arthur Winslow, Prelim. report on coal: Mo. Geol. Survey, 1891, pp. 143-150. The topography is shown on the Butler and Mound City sheets of the U. S. Geol. Survey.

Fig. 1. Escarpment of Kansas City limestone at Amsterdam.

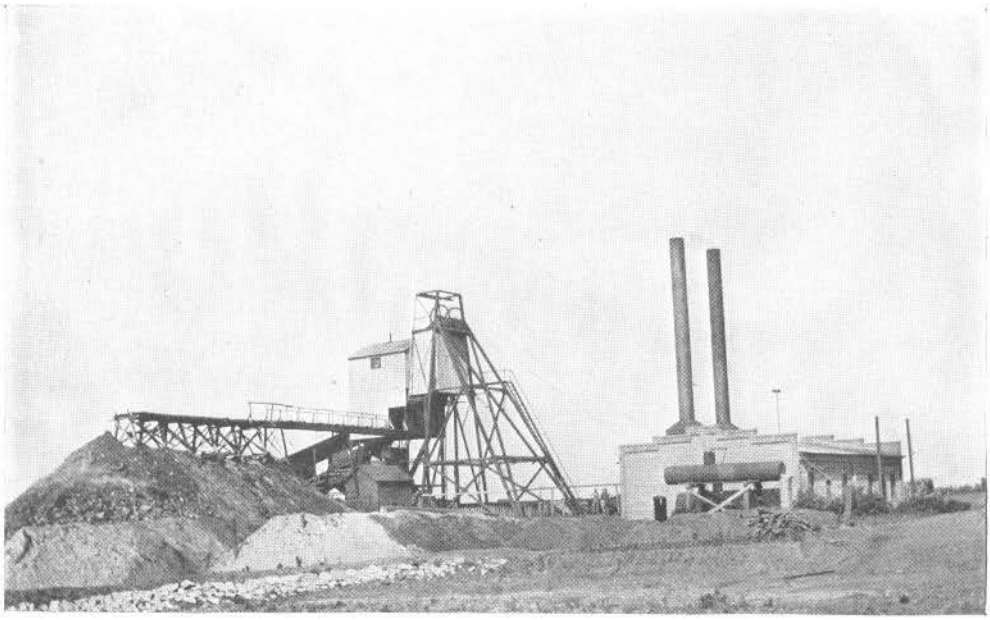

Fig. 2. Atlas Mine, New Home, Mo.

industry is due to the exhaustion of the more accessible thick beds, the competition of Kansas coal and the oil and gas of the southwest. Considerable coal is still mined however. Strip-pits and local mines are scattered throughout the country districts and coal is shipped from New Home, Rich Hill, Worland, Foster, and Amsterdam. Underground mining is done on the room and pillar method in all beds.

There is a close correspondence between the surface distribution of the formations and the topography due to differences in erosion. The lowlands on either side of the Osage and along the eastern edge of the county are formed by the soft shales and sandstone of the Cherokee. Above these is an escarpment caused by the resistant limestones of the Henrietta formation. The broad flat upland above the escarpment is eroded in the soft Pleasanton shale. There are limestones in the Pleasanton, notably in the northwest, but these are lenticular and relatively inconspicuous. The steep-sided ridges in the northwestern corner, and the high mounds dotting the prairie as far south as Hume are capped by the thick limestone beds at the base of the Missouri group. In this county the Pleasanton is 140 to 225 feet thick, the Henrietta 100 feet, and the Cherokee 325 to 370 feet. Below the Cherokee is the uneven upper surface of the thick and flinty Mississippian limestone, below the top of which there is no coal.

The general nature of the members of the formations is indicated in the drill records published below, especially in the logs from near Merwin, New Home and Rich Hill. All records examined correspond very closely, even in detail. The drilling at Appleton City, in St. Clair county, is applicable to the eastern part of Bates.

Bates county is rich in coal deposits. The highest workable bed is near the base of the Pleasanton shale, called by Broadhead the Mulberry because of numerous outcrops on Mulberry creek. It is the bed mined all along the western edge of the county. It outcrops as far east as Sprague south of the Osage, and probably underlies most of northern Bates county west of the Missouri Pacific railroad and east of it in Mound and Shawnee townships. Where mined near Worland, Foster, Sprague and Hume, it averages 30 to 36 inches. Farther north it is very variable and is reduced in thickness at many places. It is overlain by shale or locally by limestone, and underlain by a few feet of clay resting on a thick limestone (Pawnee) that is the top member of the Henrietta formation. The coal has very fair steaming qualities and in the southwestern quarter of the county deserves more attention than it has received.

At the top of the Cherokee shale, about 100 feet below the Mulberry, is the Lexington coal horizon, but the bed is less than a foot thick in most of Bates county. In the southeastern corner T. 40 N., R. 29 W., it is 12 to 14 inches thick and has been stripped in a number of places.

About 80 to 100 feet below the Lexington horizon is a bed that is persistent, but too thin to mine. The accompanying drill records show that it has a bottom-rock which is conspicuous because it is the only persistent thick limestone in the Cherokee of this region. This limestone bears a strong resemblance to a bed between the Lexington and Tebo horizons in Henry and Johnson counties. Although sufficient detailed geologic work has not been done along its horizon to justify a positive correlation of the coal, it is here tentatively named the Summit. A short distance below the Summit is another bed, the Mulky, that is too thin to be of importance in most of the county. In the eastern part of the county there is a lower bed that is sufficiently thick to mine and resembles very closely the typical Tebo of Henry county.

At a vertical distance of 240-270 feet below the Mulberry, the maximum distance being in northwestern Bates county, lies the most important bed in the county, the Rich Hill coal. It is split into two parts, here named the upper and the lower Rich Hill, by 6 to 20 feet of clay and shale. The upper Rich Hill is 9 to 26 inches thick and, like all the coal beds above it, is persistent. It is so situated that it can be stripped with the lower Rich Hill. The lower bed is the one formerly mined so extensively near Rich Hill and still taken out in large quantities at Rich Hill, New Home, and probably north of Rockville. It is a good steam coal, and even the part weathered "dead coal" of old strippings is in demand for zinc smelting. Where mined the lower Rich Hill is commonly 4 to 6 feet thick, but it is by no means uniform in thickness. The thick coal lies in many small basins and in some localities the beds at its horizon are barren. This feature of the deposit makes very thorough prospecting necessary, for a hole containing no thick coal may lie near an important basin. Although considerable prospecting has been done in many parts of the county, there is little doubt that profitable basins of thick coal remain undiscovered at the Rich Hill horizon. Most drill records in all parts of the region show some coal at that horizon and many of them have revealed beds that may be mined with profit when the market for coal is better. The lower Rich Hill bed lies at or very close to the Bevier horizon.

Broadly speaking, the strata of the county lie nearly horizontal, dipping gently to the northwest, but in places the beds show very steep dips in which no regularity has yet been detected. These dips are esspecially noticeable where the Rich Hill coal has been mined. The altitude of the bed changes as much as 100 feet or more in a quarter of a mile and is rarely level for many hundred feet. The cut of the new drainage ditch near Prairie City exposes very complicated folding and faulting on a small scale.

The Mulberry bed appears to underlie about 300 square miles in the western part of the county with an average thickness of 22 inches.

Computed at 1,800 tons per acre-foot this bed contains 633,600 tons of coal. The lower workable beds are very irregular and it is therefore very difficult to estimate their content of coal. Deep drillings and outcrop observations indicate that beds below the Mulberry average at least 40 inches, including only parts of beds 14 inches or more in thickness. On this assumption the total original tonnage of lower beds is 3,356,160,000 tons and all beds 3,989,760,000 tons. Of this total the amount already mined is proportionately so small as to be negligible.

DETAILED MENTION.

Merwin.—A drilling about one-half mile south of Merwin (N. E. ¼ S. E. ¼ Sec. 5, T. 41 N., R. 33 W.) found the Mulberry coal to be 31 inches thick and at a depth of 127 feet. Below this, to a depth of 401 feet, there was no coal over 8 inches thick. The drilling may have lacked, however, 10 or 12 feet of reaching the Rich Hill horizon. East of town two diamond drill holes were bored, the deeper being as follows:

DRILLING EAST OF MERWIN (W. ½ N. E. ¼ SEC. 27, T. 42 N., R. 32 W.)

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Soil and gravel	17	5	17	5
Pleasanton shale—					
2.	Sandstone, gray	40	7	58	....
3.	Limestone	2	10	60	10
4.	Shale, dark	3	....	63	10
5.	Limestone	3	10	67	8
6.	Shale, gray	2	8	70	4
7.	COAL (Mulberry)	1	4	71	8
8.	Clay	....	10	72	6
9.	Shale, gray	4	6	77	....
Henrietta formation—					
10.	Limestone, hard	11	8	88	8
11.	Shale, calcareous	2	6	91	2
12.	Shale, sandy	5	....	96	2
13.	Shale, gray	3	....	99	2
14.	Shale, dark	6	5	105	7
15.	Limestone	4	4	109	11
16.	Shale, dark, "slaty"	5	6	115	5
17.	Sandstone	....	9	116	2
18.	Shale, sandy	8	....	124	2
19.	Shale, dark	1	2	125	4
20.	COAL, with partings	....	2	125	6
21.	Shale, soft	10	5	135	11
22.	Limestone, gray	15	7	151	6
Cherokee shale—					
23.	Shale, black, "slaty"	4	8	156	2
24.	Shale, light	10	....	166	2
25.	Shale, dark, "slaty"	4	2	170	4
26.	COAL	....	2	170	6
27.	Clay	1	6	172	....
28.	Sandstone	1	2	173	2
29.	Shale, sandy	14	....	187	2
30.	Sandstone	69	10	257	....
31.	Shale, black, "slaty"	....	4	257	4
32.	Limestone	10	1	267	5
33.	Shale, gray	....	9	268	2
34.	Shale, black, "slaty"	....	10	269	....

		Thickness.		Depth.	
Cherokee shale—Continned.		*Feet.*	*Inches.*	*Feet.*	*Inches.*
35.	Shale, dark	13	11	282	11
36.	COAL (Mulky?)	....	9	283	8
37.	Clay	6	6	290	2
38.	Shale, dark	2	4	292	6
39.	Sandstone	3	4	295	10
40.	Shale, gray	6	4	302	2
41.	Shale, light to dark	7	4	309	6
42.	COAL (upper Rich Hill)	2	2	311	8
43.	Clay	2	6	314	2
44.	Shale	1	....	315	2
45.	Shale, dark to black, "slaty"	27	....	342	2
46.	COAL (lower Rich Hill)	2	5	344	7
47.	Clay	1	3	345	10
48.	Shale, dark	5	....	350	10
49.	Limestone	1	4	352	2
50.	Shale, "slaty"	2	....	354	2
51.	Limestone and shale	10	....	364	2
52.	Sandstone, dark to light	9	....	373	2
53.	Shale, gray, sandy	2	10	376	....
54.	COAL, with partings	....	6	376	6
55.	Shale, dark	9	8	386	2
56.	Shale, sandy	1	8	387	10
57.	Limestone	1	4	389	2
58.	Shale, dark, "slaty"	17	....	406	2
59.	Shale, calcareous	2	2	408	4
60.	Shale, sandy	2	3	410	7
61.	Shale, light	8	7	419	2
62.	Shale, sandy	33	....	452	2
63.	Shale, dark	2	6	454	8
64.	Shale, black, "slaty"	....	8	455	4
65.	COAL	....	5	455	9
66.	Clay, dark	1	5	457	2
67.	Shale, dark	10	....	467	2
68.	Shale, light, sandy	2	....	469	2
69.	Shale, gray	7	....	476	2
70.	Shale, dark	9	....	485	2
71.	Shale, hard	9	....	494	2
72.	Shale, calcareous	3	....	497	2
Mississippian series—					
73.	Limestone	6	....	503	2

The other drilling was in the east half of the same quarter section and went to a depth of 330 feet. Coal beds Nos. 42 and 46 of the foregoing record were found to be 17 inches thick at 293 feet and 20 inches at 325 feet, respectively. Otherwise the drillings were essentially the same.

Amsterdam.—On the south edge of Amsterdam is the shaft of the Amsterdam Coal Company, 92 feet deep to the Mulberry bed. Hoisting is done by steam power and the product is shipped. Because of large "horsebacks", the thickness of the bed is variable, ranging from 6 to 42 inches, averaging 24 inches. In places the coal is clean, in others it contains much pyrite. The clay between the coal and a limestone bottom-rock has an average thickness of more than 4 feet. The roof is variable, being only fair where it is shale, and excellent where a nodular limestone rests on the coal.

The shaft and slope of L. W. Decker are about 2 miles south of Amsterdam (N. E. ¼ S. E. ¼ Sec. 32, T. 41 N., R. 33 W.). The Mul-

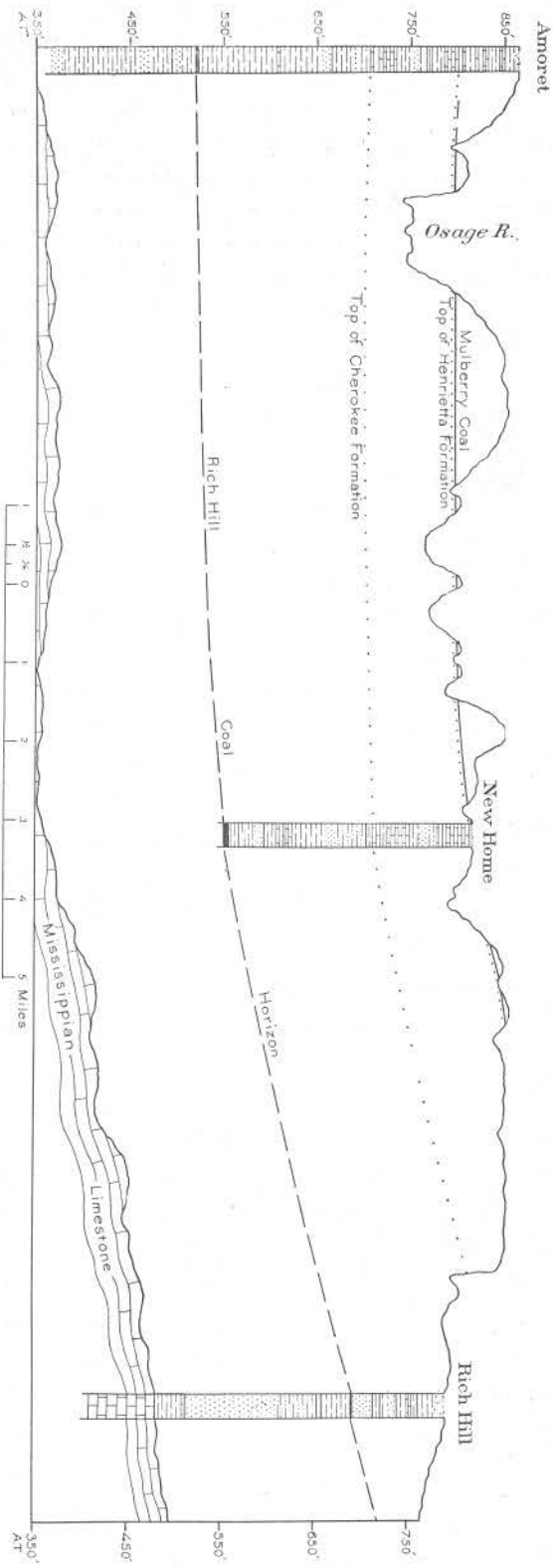

Fig. 12. Cross-section from Amoret to Rich Hill.

berry coal at this place is 36 to 40 inches thick, with a half-inch band of pyrite near the middle. The Decker mine is one of a series of a number of small mines and strippings which supply a local trade.

The water well at Amsterdam shows the Mississippian to lie 438 feet below the Mulberry. Both this and the Nickel well, 2 miles south, report another bed of coal about 280 feet below the Mulberry, probably at the horizon of the Rich Hill bed. The Nickel well penetrated Mississippian limestone about 435 feet below the Mulberry.

Mulberry. — The Mulberry coal bed outcrops up Mulberry creek as far as the north line of Sec. 32, T. 41 N., R. 33 W. The same bed has also been stripped along Miami creek below Vinton. According to Broadhead, it was also found by shafting on the prairie between the two streams. At the present time mining is largely limited to small local strippings where the coal averages 30 to 36 inches in thickness.

Amoret.—Several attempts have been made to operate shipping mines in the Mulberry bed near Amoret, but were abandoned because it was too full of pyrite and too irregular in thickness to be worked with profit. South and east of town this coal has been stripped at many places where it is reported to vary from 18 to 30 inches in thickness. North of the Osage a limestone lentil appears above the coal. In places there are 10 to 15 feet of shale between it and the coal, but in others, as in the northern part of Sec. 5, T. 39 N., R. 33 W., the lentil forms a cap-rock for the Mulberry bed.

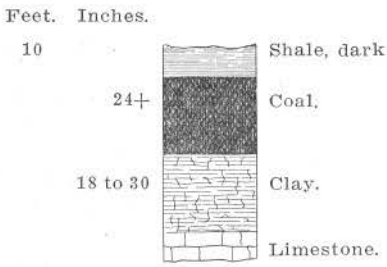

FIG. 13. The Mulberry coal bed at Amoret.

A drilling made for water on the Darby fruit farm at Amoret (center Sec. 29, T. 40 N., R. 33 W.) is as follows:

DRILLING NEAR AMORET.

	Thickness. *Feet.*	Depth. *Feet.*
Soil	5	5
Pleasanton shale—		
Shale	10	15
Limestone, yellow	5	20
Shale, blue	12	32
Limestone	6	38
Shale, drab	5	43
Limestone	4	47
Shale, drab	10	57
Limestone	3	60
Shale (horizon of Mulberry coal)	5	65
Henrietta formation—		
Limestone	15	80
Shale, blue	13	93
Limestone	5	98
Shale, black, "slaty"	5	103
Shale, drab	5	108
Sandstone	5	113
Shale, light	18	131
Limestone	19	150
Shale, black, "slaty"	4	154
Limestone	4	158
Cherokee shale—		
Shale, drab	12	170
Sandstone	4	174
Shale, drab	26	200
Sandstone, reported as gas-bearing	10	210
Shale, drab	45	255
Limestone	3	258
Shale, drab	6	264
Shale, black, "slaty," reported as gas-bearing	9	273

Cherokee shale—Continued.	Thickness. Feet.	Depth. Feet.
Shale, brown	27	300
Shale, light	26	326
Shale, dark, reported as gas-bearing	17	343
COAL (Rich Hill?)	3	346
Clay	5	351
Shale	12	363
Sandstone	6	369
COAL	2	371
Shale, dark to light	24	395
Sandstone, reported as "broken sand"	10	405
Shale	81	486
Sandstone, water-bearing	14	500

Worland.—A number of small strippings, drifts, and shallow shafts operate in the Mulberry coal east, west, and south of Worland. Some of the product is shipped at times. The coal has a rather uniform thickness of 32 inches and is overlain by 30 feet or more of hard light shale which forms a fair roof. There is a pyrite parting of an inch or less about 14 inches from the bottom and the best coal lies above it. In places as much as 15 feet of over-burden can be profitably removed. Besides the numerous strippings near the town there are two shipping mines on the Kansas City Southern railway about 2 miles south. They are: (1) James Dunkerly, on land of Charles Horton (N. E. ¼ Sec. 19, T. 39 N., R. 33 W.), horse-whim hoist, and (2) James V. Tatley, on land of John Harris (N. E. ¼ Sec. 19, T. 39 N., R. 33 W), small steam hoist (N. E. ¼ Sec. 19, T. 39 N., R. 33 W.). Both mines reach the Mulberry bed with 40-foot shafts. The coal is reported 32 inches thick and the roof a fairly firm shale.

Hume.—The Mulberry coal appears in shallow excavations on the almost flat prairie in the southwestern corner of the county. It is 34 inches thick, has a capping of 4 feet of sandy shale, and dips gently southward. At present no mining is being seriously undertaken near Hume.

Foster.—The Mulberry coal is mined at many places near Foster, by both stripping and underground work. It ranges in thickness from

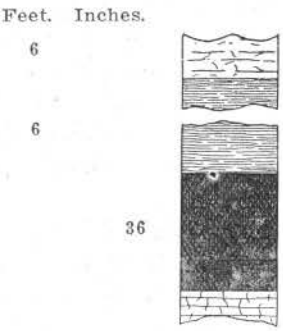

FIG. 14. The Mulberry coal bed at Foster.

34 to 42 inches, stocks well, and is of very fair quality. A parting of one inch or less of pyritiferous shale lies near the middle of the bed. The roof is a fairly strong light-colored shale about 35 feet thick. The greater part of the bed that could be obtained by stripping has been removed, large abandoned strip-pits appearing in many localities. Mines found in operation in 1911 were: (1) T. W. Whitten, slope and stripping in northeast corner of Foster; (2) "Water Moccasin," slope in southwest corner of Foster; (3) Standard Coal Company, 40-foot shaft, one mile west of Foster (N. E. ¼ N. E. ¼ Sec. 15); (4) T. Hime, drift, (S. E. ¼ S. E. ¼ Sec. 16); (5) T. W. Whitten, drift, (N. W. ¼ N. W. ¼ Sec. 21); and (6) R. Bobo, drift, (N. E. ¼ Sec. 16), on Walnut creek 3 miles west of Foster. At the Standard mine hoisting is done by horse-power and a large territory has been mined out. The product is hauled to the railroad over a tramway one-fourth mile long. The section at this mine is typical of that found at all.

STRATA AT STANDARD MINE, WEST OF FOSTER.

	Feet.	*Inches.*
Sandstone, soft	12	....
Shale, drab	33	....
COAL, dirty, 2 inches COAL, good, 16 inches (Mulberry) Shale, pyritiferous, ½ inch COAL, good, 20 inches	3	2½
Clay	3	6
Limestone (Pawnee), light gray, thin-bedded, seen on Walnut Creek	18	....

New Home.—The largest mine in Bates county and one of the best equipped in the State is the New Home mine of the Atlas Coal Company (S. E. ¼ S. W. ¼ Sec. 30, T. 39 N., R. 32 W.). Shipping is done over a 3-mile spur from the Kansas City, Fort Scott & Memphis railroad. The top-works consist of a skeleton steel tower and tipple, with self-dumping cages, hopper scales, and other modern appliances, and complete steam and electric power generating plants. The shaft is 278 feet deep to the bottom of the lower Rich Hill coal bed. This bed is of good appearance, being hard and bright, and is 4 to 6 feet thick, averaging 4½ feet. In most places there is a band of pyritiferous shale $^1/_{16}$ to 1 inch thick about 2 feet below the top of the coal. In much of the mine the shale roof requires careful timbering, though there is firm black shale in the south workings. Mining is done room and pillar and the coal shot off the solid. Pockets of inflammable gas are numerous, but careful management and strong ventilation prevent accidents with the naked lights in use.

A remarkable feature of the bed mined is the presence of dips much steeper than those observed in the higher outcropping beds. The mine is a new one, opened since a fire at a former shaft, so that entries have been driven only 800 feet south and 600 feet north. Coal on the straight south entry undulates without great change in level,

but on cross entries it dips 30° or less to the east. On the straight north entry there is a steep dip to the south that changes the level of the coal 30 feet and necessitates the use of rope haulage for 450 feet. In a distance of only 600 feet the maximum change of level is 70 feet.

The Mulberry coal is represented by weathered smut at the top of the shaft and is reported 3 feet in a neighboring shallow well. A number of diamond drillings made near New Home showed the lower Rich Hill bed to be 20 to 50 inches thick, and in one place only 4 inches.

DRILLING AT NEW HOME.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Soil	1	6	1	6
Henrietta formation—					
2.	Limestone (Pawnee)	18	....	19	6
3.	Shale, sandy	8	6	28	....
4.	Shale, blue	4	....	32	....
5.	COAL	....	4	32	4
6.	Clay	2	....	34	4
7.	Limestone, blue	2	....	36	4
8.	Shale, sandy	8	8	45	....
9.	Sandstone	14	....	59	....
10.	Shale, blue	9	....	68	....
11.	Limestone	23	....	91	....
12.	Shale, black, "slaty"	2	6	93	6
13.	Shale, drab	5	6	99	....
14.	Limestone	8	....	107	....
Cherokee shale—					
15.	Shale, blue	6	....	113	....
16.	COAL (Lexington)	....	5	113	5
17.	Clay	1	7	115	....
18.	Shale, sandy	32	....	147	....
19.	Sandstone	11	....	158	....
20.	Shale, blue	36	....	194	....
21.	Limestone	9	....	203	....
22.	Clay, blue	1	8	204	8
23.	"Rock"	4	4	209	....
24.	Shale, "slaty"	7	....	216	....
25.	Shale, drab	7	....	223	....
26.	COAL (Mulky?)	....	8	223	8
27.	Clay, sandy	6	....	229	8
28.	Sandstone	4	....	233	8
29.	Shale, blue	8	....	241	8
30.	Shale, soft, "slaty"	2	....	243	8
31.	Shale, sandy	6	....	249	8
32.	COAL (upper Rich Hill)	....	8	250	4
33.	Clay	1	....	251	4
34.	Shale, dark, banded	3	....	254	4
35.	Shale, "slaty", soft at top, hard at bottom	6	....	260	4
36.	Limestone, black, full of shells	1	....	261	4
37.	COAL (lower Rich Hill)	6	....	267	4
38.	Clay	....	3	267	7

The Holland Coal Company operates a small shipping mine on the New Home spur about 1½ miles southwest of the Atlas plant (S. E. ¼ N. E. ¼ Sec. 2, T. 38 N., R. 33 W.), hoisting by steam power. The shaft is 40 feet deep to the Mulberry bed, which is 30 to 40 inches thick. Above the coal is 38 feet of shale, and between the coal and

the limestone bottom-rock 4½ feet of underclay. A limestone in the Pleasanton formation, 65 feet above the Mulberry, outcrops in the hill by the shaft.

Sprague.—The shaft of J. M. Duzan is on the outskirts of Sprague (N. W. ¼ N. W. ¼ Sec. 9, T. 38 N., R. 32 W.). The following is the record of the strata in the shaft combined with measurments at the bottom:

SHAFT NEAR SPRAGUE.

	Thickness. Feet.	Thickness. Inches.	Depth. Feet.	Depth. Inches.
Soil and clay	8	....	8	....
Sandstone	18	....	26	....
Shale, light, sandy	26	....	52	....
COAL,	....	12	53	....
Shale, pyritiferous (Mulberry)	....	0 to ½	53	....
COAL,	....	21	54	9
Clay, in sump	4	....	58	9
Limestone, thick	....	....	....	....

The shale makes a fair roof and the coal is hard and bright. It is hoisted by horse-power and sold locally. The same coal has been stripped about 1 mile east of Sprague, where it lies at a higher level. A diamond drilling at Sprague showed the lower Rich Hill coal to be 18 inches thick and 271 feet in depth. Another drilling 2 miles southwest of town, in Sec. 18, found the same bed to be 22 inches thick and at a depth of 231 feet. The thin coal beds found near Rich Hill and at New Home lie between the Mulberry and lower Rich Hill in both drillings, but none is as much as 14 inches thick.

Adrian.—The Mulberry coal is intermittently mined for local use at several localities east of Adrian. It is exposed in few places, but is reported to be rather irregular in thickness and in places has a limestone cap-rock. It was formerly shafted about 2½ miles northeast of town (N. E. ¼ and N. W. ¼ Sec. 35, T. 42 N., R. 31 W.), where there are 28 to 32 inches of coal. North of this, about 3½ miles from Adrian (N. E. ¼ N. W. ¼ Sec. 26, T. 42 N., R. 31 W.), is the shaft of Ed. Duke, 18 feet deep to coal 18 to 56 inches thick, averaging 2 feet. The mine is worked in winter to supply a local trade and at other places in this vicinity the Mulberry coal is mined for farm use where it is 12 to more than 24 inches thick.

A drilling was made for oil and gas about one block west of the north elevator in Adrian. Mr. Charles Bateman stated from memory that the Mississippian was reached at a depth of 534 feet. Between 135 and 141 feet, a thin bed of coal was found, and there were two very thin beds below that. A drilling of this character can hardly be considered a fair test of the coal resources. Winslow states that about 6 miles a little north of west of Adrian a drilling 350 feet deep penetrated 27 inches of coal at 321 feet.

Passaic.—The Mulberry bed has been mined on Bones branch, west of Passaic, where it is 30 to 36 inches thick. At present no mining is done. It is probable that a large area west of Passaic is underlain by the same bed. The same may be said of Mound and Shawnee townships, though 7 miles northeast (N. E. ¼ N. E. ¼ Sec. 18, T. 41 N., R. 30 W.) the coal is only 12 to 14 inches thick.

Butler.—To within a year or two ago the Mulberry coal was stripped at one or two places west of Butler, though little is done at present.

SUMMARY OF DRILLING ONE-HALF MILE SOUTH OF BUTLER.*

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Interval	109	....	....	....
2.	COAL	....	8	109	....
3.	Interval	18	4	....	....
4.	COAL	....	6	128	....
5.	Interval	56	6	....	....
6.	COAL	2	....	185	....
7.	Interval	26	....	....	....
8.	COAL	....	8	213	....
9.	Interval	12	4	....	....
10.	COAL	....	2	226	....
11.	Interval	13	10	....	....
12.	COAL	....	5	240	....
13.	Interval	55	7	....	....
14.	COAL	....	4	296	....

Another drilling for oil and gas reached the Mississippian at a depth of 490 feet at Butler. More accurate core drilling is needed to reveal the actual amount of coal under the district.

Rich Hill.—The district of which Rich Hill is the center produced more coal during its period of activity than any other of like size in

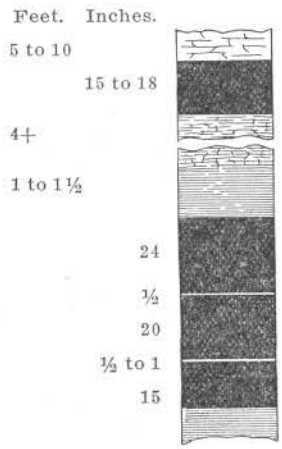

FIG. 15. The Rich Hill coal beds at Rich Hill.

*Winslow, Prelim. report on coal, p. 144.

the State. Much of the product was obtained from large strip-pits, though considerable was also taken out through shafts. The more accessible deposits are now nearly exhausted and the comparatively small amount now mined comes largely from the edges of nearly exhausted basins. The coal mined, here termed the lower Rich Hill bed, is 4½ to 6 feet thick where work has been prosecuted, is an excellent steam producer, is very hard, and contains a moderate amount of visible pyrite in small lenticular masses. The bed is notably irregular in thickness, however, and is absent in many places. It was deposited in a great number of basins in which the thicker coal was laid down only over areas of 400 acres or less. In many places the thick coal simply thins around the edges of a basin, in others it splits into several beds that in turn rapidly thin out. In places small channels, now filled with sandstone, cut out the coal.

One remarkable feature of the bed is its sudden change of altitude in many places, the coal dipping 150 feet in distances of less than half a mile, without, however, changing much in character. For this reason the bed can be stripped on one piece of land and can be reached only by shafts on adjacent property. Some of the higher parts of coal basins have been removed by recent erosion as a result of their topographic position while lower parts still exist under areas having the same altitude.

The conditions for mining are fairly good except where the steep dips occur. The roof is good, where, as in most places, black shale overlies the coal. Where the coal is overlain by a "white top" of light-colored shale, the roof is more troublesome. There are small quantities of inflammable gas in some workings.

A short distance above the lower Rich Hill bed lies another bed here termed the upper Rich Hill. It is persistent and generally ranges in thickness from 12 to 24 inches. Where it lies within 6 or 12 feet of the lower Rich Hill, both beds are sometimes stripped together, as much as 25 feet of material being in some places removed from over the thick bed. There are also two thin but persistent coal beds a short distance above the upper Rich Hill, and a third is present in places. The highest of these beds has a thick limestone bottom-rock that is a useful marker for the position of the thicker coal beneath. About 30 feet below the lower Rich Hill is another thin coal. The succession of strata is well shown in the records given below:†

†A large number of drill records were kindly furnished the writer by Mr. Joseph Stover of Rich Hill. In spite of the variations in the lower Rich Hill bed, all the records are similar in essential features.

DRILLING 4½ MILES NORTHWEST OF RICH HILL (S. E. ¼ N. E. ¼ SEC. 26.)

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
Henrietta formation—					
1.	Limestone	1	6	1	6
Cherokee shale—					
2.	Shale, drab	3	....	4	6
3.	Shale, sandy	40	7	45	1
4.	Sandstone	13	5	58	6
5.	Shale, blue	38	6	97	....
6.	COAL (Summit?)	....	8	97	8
7.	Clay	1	....	98	8
8.	Limestone	8	6	107	2
9.	Shale, black, "slaty"	5	....	112	2
10.	Shale, drab	13	6	125	8
11.	COAL (Mulky?)	....	10	126	6
12.	Clay	3	....	129	6
13.	Sandstone	3	....	132	6
14.	Shale, drab	9	5	141	11
15.	COAL (upper Rich Hill)	1	3	143	2
16.	Clay	4	4	147	6
17.	Shale, drab	3	....	150	6
18.	Shale, black, "slaty"	3	6	154	....
19.	COAL (lower Rich Hill)	3	10	157	10
20.	Clay	....	8	158	6

DIAMOND DRILLING TWO MILES SOUTHWEST OF RICH HILL (N. W. ¼ S. E. ¼ SEC. 13).

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Loose earth	12	....	12	....
Cherokee formation—					
2.	Shale, blue	8	....	20	....
3.	Shale, black, "slaty"	1	....	21	....
4.	Shale, blue	6	6	27	6
5.	COAL (Summit?)	1	1	28	7
6.	Clay	....	8	29	3
7.	Limestone	5	9	35	....
8.	Shale, black, "slaty"	6	6	41	6
9.	Shale, drab	9	6	51	....
10.	COAL (Mulky?)	....	10	51	10
11.	Clay	12	8	64	6
12.	Shale, black, "slaty," soft	4	....	68	6
13.	COAL	....	6	69	....
14.	Clay	4	....	73	....
15.	Shale, black, "slaty"	2	8	75	8
16.	COAL (upper Rich Hill)	....	7	76	3
17.	Clay	6	7	82	10
18.	Sandstone	14	....	96	10
19.	COAL (lower Rich Hill), "slaty"	3	11	100	9
20.	Shale, blue	26	....	126	9
21.	Shale, black, "slaty"	3	....	129	9
22.	COAL	1	10	131	7
23.	Clay	2	....	133	7
24.	Shale, blue	2	2	135	9
25.	COAL	....	2	135	11
26.	Clay	3	10	139	9
27.	Shale, sandy	25	....	164	9
28.	Sandstone	5	....	169	9
29.	Shale, sandy	8	....	177	9
30.	Sandstone, gray and white	99	....	276	9
31.	COAL	....	5	277	2
32.	Shale, blue	5	1	282	3
33.	Shale, black, "slaty"	3	....	285	3
34.	Shale, blue, sandy at top, "slaty" below	23	5	308	8
35.	COAL	....	10	309	6
36.	Clay	4	4	313	10
Mississippian series (lower limit of coal)—					
37.	Limestone	66	2	380	....

There are in the Rich Hill field three districts in which mining has been undertaken: (1) south of the city to the county line and beyond, (2) north and northwest of the city, near Ovid, and (3) a small area northeast of the city. South of Rich Hill are the following mines: (1) Carr Coal Company (N. W. ¼ S. E. ¼ Sec. 17), shaft 40 feet, small steam hoist, ships, now pulling pillars, coal about 4 feet thick in a trough trending northeast-southwest, dip to west, roof 4 feet of firm black shale; (2) Eli Goret (N. E. ¼ S. W. ¼ Sec. 17), short slope, local trade, coal 42 inches, roof sandy shale; (3) H. C. Ritchie (S. E. ¼ N. E. ¼ Sec. 17), strip-pit and short slope, local trade, coal 4½ to 5 feet, roof black shale; (4) Reese Coal Co. (N. E. ¼ N. E. ¼ Sec. 21), slope, ships over spur from Missouri Pacific, coal averages 4 feet in a basin of 200 acres, strong dip to southwest, bed varies 50 feet in altitude, roof black shale. South and west of Ovid are many large strippings, the edges of which are occasionally re-worked for local trade. Where mined the coal is 3½ to 5 feet thick. The only mines found in operation were: (1) Emmet Wear (N. E. ¼ N. E. ¼ Sec. 31, T. 39 N., R. 31 W.), strip-pit, coal 40 inches, roof 2 feet black shale; and (2) Denayer Brothers (S. E. ¼ N. E. ¼ Sec. 35, T. 39 N., R. 32 W.), drift, coal 57 inches, roof black shale, dip 10° N. W. One mile or less northeast of Rich Hill are large old strippings, one 50 acres in extent. Coal is now being taken out and hauled to the city by: (1) Spencer Brothers (N. E. ¼ S. E. ¼ Sec. 5), strip-pit, coal 4½ feet, roof 7 feet black shale; (2) J. M. McCombs (N. E. ¼ N. W. ¼ Sec. 4), strip-pit and drift, excellent roof of black shale in drift.

OUTCROP IN McCOMBS STRIP-PIT.

	Feet.	*Inches.*
Shale, light drab	10	....
Shale, dark, coaly	....	10
COAL (upper Rich Hill), good	2	4
Clay	3	....
Shale, light	5	....
COAL (lower Rich Hill), excellent	5	....

Prairie City.—The region around Prairie City slopes gently from the foot of the Henrietta escarpment southward to Osage river and is so deeply covered with soil that little coal is exposed, though beds of 18 to 30 inches have been found by shallow shafting and stripping in several places near Willow and Shaw creeks.

On Willow creek, 2 miles northwest of Prairie City, is the mine of H. H. McClendon (S. W. ¼ N. E. ¼ Sec. 2, T. 38 N., R. 30 W.). At the bottom of a 16-foot shaft is the following:

	Feet.	*Inches.*
Limestone, dark blue when fresh, very hard	1	2
Shale, light	....	10
Shale, black, "slaty"	3	....
COAL (Tebo?)	1	6
Clay	4	6
Shale, blue	4	....

The coal is worked on the longwall plan and sold locally. This section closely resembles that associated with the typical Tebo seam of Henry county. The same coal has been found at other places in this vicinity, 18 to 26 inches thick.

The strippings of D. H. Robinson are about 5 miles northwest of Prairie City (N. W. ¼ N. W. ¼ Sec. 4, T. 38 N., R. 30 W., and S. W. ¼ S. W. ¼ Sec. 33, T. 39 N., R. 30 W.). The coal is 24 inches thick, overlain by at least 22 inches of shale.

In the new drainage ditch, 1½ miles south of Prairie City, are exposures of 6 to 20 inches of coal, probably in 2 or more beds. Drilling near here is said to have revealed 42 inches of coal in one bed. As shown by the exposures in the ditch, however, the strata are so much folded and faulted as to make mining operations very difficult.

Rockville.—Though the region north of Rockville has been subject to some stripping, few or no attempts have been made to obtain coal by shafting. An exceptionally large stripping is that of D. D. Peeler, a little over 5 miles northwest (S. E. ¼ S. E. ¼ Sec. 29, T. 39 N., R. 29 W.) on the land of Sandburne and Morris. As much as 20 feet of over-burden has been removed and the product is sold locally or hauled to Rockville. If this is the Rich Hill bed, as it appears to be, it is probably a basin deposit. Prospecting in the district might reveal other important basins.

SECTION AT PEELER STRIPPING.

	Feet.
Limestone, fragments, not in place (base at Henrietta formation)	....
Slope, sandy shale and shaly sandstone showing in places	50
Limestone, massive, gray when fresh, weathered into nodules	2
Shale, light, sandy at top, dark and "slaty" at base, shaly slope between	65
COAL (lower Rich Hill), reported	5

On Panther creek, 5 to 6 miles north of Rockville, a bed of coal 2 to 3 feet thick outcrops in many places. All of this region has large undeveloped coal resources.

The Hunt slope is about 9 miles north of Rockville (N. E. ¼ S. W. ¼ Sec. 3, T. 39 N., R. 29 W.) on a branch of Panther creek. The coal is reported to be 48 to 54 inches thick. Over the coal is dark to black laminated shale containing a few "niggerheads." The product is sold locally or hauled to Appleton City, where it has a good reputation. The same coal has been utilized one mile southeast, on the same creek, where it is 41 to 48 inches thick. Another bed, 16 to 18 inches thick, is reported to lie 8 feet above the thick coal. These are probably the upper and lower Rich Hill beds, respectively.

Spruce.—Three beds of coal, all of them relatively thin, have been mined near Spruce. The Lexington coal is stripped for farm use in the hills in the southeast corner of Deepwater township, where it is 12 to 14 inches thick. Along Deepwater creek 2 to 3 miles east of the

village are several strippings in the Tebo coal. The following section was measured in the N. E. ¼ N. E. ¼ Sec. 23, T. 40 N., R. 29 W.:

	Feet.	Inches.
Limestone, gray	....	6–19
Shale, black, "slaty"	3	4
COAL, contains some pyrite	....	18

Johnstown.—Two seams have been mined, principally for farm use, along North Deepwater, Long branch, and Rockbottom creeks. The upper bed is not more than 12 inches thick, but the lower one is generally 18 to 24 inches. The following section was measured at a stripping in the N. E. ¼ N. E. ¼ Sec. 26, T. 41 N., R. 29 W.:

	Thickness. Feet.	Inches
COAL, weathered, reported	....	12
Shale, clayey at top, black, "slaty" below	11	8
Limestone, brown, ferruginous	....	6
COAL, reported	....	24

Aaron.—In a few places near Aaron, coal has been stripped for farm use. Most of this has come from the Tebo bed on Peter and Cove creeks, where it averages about 18 inches. South of Aaron some drilling has been done in sections 29 and 32, T. 42 N., R. 29 W., and several coal beds, 18 to 22 inches thick, reported. It is probable that the coal mined at Creighton, Cass county, will be found in this part of Bates county.

BENTON COUNTY.

Aside from thin Coal Measures deposits in the northwest corner of the county and small outliers elsewhere, the surface deposits of Benton county are all older than the Pennsylvanian, and in consequence contain no coal. The Pennsylvanian of the northwest corner consists chiefly of sandstone and sandy shale, with little coal. The only place in the county where mining has been done is on the Henry county line, 1½ miles southeast of Windsor, at a mine described in the report on Henry county. Pockets of coal probably exist some distance beyond the border of the main body of Coal Measures, but the small amount of coal in most of these pockets makes them of merely local importance.

BOONE COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....27,124 TONS.

As shown on the state geological map contained in this volume, not quite half of Boone county is underlain with Coal Measures. Although it includes part of the Henrietta formation and all of the

*The geology of Boone county is briefly described by G. C. Broadhead: Mo. Geol. Survey, vol. XII, pt. 2, 1898, pp. 375-409, and the coal mines formerly in operation, by Arthur Winslow, Preliminary report on coal: Mo. Geol. Survey, 1891, pp. 73-76. The topography of the coal area is shown on the Moberly and Jefferson City atlas sheets of the U. S. Geol. Survey. Considerable information was communicated orally by C. F. Marbut.

Cherokee shale, the Pennsylvanian is thin, comprising less than 160 feet of strata where thickest and still less in most localities. The coal beds present and the relationships of the strata are most readily shown by means of the general section given below:

GENERAL SECTION, PENNSYLVANIAN SERIES IN BOONE COUNTY.

Number.	Stratum.	Maximum thickness. *Feet.*	Maximum distance from top. *Feet.*
Henrietta formation—			
1.	Limestone, dark blue to gray, semi-crystalline	5	5
Cherokee shale—			
2.	Shale, with coal smut (horizon of Lexington coal bed), about	5	10
3.	Limestone, light blue to dark gray ("Chaetetes Limestone")	4	14
4.	Shale, thins to the southeast, 9 feet to	30	44
5.	Limestone, blue to gray, compact, rings under hammer ("bell-rock"), perpendicularly jointed, forms pavements in creek beds, 2 feet to	3½	47½
6.	Shale, soft and clayey at top, black and "slaty" in greater part, 8 inches to	3½	51
7.	COAL (Summit), 10 inches to	2½	53½
8.	Clay	2	55½
9.	Limestone, gray, one foot to	2	57½
10.	Shale, with sandstone in middle portion, 20 feet to	40½	98
11.	COAL (Bevier), 2-inch clay parting below the middle, 2 feet to	4	102
12.	Clay, 5 inches to	3	105
13.	Limestone, dark blue to bluish gray, very rough on upper surface, in places with shale parting, 18 inches to	3	108
14.	Shale, drab, 14 inches to	3	111
15.	Limestone, light blue to gray, upper part nodular, lower compact, one foot to	3	114
16.	Shale, light drab in upper part, black and "slaty" in lower, 3 feet to	6	120
17.	Limestone, blue gray, slightly nodular, in one bed	1½	121½
18.	COAL (Tebo), nothing to	1½	123
19.	Clay, variegated, in places with one or two thin limestone beds near top, probably in greater part a good fire clay, 10 feet to	40	163
20.	Flint conglomerate, not commonly present	....	....
Mississippian series—			
21.	Limestone and flint	....	....

With the exception of No. 10, which is in places much more sandy than in others and varies considerably in thickness, all the strata above number 13 are fairly constant in character and occurrence. Below number 13, however, there are minor variations from point to point, the number of limestone beds ranging from two to four or even five, and the total thickness of material between the Bevier and the Mississippian being somewhat greater in many places than is shown above. The members of the Henrietta formation outcrop only in patches in the small areas shown on the State geologic map, but numbers 5 to 20 are widely distributed.

As shown in the section, there are in Boone county three horizons at which workable coal occurs in regular beds. The uppermost of these is the Summit, where there is a bed that averages about 18 inches

in thickness west of the Wabash railroad and is easily detected by its relation to the thicker Bevier bed below it, and to its own limestone cap-rock, a stratum that outcrops rather conspicuously in many places. The Summit coal is of excellent quality, containing only a moderate amount of sulphur in thin streaks of iron pyrites and in white gypsum scale in the joints, and can be very easily mined longwall because of its "slate" and limestone roof. Southeast of the railroad the Summit is in many places less than 14 inches thick.

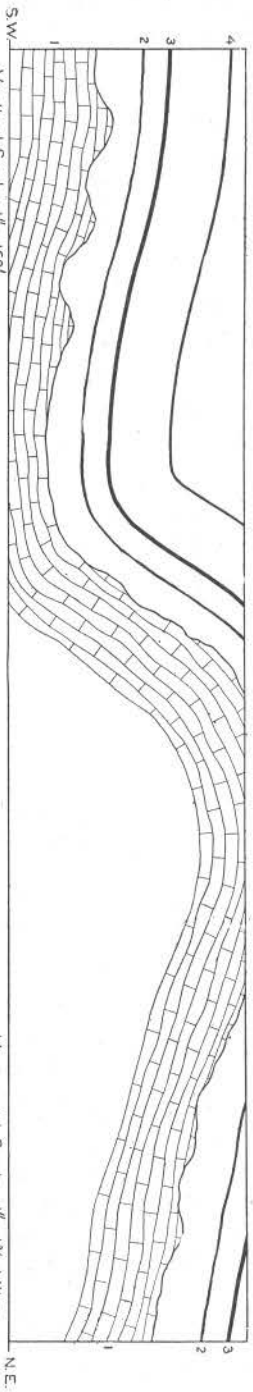

Fig. 16. Diagrammatic cross-section from southwest to northeast across the Browns station anticline. (1) Mississippian limestone. (2) Tebo coal. (3) Bevier coal. (4) Summit coal.

The Macon City coal bed, found below the Summit in Randolph, Howard and other counties, is represented in Boone only by thin laminated shale immediately beneath the Summit sump-rock.

The next lower coal bed is the Bevier, which is extensively mined at Bevier, Huntsville, Higbee, Fulton, and other points in neighboring counties. This seam outcrops in nearly every valley in the neighborhood of Rucker, Harrisburg, Butler, and north and east of Columbia, and averages three feet in thickness, being slightly thicker in the northwest corner of the county than farther southeast. The roof of the coal bed is a "soapstone" shale that requires considerable attention in the mines, though it is probable that with improved methods of longwall mining less difficulty would be experienced than with the system commonly in vogue. The coal itself is of fair quality, as shown by the analyses published elsewhere in this volume. The bed is in some areas slightly cut up by small vertical or highly inclined clay seams, which, however, are only local in occurrence. Nearly everywhere a horizontal and very regular clay seam parts the bed about six inches from the bottom. Below the underclay is a limestone bed, so that the setting and maintenance of props are greatly simplified.

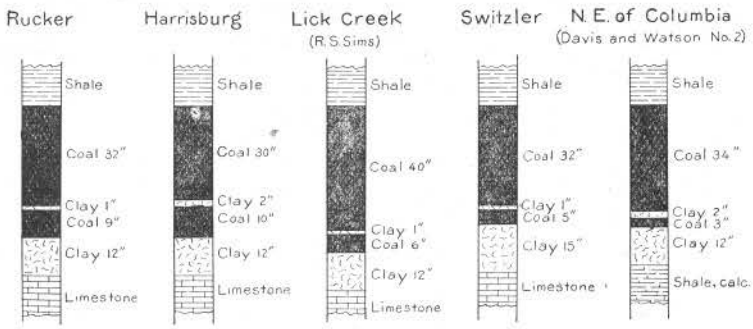

Fig. 17. The Bevier coal bed in Boone County.

The Tebo coal bed is rarely more than 18 inches thick and in most places is thinner or absent. It may be that all exposures that have been termed Tebo in this report are not of the same bed, but all are less than twenty feet below the Bevier coal bed and may be considered the same for all practical purposes. Below the Tebo coal bed are in a few places one or two thin basin deposits of small lateral extent, as well as some pockets of thicker coal at the base of the Pennsylvanian that have attracted much more attention than their importance merits. Pockets occur in the southern part of the county, some distance from the main body of the Coal Measures. So far as known, the Bevier bed is the lowest that is of present commercial importance; it rarely lies more than 50 feet above the lowest possible coal, that is, above the Mississippian limestone.

The structure of Boone county strata is extremely interesting and more complicated than is common in other coal fields of the State. In the southern part of the coal field the beds are practically level, but on the north and east are greatly affected by an arch termed by Marbut the Browns Station anticline. On the southwest side of this anticline the strata dip to the southwest at angles varying from 5° to 45°, the greater dips being in the central part of the county, along a narrow zone extending from two miles south of Rucker to Browns Station and thence southeast to Callaway county. Northeast of this zone the strata are again horizontal and a few miles farther in the same direction dip to the northeast. The anticline, then, is two to three miles wide, and in the territory affected by it the Coal Measures were raised to such a height that they were afterward completely removed by erosion, leaving the Mississippian limestones the highest stratified rocks at Perche Church, Riggs, the Pinnacles, just north of Brown, and elsewhere. It is useless to search for coal on the Browns Station anticline. On Roche Perche creek, south of Rucker, the arch flattens out considerably, so that Pennsylvanian strata are not completely removed from the divide between that creek and Moniteau. The effects of the

uplift are also evident on a smaller scale at Blue Bluff and other places in Howard county. In the county southeast of Brown, between Shaw and Murray, are a number of narrow arches, the zone of disturbance apparently being broader and less simply defined east of the Wabash railroad. Close to the southwest side of the central portion of the anticline is a narrow syncline, or trough, in which higher rocks are exposed than elsewhere in the region. Near the northeast corner of the county are one or more arches, probably parallel to the Browns Station anticline and separated from it by one or more synclines.

In recapitulating the main points of economic importance it may be stated that the Bevier coal bed is three to four feet thick under all the divides in a strip of country four to five miles wide lying south and west of a line drawn from Perche Church southeast through Browns Station to Cedar creek. The country northeast of the Browns Station anticline is in greater part drift-covered prairie where there are no exposures and where the structure cannot be unraveled until more drill records are available. It is significant, however, that the coal at Younger, the Coon mine, and south of Sturgeon are in a line lying northwest-southeast, parallel to the main arches. Drilling near the railroad a few miles northeast of Hallsville or elsewhere along this line might bring to light the coal beds shown in the general section.

Coal mining was begun in Boone county at an early date but has never become very important. By far the greater number of mines have been and are now small strip-pits, drifts, and slopes that supply neighboring farmers. For several years shaft mines north of Columbia have been worked to supply that city with fuel. Shipping mines have been opened from time to time along the line of the Wabash railroad between Columbia and Brown, and have shipped coal to Centralia, Columbia, and other points not far distant. None of these mines seems to have been prosperous and only one is now in operation.

The number of tons of coal originally in the ground is roughly estimated in the following table, in which beds or parts of beds less than 14 inches in thickness are disregarded and there are considered to be 1,800 tons to the acre-foot.

Range.	Township.	Thickness of beds.	Area in square miles.	Tons of coal.
11 W.	51 N.	Summit (?) 24 inches, Bevier (?) 30 inches	10 (?)	51,840,000
12 W.	51 N.	Bevier 39 inches, Tebo 14 inches in ½ of area	15 (?)	66,210,000
13 W.	51 N.	Bevier 41 inches, Tebo 14 inches	18	95,040,000
14 W.	51 N.	Summit 20 inches, Bevier 42 inches, Tebo 14 inches	6	43,776,000
11 W.	50 N.	Bevier 32 inches	10 (?)	30,720,000
12 W.	50 N.	Summit 24 inches in ½ of area, Bevier 37 inches, Tebo 14 inches in ½ of area	6	32,256,000

Range.	Township.	Thickness of beds.	Area in square miles.	Tons of coal.
13 W.	50 N.	Summit 28 inches in ½ of area, Bevier 40 inches, Tebo 14 inches	24	156,672,000
14 W.	50 N.	Bevier 40 inches, Tebo 16 inches	8	43,008,000
11 W.	49 N.	Bevier 30 inches	7	20,160,000
12 W.	49 N.	Summit 18 inches in ½ of area, Bevier 33 inches, Tebo 18 inches in ½ of area	26	119,808,000
13 W.	49 N.	Summit 18 inches, Bevier 30 inches	7	32,256,000
11 W.	48 N.	Bevier 30 inches	15	43,200,000
12 W.	48 N.	Summit 14 inches in ½ of area, Bevier 32 inches, Tebo 14 inches	20	101,760,000
		Basins and pockets near base of Pennsylvanian in many parts of the county	.....	10,000,000
			172	846,706,000

DETAILED MENTION.

Centralia.—A description of coal found a short distance east and north of Centralia is given in the report on Audrain county. Deep wells at Centralia itself have failed to penetrate any important coal but indicate that the drift clays are at least 150 feet deep in places and that the top of the Mississippian lies about 240 feet below the city. Six miles southwest of Centralia what appears to be the Bevier coal bed is mined in a small way by J. W. Simco, on the land of J. J. Coon (S. W. ¼ Sec. 36, T. 51 N., R. 12 W.). The shaft penetrates:

		Feet.
1.	Soil and drift	12
2.	Sandstone	5
3.	Shale, drab ("soapstone")	8
4.	COAL, with ½-inch clay seam (Bevier)	3½

Two limestone beds lie beneath the underclay of this coal, and below these, separated from their base by a thin layer of "slaty" shale, is reported to be 14 inches of coal, in another bed, the Tebo. The territory occupied in this district by these two beds is not known. It is bound on the southwest by the Browns Station anticline and possibly is limited in other directions by other arches or by preglacial channels filled with drift. Nevertheless it is highly probable that the drill will reveal important remnants of the Bevier coal in portions of northeastern Boone county. Many years ago a shaft was worked three miles south of Sturgeon. A shaft sunk to a depth of 200 feet a short distance west of Sturgeon is said to have penetrated no coal, however.

Rucker.—One mile west of Rucker, on the west side of Roche Perche creek (S. W. ¼ Sec. 6, T. 51 N., R. 13 W.), are small drifts operated by J. H. White and A. B. Lewis. The product is sold locally and hauled to Sturgeon. No powder is used, the coal being undercut and wedged down after ribs have been cut 20 inches deep at the ends

of 24-foot rooms. The bed worked is the Bevier, is 41 inches thick, and has an inch of clay about 9 inches from the bottom, a fair roof of shale ("soapstone"), and a sump-rock of nodular limestone under one foot of fire clay. An 18-inch bed (Tebo) is reported to lie a short distance below the Bevier.

The determination of the territory underlain by the Bevier coal in the Rucker district is made difficult by complex structural features and poor outcrops. At the mines the coal lies about 20 feet above creek level, but rises to the south until Mississipian limestones are exposed 20 or 30 feet above the creek. About a mile south of Perche Church (N. E. ¼ Sec. 30, T. 51 N., R. 13 W.) the Bevier may be seen dipping steeply to the southwest, and rocks occupying a higher horizon outcrop about one mile northwest of the church in the next valley west of Roche Perche. It is evident that the axis of the Browns Station anticline lies between Rucker and Perche Church, trending northwest-southeast, and that coal is absent in the narrow strip affected by that arch. Whether coal exists in the territory between Rucker and Sturgeon can be shown only by the drill. The Bevier coal is known to underlie the divide a short distance north of Rucker, but that it is absent or too near the surface to be of value under the village itself is shown by the following outcrop of lower strata measured in the road leading west to the bridge over Roche Perche creek:

		Feet.	*Inches.*
1.	Drift	....	....
2.	Limestone, light gray, nodular (Bevier sump-rock)	1	8
3.	Shale, light drab	1	8
4.	Limestone	....	7
5.	Shale	1	6
6.	Limestone, light gray, in one bed	....	10
7.	Shale, light drab, sandy, small limestone concretions 3 feet from base	17	4
8.	COAL (Tebo)	1	2
9.	Clay	8	....
	To Roche Perche creek	10	....

Harrisburg.—The Bevier and Tebo beds underlie the divide on which Harrisburg stands, at least as far south as that village, and have attracted considerable attention recently because of the proposed construction of rail communication with the district and the leasing of a large area of coal land by outside capitalists. On the west side of the divide, in Howard county, the Summit bed and higher rocks are also present; but near Harrisburg these beds have been removed by preglacial erosion and replaced by thick drift deposits. No coal crops out south of Harrisburg, and probably only remnants of coal beds exist between the drift and the Mississippian. South of Woodlandville and up the valley of Callahan and Roche Perch creeks to within three miles of Harrisburg, Mississippian limestone outcrops.

The Bevier coal bed is about 40 inches thick at Harrisburg and has a two-inch clay parting about 10 inches from the bottom. The roof

is a firm one of "slaty" shale that would probably accommodate itself to the longwall method of mining. The coal is of good quality and contains only a moderate amount of sulphur in the form of lenses of iron pyrites. At present it is mined only in strip pits in small valleys one to two miles east of Harrisburg, where 5 to 15 feet of shale and drift are removed from above it. In September, 1910, four pits were in operation: R. Beasley (S. W. ¼ N. E. ¼ Sec. 12, T. 50 N., R. 14 W.), F. J. Carey (N. W. ¼ S. E. ¼ Sec. 12), Mrs. McKenzie (S. E. ¼ S. W. ¼ Sec. 7, T. 50 N., R. 13 W.), and S. S. Price (N. W. ¼ N. E. ¼ Sec. 18). Three miles northwest of Harrisburg (S. E. ¼ Sec. 6, T. 50 N., R. 13 W.) are old strippings in which the Bevier is reported to be 3½ feet thick; it is overlain with 35 feet of light blue shale and thin-bedded sandstone.

The Tebo coal bed is 18 inches thick and outcrops with higher rocks in the bed of the small branch just below the Carey stripping:

		Feet.	*Inches.*
1.	Bevier coal	....	....
2.	Clay	1	6
3.	Limestone	2	6
4.	Shale, very calcareous	3	....
5.	Limestone	1	....
6.	Shale, dark drab	1	2
7.	Limestone, compact	3	....
8.	Shale, drab at top, black and "slaty" at bottom	6	....
9.	Limestone, compact	1	6
10.	Shale, bluish black, "slaty"	3	....
11.	COAL (Tebo)	1	6

Butler.—On the east side of Lick creek above Butler several small strip-pits are intermittently operated for local use. J. W. Stone (S. E. ¼ S. E. ¼ Sec. 8, T. 50 N., R. 13 W.) excavates the Summit coal bed, here only 10 feet above creek level, 2 to 3 feet thick, and overlaid by 2½ feet of black "slaty" shale above which is a 42-inch, compact, massive limestone that rings under the hammer ("bell rock"). Near the M. A. Sims pit (S. E. ¼ N. E. ¼ Sec. 8) the Bevier coal lies at the level of Lick creek and rises toward the northeast; the bed measures as follows:

		Feet.	*Inches.*
1.	Shale, sandy	3+	....
2.	Shale, gray, tough	2	6
3.	COAL, 30 inches Clay, 1 inch COAL, 6 inches (Bevier)	3	1
4.	Clay	2	....
5.	Limestone	....	....

The R. S. Sims strip-pit (S. E. ¼ S. E. ¼ Sec. 5, T. 50 N., R. 13 W.) is in the Bevier bed, which is here four feet thick because of an increase in the thickness of the upper bench. The coal at the S. C. Alspaw slope (S. W. ¼ N. W. ¼ Sec. 4) is said to be the same as at

the R. S. Sims pit. Less than two miles farther up Lick creek (Sec. 28, T. 51 N., R. 13 W.) the Mississippian series outcrops high on the divides and dips as much as 20° to the southwest in places, showing that the southwest limb of the Browns Station anticline traverses this territory. As already stated, no coal is present on this arch, which is here at least two miles wide from northeast to southwest. At Riggs, also, the Mississipian is high up in the hills but lies nearly horizontal.

Dripping Spring.—North and south of Dripping Spring strip-pits are occasionally opened, chiefly in the Summit bed, which in places attains a thickness of 30 inches. Up Silver fork a dip to the northeast carries the Summit to lower levels as far as the Thomas Coates land (S. E. ¼ S. W. ¼ Sec. 14, T. 50 N., R. 13 W.), where it is only 15 feet above the bed of the fork. Farther north the dip reverses sharply, so that within little more than a mile of this place Mississippian limestones crop out high in the hills and no Coal Measures can be seen. At "The Pinnacles", a well-known landmark on Silver fork (Sec. 12, T. 50 N., R. 13 W.), bluffs of Mississippian limestone stand nearly a hundred feet high, and this is the only formation observed to outcrop in the valley from Sec. 14, T. 50 N., R. 13 W., to Sec. 33, T. 51 N., R. 12 W., the interval in which the fork cuts across the Browns Station anticline.

On the Coates land, mentioned above, a drift is operated in the coal bed shown in the following measurements:

		Feet.	*Inches.*
1.	Limestone ("Chaetetes"?)	3+	....
2.	Concealed, probably shale	30	....
3.	Limestone, bluish gray, compact, rings under hammer	3	6
4.	Shale, drab	1	....
5.	Shale, bluish black, "slaty," an excellent mine roof	2	6
6.	COAL (Summit)	2	....
7.	Clay	1	6
8.	Limestone, rough on upper surface	1+	....

The Bevier bed, which is between three and four feet thick, was formerly mined near here by small shafts and slopes. A short distance south of the Gosset mine an old channel, now filled with sandstone, cut out the coal in a narrow strip of land.

Hinton.—One-half mile south of Hinton the entire section from the Summit cap-rock to the Tebo horizon is exposed in the road and a small draw. The full thickness of the Summit and Bevier coal beds could not be seen; the Tebo is only eight inches thick. The interval between the Summit and Bevier is considerably less than in most of the county; that between the Bevier and Tebo is occupied by a succession of strata very similar to that near the Carey pit at Harrisburg. The rocks dip steeply toward Rocky branch. Two miles north of Hinton the Summit coal bed, here 28 inches thick and separated from its cap-rock by three feet of black laminated shale, is stripped on the land of C. Gooding (S. W. ¼ N. W. ¼ Sec. 36, T. 50 N., R. 13 W.).

At the pit it is near the top of the divide, but dips steeply down a small draw towards Rocky branch.

Brown.—Two shipping mines were operated in former years at Browns Station, but irregularity in the thickness of the coal and faults ("slips"), one of which had a downthrow of 9 feet to the southwest, caused their abandonment. The Bevier coal seam lies at an exceptionally low level at Brown because of the presence of the trough or syncline mentioned as lying close to the Browns Station anticline. A short distance north of the village the Mississippian rises to a higher level than that of the Bevier coal at the station, as was discovered when a shaft sunk by Mr. Price reached the heavy limestone without penetrating any coal beds whatever. Following is a record of a shaft sunk in 1903 about one-half mile south of Brown, furnished by J. J. Hubbard:

	Thickness.	Depth.
	Feet.	*Feet.*
Drift clay, sand, and gravel	100	100
Shale, red and white, clayey	10	110
Limestone, blue	3	113
Shale, "slaty"	1	114
COAL (Summit)	2	116
Clay	4½	120½
Limestone	2½	123
Clay, shale, and "boulders"	4½	127½
Shale, hard	6½	134
Sandstone	8	142
Shale ("hard soapstone")	10	152
COAL (Bevier), exceptionally thick	4	156

About a mile west of Browns Station (N. E. ¼ N. E. ¼ Sec. 8, T. 49 N., R. 12 W.) is a shaft 30 feet deep operated for local trade by I. R. Davis. Horse power is used to hoist coal from the Bevier bed, which is 33 inches thick and has the usual one-inch clay band four inches from the bottom. The Macon City coal bed lies 40 feet above the Bevier and is 18 to 24 inches thick. Three-fourths mile from the Davis shaft is the short slope of J. W. Gaither (S. W. ¼ S. E. ¼ Sec. 8) to Bevier coal 36 inches thick. In both mines the roof is a clay shale of fair strength; "clay slips" are moderately common.

A new shaft, 35 feet deep, has been sunk two miles north of Davis by A. McGee (N. E. ¼ S. W. ¼ Sec. 32, T. 50 N., R. 12 W.). Here the Bevier coal bed is only 30 inches thick, in addition to the usual clay parting, but at the old shaft 1½ miles northwest (S. E. ¼ Sec. 19) it is said to be 42 inches. The Summit coal bed, from 18 to 30 inches in thickness, has been stripped in several places in small ravines between McGee's mine and Rocky creek, and the "Chaetetes limestone" outcrops 32 feet above it in places. These outcrops are in the trough mentioned as passing under Brown. One-fourth mile east of McGee's, near the cemetery, Mississippian appears in the creek bottom, dipping 30° southwest, and in a short distance both north and east rises to nearly the

tops of the hills, showing that the Browns Station anticline passes through this district.

Three miles east of Brown are two small drifts, the Frank Neighnaber (N. E. ¼ S. W. ¼ Sec. 12, T. 49 N., R. 12 W.) and the Thomas Brink (S. W. ¼ N. E. ¼ Sec 12), in small valleys tributary to Hinkson creek. The coal bed worked by them, the Bevier, is 30 inches thick, includes a quarter-inch clay seam, and lies at least 40 feet above creek level because of its position well up on the limb of an anticline. The bed shows few faults or clay seams and only a moderate amount of "sulphur." The Bevier has the same thickness at the small strip-pit and drift on the land of J. Y. McLean (S. W. ¼ N. E. ¼ Sec. 13, T. 49 N., R. 12 W.). Under the coal are 14 feet of thin limestone and shale beds, below which are five feet of bluish white fire clay, which lies at the level of a branch of Hinkson creek; the Tebo coal appears to be represented only by carbonaceous shale. A short distance down stream the Mississippian outcrops.

Switzler.—The Columbia Coal Co. operates a shipping mine at Switzler on the Wabash railroad. Steam power is used to hoist coal 132 feet from the Bevier bed, which is 37 inches thick, exclusive of a clay parting one inch thick. Both the longwall and room and pillar methods of mining have been tried with varying success, as the roof is a "soapstone" shale of only fair strength, and "clay slips" averaging two inches in width are somewhat numerous. About eight inches of shale comes down with the coal and three feet falls in the roadways before the roof stands firmly. There are said to be about 90 feet of drift in the shaft, the Summit coal remaining only in isolated patches beneath the divide traversed by the railway.

About three miles west of Switzler, near the Columbia gravel road, are three mines that supply Columbia with considerable coal, the product being hauled four miles in wagons. At the Davis and Watson No. 1 (N. W. ¼ N. W. ¼ Sec. 19, T. 49 N., R. 12 W.) is a shaft 110 feet deep, at the W. R. Prather (N. E. ¼ S. E. ¼ Sec. 24, T. 49 N., R. 13 W.) a shaft 55 feet deep, and at the Hubbard and Coates (N. E. ¼ Sec. 24) a slope entering nine feet above the coal. All three mines employ horse-power for raising the product to the surface, and the room and pillar system of mining, shooting off the solid. The roof is of "soapstone" shale of fair strength and the sump-rock affords a firm bed for the tracks. There is little "draw shale," but a few "clay slips" are present. At the Davis and Watson one fault with a downthrow of 6 feet to the southwest was noted. The thickness of the bed worked, the Bevier, is variable, being 37 inches at the Davis and Watson, and only 24 at the slope mine. At the Davis and Watson the Summit coal is reported to be 18 inches thick, but to be cut out in places by preglacial channels that in the south workings reach down

almost to the Bevier horizon. At the Hubbard and Coates mine the following are exposed:

		Feet.	Inches.
1.	Limestone, light gray, thin-bedded ("Chaetetes Limestone")	1+	....
2.	Concealed, probably shale	25	....
3.	Limestone, light gray and dark blue, compact, about	1	3
4.	Shale, black, "slaty"	1	....
5.	COAL (Summit)	1	....
6.	Clay	4	....
7.	Limestone, light gray, very nodular	2	....
8.	Shale, upper half sandy, with 2 feet of sandstone in center	40	....
9.	COAL, 18 inches Clay, 1 inch COAL, 6 inches (Bevier)	2	1
10.	Clay	....	8
11.	Interval containing limestone and shale	15	....
12.	COAL (Tebo), reported	1	....

Persinger.—An abandoned mine at Persinger, south of Switzler, reached the Bevier seam at 69 feet. Developments in this neighborhood showed that the coal has been removed in places by preglacial erosion and replaced with drift.

West of Persinger the Bevier coal bed lies at the level of Hinkson creek, where it is mined in a small slope by J. R. Davis (S. W. ¼ Sec. 27, T. 49 N., R. 12 W.). Above this point, on both main branches of Hinkson creek, the strata rise rapidly and Mississipian outcrops less than a mile north and shows above creek level for several miles up stream. Near the Davis mine nearly the complete Pennsylvanian section of the county is exposed as follows:

		Feet.	Inches.
1.	Limestone, brownish gray, irregularly bedded, ("Chaetetes")	3	4
2.	Concealed, probably shale	30	....
3.	Limestone, light gray, compact	1	3
4.	Shale, clay, and 10 inches coal (Summit)	6	....
5.	Limestone	....	10
6.	Shale, with some sandstone	45	....
7.	COAL, one-half inch pyritiferous clay in center (Bevier)	2	5
8.	Clay, drab	1	....
9.	Limestone, light gray, weathers unevenly	3	3
10.	Clay, white	1	....
11.	Limestone, light gray, in one bed	....	10
12.	Shale, with limestone nodules	1	....
13.	Limestone, light gray, irregularly bedded	2	10
14.	Shale, black, "slaty," with limestone lenses	2	....
15.	Limestone, light gray	1	2

Columbia.—From the J. R. Davis drift down Hinkson creek for several miles the Bevier coal bed remains near water level; then rises to the southwest so that east of Columbia Mississippian appears in the bottom of the valley. Three miles northeast of Columbia is the J. R. Daly drift, in a small ravine on the east side of Hinkson creek, about 45 feet above water level. The Bevier coal bed, here 36 inches thick, is undercut two feet and ribs cut 2½ feet before it is shot. The product is hauled to Columbia. The Tebo is 10 feet lower than the Bevier, is 18 inches thick, and has a roof of black "slaty" shale. About one-half mile northeast of the Daly drift is the Davis and Watson

No. 2, where coal from the Bevier bed is hoisted by a horse-whim. Coal is shot off the solid and a considerable output hauled to Columbia for sale. There are a number of "clay slips" and the usual amount of "sulphur." The succession of strata above the Bevier is revealed by the following measurements made in a new shaft at this mine:

		Feet.	*Inches.*
1.	Soil and drift	13	....
2.	Limestone, "bell rock"	2	8
3.	Clay, white	2	4
4.	Shale, bluish black, "slaty"	1	....
5.	COAL (Summit)	1	1
6.	Clay	4	....
7.	Limestone, compact, very hard	1	10
8.	Shale, black, "slaty" (horizon of Mulky coal)	1	....
9.	Clay	5	....
10.	Shale, blue	16	....
11.	Sandstone	8	....
12.	Shale, blue, hard at base	5	10
13.	COAL, 34 inches Clay, 2 " COAL, 3 " (Bevier)	3	3
14.	Clay, hard	1	....
15.	Shale, calcareous	2	....
	Depth of shaft	68	....

On the divide on the west side of Hinkson creek, Coal Measures cap the hills as far south as Columbia, but south of the mines already described workable coal beds exist only in patches between drift filled channels. South of the Daly drift the Bevier coal rises until it is near the top of the hills, but it outcrops along the upper courses of Hominy and Grindstone creeks. The succession of strata in this territory is shown in the following generalized section:

		Feet.
1.	Limestone, light blue, compact ("Chaetetes limestone")	1½
2.	Concealed, probably shale	9
3.	Limestone, compact, "bell rock"	2⅔
4.	Shale	3
5.	COAL (Summit)	1 to 1½
6.	Clay and limestone	2
7.	Shale, sandy and clayey, with lenses of sandstone	25 to 40
8.	COAL (Bevier)	2½ to 3½
9.	Clay, with concretions	2 to 5
10.	Limestone, dark blue, weathers bluish buff	1½ to 3
11.	Shale, dark below, light above	1½
12.	COAL (Tebo)	to 1½
13.	Shale	5
14.	Limestone, dark blue, weathers unevenly	2½
15.	Shale	2 to 8
16.	Limestone, dark blue to buff, in one layer	2
17.	Shale, dark, contains numerous small concretions	2½
18.	COAL	⅚
19.	Fire clay, white, thickness very variable, average	20
20.	Mississippian limestone	....

On Hominy branch, three miles east of Columbia, are several abandoned drifts in the Bevier bed and one that is being reopened by W. H. Atkins on the land of F. Dawson (N. E. ¼ N. E. ¼ Sec. 9, T. 48 N., R. 12 W.). The Bevier is only a few feet above creek level and is three feet thick. The Summit and Tebo are reported to be

14 inches each in thickness. Coal is also taken from a strip-pit on the land of F. M. Thompson, on the south branch of Grindstone creek west of Harg (N. E. ¼ N. E. ¼ Sec. 22, T. 48 N., R. 12 W.), where the Bevier is 30 inches thick. The same bed has been mined in a small way in many other places in the rough country east of Columbia and also at Stephens Store and Younger, as described in the report on Callaway county.

The prairie country south of the Columbia-Fulton gravel road contains very few outcrops of Pennsylvanian rocks, as it is covered with a mantle of loess and drift that conceals all the stratified rocks except Mississippian limestone and flint that is uncovered in the bottoms of the principal water courses. It is probable that the lowest Coal Measures occur in patches as far south as the northeast corner of T. 46 N., R. 12 W., a few miles northeast of Ashland, but that little workable coal exists in that area.

BUCHANAN COUNTY.*

In Buchanan county no coal has been mined except a small amount taken for local use from surface beds in the southwest corner of the county. The surface formation in by far the greater part of the county is the Douglas, which is nearly 300 feet thick and consists chiefly of shale and sandstone. At its top is the conspicuous limestone known as the Oread, which is a useful horizon marker. In the southwest quarter of the county and northeast of St. Joseph, the Shawnee formation overlies the Douglas but is not sharply differentiated from it in character. Along Platte river below Agency and on Castiles creek the limestone beds at the top of the Lansing formation outcrop.

At Atchison and other places in Kansas there are a few coal beds in the Douglas formation and a small amount of coal has been taken from them at a profit. In Buchanan county, however, the known surface beds contain only a foot or less of coal, and are in most places rendered unfit for use by partings of clay and shale. Broadhead cites a boring at St. Joseph which went to the depth of 402 feet and penetrated 4 coal beds, the lowest and thickest of which was 30 inches thick. It is probable, however, that this includes some bituminous shale. The highest horizons at which coal of real value likely to be found lie below the bottom of this drilling, in the Des Moines group. That there is considerable deep-lying coal is shown in the following drilling made at Saxton to the bottom of the Coal Measures:

*The geology of Buchanan county is described by G. C. Broadhead: Rept. Mo. Geol. Survey for 1872, pt. 2, pp. 92-93, 121-124, 344-358. Brief mention of coal is made by Arthur Winslow: Prelim. report on coal, Mo. Geol. Survey, 1891, pp. 102-103. The topography of the southwest corner is shown on the Atchison sheet of the U. S. Geol. Survey.

SAXTON DEEP DRILLING.

	Thickness. Feet.	Inches.	Depth. Feet.	Inches.
Drift clay, sand, and gravel	29	....	29	....
MISSOURI GROUP.†				
Douglas shale—				
Shale, blue	1	....	30	....
Lansing formation—				
Limestone and blue shale	126	....	156	....
Kansas City limestone—				
Limestone and shale, with exceptionally thick limestone beds in lower part	165	....	321	....
DES MOINES GROUP.				
Pleasanton shale—				
Shale, black	1	....	322	....
COAL	....	1	322	1
Shale, sandy	40	11	363	....
Shale, blue	53	....	416	....
Shale, sandy	13	1	429	1
Shale, blue	11	1	440	....
Limestone	1	....	441	....
Shale, blue	8	....	449	....
Henrietta formation—				
Limestone (Pawnee)	3	....	452	....
Shale, sandy	6	....	458	....
Limestone	2	....	460	....
Shale, sandy	3	....	463	....
Shale, blue	12	....	475	12
Shale, calcareous	8	....	483	....
Limestone	2	....	485	2
Shale, black	3	....	488	....
Limestone	1	....	489	....
Sandstone	6	....	495	....
Shale, black	11	6	506	6
Shale, blue, sandy at top	2	6	509	6
Shale, black	1	....	510	....
Shale, blue	....	5	510	5
COAL	....	7	511	....
Shale, blue	8	....	519	....
Limestone	7	....	526	....
Shale, blue	9	....	535	....
Limestone	3	....	538	....
Shale, mixed with limestone	5	....	543	....
Limestone	4	6	547	6
Cherokee shale—				
Shale, with layers of sandstone	3	....	550	6
Shale, blue	2	6	553	....
Sandstone	5	....	558	....
Clay	4	....	562	....
Sandstone	3	....	565	....
Shale, sandy	13	....	578	....
Shale, blue	9	....	587	....
Sandstone	3	....	590	....
Shale, blue	6	....	596	....
Sandstone	2	....	598	....
Shale, blue	16	....	614	....
Cap-rock	1	....	615	....
COAL (Bedford)	1	8	616	8
Sandstone	11	4	628	....
Shale, blue	17	....	645	....
COAL (Bevier)	1	9	646	9
Shale, blue	3	3	650	....

†A detailed description of the Missouri group portion of this drilling, with correlations, will be included in a publication now in preparation.

SAXTON DEEP DRILLING—Continued.

	Thickness.		Depth.	
Cherokee shale—Continued.	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Limestone	3	....	653	....
Shale, blue	4	....	657	....
Shale, sandy	8	....	665	....
Shale, blue	2	....	667	....
Sandstone	8	....	675	....
Shale, sandy	5	....	680	....
Shale, black	3	....	683	....
Shale, sandy	3	....	686	....
Shale, black	2	4	688	4
COAL (Tebo)	1	5	689	9
Shale, blue	2	3	692	....
Shale, sandy	18	....	710	....
Shale, black	8	6	718	6
COAL	1	6	720	....
Shale, clay	14	....	734	....
Shale, black	8	9	742	9
COAL	1	6	744	3
Shale, blue	3	9	748	....
Shale, sandy	9	....	757	....
COAL, "slaty"	....	3	757	3
Shale, sandy	9	9	767	....
Shale, blue	2	....	769	....
Sandstone	11	....	780	....
Shale, blue	4	....	784	....
Sandstone	2	....	786	....
Shale, blue	80	....	866	....
Sandstone	1	....	867	....
Shale, blue	3	....	870	....
Sandstone	12	....	882	....
Conglomerate	5	....	887	....
Shale, sandy	17	....	904	....
Shale, blue	5	....	909	....
Sandstone	9	....	918	....
Shale, sandy	1	....	919	....
Sandstone	9	....	928	....
COAL	....	6	928	6
Shale, blue	20	6	949	....
COAL	....	7	949	7
Shale, sandy	6	5	956	....
Shale, blue	4	4	960	4
COAL	1	4	961	8
Sandstone	3	4	965	....
Shale, blue	7	....	972	....
Limestone	3	....	975	....
Shale, blue	7	....	982	....
Sandstone	2	....	984	....
Shale, blue	6	....	990	....
Shale, sandy	3	....	993	....
COAL	....	10	993	10
Sandstone	3	2	997	....
Shale, sandy	1	....	998	....
Sandstone	5	....	1,003	....
Shale, sandy	19	....	1,022	....
Shale, blue	24	....	1,046	....
Sandstone	4	....	1,050	....
Shale, blue	1	....	1,051	....
Sandstone	26	....	1,077	....
Mississippian series—				
Limestone	39	....	1,116	....

The thickest coal bed (Bevier) in this drilling measures only 21 inches, but it is the same bed that is extensively mined at Leavenworth and is apparently in much the same condition. It is very persistent,

underlying much territory, probably all of Buchanan county. It was found also in the deep drilling at Forest City, in Holt county, where it is 15 inches thick, and at Stewartsville, in Clinton county, where it is 23 inches thick. Below the Tebo coal the coal beds are less persistent, though possibly in places thicker than the Bevier.

The horizons of the coal beds in the Saxton drilling are nearest the surface in the eastern part of the county, especially in the deeper valleys of the southeastern corner, where the Bevier lies about 600 feet deep. The bottoms near St. Joseph are at the level of the top of the Saxton drilling, stratigraphically, and the various coal horizons lie at about the same distance below the surface in the two localities. St. Joseph and Saxton are situated on an anticline (arch), however, and the lower horizons lie nearer the surface there than at many other points of equal altitude above sea level in the western and northeastern parts of the county. At Agency the depth to the Bevier horizon is about 625 feet and at Stockbridge about 700. In 1884 a churn-drill hole was put down at St. Joseph to the depth of 1308 feet. Black bituminous shale beds, ranging in thickness from 1 to 7 feet, were encountered at depths of 122, 184, 229, 338, 361, 529, 693, and 1083 feet, and it is possible that some coal is associated with them. Thin laminae of coal were recognized at 950 and 1083 feet. The base of the Coal Measures was reached at 1200 feet and Mississippian limestone penetrated for 108 feet. The fact that no regular coal beds were identified in a churn-drill record of this character does not necessarily mean that coal beds similar to those in the Saxton record do not underlie St. Joseph.

The strata underlying the southwestern part of the county are well shown in the carefully kept record of the core from a boring on the west bank of the Missouri river at Atchison, Kansas.*

The strata in this boring correspond very well with those in the Saxton drilling, though the coal beds are at a lower level because of the synclinal trough, which passes through Atchison. Two coal beds thicker than the Bevier were found below it, but are probably not persistent under large areas. The 36-inch bed is the same as the 16-inch one found at 960 feet in the Saxton drilling.

COAL SUMMARY OF ATCHISON, KANSAS, DRILLING.

	Thickness. *Inches.*	Depth. *Feet.*
COAL (Mulberry)	3	628
COAL (upper Fort Scott)	12	682
COAL, shale partings	10	764
COAL (Bedford)	2½	778
COAL (Bevier), good quality	22	799
COAL (Tebo)	12	835

*Published as Plate CVI in vol. IX of the University Geological Survey of Kansas, 1908, and in greater detail in Mineral Resources of Kansas for 1900-1901.

COAL SUMMARY OF ATCAISON, KANSAS, DRILLING—Continued.

	Thickness. *Inches.*	Depth. *Feet.*
COAL	9	878
COAL	1	996
COAL	2½	1,074
COAL	1	1,120
COAL, good	36	1,124
COAL	6	1,134
COAL	4	1,152
COAL	2	1,167
COAL	28	1,188
COAL	15	1,198
COAL	11	1,257
Mississippian limestone (lower limit of coal)	....	1,315

The Saxton and Atchison drillings indicate that a large amount of coal, though not in very thick beds, underlies Buchanan county. The drilling at Stewartsville, in Clinton county, shows fully as much coal in the strata penetrated, but it did not explore beds more than 125 feet below the Bevier horizon. In the Saxton drilling there are 110 inches of coal in beds 14 inches or more in thickness, and in the Atchison drilling 101 inches. There is therefore every probability that an average of 105 inches underlies the entire county and that the total original content is 4,203,360,000 tons.

CALDWELL COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....11,822 TONS.

Mining operations on a small scale have been in progress in the county for many years, and shafts have been sunk near Hamilton, Cowgill, and Kingston. At present only the mine at Hamilton is in operation.

Most of the indurated surface formations belong to the lower part of the Missouri group. As shown on the State map, the three limestones at the base of the group outcrop near the eastern edge of the county and extend up Shoal creek to the vicinity of Kingston. The two principal coal beds in the county, the Lexington and Bevier, lie 200-250 and 320-380 feet, respectively, below these limestones, so that workable coal will be found nearest the surface along Shoal creek and its tributaries and farthest below it under the divides north and south of that stream and in the western part of the county.

The effect of a slight dip to the north of west is well illustrated by the depth to the Lexington bed, which is reported to be 79 feet at a point two miles northeast of Braymer and 594 feet at Cameron, Clinton county. There are a few thin coals above the Lexington and some of them crop out, but probably none is of any value. The Lexington coal probably extends under the whole county. Where

*The coal in Caldwell county is described by Arthur Winslow; Prelim. rept. on coal, Mo. Geol. Survey, 1891, pp. 105-107.

prospected, it varies between 2 and 28 inches in thickness. The bed has been mined at Cowgill, Kingston, and Hamilton, but appears to be rather irregular and "faulty" at these places; whether this characteristic prevails under the whole county is not known.

About 100 feet below the Lexington is another coal bed, probably the Bevier, which averages about 18-20 inches thick but has been reported as thin as 6 inches. This is the bed now mined at Hamilton. Other beds will probably be found below it, though very little is known concerning them in this area. The heavy Mississippian limestone, which marks the lower limit of coal, probably lies at least 200 feet below the Bevier horizon.

The Lexington seam averages about 20 inches but on account of its irregular nature is not thought to be workable over more than three-fourths of the county, giving 612,480,000 tons. The next seam below probably averages 18 inches over the same area, yielding 551,132,000 tons. The one drilling that has penetrated below this bed found 28 inches of coal, which probably extends over at least one township, adding 96,768,000 tons. The total for the county is, therefore, estimated at 1,260,380,000 tons.

DETAILED MENTION.

Hamilton.—The mine of the Caldwell Coal Company is two miles east of Hamilton (S. W. ¼ Sec. 17, T. 57 N., R. 27 W.), and is connected by a short switch with the Hannibal and St. Joseph branch of the Chicago, Burlington and Quincy railroad. A shaft 470 feet deep,† one of the deepest in the State, reaches a seam of coal, probably either the Bedford or the Bevier, which is 18-20 inches thick. The product is hoisted by steam power and is sold locally and shipped. The roof varies from slaty and softer shale in some places to sandstone in others, but is everywhere sufficiently strong to permit mining by the longwall method. Some trouble has been caused by the hardness of the mining clay below the coal. Winslow gives the following sections of the bed:

Feet.	Inches.		
			Limestone, "cap rock."
	18 to 20		Shale, black, "slaty."
	10		Coal.
	2 to 3		Shale parting.
	15		Coal.
3			Clay.
			Limestone.

FIG. 18. The upper coal bed at the Caldwell Coal Co.'s shaft

†By some authorities this is given as 507 feet.

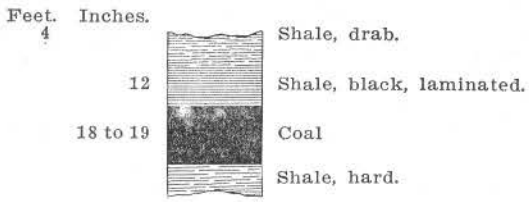

FIG. 19. The lower coal bed at the Caldwell Coal Co.'s shaft.

	Inches.
Shale, drab	48
Shale, black, fissile	12
COAL	18 to 19
Shale, hard	....

According to Winslow the Lexington coal was found at 365 feet, 107 feet above the one now mined. Work was carried on in it for a time, but was abandoned because of irregularities in the coal and roof. A section of the Lexington is shown in the accompanying sketch. Twelve inches of coal has been found below the bed now mined, at an interval variously reported from 40 to 90 feet.

About two miles south of Hamilton (S. ½ S. W. ¼ Sec. 26, T. 57 N., R. 28 W.), the Lexington was formerly mined by the Hamilton Coal Co. in what was known locally as the Tom Creek shaft. The record of this shaft, as given by T. W. Hines of Kingston, and combined with detailed measurements of the coal by Winslow, is as follows:

RECORD OF SHAFT SOUTH OF HAMILTON.	Thickness. *Feet.*	Depth. *Feet.*
Surface	49	49
Kansas City limestone—		
Limestone, blue	2	51
Shale	15	66
Limestone, soft	31	97
Shale, with 4 or 5-inch rock seams interspersed	7	104
Shale, black, "slaty"	2½	106½
Shale, sandy	8	114½
Gravel (concretions?)	1½	116
Flinty rock, spotted, hard, (Bethany Falls)	15	131
Shale, sandy	10	141
Limestone (Hertha)	8	149
Pleasanton shale—		
Gravel (concretions?)	4½	153½
Shale	82	235½
Sandstone, coarse	27	262½
"Six-inch flint seams"	1½	264
"Kimball," soft paint material (red shale?)	3	267
Shale	21	288
Henrietta formation—		
Hard limestone	4	292
"Kimball" (red shale?)	2	294
"Hard flint" (limestone?)	5	299
Limestone	2	301
Cherokee shale—		
Shale, drab	2	303
Shale, black, "slaty"	1	304
COAL, 10 inches Shale, 2 " COAL, 15 " } (Lexington)	2¼	306¼
Clay	1½	307½
"Gravel" (nodular limestone?)	3	310½
Sandstone, fine-grained	14	324½

Winslow said of this mine, "The roof is poor and in the northwestern part of the mine a brown, bituminous sandstone replaces the shale and sometimes reaches down into the coal. The black shale and the coal, where this sandstone occurs, contain a great amount of bitumen which exudes in drops. This coal bed is broken by many faults and slips which seriously increase the cost of mining and limit the extent of the workings. A lower bed, 110 feet deeper, has been shafted to here. It is 19 inches thick and is covered by about 10 inches of black shale which is overlain by drab shale. This lower bed is not much faulted, but is reported to contain a good deal of pyrite."

Kingston.—The Kingston Coal Company formerly operated a shaft about one mile north of Kingston (S. E. ½ S. W. ¼ Sec. 15, T. 56 N., R. 28 W.), on a switch from the Hamilton and Kingston railroad. The coal is reported to lie at a depth of about 235 feet. The following is a record of the shaft* combined with details of the coal by Leo Glück:

KINGSTON COAL COMPANY'S SHAFT.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil	6	....	6	....
Kansas City limestone—				
Limestone, blue	9	....	15	....
Shale, black, "slaty"	3	....	18	....
Clay	3	6	21	6
Limestone, last foot hard (Bethany Falls)	18	....	39	6
Shale, clay	2	....	41	6
Shale, black, "slaty"	2	10	44	4
Limestone	....	6	44	10
Clay	....	6	45	4
Limestone, light-colored (Hertha)	5	4	50	8
Pleasanton shale—				
Shale	1	6	52	2
Limestone, brown concretionary	4	....	56	2
Shale	1	6	57	8
Limestone	....	6	58	2
Clay, blue	3	....	61	2
Sandstone, gray	4	....	65	2
Shale, sandy	70	....	135	2
Sandstone, fine-grained at top, coarse at bottom	27	....	162	2
Shale	3	6	165	8
Limestone, hard	1	6	167	2
Clay	3	....	170	2
Sandstone	15	....	185	2
Shale, sandy	4	....	189	2
Shale, black, "slaty"	1	6	190	8
Sandstone	....	6	191	2
COAL (Mulberry)	....	4	191	6
Clay	2	....	193	6
Henrietta formation—				
Limestone, hard	1	6	195	....
Clay	....	6	195	6
Limestone, mixed with clay	4	6	200	....
Shale	4	6	204	6
Limestone and shale	4	....	208	6
Clay and shale	16	6	225	....
Limestone	4	....	229	....
Shale, black	....	8	229	8
Limestone	1	8	231	4

*The log from which this is taken is somewhat imperfect, but it is believed the record here given is approximately correct.

KINGSTON COAL COMPANY'S SHAFT—Continued.

	Thickness.		Depth.	
Cherokee shale—	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Shale, black, "slaty," 16 to 24 inches, average	1	8	233	....
COAL (Lexington), 0 to 28 inches, average	1	6	234	6
Clay	3	....	237	6
Shale, pyritiferous	1	....	238	6
Limestone	....	....	....	....

According to mine inspectors who visited this mine, the coal generally varied in thickness from 15 to 28 inches but was irregular and "faulty," and in places ran as low as eight inches. It was last worked in 1894.

About a mile south of town (S. E. ¼ N. E. ¼ Sec. 28, T. 56 N., R. 28 W.) a drilling is reported to have found 28 inches of coal at a depth of 196½ feet—probably the same coal that is worked at the Kingston shaft. The coal was overlain by five feet of black, laminated shale and was underlain by clay.

Cowgill.—A shaft 337 feet deep to the Lexington coal was formerly operated about two miles west of town. The top of the Bethany Falls limestone is reported to have been encountered at a depth of 85 feet, so that the coal is 240 feet below it. The following details of the coal at Cowgill were given to Winslow:

	Inches.
Limestone cap-rock	72
Shale, black, fissile	12
COAL	8 to 10
Shale parting, about	1
COAL	16 to 20
Clay	24

Inspectors who visited this mine while it was in operation report the coal irregular and "faulty," running as low as five inches in places. It was abandoned about 1894.

Braymer.—Mr. R. Hawkins of Chillicothe reports a drilling on the farm of Dan Braymer, near Braymer, in which 18 inches of coal overlain by one foot of black shale and two feet of limestone was found at a depth of 220 feet and 28 inches of coal overlain by sandstone at 370 feet. Two miles northeast of Braymer the following drilling failed to penetrate any workable coal:

DRILLING NEAR BRAYMER.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Surface	5	....	5	....
Pleasanton shale—				
Sandstone	5	....	10	....
Shale	1	10	11	10
Shale, bituminous	....	10	12	8
Sandstone, soft	2	6	15	2
Shale	2	6	17	8
Limestone	....	4	18	....
Shale, red	14	....	32	....
Shale	1	....	33	....

DRILLING NEAR BRAYMER—Continued.

	Thickness.		Depth.	
Henrietta formation—	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Limestone	....	8	33	8
Shale	9	....	42	8
Limestone	3	....	45	8
Shale, red	3	....	48	8
Shale, sandy	2	6	51	2
Shale	6	6	57	8
Limestone	....	8	58	4
Shale	5	6	63	10
Limestone	2	....	65	10
Shale, sandy	6	....	71	10
Limestone	1	2	73	....
Shale, sandy	2	....	75	....
Limestone, dark gray	3	....	78	....
Cherokee shale—				
Shale	....	4	78	4
Shale	....	6	78	10
COAL (Lexington)	....	2	79	....
Shale, mixed with coal	5	....	84	....
Limestone, dark gray	3	3	87	3
Shale	1	....	88	3
Sandstone, fine-grained	20	....	108	3
Shale, sandy, gray	3	2	111	5
Shale, black	7	....	118	5
Limestone	1	6	119	11
Shale, bituminous	2	2	122	1
Limestone	....	6	122	7
Sandstone, shaly	1	6	124	1
Shale	4	....	128	1
Limestone	4	4	132	5
Clay	....	4	132	9
Limestone, gray	3	9	136	6
Sandstone and shale	34	....	170	6
Sandstone, shaly	3	....	173	6
Shale	1	6	175	....
COAL	....	8	175	8
Sandstone	13	....	188	8
Shale	25	6	214	2
Sandstone, coarse	7	....	221	2
Clay with concretions	5	....	226	2
Shale, bituminous	4	6	230	8
COAL (Bevier?)	....	6	231	2
Clay	1	6	232	8
Sandstone, micaceous	2	....	234	8
Shale	1	6	236	2
Limestone	3	10	240	....
Shale	2	....	242	....
Limestone	2	10	244	10
Shale	4	....	248	10
Limestone, ferruginous	16	....	264	10
Shale	12	....	276	10

CALLAWAY COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....32,422 TONS.

Although the surface rocks of the greater part of the county belong to formations older than the Pennsylvanian, those of the northwestern third of the county and of the strip along its northern border

*A brief discussion of the coal deposits in Callaway county is given by Arthur Winslow (A Preliminary Report on Coal: Mo. Geol. Survey, 1891, pp. 77-78), and of pockets near Hibernia by G. C. Broadhead (Mo. Geol. Survey, 1873-1874, pp. 338-340). The clays are fully described by H. A. Wheeler (Mo. Geol. Survey, vol. XI, 1896, pp. 273-281) *et al.* The topography of most of the county is shown on the Jefferson City and Fulton sheets of the U. S. Geol. Survey, and the northern edge on the Moberly and Mexico sheets.

are of Coal Measure age. The Pennsylvanian, however, is thin, being less than 100 feet thick in nearly every part of the region, and is remarkable for the considerable quantity of limestone it contains so close to its base. The strata vary considerably from point to point, but the following may be considered typical for the county:

GENERAL SECTION.

PENNSYLVANIAN SERIES IN CALLAWAY COUNTY.

Number.	Stratum.	Average thickness. *Feet.*	Average distance from top. *Feet.*
1.	Limestone, dove-colored, thin and irregularly bedded	20	20
2.	Limestone, brownish gray to blue, in one bed, compact, vertically jointed	1½	21½
3.	Shale, blue (horizon of Summit coal)	4½	26
4.	Limestone, light blue, thin and unevenly bedded, very impure, 2 to 16 feet	10	36
5.	Shale and clay, dark drab, in places with streak or thin bed of coal at base (horizon of Mulky coal), 2 to 4 feet	3	39
6.	Shale and clay, drab, nothing to 10 feet	5	44
7.	Sandstone, commonly white and locally so calcareous as to resemble a limestone, elsewhere brownish, one to 11 feet	5	49
8.	Shale, in many places bearing a thin, impure limestone "cap-rock," 8 to 28 feet	11½	60½
9.	COAL (Bevier), 18 to 48 inches	2½	63
10.	Clay, 1 to 4 feet	2	65
11.	Limestone, with thick shale partings, 1 to 11 feet	2	67
12.	Shale, nothing to 2 feet	....	....
13.	COAL (Tebo), nothing to 6 inches	....	....
14.	Clay, variegated, good fire clay in lower part, 10 to 65 feet	20	87
15.	Sandstone, white to brown	2	89
16.	Conglomerate, flint and a few limestone pebbles and boulders in a firm silicious matrix, 5 to 50 feet	15	104
17.	Mississippian limestone	....	....

Part of number 1 of the general section forms the base of the Henrietta formation and the remainder constitutes the Cherokee. Number 4 is probably the sump-rock of the Summit coal bed, thickening notably to the east. The interval included in numbers 5 to 8 contains little but shale in the southern part of the coal region and is as much as 34 feet thick, but at Fulton it is thinner and contains 10 feet of calcareous sandstone, as well as a thin limestone "cap-rock" near the base. The limestones below the Bevier bed thin to the east and are very inconspicuous on Middle river. The reader is referred to the detailed sections for the local variations in the stratigraphic succession.

The structural features of the county are closely allied with those of Boone county. The axis of the Browns Station arch, or anticline, lies between Younger and Stephens Store and extends southeastward through a point a few miles north of Fulton; the anticline found in the southwestern corner of Audrain county extends southeastward to a point just north of Auxvasse. Probably no coal will be found along

narrow zones on either side of the axes of these arches. The coal at Younger, McCredie, and Calwood lies in a shallow trough between the two arches; that at Stephens Store and Fulton lies close to the southwestern side of the Browns Station anticline. The coal region is affected not only by these main structural features, but by numerous minor folds of small amplitude, though when broadly considered the strata are nearly horizontal over large areas.

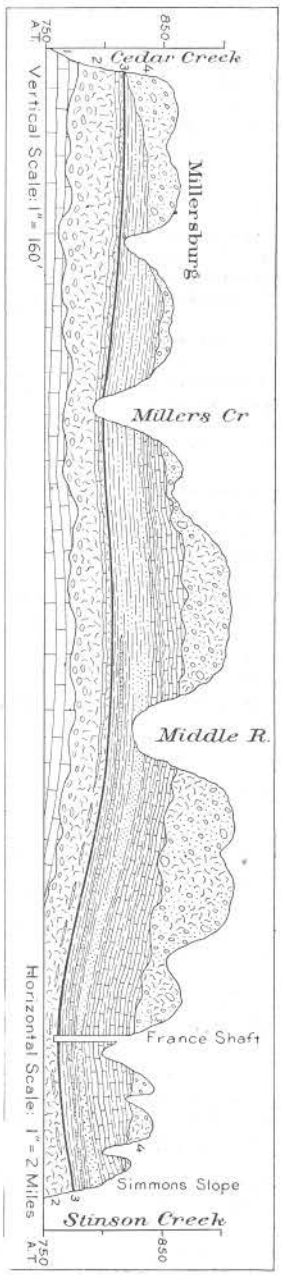

Fig. 20. Cross-section near Columbia gravel road from Millersburg to Fulton. (1) Mississippian limestone. (2) Basal conglomerate and fire clay. (3) Bevier coal. (4) Glacial drift.

It is only in the northeastern part of the county that the Mulky coal bed can be considered of any economic importance whatever, and even there it is workable in but small areas. Where the Mulky is present the Bevier, generally speaking, is very thin or is absent, the general section in such places resembling very closely that of eastern Audrain county. The Bevier bed is workable, however, over a large area and is mined on a large scale at Fulton and in a smaller way at Younger, Stephens Store, Millersburg, Carrington, and numerous places not near towns. It may be considered to underlie, with an average of more than two feet in thickness, an unknown area in the extreme northwestern corner of the county and nearly all of the territory bounded by a line drawn from Stephens Store to the headwaters of Stinson creek, down Stinson to Fulton, thence south to a point west of Hams prairie, thence west to a trifle north of Guthrie, thence northwest to Cedar creek, and up Cedar to Stephens Store. Over the greater part of this area the coal can be easily reached by drifts or shallow shafts in the numerous deep valleys or by shafts less than 150 feet deep on the high divides. The coal is not of particularly high quality and the roof is a shale that requires careful attention. Beyond the main body of the Coal Measures, in the southern and eastern parts of the county, are numerous coal pockets, some of remarkable thickness, but each containing only

a small aggregate of coal. These are of local importance though not commercially profitable unless they are exceptionally large

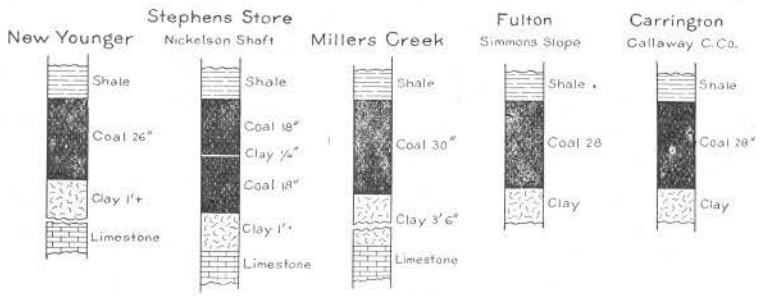

Fig. 21. The Bevier coal bed in Callaway County.

and can be stripped with unusual facility. Similar pockets are undoubtedly concealed beneath the Coal Measures area also, and when penetrated by a drill may cause unwarranted excitement. If every foot of coal be considered to yield 1,800 tons per acre and if deposits less than 14 inches in thickness be excluded, the county's original coal supply may be roughly estimated as follows:

Range.	Township.	Thickness of beds.	Area in square miles.	Tons of coal.
7	49	Summit and Mulky 14 inches	18	24,192,000
8	49	Summit and Mulky 14 inches	6	8,064,000
10	49	Bevier 26 inches	10 (?)	24,960,000
11	49	Bevier 30 inches	8 (?)	23,040,000
8	48	Mulky 14 inches, Bevier 14 inches	5	13,440,000
9	48	Mulky 15 inches in one-third of area, Bevier 14 inches	25	45,600,000
10	48	Bevier 28 inches	24	64,512,000
11	48	Bevier 30 inches	15	43,200,000
9	47	Bevier 28 inches	8	21,504,000
10	47	Bevier 28 inches	35	94,080,000
11	47	Bevier 28 inches	12	32,256,000
10	46	Bevier 30 inches	16	46,080,000
		Pockets and basins in all parts of the county	.....	10,000,000
			182	450,928,000

Utilization of the coal resources of Callaway county began at an early date, pockets near the Missouri river being among the first to be mined. Since 1887, the period during which statistics have been collected regularly, the annual production has varied between 12,633 tons in 1889 and 50,719 in 1908.

DETAILED MENTION.

Shamrock.—The coal beds near Martinsburg in Audrain county are found also in the northern part of Shamrock township as far

south as Shamrock postoffice. The upper bed, however, occurs only in patches under the drift cover of the higher divides, and the lower does not appear to be sufficiently thick to be of much economic importance. In the valley and around the headwaters of Bachelor creek and along Loutre creek as far up as the Audrain county line, Mississippian limestone outcrops.

Auxvasse.—In the valley of Bynum creek, west of Auxvasse, only Mississippian rocks appear under the heavy mantle of drift, and no Pennsylvanian was found between that town and Shamrock on the east or Ortiz on the north. It is probable that the axis of an anticline, or arch, trending northwest-southeast lies near Auxvasse and that only patches of Coal Measures rocks occupy Jackson and the northeastern half of Liberty townships. Due south of Auxvasse, on the north side of Auxvasse creek, 10 feet of brownish red Pennsylvanian sandstone lies only 35 feet below the level of the town; the walls of the deep gorge through which the stream flows are of Mississippian age. Five miles up the creek, at the ford in section 25, 12 feet of flint conglomerate and 20 feet of light-colored sandstone overlie the Mississippian, which appears only in the creek bed. One and one-half miles farther up stream (Sec. 23, T. 49, R. 10) this basal conglomerate of the Coal Measures lies in the creek bed, but farther up all outcrops are concealed by drift. No evidence of the presence of coal was gathered on the north side of Auxvasse creek.

McCredie-Calwood-Callaway.—Two miles northeast of McCredie, on the land of J. S. Henderson (N. ½ Sec. 2, T. 48 N., R. 9 W.), are some small openings, from which, however, coal has not been taken for more than 10 years. The coal here is reported to be 32 inches thick and to have a roof of black laminated shale capped by a thick limestone. No coal has been found on the west side of the railroad, although a line of small strip-pits shows its presence high up in the bluffs on the south and west sides of Auxvasse creek from Henderson to Calwood. The bed worked is very variable in thickness, in many places measuring less than one foot. In section 18, just north of Calwood, this bed is overlain by about eight feet of shale, drab in the upper part and black in the lower, and this in turn is overlain by 12 feet of limestone. In a draw east of Calwood (Sec. 20, T. 48 N., R. 8 W.) the basal conglomerate of the Pennsylvanian outcrops beneath sandstone; about 20 feet above the sandstone is a coal bed that has above it considerable sandy shale and is perhaps the Bevier. Three miles due east of Calwood, on the east side of Auxvasse creek, what may be the same bed is reported as 30 inches thick, and a pocket of seven-foot coal lies about the same distance southeast of the village. One mile west of Callaway, on the bank of Richland creek, 20 inches of coal outcrops, and the same bed may also be seen three-fourths mile farther west, where is exposed:

		Feet.
1.	Limestone, yellowish	15
2.	Shale, dark gray, soft	2
3.	Shale, black, "slaty"	2
4.	COAL (Mulky?)	½ to 2
5.	Clay, yellow to brown, to creek level	3

The coal bed at Callaway, McCredie, and Calwood, resembles in stratigraphic associations that so universally present in eastern Audrain county, and may be identical with it. It is very irregular in thickness, probably too thin to mine in most places, but underlies a large territory embraced within a line drawn from McCredie along Auxvasse creek to Calwood and thence to Callaway and westward. The Fulton coal bed (Bevier) is probably present in some places but not in all.

New Younger.—In the extreme northwest corner of the county at New Younger the Bevier coal bed, reported 26 inches in thickness, was mined from a shallow shaft years ago. A poor roof caused a cessation of operations. The limestone that lies just below the coal may be seen in the hollow near the store dipping slightly to the east or northeast. This, combined with the fact that Mississippian limestone outcrops at a higher level one-half mile southeast of the shaft, indicates that the Younger coal lies on the northwestern side of the Browns Station anticline, and has been removed by erosion along a narrow strip between New Younger and Stephens Store. It may be present, however, under the high country north and southeast of New Younger.

Stephens Store.—Shafts with horse-whim hoists have been operated at Stephens Store for many years to supply a considerable country trade. In 1911 three mines were in operation—those of C. Griffith and of Krutell and Thacker on the north side of the village and the new mine of C. M. Nickelson on the east side. The shaft of the first named is 30 feet deep, of the second 52 feet, and of the third 40 feet to the Bevier coal bed.

The Bevier has here many of the characteristics it possesses near Columbia and other points in Boone county; the clay parting, however, is not everywhere present. Lenses of iron pyrites ("sulphur") are plentiful and vertical films of white gypsum are found. Where the black laminated shale lies next the coal the top is fair, but where softer shale takes its place a few inches of the top coal are left up in places to strengthen the roof. Vertical and highly inclined clay stringers traverse the coal in places. A second coal bed (Tebo) is said to lie about 20 feet below the Bevier and to be 10 inches thick. The strata underlying the Stephens Store district are shown in the following shaft sections reported by Mr. Nickelson and combined with mine measurements by the writer.

Kruteil & Thacker shaft.		Kind of rock.	Nickelson shaft.	
Feet.	*Inches.*		*Feet.*	*Inches.*
30	6	Drift	9	....
1	6	Limestone, hard, in one bed	1	10
1	6	Clay, blue	1	6
10	....	Sandstone	....	....
7	....	Shale, blue to drab, clayey	26	6
1	6	Shale, black, "slaty"	1	6
3	4	COAL (Bevier), ¼-inch clay parting in center	3	....
1	2	Clay	1	....
8	....	Limestone, impure, with shale partings	4+	....

The sump-rocks of the Bevier bed may be seen up Cedar creek for nearly two miles, down stream for a considerable distance, and on a small tributary one-half mile southeast of Stephens Store, where there are abandoned drifts in the Bevier bed. The coal is not everywhere as thick as in the mines described, however.

Rocks which probably lie a very short distance below the Bevier coal outcrop as follows in a bluff on Cedar creek, 1½ miles southwest of Stephens Store:

		Feet.	*Inches.*
1.	Shale, drab	6	....
2.	Limestone, brownish gray, in two beds with thin clay parting, compact	2	2
3.	Shale, light blue	1	6
4.	COAL (Tebo)	....	6
5.	Clay and shale, drab	7	....
6.	Limestone, light gray, nodular	1	2
7.	Shale, light drab to dark blue	3	....
8.	Clay, drab, with coal streaks	2	2
9.	Clay, white, very sandy	4	....
10.	Sandstone, white, thin-bedded, to creek level	2	....

Millersburg.—Where the Columbia-Fulton gravel road crosses Cedar creek the top of the Mississippian limestones lies 20 feet above water level, beneath a layer of flint conglomerate and about 20 feet of fire clay. The Bevier coal, therefore, lies well up in the hills in this part of Cedar valley. A short distance north of Millersburg it was formerly mined from a shaft only 10 feet deep. Alongside the Fulton road, two miles southeast of Millersburg, it lies only a few feet above Miller creek and is mined in a small drift on the land of J. S. Lloyd (N. E. ¼ S. W. ¼ Sec. 6, T. 47 N., R. 10 W.). Due south of Millersburg (S. E. ¼ N. W. ¼ Sec. 13, T. 47 N., R. 11 W.), near a small drift, the Mississippian appears in the creek bottom. A little coal is occasionally stripped at other places along Millers creek between the two drifts. The rocks exposed in the creek valley are:

		Feet.	*Inches.*
1.	Limestone, steel blue, compact	1	6
2.	Concealed	3	....
3.	Limestone, blue to gray, compact, vertically jointed, 10-inch shale parting near top	2	4
4.	Shale, light-colored at top, dark below (Summit coal horizon)	6	....
5.	Limestone, light gray, nodular	1	6
6.	Shale, upper part sandy, lower clayey, with thin layers of sandstone	34	....
7.	COAL (Bevier), 2 feet to	2	9
8.	Clay	3	6

		Feet.	Inches.
9.	Limestone, dark blue, weathers unevenly, shale parting in center, thickness variable	2	9
10.	Shale, variegated	6	....
11.	Interval, chiefly white clay	7	....
12.	Mississippian limestone	....	....

The Bevier coal is mined in a very small way from shallow shafts and strip-pits on Smiths creek. At one place (N. E. ¼ Sec. 19, T. 47 N., R. 10 W.) 30 inches of coal was observed under 20 feet or more of shale and sandstone.

Fulton.—For many years a considerable quantity of coal has been mined west and southwest of Fulton and hauled to the city for use at the State institutions and elsewhere. Very little of the product is shipped. All the mines utilize the Bevier bed and employ the longwall system of mining, wedging the coal down after undercutting. The coal bed bears considerable "sulphur" in thin streaks of iron pyrites and is cut up in places by vertical or highly inclined clay seams; the roof is poor and all below the thin limestone cap-rock is liable to fall in the roadway. The seam is irregular in thickness, ranging from one to four feet, but averages about 28 inches. The field lies south and west of Stinson creek; east of Stinson creek and north nearly to Callaway an arch or anticline has raised the Pennsylvanian so high that all except patches of it have been removed by erosion.

In the southwest corner of Fulton a fire clay pit of the Fulton Fire Brick Co. exposes 40 feet of the white and gray clay that lies just below the Bevier coal bed. The top of the pit is 25 feet below the Fulton coal and the base of the clay is not yet uncovered, showing that the fire clay in this depression has the remarkable thickness of more than 65 feet. A short distance up Stinson creek Mississippian rocks rise above creek level and the flint conglomerate that lies under the fire clay is nine feet thick; down stream the conglomerate rises in a bluff 50 feet high. Up small draws on the south side of Stinson creek, near the clay pit, are the two shafts of the Harris-Trigg Coal Co. and the slope of J. W. Simmons. The shafts are 30 and 40 feet deep and hoisting is done with a horse whim; the slope mouth is about seven feet above the coal and the haul from the face is about 1700 feet. The rocks outcropping on the ridge on either side of which the mine openings are situated are:

		Feet.
1.	Limestone	16
2.	Shale	3
3.	Sandstone, light buff, very calcareous in places	10
4.	Clay, very sandy	5
5.	Limestone, impure, concretionary, one foot to	2
6.	Shale, in part sandy	5
7.	COAL (Bevier), 18 to 36 inches, average	2½
8.	Fire clay, more than	20

One and one-half miles west of Fulton, beside the Chicago and Alton railroad (N. W. ¼ S. W. ¼ Sec. 18, T. 47 N., R. 9 W.), the Fulton Fire Brick Co. mines the same bed at a depth of 100 feet, hoisting by steam power and shipping the product to Fulton for use at the company's clay plant. The coal bed is 20 to 48 inches in thickness, with an average of 30 inches. Under the coal is 25 to 30 feet of fire clay, the lower portion of which was formerly mined. North of this mine are two shafts—those of J. F. Reed, 27 feet deep (S. W. ¼ S. E. ¼ Sec. 12, T. 47 N., R. 10 W.), and of Joseph France, 57 feet deep (N. E. ¼ N. E. ¼ Sec. 13), both of which employ horse-whim hoists. The thickness of the bed worked varies, as at the Fulton Fire Brick Co. shaft. Along the south side of Stinson creek from near the Reed mine to Fulton is a line of dumps from abandoned mines. The France shaft was being sunk at the time the district was visited by the writer, furnishing an opportunity to measure the following vertical section in it and at neighboring outcrops:

		Feet.
1.	Limestone, dove-color, thin and irregularly bedded	20
2.	Limestone, brownish gray to blue, in one bed, vertically jointed	1½
3.	Shale, blue (horizon of Summit coal)	4
4.	Limestone, light blue, thin and irregularly bedded, weathers unevenly on top, very impure	16
5.	Shale, dark drab (horizon of Macon City coal)	2½
6.	Sandstone, light gray, very calcareous, compact	6
7.	Shale	1½
8.	Limestone, very impure, concretionary	3
9.	Shale	7
10.	COAL (Bevier)	2
11.	Fire clay, more than	5

Shafts have been sunk at several places along the Jefferson City road within two miles of Fulton; at present two mines are in operation. The Fulton Coal Co. shaft 100 feet (S. W. ¼ N. E. ¼ Sec. 19, T. 47 N., R. 9 W.), and the W. T. Sims mine (N. E. ¼ S. W. ¼ Sec. 19) are operating. Both use steam hoists. The rocks in this district are essentially the same as at the Simmons slope at Fulton and lie at about the same level, but the coal is somewhat less variable in thickness and averages nearly 36 inches.

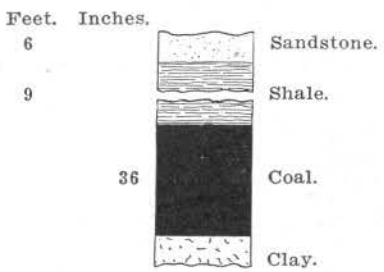

FIG. 22. The Bevier coal bed southwest of Fulton.

Carrington.—On a branch of Middle river, one-half mile east of Carrington, operations have been begun by the Callaway Coal Co. to excavate with a steam shovel the Bevier coal bed, which underlies the bottom lands and dips gently down the branch at an angle equal to the gradient of the stream. Owing to the dip a large quantity of fuel can be obtained by stripping 15 feet or less of the alluvium and shale that lies over the 28-inch coal bed, and it is the intention of the company to ship over a spur to the Chicago and Alton railroad. The heavy limestone of the Fulton section lies 32 feet above the coal, the interval containing shale and a thin bed of sandstone. Mr. Pugh reports that in drilling he encountered a 20-inch coal bed 16 feet below the Bevier; this lower bed was not seen to outcrop and is evidently a local basin deposit.

The Bevier coal bed outcrops low down in the valley of Middle river from near the Columbia road (Sec. 10, T. 47 N., R. 10 W.) to below the Jefferson City road (Sec. 12, T. 46 N., R. 10 W.), below which it rises to the top of the divide. In the upper part of the valley the strata above the coal are much like those at the France shaft, the upper limestones being more than 25 feet thick, the interval between them and the coal containing 32 feet of sandstones and shales, and the coal averaging 28 inches in thickness. Where the Jefferson City road descends to Middle river and in the steep bluff a short distance south (S. E. ¼ S. E. ¼ Sec. 2, T. 46 N., R. 10 W.), the following section is exposed:

		Feet.
1.	Sandstone, ferruginous, coarse, one foot to	5
2.	Limestone, gray, thin and very irregularly bedded, about	20
3.	Shale, drab	2
4.	COAL, streak (Mulky horizon)	....
5.	Clay and shale, drab, in part very sandy and with thin layers of sandstone	34
6.	COAL, upper six inches dirty (Bevier)	3
7.	Clay, with concretionary limestone in lower part	4
8.	Clay, yellowish drab	12
9.	Sandstone, white, thickness variable, more than	2
10.	Conglomerate, rounded pebbles of flint and limestone firmly cemented, more than	5
11.	Mississippian limestone	....

Hams Prairie.—Between the locality last mentioned and Hams prairie the Bevier coal bed and its overlying limestones are exposed along the upper courses of Craghead creek and its tributaries. Near the south line of Sec. 6, T. 46 N., R. 9 W. the coal is mined for the country trade by means of a horse-whim shaft and from several drifts near creek level. The following section is exposed:

		Feet.	*Inches.*
1.	Limestone, brownish gray, thin and irregularly bedded	25	....
2.	Interval, chiefly clay shale	32	....
3.	COAL, upper 8 inches very dirty and worthless	3	2

One-half mile down Craghead creek the flint conglomerate outcrops in the stream bed and the coal lies 20 feet above it. A short distance farther down stream Mississippian limestone appears and the coal

rises high in the divides. If the Fulton coal bed is present near Hams prairie it lies only in patches on the higher lands. Several thick coal pockets have been found in the district, of which the best known is that of W. C. Weeks (N. E. ¼ Sec. 16, T. 46 N., R. 9 W.), where a pocket containing 5 to 12 feet of coal, the lower part cannel and the upper bituminous, has been mined to a very slight extent. Devonian limestone, dipping steeply, lies a few feet below the coal and outcrops at higher levels in the adjoining hill.

Guthrie.—Near Guthrie wells and outcrops show that the Fulton coal has been eroded away and that only part of the fire clays below it remain. About a mile northeast of town, however, the Bevier bed has been drifted about 25 feet above Snells creek and is 30 inches thick. This seam probably underlies most of the territory between this point and Carrington and beyond. It is reported that an important pocket of coal has been worked with a shaft three miles east of Guthrie, near the Jefferson City road; it may be re-opened. The pocket is said to be 1500 feet wide and 14 feet thick. Other pockets are exposed near Caldwell.

Other Pockets.—Callaway county has long been noted for its pockets of thick coal and much money has been wasted by those who have attempted to mine them on a large scale. Although many are remarkably thick, containing as much as 80 feet of coal, most of them are very small in lateral dimensions and do not contain more than sufficient coal for purely local use. These pockets occur in all parts of the county, but are exposed only outside the area covered by the main body of the Pennsylvanian. They are especially well known in the rough country near the Missouri, where many were mined during early days to supply fuel for the boats then so numerous on the river. Many old workings may be observed near Hibernia and Mokane and exaggerated statements as to the amount of coal in those districts are still current.

CARROLL COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....1,467 TONS.

Carroll is one of the counties in which coal mining has been chiefly confined to small mines from which coal is taken, principally during the winter months, to supply a local trade. The upper part of the Cherokee shale, including thin but persistent coal beds, is at or near the surface over much of the county, and consequently coal may be obtained in many places from drifts or from shallow shafts.

*A few sections in Carroll county are given by G. C. Broadhead (Iron ores and Coal fields: Mo. Geol. Survey, pt. 2, 1873, pp. 59-61 and 73-75). Coal is mentioned by Arthur Winslow (Prelim. rept. on coal: Mo. Geol. Survey, 1891, pp. 107-110). The topography of the southern two-thirds of the county is shown on the Lexington and Marshall sheets of the U. S. Geol. Survey.

The area bordering the bluffs of the Missouri and Grand rivers is underlain by the shales and sandstone of the Cherokee. Northwest of this area a belt extending from the southwest corner to Hale is characterized by the barren limestones and shales of the Henrietta formation. The table-lands and mounds in Hill, Leslie, and Stoke's Mound townships are capped by the basal beds of the Kansas City limestone and the remainder of the county by the shales and sandstones of the Pleasanton. In that part of the region in which formations other than the Cherokee outcrop, important coal horizons lie concealed. The general section of outcropping rocks is essentially the same as in Livingston county. (See p. 264.) In Carroll county, however, the Mulberry coal is absent from the base of the Pleasanton, its horizon, wherever exposed, being marked by a conspicuous layer of red and greenish shales.

The Lexington bed is absent in all parts of the county in which its horizon is exposed but may be present below the surface in the northwest corner; the Summit coal is not known to be over six inches thick; the Mulky is locally workable; the Bedford, Bevier, and Tebo beds appear to be present over most of their outcropping areas, though the upper two are rather variable in thickness. The Tebo is the lowest outcropping seam, and there is little information concerning the 200 feet or more of Coal Measures between it and the thick Mississippian limestones. In this interval there may be several beds of coal, perhaps locally quite thick but not very persistent; individual basins probably underlie only a few square miles. Developments at Waverly, in Lafayette county, show the possibilities of these lower strata. Along Grand river and in neighboring country, strong dips are so common as somewhat to complicate mining conditions.

The absence of deep drillings in the western part of the county throws doubt on estimates of the thickness of coal in that region. The following estimate is based on areas more or less certainly known to contain coal in seams 14 inches or more in thickness:

Mulky coal,	18	inches,	3	square	miles	.....	5,184,000 tons
Bedford "	16	"	100	"	"	.....	153,600,000 "
Bevier "	16	"	150	"	"	.....	230,400,000 "
Tebo "	18	"	100	"	"	.....	172,800,000 "
For the county						.....	561,984,000 tons

Probably other deposits concealed beneath the surface, especially in the northwest corner of the county, would bring the grand total to at least 1,000,000,000 tons.

DETAILED MENTION.

Carrollton.—About one mile west of Carrollton (N. E. ¼ and S. E. ½ S. E. ¼ Sec. 31, T. 53 N., R. 23 W.) several shafts were operated

but their depths could not be ascertained. Mr. J. S. Atwood, on whose land they were located, reports the coal as being in a trough having a northeast-southwest direction. The coal was 16 inches thick in the middle, thinning to 4 inches on the upturned edges. In a ravine just west of the shafts are some abandoned drifts. The beds that should contain the Summit and Mulky coals outcrop in the bluffs near Carrollton, but are barren of workable coal. Mr. S. M. Wilcoxson furnished the following record of a hole drilled from a low level on the west side of the Burlington railroad at Carrollton (N. E. ¼ S. W. ¼ Sec. 32, T. 53 N., R. 23 W.):

DRILLING AT CARROLLTON.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay	25	....	25	....
Shale, gray	13	....	38	....
Shale, black	11	....	49	....
"Rock"	1	....	50	....
Shale, gray	3	....	53	....
"Rock"	1	....	54	....
Shale, black	5	....	59	....
"Rock"	1	....	60	....
Shale, dark gray	6	....	66	....
Sandstone	3	....	69	....
Shale, light and dark with 12 inches of "slaty" COAL	21	....	90	....
Shale, like last, showing some red	30	....	120	....
Sandstone	4	....	124	....
Shale, sandy, light and dark	17	....	141	....
Sandstone	3	....	144	....
Shale, gray and dark	47	....	191	....
Sandstone, soft, white	20	....	211	....
Shale, dark	5	....	216	....
Sandstone, red	6	....	222	....
Shale, dark	10	....	232	....
COAL	....	5	232	5
Shale, dark, mixed with nodules	1	7	234	....
Limestone, hard (Mississippian, lower limit of coal)	7	....	241	....

A little over 3 miles east of Carrollton (N. W. ¼ S. E. ¼ Sec. 36, T. 53 N., R. 23 W.) is the shaft of Henry Brooks, in which the following section was measured:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Concealed	11	6	11	6
Shale, black, "slaty," grading up to light shale	2	....	13	6
COAL (Summit)	....	6	14	....
Shale, soft, light drab	4	8	18	8
Limestone, light gray, weathers buff	2	4	21	....
Shale, drab, hard	2	10	23	10
Limestone, light gray, hard	2	8	27	6
Shale, black, "slaty," containing hard black concretions and layers of black, bituminous limestone at base	6	....	33	6
COAL (Mulky)	1	7	35	1
Clay, soft	6+	....	41	1

The coal varies from 14 to 24 inches, averaging 18 inches. Aside from one inch of dirty coal at the bottom, the bed is fairly clean except for scattered veins and streaks of pyrite, gypsum, and calcite. Mining is done on the longwall plan, the roof being good except for sporadic

oval limestone "niggerheads" that in places cut down into the coal and are held only loosely in the roof shale. The underclay is 6 to 14 feet thick and tends to "heave." The coal is hoisted by horse-power and is sold locally or hauled to Carrollton. Across the road to the south the same coal was mined by P. M. Wallen (N. E. ¼ N. E. ¼ Sec. 1, T. 52 N., R. 23 W.). The area of workable coal is much decreased in the district by the irregularity in the under surface of the roof. Near Carrollton the Mulky is very thin.

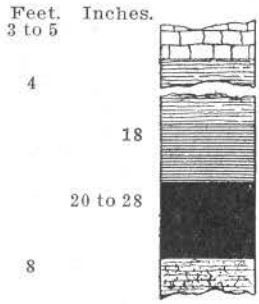

FIG. 23. The Mulky coal bed, near Wakenda.

Wakenda.—The Mulky coal is mined north and west of Wakenda, where it is about 40 feet above the Missouri bottoms. About two miles northwest (S. W. ¼ Sec. 8, T. 52 N., R. 22 W.), in the drift of Adkins and Sparks on land of Walter Woodson, the coal averages 18 inches, but varies from nothing to 26 inches. The roof is strong, and in places cuts down badly into the coal. Other small mines in the same bed have been worked in the vicinity. Near this place, at Hardwick's Mill, is the following section:*

	Feet.	*Inches.*
Limestone, upper 2 feet hard, compact; lower 3 feet, marly, concretionary	5	....
Clay and sand, shale at intervals	15	....
Limestone, hard	1 to 2	....
Shale, buff above, bituminous, fissile	3	....
COAL (Summit)	....	6
Clay	1	6
Shale, dark	4 to 5	....
Limestone, hard blue	3 to 5	....
Shale, upper 4 feet light drab, lower 1½ feet black, fissile, contains globular and ovoid concretions	5	6
COAL (Mulky), drifted	....	20 to 28
Clay	4 to 8	....

Miami Station.—Between Miami station and White Rock quarry, more than a mile southwest, the regular beds of the Coal Measures are replaced by massive sandstone that fill an ancient channel similar to the Warrensburg and Moberly channels in other parts of the State and perhaps belonging to one or both of them. At the quarry there

*From notes of C. H. Gordon.

are nearly 100 feet of white sandstone thinning at its northern end where it overlies 3 feet of black, laminated shale lying above 18 inches of sulphurous coal in regular Cherokee deposits; both the "slate" and the coal are cut off abruptly by the sandstone.

One mile northwest of the quarry, in the drift of John Amos on land of John Bargold (N. E. ¼ S. W. ¼ Sec. 6, T. 52 N., R. 21 W.), the coal varies from 10 to 20 inches, averaging 18 inches. Near the entrance "slaty" shale forms the roof, but further back soft shale wedges in and makes mining impracticable. The coal is mined on the longwall plan and is sold locally. In a near-by ravine, the following section was measured:

		Thickness. Feet.	Inches.
1.	Clay, white	2	....
2.	Shale, light drab, ferruginous layers at top and bottom	4	1
3.	Shale, light drab	15	....
4.	Shale, black, "slaty"	3	....
5.	COAL, weathered	1	7
6.	Clay, drab, very hard	1	1
7.	Limestone, hard, impure, concretionary	....	6
8.	Shale, dark to light drab	1	5
9.	Shale, black, "slaty"	....	8
10.	COAL mined by Amos	1	6

The lower coal is near the level of the flood plain at this point but rises to the southeast and one-quarter mile away is 30 feet above the bottoms. The same two beds have been mined at several places both to the east and the west.

DeWitt.—Coal, probably the Tebo, has been mined about 3 miles west of DeWitt at the shaft of Chas. Carter on land of John Griffith (N. W. ¼ S. E. ¼ Sec. 28, T. 53 N., R. 21 W.), but the opening has been temporarily abandoned. Mr. Carter reports the following section:

	Thickness. Feet.	Inches.	Depth. Feet.	Inches.
Soil	19	....	19	....
COAL, dirty	....	4	19	4
Shale and clay	4	....	23	4
COAL (Bevier)	1	8	25	....
Limestone, compact	4	....	29	....
Shale, black, "slaty"	2	....	31	....
COAL (Tebo), mined	1	8	32	8
Clay	4+	....	36	8

In a ravine below the mine the Bevier coal is 22-24 inches thick with "soapstone" shale, and, locally, "black bat" above it. Several old drifts have been driven into this bed.

About 6 miles northwest of DeWitt is the shaft of John Kenyon (N. W. ¼ N. W. ¼ Sec. 8, T. 53 N., R. 21 W.). It was opened about four years ago but is worked only in winter. The shaft, 16 feet deep, reaches 18-20 inches of coal, probably the Bevier. The bed is overlain by gray shale which permits it to be mined on the longwall plan. The coal is hoisted by a horse-gin and is sold locally or hauled to near-by

villages. Mr. Kenyon reports 42 inches of coal at a depth of 147 feet near his house.

Bosworth.—Mining on a small scale has been carried on about 5 miles northeast of Bosworth, near Grand river. On the land of H. W. Metcalf (N. E. ¼ N. E. ¼ Sec. 8, T. 54 N., R. 21 W.) the Bedford coal, 28 inches thick, has been stripped; it is overlain here by 3 feet of shale, so that the full thickness is present. The coal is free from "sulphur." A short distance southeast the following section was measured in an abandoned drift in the Bevier coal:

	Thickness.	
	Feet.	*Inches.*
Shale, drab	6+	.....
Shale, soft, black	2	.....
Limestone, black, full of shells	1	7
COAL Parting of black shale COAL	1	10
Clay, dark	.....	4+

The Tebo coal is exposed in a ravine near the stripping, but is only 12 inches thick. West of the stripping the strata are apparently faulted, beds being exposed stratigraphically more than 100 feet above the Tebo. Up the branch, these higher beds dip strongly to the east, so that a shaft 125 feet deep would be required to reach the Bedford coal just west of the stripping.

West of Bosworth railroad cuts expose a few inches of the Summit coal. Other cuts near-by show no coal at the Lexington horizon.

Bogard.—Stratigraphically, Bogard is about 50 feet above the top of the Henrietta formation; consequently no coal of importance outcrops in the vicinity, the horizons of the Bedford, Bevier, and Tebo beds being about 150-200 feet below the level of the depot. The country rock to the west is rather heavily buried beneath the drift, as shown by the drilling at Bingham, 7 miles southwest, where no solid rock was found to a depth of 200 feet.

Tina.—The strata commonly containing the Mulberry, Lexington, Summit, and Mulky coals are exposed within short distances of Tina, but all are barren of coal. An imperfect record of a drilling for oil near Tina reports about 4 feet of coal at 44 feet and about 2 feet of coal at 73 feet. This has not been verified by a shaft. A record 2 miles southwest (S. W. ¼ S. W. ¼ Sec. 3, T. 54 N., R. 23 W) reports 2½ feet of coal at a depth of 187 feet.

Hale.—A few miles east of Hale, along Grand river, are many outcrops of coal and several mines and strippings. The largest operations are in the vicinity of Little Compton, where the Tebo has been stripped in pits covering several acres. The Tebo coal varies from 18 to 30 inches, is hard, lustrous, irregularly bedded, and generally free from pyrite in scattered nodules of large size. It is overlain by blue shale, which varies from nothing to 6 feet in short distances and is in turn

overlain by hard, black shale containing "niggerheads." The coal is sold locally or hauled to Hale. Dips are numerous and erratic. The mines in the district are: R. M. Cowan (S. W. ¼ S. E. ¼ Sec. 8, T. 55 N., R. 21 W.), drift in 22 to 26 inches of coal; Thomas White, on land of Chas. Baughn (N. W. ¼ N. E. ¼ Sec. 17, T. 55 N., R. 21 W.), stripping in 18 to 23 inches; R. E. Callaway (N. W. ¼ N. W. ¼ Sec. 16, T. 55 N., R. 21 W.), slope to 23 inches; James Odell (S. E. ¼ N. E. ¼ Sec. 17, T. 55 N., R. 21 W.), shaft (abandoned) 40 feet to 23 inches.

At "Mowhee Bluff" (S. W. ¼ Sec. 17, T. 55 N., R. 21 W.), near Little Compton, 13 to 20 inches of Bedford coal is exposed directly

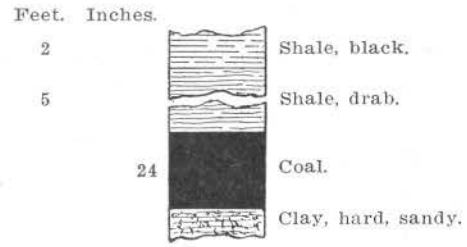

FIG. 24. Coal bed at Little Compton.

beneath 25 feet of sandstone. Two other beds are reported in the lower part of the bluff; they probably lie at the Bevier and Tebo horizons.

The Tebo coal apparently retains a position above water level of Grand river as far as the northeast corner of the county. The shale and sandstone above the Bedford coal are exposed at many places south and east of Hale, so that the coal along Grand river is not over 50 or 75 feet below the surface. A well at the creamery is said to have reached, at a depth of 290 feet, the thick Mississippian limestone that marks the lower limit of coal.

Plymouth.—Extending from the north line of the county south to Mandeville is a table-land capped by the Kansas City limestone, which lies at the base of the Missouri group. Coal, reported in a number of places, probably belongs to the Ovid or to some other bed in the Pleasanton shale and is not of great importance.

CASS COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....4,032 TONS.

Coal is mined in a number of places but chiefly for local use, being shipped only from Creighton.

Little is known about the county's coal resources, as drilling has

*The geology of Cass county along the Missouri Pacific railroad was first described by G. C. Broadhead (Mo. Geol. Survey, Rept. for 1872, pt. 2, pp. 167-168, 195-201). Coal is mentioned by Arthur Winslow (Mo. Geol. Survey, Prelim. rept. on coal: 1891, pp. 132-133). The topography is shown on the Harrisonville, Olathe, Mound City, and Butler sheets of the U. S. Geological Survey.

been confined to a few localities and the chief coal horizons lie too deep to be exposed. The escarpment formed by the thick beds at the base of the Kansas City limestone crosses the county sinuously from the southwest to the northwest corner. West of it the important coal horizons lie at depths of 200 feet or more. East of it the general level of the county is about 200 feet lower and the outcropping rocks belong mainly to the Pleasanton shale and the Henrietta formation. In the southeast corner of the county, along Grand river, the shales and sandstones of the Cherokee shale outcrop in a small area. The general succession of strata is shown in an outcrop and drill record at Pleasant Hill, given below:

OUTCROPS AT PLEASANT HILL (AFTER BROADHEAD).

	Thickness. Feet.
Kansas City limestone—	
1. Shales, clayey	4
2. Ochre, brownish, decomposing, fossiliferous	½
3. Shale, dark drab, clayey	4
4. Limestone, buff to drab	7
5. Limestone, grayish-drab, rough and irregularly bedded; has buff shaly partings	8
6. Shale, brown and buff, calcareous	1½
7. Limestone, blue, shaly, turns brown on exposure	4
8. Shale, blue and bituminous with an occasional knife-edge of coal	4
9. Clay, blue and buff	3
10. Limestone, light-drab to gray (Bethany Falls)	16
11. Shale, blue and bituminous, with limestone bands near center	11½
12. Limestone, gray, in places ferruginous (Hertha)	4
Pleasanton shale—	
13. Shale	14
14. Sandstone, calcareous, or sandy limestone, dark brownish gray when weathered, blue when fresh	2
15. Sandstone and sandy shale	40

DRILLING AT PLEASANT HILL.†

150 FEET SOUTH OF MISSOURI PACIFIC STATION.

	Thickness.		Depth.	
	Feet	Inches.	Feet.	Inches.
Dark clay	30	....	30	....
Gravel, water-bearing	2	....	32	....
Pleasanton shale—				
Clay, with thin layers of sandstone	43	....	75	....
Black, bituminous shale, with thin streaks of coal (Mulberry)	3	....	78	....
Dark shales, with thin limestone layer	2	....	80	....
Dove-colored shales	9	....	89	....
Henrietta formation—				
Limestone, gray	5	....	94	....
Dove-colored calcareous shales	7	....	101	....
Dark shales with red bands	2	6	103	6
Shales	28	....	131	6
Sandstone	3	....	134	6
Shales and limestone	17	....	151	6
Black shales with thin coal ceams	3	....	154	6
Shales and clay	3	....	157	6
Blue limestone	10	....	167	6
Dark shales and sandstone	7	....	174	6
Dark blue and red shales	15	....	189	6
Hard blue limestone	2	....	191	6

†Shepard, E. M., Underground Waters of Missouri; Water-Supply Paper, U. S. Geol. Survey, No. 195, 1907, pp. 113-114.

DRILLING AT PLEASANT HILL—Continued.

	Thickness. Feet.	Inches.	Depth. Feet.	Inches.
Cherokee shale—				
Dark shales and coal (Lexington)	1	6	193	....
Clay	2	....	195	....
Sandstone	10	....	205	....
Limestone	2	....	207	....
Sandstone	3	....	210	....
Shales and coal	1	....	211	....
Alternating sandstone and shale	80	....	291	....
Dark shales	1	....	292	....
Shales	9	....	301	....
Bituminous "slate"	3	....	304	....
Sandstone and shales	18	....	322	....
Shale, "slate," and a foot of coal	2	....	324	....
Sandstone and shales with pyrite	31	....	355	....
Limestone	1	....	356	....
Shales	3	6	359	6
Good bituminous COAL	1	6	361	....
Fine clay, with nodules of ironstone	5	....	366	....
Clay, shales and ironstone	10	....	376	....
Micaceous sandstone, with some clay	105	....	481	....
Dark clay, with a foot of coal	5	....	486	....
Sandstone and blue shales with pyrites	47	....	533	....
Shale	19	....	552	....
Brown sandstone	28	....	580	....
Mississippian series (lower limit of coal)—				
Limestone and chert	25	....	605	....

The record of the drilling and the outcrop measurement together form practically a complete, though very imperfect, section of the Pennsylvanian of the county. It may be considered fairly typical for strata above the Cherokee formation, though below that the strata probably vary considerably from place to place. Some of the coal horizons of the Cherokee are probably as persistent as in other counties, but, owing to the absence of limestone, they can not be identified with certainty.

Three coal beds of general distribution, the Ovid, the Mulberry, and the Lexington, outcrop in the county. The Ovid seam lies near the top of the Pleasanton shale, and, while relatively persistent, it rarely exceeds two or three inches in thickness. The Mulberry bed lies a few feet above the base of the Pleasanton shale in the southeastern portion of the county. A few miles to the south, in northwestern Bates county, it is an important bed, but its maximum known thickness in Cass county is only 12 inches. It has been stripped in a few places for local use. The Lexington bed, though not utilized in Cass county, is mined at several places in Johnson county, where it varies from 14 to 18 inches in thickness. In the vicinity of Creighton it is either absent or too thin to be of any value. In the Pleasant Hill drilling it is reported as 18 inches of dark shale and coal.

Drillings at widely separated points indicate that the whole county is underlain by one or more workable beds. Any estimate as to the coal resources of the region, however, must necessarily be very rough.

An examination of the available drill and outcrop records indicates that the assumption of an average of 36 inches of coal in beds not less than 14 inches thick is very conservative. On this basis the total original coal reserve of the county is 2,460,672,000 tons.

DETAILED MENTION.

Creighton.—Mining has been carried on near Creighton for several years and a shipping mine, opened in 1898, is now operated by Stone and Son (S. E. ¼ N. W. ¼ Sec. 24, T. 43 N., R. 29 W.). The shaft is 165 feet deep. The product is hoisted by steam and loaded on a tramway three-fourths mile long and connected with the Kansas City, Clinton & Springfield railway.

MEASUREMENT AT CREIGHTON MINE.

	Inches.
Shale, hard, forming a good roof	24
Shale, black, soft, up to 5 inches, usually	2
COAL, clean except for one-fourth inch of pyrite in places near middle	28-34
Clay, sandy, hard	12+

The underclay is too hard for undercutting and the room and pillar method has been adopted. The stratigraphic position of the coal is somewhat doubtful, though its distance below the Lexington coal and to some extent the nature of the strata above it indicate that it lies at the horizon of the Tebo, the coal bed mined in many places in Henry county.

DIAMOND DRILLING NEAR CREIGHTON MINE (S. E. ¼ N. W. ¼ SEC. 24, T. 43 N., R. 29 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Loose earth	15	....	15	....
Henrietta formation—				
COAL	....	4	15	4
Clay	2	2	17	6
Limestone	1	8	19	2
Cherokee shale—				
Shale	6	10	26	....
COAL (Lexington)	....	3	26	3
Clay	2	9	29	....
Shale	9	....	38	....
Ochre, red	3	....	41	....
Shale	3	....	44	....
Sandstone	2	6	46	6
Shale	3	5	49	11
COAL	....	8	50	7
Clay	7	11	58	6
Shale, black, "slaty"	1	....	59	6
Shale, dark	8	....	67	6
Sandstone	13	4	80	10
Shale, black	5	8	86	6
COAL, a few inches	....	....	....	....
Shale, red	13	....	99	6
Shale, sandy	5	....	104	6
Sandstone	3	6	108	....
Shale, sandy	2	6	110	6

DIAMOND DRILLING NEAR CREIGHTON MINE (S. E. ¼ N. W. ¼ SEC. 24, T. 43 N., R. 29 W.)—Continued).

Cherokee shale—Continued.	Thickness. Feet.	Thickness. Inches.	Depth. Feet.	Depth. Inches.
Shale, "slaty"	10	6	121	....
COAL, a few inches (Bevier?)	....	....	....	....
"Rock," hard	....	6	121	6
Shale, dark, sandy	9	....	130	6
Sandstone, hard, shaly	3	....	133	6
Shale, blue, sandy	4	....	137	6
COAL (Tebo?), mined	3	5	140	11
Shale, black	....	4	141	3
Clay	4	2	145	5
Sandstone	1	6	146	11

A drilling not far distant (S. W. ¼ N. E. ¼ Sec. 24) and beginning at a higher level, shows:

	Thickness. Inches.	Depth. Feet.	Depth. Inches.
COAL	6	32	6
COAL	9	42	9
COAL	16	85	4
COAL	27	168	5
COAL	18	261	....
Bottom of drilling	....	326	....

About five miles northwest of Creighton, near Walnut creek (S. W. ¼ Sec. 34, T. 44 N., R. 29 W.), the following beds were encountered.

	Thickness. Inches.	Depth. Feet.	Depth. Inches.
COAL	5	10	5
COAL	20	33	....
COAL	18	84	6
COAL	10	131	10
COAL	16	169	10
COAL	31	185	7

The last bed mentioned is probably the same as that mined at Creighton, the drilling beginning at a higher level, stratigraphically, than either of the other drillings quoted.

Harrisonville.—Several years ago a hole was bored at Harrisonville to a depth of 505½ feet in search of gas. At 292 feet, 18 inches of coal mixed with laminated shale was found. The record is too imperfect to fairly represent the coal resources of the district.

Miscellaneous localities: Drilling has been done at many other places in Cass county, among them Garden City, Lone Tree, Austin, and Lisle, but the records are not available. At Paola, Kansas,‡ a drilling is reported to have struck 4 feet of coal at a depth of 631 feet (115 feet below the Lexington horizon). The thickness reported is questionable, but it is to be noted that the coal apparently lies at the same stratigraphic level as that mined at Creighton.

‡Univ. Geol. Survey, Kansas, vol. IX, 1908, pl. 88.

CEDAR COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....748 TONS.

Cedar county is on the border of the Ozark region; and in it the Pennsylvanian rocks are confined to the higher ridges, having been removed from much of the area by post-Pennsylvanian erosion. Coal mining, for local consumption only, is carried on chiefly near Jerico, Lebeck, and Balm, and east of Caplinger Mills, by stripping or drifting. The Pennsylvanian consists chiefly of sandstones of a reddish, brown, buff, or orange color. The principal coal bed lies but a few inches below the base of a considerable thickness of sandstone. Widely separated outcrops of coal exhibit marked similarities in character and associations, yet, owing to the absence of good horizon markers, it is unsafe to correlate beds on opposite sides of a large upland area. Any of the areas shown on the State geological map as Pennsylvanian may contain coal, but in many districts the fact can be determined only by drilling.

The following estimate of the total coal reserve is based on 1,800 tons per acre-foot, and includes only beds over 14 inches thick:

	Tons.
Eldorado Springs, average 20 inches, 36 square miles	69,120,000
Jerico, average 20 inches, 36 square miles	69,120,000
Lebeck-Balm, 18 inches, 9 square miles	15,552,000
Caplinger Mills, 20 inches, 6 square miles	11,520,000
Other beds and pockets	5,000,000
For the county	170,312,000

DETAILED MENTION.

Jerico.—The divide in the southwestern part of the county between Horse and Cedar creeks is largely capped with Pennsylvanian rocks, chiefly sandstone. Below the sandstone in many places is a bed of coal that lies less than 50 feet above the base of the Coal Measures. Whether the coal is coextensive with the sandstone is a question which can be determined only by drilling, but the probabilities point to the existence of many barren areas. The sandstone in some places rests directly on the coal, but in others is separated from it by a thin shale that weakens the roof in the mines when it exceeds one or two feet in thickness. In the Jerico district the coal mined is generally found in two benches, each varying from about 7 to 15 inches, with a shale parting of 8 to 24 inches. The coal, while generally of good quality,

*The geology of Cedar county was described by G. C. Broadhead (Rept. for 1873-1874: Mo. Geol. Survey, pp. 62-76). The coal is mentioned by Arthur Winslow (Prelim. rept. on coal: Mo. Geol. Survey, 1891, p. 160). The topography is shown on the Stockton and Nevada sheets of the U. S. Geol. Survey.

may be only fair, and contains a moderate amount of pyrite in thin streaks or scales. The following drifts were in operation when the district was visited: L. Godfrey, one-fourth mile west of Jerico, 17 inches of coal with a 12-inch parting; Chas. Carter, 1 mile southwest, 26 inches of coal with an 8-inch parting; Pogue bank, 3 miles southwest (N. E. ¼ S. E. ¼ Sec. 20, T. 33 N., R. 28 W.), 24 to 27 inches of coal with 18 to 24-inch parting; William Givit (Old Duncan bank), about 3½ miles south of west (N. W. ¼ N. W. ¼ Sec. 13, T. 33 N., R. 29 W.), 22 inches of coal with an 18-inch parting; R. T. Taylor 5 miles southwest (S. W. ¼ S. W. ¼ Sec. 24, T. 33 N., R. 29 W.), 25 inches of coal, with a 6-inch parting; at the latter place the lower four inches of the coal was dirty.

In the next township north of Jerico coal has been reported from a few places both east and west of Tingley, also from 4½ miles north of Jerico (Sec. 3, T. 34 N., R. 28 W.), but it appears to be thinner than that south of Jerico.

Eldorado Springs.—The area in the vicinity of Eldorado Springs, bounded on the west by Clear fork and on the east by the tributaries of Little Clear fork and Alder creeks, contains much sandstone, below which, at least in places, is coal. At the drift of Geo. Anson, about a mile southwest of town (N. E. ¼ N. E. ¼ Sec. 29, T. 39 N., R. 28 W.), there are 22 to 36 inches of coal below 5½ feet of shale. Sandstone appears above the shale. In the northeast corner of the town what appears to be the same bed of coal is reported to be only one foot thick.

Lebeck.—Just west of Lebeck and at "Coal Hill," about one mile southwest, coal has been extensively stripped. The region is covered with sandstone, beneath which and overlying the coal is an extremely variable layer of shale, sandstone or conglomerate, which ranges in thickness from nothing to 2 feet and which in some places is so hard that it has to be blasted out before stripping can proceed. The coal varies from 11 to 22 inches in thickness, is rather irregularly bedded and contains a few plates of pyrite on the bedding planes, particularly near the base. The coal is used locally or hauled to Eldorado Springs. The following are the more important strippings in the district:

			Thickness of coal. *Inches.*
C. A. Schroder	S. E. ¼ N. E. ¼	Sec. 19, T. 36 N., R. 27 W.	18
C. M. Schroder	N. E. ¼ S. E. ¼	Sec. 19, T. 36 N., R. 27 W.	18
C. M. Schroder	N. W. ¼ S. W. ¼	Sec. 19, T. 36 N., R. 27 W.	11-22
John H. Selby	S. W. ¼ N. W. ¼	Sec. 20, T. 36 N., R. 27 W.	18
Edward Davisson	S. E. ¼ N. W. ¼	Sec. 20, T. 36 N., R. 27 W.	18
W. E. Reynolds, on land of Andrew Ogleby	N. W. ¼ N. W. ¼	Sec. 20, T. 36 N., R. 27 W.	18
Daniel Boyer	S. W. ¼ N. E. ¼	Sec. 17, T. 36 N., R. 27 W.	18
Bert Bailey	S. E. ¼ N. E. ¼	Sec. 17, T. 36 N., R. 27 W.	18
Isaac Williams	S. E. ¼ N. E. ¼	Sec. 17, T. 36 N., R. 27 W.	20
J. W. Andes	S. W. ¼ N. W. ¼	Sec. 16, T. 36 N., R. 27 W.	18
E. M. Beebe	S. W. ¼ N. W. ¼	Sec. 16, T. 36 N., R. 27 W.	18

Balm.—Coal resembling that at Lebeck is mined in the vicinity of Balm. At the crossroads on the southern edge of the village (N. E. ¼ S. W. ¼ Sec. 22, T. 36 N., R. 27 W.), 18 inches of coal was formerly stripped and drifted. About one-half mile south of Balm is the stripping of William Smith (N. W. ¼ N. W. ¼ Sec. 27, T. 36 N., R. 27 W.), at which the following section was measured:

	Feet.
Sandstone	....
Shale, sandy, grading into next below	.5 to 5½
Shale, "blue slate," hard when fresh, weathers blue or red	½ to 1
COAL, 15 to 22 inches, average	1½
Clay	6+

North of Balm, near the north line of the county, coal is reported 20 inches thick.

Caplinger Mills.—The only area east of Sac river in which coal is known to occur, lies east of Caplinger Mills, in the east-central part of T. 35 N., R. 26 W. Broadhead, who estimates its area at six square miles, gives the following section, obtained in the S. E. ¼ S. W. ¼ Sec. 13, T. 35 N., R. 26 W.:

	Thickness. Feet.	Inches.
Sandstone	....	....
Shale	10	....
COAL, tolerably good, containing a good deal of pyrite and somewhat "slaty" at top	1	4
Shale and clay, passing into sandstone below	2 to 3	....
COAL, more compact than top seam; said to be better, but contains some pyrite	1	6

In the N. E. ¼ S. W. ¼ of the same section the coal was found to be 36 inches thick, and in the N. W. ¼ S. W. ¼ to be 20 to 36 inches thick. It is also reported in the N. E. ¼ of section 24, same township.

CHARITON COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....8,403 TONS.

Although there are important fields adjacent to it on the north and east, Chariton county has never produced much coal. There are many small mines on thin coal beds in the region, but no shipping mines have ever been operated in the county except a few that were worked intermittently, for the region contains no thick coal beds and no thin ones of good quality, except in districts rather remote from railroads.

In the north-central part of the county, near Rothville and on Mussel fork, are exposed sections embracing rocks from the lower

*The topography of the southern part of Chariton county is shown on the Marshall and Glasgow atlas sheets of the U. S. Geol. Survey. Brief mention of coal is made by Winslow, Preliminary report on coal: Mo. Geol. Survey, 1891, pp. 91-92. The geology and topography of the eastern edge of the county are represented on the map of the Bevier quadrangle republished in this volume with the report on Macon county, and of the Huntsville quadrangle with the report on Randolph county.

part of the Henrietta formation to the Tebo coal beds, and these represent nearly all the strata found above drainage within the limits of the county. Except in parts of the valleys of East fork, Middle fork, Mussel fork, main Chariton, and the northern part of Yellow creek, there are few good exposures, as a heavy mantle of drift and other loose surface material covers much of the region. This drift covering combined with channel deposits that are similar to those occurring in Randolph county and are apparently rather irregularly distributed, and also with the absence of conspicuous limestone or other persistent beds to act as markers, renders the geology of Chariton county somewhat difficult to unravel. There are four horizons at which workable coal occurs:

COAL BEDS OF CHARITON COUNTY.

		Feet.
1.	Mulky coal	0 to 2
	Interval	15 to 50
2.	Bevier coal, in two benches	1 to 5
	Interval	10 to 25
3.	Tebo coal	0 to 2½
	Interval	60+
4.	Eureka coal	0 to 5

The highest bed, the Mulky, lies just beneath black laminated shale which grades upward into softer material and contains concretionary "niggerheads." Over the shale is a thin but compact limestone caprock, the whole forming an excellent mine roof. This bed has been removed by erosion from a wide territory in the western and southern part of the county and was never deposited in workable thickness in much of the remainder of the county. Its most important known occurrence is at Rothville.

The rocks next below the Mulky consists of sandstone and shale and which are very irregular in thickness and character. The Bevier coal bed, so important in Macon, Randolph, and other counties, is also

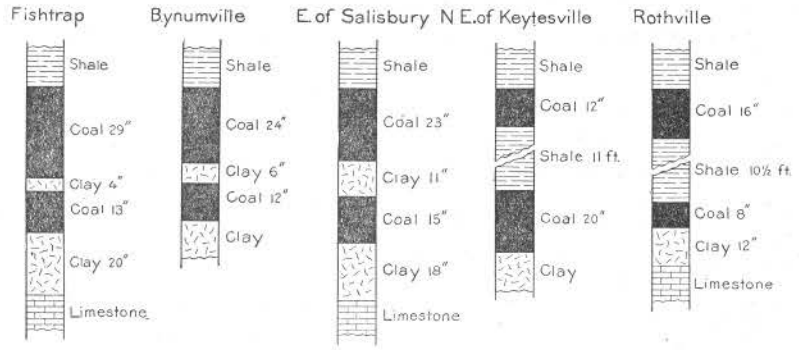

Fig. 25. The Bevier coal bed in Chariton County.

a potential though neglected factor in the development of northeastern Chariton county. As shown at the mines at Fishtrap, Prairie Hill, east of Salisbury, and east of Shannondale, the quality of this coal is

good and the bed is only slightly thinner than in the main producing fields farther east. A factor with which to reckon, however, is the "bench rock," or clay parting, which divides the bed into two benches and in many places thickens so much as to render mining difficult. In spite of this fact, several profitable though practically unknown coal fields lie along the eastern edge of the county, and especially in its northeast corner. Further west the parting thickens to 10 feet or more, separating the Bevier into two distinct beds, distinguished in this report as the upper and lower Bevier. In some places the upper and in others the lower is thick enough to justify mining, though only on a small scale. Local mines are operated in these deposits at Eccles, south of Keytesville, at Guthridge Mills, and near Trade.

Under the limestone member that lies below the underclay of the Bevier bed is a succession of shales bearing a few thin bands and concretionary layers of limestone. Under this is the Tebo coal, a bed that underlies nearly all of the county except a strip about five miles wide on the west and south. It attains a thickness of 27 inches at South Marceline and possibly more in the upper part of Mussel fork valley, but in most of the county is less than two feet. The roof is in part a firm "slaty" shale and in part a weaker clay shale. The quality of the coal is in general not so good as that of higher beds, as it contains a larger amount of "sulphur" and other impurities. It underlies nearly all of the county except the main bottom lands and has been mined for local consumption northeast of Sumner, west of Rothville, near Brunswick, south and southeast of Keytesville, near Eccles, south of Salisbury, and east of Shannondale. This bed is now being utilized at very few of these localities. On the county line, at Marceline, it is being mined for railroad and shipping purposes.

About 60 feet below the Tebo and separated from it by shales and sandstone is the Eureka horizon. Very little is known about the nature of this coal bed, as it lies too low to outcrop and little drilling has been done in this region. In counties on the east it lies in basins of fair thickness separated by rather broad barren areas. It is not safe to sink to this bed until drillings have proved a minable thickness under the entire area it is planned to work. If the bed formerly mined in the town of Salisbury and found by drilling south of town is the Eureka, as seems probable, basins of thick but irregular coal will be found by the drill in other localities. The Eureka is the lowest coal likely to be discovered. As shown by a drilling at Brunswick and several in neighboring counties, the Mississippian underlies the Coal Measures at depths very little below the Eureka horizon and in places probably projects above it. There is probably no coal under the bottom lands of the Missouri and Grand rivers.

The total original tonnage of the county is very roughly estimated

in the following table. The estimate includes no parts of beds less than 14 inches thick and assumes a content of 1800 tons to the acre-foot. The quantity already mined is so small as to be negligible:

Bed.	*Tons.*
Mulky	172,800,000
Bevier, both upper and lower	997,000,000
Tebo	849,000,000
Eureka (problematical)	150,000,000
Total	2,168,800,000

Broadly speaking, the strata of Chariton county are horizontal; so that the depth of a bed below the uplands may be roughly determined by the level of its nearest outcrop in the valley. There is a very gentle general dip to the south, which is approximately equal to the gradient of the main streams. There are, however, minor undulations that cause variations in the level of beds along certain zones.

DETAILED MENTION.

Lagonda.†—A shaft sunk many years ago at Lagonda, in the northeast corner of Chariton county, is said to have encountered the Mulky and Summit coal beds. The surprising feature of this is that the Mulky lies at an altitude of 670 feet, although at a place one mile south and at Hammacks Mill, five miles north, it lies about 50 feet higher.

SHAFT AT LAGONDA‡ (S. W. ¼, S. E. ¼, SEC. 18, T. 56 N., R. 16 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay (drift)	14	....	14	....
Limestone	3	....	17	....
Shale, black, "slaty"	5	6	22	6
COAL (Summit)	1	1	23	7
Clay	....	6	24	1
Shale, bluish white	18	....	42	1
Limestone, hard	3	....	45	1
Shale and COAL (Mulky)	4	....	49	1

Fishtrap Ferry.—The Bevier bed§ is exposed just above water in the Chariton at Fishtrap, where a drift has been driven into it and operated by J. A. Clark (N. W. ¼ S. W. ¼ Sec. 29, T. 56 N., R. 16 W.). One-half mile north J. H. Jeffrey has sunk a shaft (N. W. ¼ N. W. ¼ Sec. 29, T. 56 N., R. 16 W.), hoisting with a horse-whim. The coal at these local mines is of fine quality and comparatively free from "sulphur." There is an average of 42 inches of coal split into two benches by a parting of hard clay that lies about one foot from the bottom and averages four inches in thickness, though in one or two places it is as much as 16 inches thick. This parting does not appear

†See map of Bevier quadrangle in report on Macon county.

‡A report on the Bevier sheet: Mo. Geol. Survey, 1893, p. 35.

§This bed was doubtfully correlated with the Mulky (Macon City) by Gordon (A report on the Bevier sheet: Mo. Geol. Survey, 1893, p. 36), but high water prevented his examining the section, and information recently gathered shows conclusively that the coal mined is without question the Bevier.

to interfere with the economical working of the mines and both benches are cut by one shot. Above the coal is more than 14 feet of shale that is drab at the top and black and hard at the base, forming a very fair roof. Below the coal is clay that averages about 20 inches, but varies because of the uneven surface of the limestone upon which it rests. The latter is at least two feet thick and very hard and compact. W. T. Wilson has recently sunk a shaft west of the Jeffrey mine (N. W. ¼ N. E. ¼ Sec. 36, T. 56 N., R. 16 W.), reaching the Bevier at 60 feet. He reports that the coal is 58 inches thick and the clay parting only one inch. Over the coal is about 30 inches of black shale, over which is 24 feet of alternating sandstones and shales lying under 34 feet of drift. Thick coal probably underlies a large territory in this corner of the county, and deserves more attention than it has received.

Bynumville.—The Bevier bed was formerly explored by a shaft on the land of C. R. Billeter on the east side of Bynumville (N. W. ¼ S. E. ¼ Sec. 35, T. 56 N., R. 17 W.), where it lies only a few feet below the level of Elm branch, and where in 1911 a new shaft was being sunk. What is probably the Mulky bed, but may be the Summit, was found in a well not far distant.

SECTION AT BYNUMVILLE.

		Feet.	Inches.
1.	Limestone, compact, one-half inch clay parting near middle	2	6
2.	Shale, soft at top, black and "slaty" in lower part	3	....
3.	COAL (Mulky?)	1	....
4.	Clay, white	2	....
5.	Interval	30	....
6.	Shale, light at top, becoming darker towards bottom	18	....
7.	COAL, 24 inches, "Bench rock," 6 to 12 inches, COAL, 12 inches, (Bevier)	3	6

Hamden.—In the summer of 1911 a shaft was being sunk between Hamden and Mussel fork by Arthur McSparns (N. E. ¼ N. W. ¼ Sec. 20, T. 55 N., R. 17 W.), who expected to find three to four feet of coal at less than 50 feet, an opinion based on coal found in an old well located a short distance east.

*Prairie Hill.**—When Prairie Hill was visited a shaft had been sunk 42 feet through the following:

SHAFT AT PRAIRIE HILL (S. E. ¼ S. W. ¼ SEC. 32, T. 55 N., R. 16 W.).

	Thickness.		Depth.	
	Feet.	Inches.	Feet.	Inches.
Drift clay	20	....	20	....
Limestone	1	6	21	6
Shale	10	....	31	6
Limestone, blue	3	....	34	6
Shale, black, "slaty" (horizon of Mulky coal)	6	....	40	6
Sandstone, white	1	6	42	....

It is said that below this are 44 feet of sandstone and shale to a coal bed 54 inches thick, including a four-inch shale parting, and it is

*See map of Bevier quadrangle in report on Macon county.

the intention of Mr. Sears to begin operations in it. A well one-half mile north of the shaft penetrated this bed. Two miles southeast of Prairie Hill, on land now owned by Harlan Moffet (N. E. ¼ N. W. ¼ Sec. 9, T. 54 N., R. 16 W.) an abandoned shaft 102 feet deep is reported to have reached coal four feet in thickness. The coal mined in this district is probably much the same as that at Thomas Hill in Randolph county, where the Bevier bed is shafted.

Salisbury.—In 1894 a company of citizens of Salisbury sank a shaft 180 feet in the southwest corner of the city. At first coal nearly five feet thick was mined, a railroad switch was laid, and preparations made for a large production, but as the bed proved to be very irregular in thickness and the roof soft, operations were soon abandoned. Judged by elevations alone, the bed mined appears to be the Eureka, and further prospecting might reveal important deposits at this horizon.

SALISBURY COAL SHAFT.	Thickness. *Feet.*	Depth. *Feet.*
Drift	10	10
Sandstone	100	110
Shale	60	170
Limestone and shale	5	175
COAL (Eureka?)	5	180

As shown in this and other drillings at Salisbury, the horizon of the Bevier bed, which contains workable coal only two miles east, is occupied by a sandstone that very probably fills a channel identical with or similar to the main Moberly channel. Red sandstones and sandy shales that probably lie at the base of this channel may be seen on the bank of Middle fork east of Salisbury (S. E. ¼ S. E. ¼ Sec. 1) and at least 30 feet of the same material in a small quarry and its vicinity, one-half to one mile south of the city. South and southwest of Salisbury, near Middle fork, are several small abandoned drifts in a thin coal bed (Tebo). Winslow† states that a lower bed composed of two benches of two feet each, separated by two feet of shale, was found here, was shafted, and was soon abandoned. The lower bed is evidently the same (Eureka) as the one mined at 180 feet in the shaft at Salisbury.

OUTCROPS ONE MILE SOUTH OF SALISBURY (N. W. ¼ N. W. ¼ SEC. 14, T. 53 N., R. 17 W.).

		Feet.	*Inches.*
1.	Sandstone, red, evenly bedded, in part massive (Moberly)	30	....
2.	Limestone, light brownish gray	....	6
3.	Concealed, probably shale	5	....
4.	Limestone, dark blue, compact	....	4
5.	Shale, black, "slaty," with "niggerheads"	2	6
6.	COAL (Tebo), reported	1	6
7.	Concealed, about	15	....
8.	COAL, dirty	....	4
9.	Clay	8	....
10.	Limestone, reddish, concretionary, in bank of Middle fork	....	5

†Preliminary report on coal: Mo. Geol. Survey, 1891, p. 91. The writer can not agree with his correlation.

Fig. 1. Pavement of Summit cap-rock in stream bed and the "Chaetetes" limestone bluff.

Fig. 2. Sandstone quarry one-half mile south of Salisbury, Mo.

Although the Bevier bed is not present in the immediate vicinity of Salisbury, it is typically developed two miles or more east of the town, where it lies just above the level of Middle fork. Shafts about 50 feet deep have been sunk beside the railroad and operated for short periods before being abandoned because of four to 12 inches of hard clay that separated the coal into two benches. Two local mines situated near Middle fork are now supplying a large wagon trade. One of these is operated two miles northeast of Salisbury by J. P. Henderson.

HENDERSON SHAFT (S. W. ¼ S. W. ¼ SEC. 31, T. 54 N., R. 16 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	17	....	17	....
Sandstone	4	....	21	....
Shale, sandy	8	....	29	....
Limestone	1	6	30	6
Shale (horizon of Mulky coal at top)	40	....	70	6
COAL, 23 inches Clay, 16 inches (Bevier) COAL, 12 inches	4	3	74	9
Clay	1	6	76	3
Limestone, upper surface uneven	....	....	....	....

At this mine the clay parting is hard, contains clusters of iron pyrites ("sulphur") and streaks of coal, and varies in thickness from 8 to 36 inches, with an average of 16 inches. Except the upper two inches, the coal is of good quality and changes little in thickness. The other mine is a horse-whim shaft, 32 feet deep, operated by W. A. Anderson (S. E. ¼ N. E. ¼ Sec. 31, T. 54 N., R. 16 W.).‡ Here the upper bench of coal is 23 inches, the lower 17, the clay parting three to eight with an average of six inches, and the underclay at least three feet. Both mines hoist with horse-whims and work room and pillar. The upper bench is shot first, then the lower is either shot out or pried up. The roof is a "soapstone" of fair stability, more than three feet of it seldom falling in the entries.

Shannondale.—There are no outcrops in the broad, open valley in which Shannondale lies and probably no coal, as the drift is evidently very thick. One well on high land southwest of town (N. W. ¼ N. W. ¼ Sec. 6, T. 52 N., R. 17 W.) reached no solid material in 112 feet. In the bank of East fork, at the northwest corner of Howard county, is 18 inches of coal at the Lower Ardmore horizon,§ the section exposed being:

OUTCROP ON EAST FORK (S. E. ¼ SEC. 35, T. 53 N., R. 17 W.).

		Feet.	*Inches.*
2.	Concealed, about	3	....
3.	Limestone, dark blue to drab, in one layer	1	....
4.	Shale, black, "slaty"	2	6
5.	Limestone, like No. 10	....	6

‡For location, see map of Huntsville quadrangle in report on Randolph county.
§See end of report on Howard county.

OUTCROP ON EAST FORK (S. E. ¼ SEC. 35, T. 53 N., R 17 W.)—Continued.

		Thickness. Feet.	Thickness. Inches.	Depth. Feet.	Depth. Inches.
1.	Limestone nodules, loose	....	....	....	....
6.	Shale, black, "slaty," with large lenses and "niggerheads" of limestone near base			5	6
7.	COAL, dirty (Tebo)			1	6
8.	Clay			1	6
9.	Limestone, bluish gray, very concretionary			....	6
10.	Clay, light yellow			3	6
11.	COAL, impure			....	1
12.	Clay, at water level			2	....

Less than one mile east of this the Bevier coal and other strata lying just above the last section are exposed in a gully.

EXPOSURE NEAR EAST FORK (S. E. ¼ S. W. ¼ SEC. 36, T. 53 N., R. 17 W.).

		Feet.
1.	Sandstone, reddish brown, thin-bedded (Moberly?)	10
2.	Shale, sandy above, clayey below	45
3.	COAL, 5 inches Shale, 10 inches (Bevier) COAL, 21 inches	3
4.	Clay	2
5.	Limestone nodules	....

The Tebo coal appears again in a narrow strip between Doxies creek and Glasgow, but can hardly be considered of importance. The Bevier, however, has been drifted a little near Finnel branch (N. E. ¼ S. W. ¼ Sec. 32, T. 53 N., R. 16 W.), where Marbut reports it as three feet thick, and stripped in a bed of Silver creek. Marbut* also notes the occurrence of two feet of coal at the Mulky (Macon City) horizon near Finnel branch, 28 feet above the Bevier; this is one of the few places in eastern Chariton county where this bed is of workable thickness.

Rockford.—At Rockford bridge (N. E. ¼ Sec. 3, T. 52 N., R. 18 W.) regular Coal Measures strata, including two very thin coal beds, may be seen lying horizontally, though a few yards below they dip 30° or more down river. In a ravine near the Chariton bottoms, a mile southeast of Rockford, 18 inches of coal is exposed. This is the lower Bevier bed which here dips west of south. At the same place 10 inches of coal at the Summit of Mulky horizon is exposed, evidently faulted down. Above is Moberly red sandstone. In a narrow steep-sided valley opening into the Chariton near Rockford is a great quantity of red Moberly sandstone resting on the upturned edges of regular Cherokee limestones. Near the head of the valley (N. W. ¼ N. E. ¼ Sec. 35, T. 53 N., R. 18 W.) is a well in which 110 feet of sandstone were found. Bluffs extending several miles up the Chariton from Rockford are composed of this same sandstone. The steep dips near Rockford and the presence of the deep sandstone channel make this region unfavorable territory for the coal miner.

*The Huntsville quadrangle: Mo. Geol. Survey, vol. XII, 1898, p. 341.

Keytesville.—One and one-half miles south of Keytesville depot several small drifts have been worked, and one is now operated in 18 inches of coal at the Bevier horizon on the land of John Meyer (N. W. corner Sec. 22, T. 53 N., R. 18 W.). There are three beds of coal in this vicinity, as shown by the following section measured by F. C. Greene:

NEAR BRIDGE OVER CHARITON (S. W. CORNER SEC. 15, T. 53 N., R. 18 W.).

		Feet.	*Inches.*
1.	Limestone, blue, hard	3	....
2.	Shale, black, "slaty," about	5	....
3.	COAL (Mulky), reported	1	6
4.	Interval, chiefly shale, about	35	....
5.	COAL (Bevier)	1	2
6.	Clay	3	4
7.	Limestone, nodular	2	6
8.	Shale, with three very thin limestone bands	12	2
9.	COAL (Tebo), thickens locally	1	....
10.	Clay and shale	5	....
11.	Limestone, gray, nodular	1	8
12.	Shale, light gray, with ferruginous concretions	9	....
13.	Sandstone, with partings of white shale, to river level	10	8

These beds dip southwest, and below the center line of Sec. 21 are replaced by red channel-filling Moberly sandstones that form bluffs over 75 feet high. Southeast of Keytesville, near the Chariton bridge, is the small drift of H. Drew on land of Chas. Thrash (N. E. ¼ S. W. ¼ Sec. 2, T. 53 N., R. 18 W.), where the Tebo coal bed has been operated in a small way for a long time. The coal is 12 to 20 inches thick and is of fair quality. The roof is 30 inches of dark gray "slaty" shale, with a thin layer of "soapstone" wedging in locally. Above the coal is seven inches of limestone and above this 30 inches of shaly clay containing two thin limestone bands. Below the coal is mainly sandstone and shale to river level, which lies about 30 feet lower. This coal bed, and perhaps the Bevier also, underlie Keytesville itself. A 22-inch coal of doubtful stratigraphic position was formerly mined about one mile north of the city.

Dalton.—A short distance northeast of Dalton is the local drift of H. Hughes on land of T. G. Grotjan (S. E. ¼ N. E. ¼ Sec. 14, T. 53 N., R. 19 W.), where there is 17 inches of coal overlain with 10 feet or more of clay shale. The underclay is two feet thick and rests on limestone. There is said to be a 14-inch coal about 22 feet above this bed, and it may be that the two form the upper and lower benches of the Bevier bed. The 17-inch bed was shafted at Dalton, but was soon abandoned. A shaft sunk farther west 30 years or more ago is said to have reached four feet of coal at 65 feet. This report needs verification, but is significant in placing this thicker bed at about the horizon of the Eureka coal.

Eccles.—Eccles is a small trading point five miles northeast of Keytesville. As determined by F. C. Greene, there are four coal beds, the two middle ones a split from one bed.

GENERAL SECTION IN ECCLES DISTRICT.

		Feet.	Inches.
1.	Limestone	2	6
2.	Shale, "slaty," about	5	....
3.	COAL (Mulky), reported	1	6
4.	Interval, shale at base, about	35	....
5.	COAL (upper Bevier), average	1	2
6.	Shale	11	....
7.	COAL (lower Bevier), average	1	8
8.	Clay	3	....
9.	Limestone	2	....
10.	Concealed, chiefly shale	10	....
11.	Limestone	....	2
12.	Shale, dark	2	5
13.	Limestone	....	8
14.	Shale, black, "slaty"	2	6
15.	Shale, soft, nothing to six feet	3	....
16.	COAL (Tebo)	1	8

These beds vary somewhat from place to place, but owing to the general persistency of the different phases the coal beds may be rather easily identified by the strata above and below them. The Mulky bed is not commonly present or does not outcrop except under very favorable conditions, and the upper Bevier is irregular and commonly inconspicuous, so that the lower Bevier is often called the "upper vein" by miners. At the edge of the bottom lands of the Chariton, behind the store at Eccles, there is a small drift (N. E. ¼ N. E. ¼ Sec. 13, T. 54 N., R. 18 W.) operated by J. Q. Perkins in the Tebo. The coal is variable but averages two feet in thickness. The roof is a black laminated shale except where one inch to six feet of clay shale wedge in below it. Near the center of Section 13 is the lower Bevier bed, 19 inches of good coal capped by a few inches of dirty material, and 12 feet above it the upper Bevier, 15 inches of good coal overlain with seven of dirty coal. Both beds have shale roofs.

Farther down the Chariton are several other local mines. The Eadington and Twigg and the J. W. Cooley drifts open side by side on the land of D. N. Cooley (N. W. ¼ S. E. ¼ Sec. 24, T. 54 N., R. 18 W.), and the Chas. Phillips in the next quarter south on the opposite side of a narrow ridge. All work the lower Bevier bed, which is 20 inches thick in addition to a few inches of dirty coal at the top, contains considerable pyrite ("sulphur") and is affected by "clay slips" and clay rolls in the roof. The longwall plan of working is used, the coal being wedged or shot, eight inches of "draw ply" being taken down so that the permanent roof consists of sandy shale. Eleven feet above the lower Bevier, separated from it by shale, is 12 inches of dirty coal, forming the upper Bevier. The Tebo is said to be 22 inches thick and to have been worked until water drove the miners out. Wm. Dooley has two drifts close together farther south (S. E. ¼ N. E. ¼ Sec. 25, T. 54 N., R. 18 W.), where the lower Bevier is 19 inches thick and lies about 20 feet above the Chariton. The coal is rather soft and is much cut up by "clay slips." The Tebo is said to

contain the best coal and to have been worked until high water prevented. It is 18 inches thick and lies about 12 feet below the Bevier. Above it is 18 inches of black laminated shale capped with a thin compact limestone.

Northwest of Eccles is the local drift of Kinzlie Bros. (N. E. ¼ S. W. ¼ Sec. 12, T. 54 N., R. 18 W.) in the lower Bevier bed, which is 20 inches thick and is worked room and pillar, the coal being undercut and wedged down. Slips are few and the roof is fair. Above the coal is said to be 15 feet of sandy shale capped with six feet of sandstone; below it is at least five feet of clay. The Tebo lies 24 feet below the Bevier, is 20 inches thick, and has the same type of roof as at Eccles. In a strip pit on the next quarter west of Kinzlie the upper Bevier is reported 24 inches thick and 10 feet above the lower. The Mulky is said to be 35 feet higher and 10 inches thick, though it is 18 inches thick one-half mile southwest (S. E. ¼ S. W. ¼ Sec. 11), where it is stripped and has a roof of black laminated shale capped with a 30-inch limestone.

Guthridge Mills.—Two small mines have been operated at Guthridge Mills: (1) O. F. Smith slope (N. W. ¼ N. W. ¼ Sec. 5, T. 54 N., R. 18 W.) and (2) F. J. Ellis drift (S. E ¼ S. W. ¼ Sec. 32, T. 55 N., R. 18 W.). Both worked the Bevier bed, which is 19 to 24 inches thick. Over it is a thin layer of soft black shale which grades upward into light shale; below is at least five feet of underclay above a limestone sump rock two feet or more in thickness, which outcrops at the Mussel fork bridge. The upper Bevier coal appears to be very feebly developed in this vicinity. Two miles northwest of Guthridge Mills the Mulky bed is mined at the shallow shaft of C. E. Davis on the land of U. N. Colley (S. E. ¼ N. E. ¼ Sec. 25, T. 55 N., R. 19 W.). The coal is 18 to 22 inches thick, and is overlain with seven feet of shale, the lower half of which is black and "slaty" and contains large and small calcareous concretions ("niggerheads").

Trade.—In the bluffs of Mussel fork, at Trade, Westville, and farther north, are exposures of rocks as high as the base of the Henrietta formation, the succession of strata being practically the same as in the drill records at Marceline, published in the Linn county report. Near Trade, a coal bed, said to be 26 inches thick and overlain with shale, has been drifted a trifle just above the level of the bottoms (N. ½ S. W. ¼ Sec. 2, T. 55 N., R. 18 W.). A lower bed of 33 inches is reported from a prospect shaft and 48 to 54 inches from strippings at low water in Mussel fork, a short distance below the bridge. These figures could not be confirmed by actual observation, as no exposures of the coal beds were to be seen. It is probable that the upper and thinner bed is at the Bevier horizon and the thicker coal at the Tebo.

Glee.—Between Glee and Marceline thin coal has been mined at

a few places on the east side of Mussel fork. What appears to be the Bevier bed lies near the county line about 50 feet above the fork and is 18 inches thick at the small drift of T. A. Edgar (S. E. ¼ S. W. ¼ Sec. 1, T. 56 N., R. 18 W.) and 24 inches, less than a mile farther north. Between Mussel fork and Chariton river there are almost no outcrops of the indurated strata.

Rothville.—Mining on a small scale has been prosecuted in the Mulky bed for many years about one mile east of Rothville station. Of numerous drifts situated near the level of the bottom lands, the only mines found in operation were those of Wm. Walters and H. Stewart (S. E. ¼ Sec. 21, T. 56 N., R. 19 W.). A section measured on the road leading up from the bottoms near the mines, combined with detailed measurements of the coal beds, includes all of the rocks exposed on that side of Yellow creek:

SECTION EAST OF ROTHVILLE.

		Feet.	*Inches.*
1.	Limestone fragments	....	....
2.	Shale, gray, sandy	22	....
3.	Limestone, blue, hard	1	5
4.	Shale, black and "slaty" top, light below	5	....
5.	COAL (Summit)	....	4
6.	Clay	3	....
7.	Concealed, probably shale	9	....
8.	Limestone, buff, sandy	3	4
9.	Shale, light gray, calcareous, hard	3	....
10.	Shale, black, "slaty," with large concretionary "niggerheads"	1	8
11.	COAL (Mulky), 14 to 22 inches, average	1	5
12.	Clay	5	....
13.	Limestone, red, impure	1	....
14.	Shale, drab to light gray	10	....
15.	COAL (upper Bevier)	1	....
16.	Clay	1	6

The upper Bevier bed, known locally as the "soapstone vein," thickens in places to as much as 20 inches. The Mulky bed, known locally as the "slate vein," thins to seven inches in the next section east and appears to be thicker at the mines than elsewhere in this part of the county. There is a thin coal bed, the lower Bevier, a few feet below the upper Bevier, as shown by the following outcrop in the bank of Yellow creek at Rothville:

		Feet.	*Inches.*
1.	Shale, with ferruginous concretions	10	....
2.	COAL (upper Bevier)	1	4
3.	Shale, light at top, dark at base, sandy	10	6
4.	COAL (lower Bevier), poor	....	8
5.	Clay	1	6
6.	Limestone, nodular	5	6
7.	Sandstone	10	....

In a shaft operated until recently by J. O. Davis two miles west of Rothville, the Tebo coal bed was mined at 80 feet below the surface and 42 feet below 18 inches of coal at the upper Bevier horizon. The Tebo is here 20 inches thick and has over it eight feet of clay shale overlain with three feet of laminated shale. This coal bed is the one

extensively mined at Marceline and probably underlies considerable territory in the Rothville district.

Sumner.—The entire northwest corner of the county is gently rolling and so heavily covered with drift that there are no outcrops of coal beds or associated strata. It may be assumed, however, that the rather thin coal beds outcropping on Grand river in Carroll county and southwest of Laclede in Linn county underlie the greater part of the area. This assumption is upheld by the known occurrence of the Tebo bed on the M. F. Andrews farm, four miles northeast of Sumner on Turkey creek, where it is being mined by J. O. Davis. The coal contains considerable "sulphur" in the form of vertical and horizontal streaks of iron pyrites and in vertical films of white gypsum scale, but is widely used by a large farming community. The product is hoisted 49 feet with a small steam outfit.

ANDREWS SHAFT (S. E. ¼ N. W. ¼ SEC. 8, T. 56 N., R. 20 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	9	....	9	....
Sandstone	20	....	29	....
Limestone	1	....	30	....
Shale, black	3	....	33	....
Limestone	1	6	34	6
Shale, black, "slaty"	3	....	37	6
Shale, "soapstone"	9	....	46	6
COAL, 11 inches Clay, 2 inches (Tebo) COAL, 14 inches	2	3	48	9

Indian Grove.—Of several deep wells drilled near Indian Grove the only one to show coal is one mile north of the village, where 18 inches was struck at 81 feet, though the strata are barren from that to the bottom of the drilling at 226 feet. Another well in the same district penetrated only shale and sandstone to a depth of 226 feet. One a mile and a half southeast of the Grove passed through soft and dark gritty shale for 170, and one five miles south of Mendon found no coal in 126 feet. The records of these wells, however, do not appear to have been kept with great care, so that any but exceptionally thick beds of coal might have been overlooked. Two miles southwest of Indian Grove, on Lake creek, is a small slope worked by G. T. Williams on the land of A. Clair (N. E. ¼ S. W. ¼ Sec. 17, T. 54 N., R. 19 W.). The bed worked is 18 inches thick, is overlain with three to 12 inches of clay bearing stringers of coal and this in turn with eight feet of clay shale. Under it is said to be five feet of clay resting on rock. The same or similar thin coal beds have been stripped west of this and farther south in small eastern tributaries of Lake creek. At least one thin bed seems to be everywhere present in this district, but not to have been utilized to any extent. In the hills, at levels higher than

that of the Clair mine, is a considerable thickness of more or less massive sandstone.

Brunswick.—Coal 12 to 18 inches thick outcrops at the north edge of Brunswick. It has a roof of 10 feet of soft shale above which is nodular limestone. Attempts to mine it were not adequately rewarded. Mining was more successful at pits formerly operated near the railroad tracks about two miles northwest of town. This bed is tentatively correlated with the Tebo and is shown in the accompanying sketch.

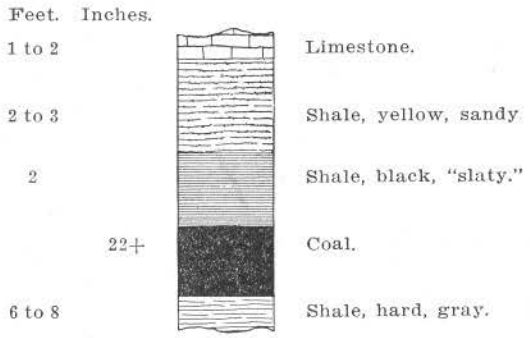

FIG. 26. Coal bed formerly mined northwest of Brunswick.

Some years ago a gas well was drilled to a depth of 1460 feet one-fourth mile north of the Brunswick city hall, on a bluff about 65 feet above the railroad. According to this record one foot of coal was found at the Eureka horizon 60 feet below the Tebo, and practically nothing else but shale to the Mississippian, which lies 80 feet below the Tebo. The lower limit of coal, therefore, lies only a short distance below the Missouri flood plain.

CLARK COUNTY.*

Clark consists of gently rolling prairies cut by numerous valleys trending northwest and southeast. The only formations represented beneath the drift are the Cherokee shale at the base of the Pennsylvanian, and the Mississippian. The western half of the county, the greater part of T. 66 N., R. 7 W. and small areas in the western part of the other townships in R. 7 W. are underlain with Coal Measures. In the western part of the county, however, the drift is so thick, probably more than 100 feet in many places, that the stratified rocks are not exposed. East of the main body of the Pennsylvanian are many

*A brief geological sketch of Clark county and a map that is used as a basis for depicting the Pennsylvanian-Mississippian boundary in this report were made by B. F. Shumard: Mo. Geol. Survey, 1855-1871, pp. 314-323. Coal mines are mentioned by Arthur Winslow, Preliminary report on coal: Mo. Geol. Survey, 1891, pp. 52-53. The topography of most of the county is shown on the Kahoka sheet of the U. S. Geol. Survey.

outliers of coal-bearing strata generally lying in basins eroded in the upper surface of the Mississippian series. Owing to the fact that the Pennsylvanian is composed chiefly of sandstone and shale with little or no limestone, while the Mississippian consists of heavy limestone beds separated by thin shales, the two series are easily distinguished.

All coal deposits that have been worked in Clark county are situated near the base of the Pennsylvanian and also near its eastern limit, where they have been more readily exposed by recent erosion. All the coal beds appear to be of the lenticular character of those in neighboring counties of Iowa—a character that in this region is due to two causes: (1) Most of the beds were laid down in small coal swamps, the irregular upper surface of the Mississippian being a prime factor in limiting their area; and (2) erosion removed all or part of many beds before the glacial drift was deposited. That important coal beds will at some time be discovered in this region cannot reasonably be doubted, but only extensive and systematic drilling can disclose them. The finding of thick coal in one drill hole would not mean that an extensive deposit had been revealed. The coals never lay in "blanket veins" in this region, and preglacial channels have removed the coal-bearing strata in many places, as at the Keokuk Canning Co. well at Kahoka, where 157 feet of drift rests on the Mississippian.

Any attempt to estimate the amount of coal in this county is obviously little better than a mere guess, but it may be provisionally stated that there are at least 200,000,000 tons in beds 14 inches thick or more.

Only a few mines are operated, and these are all small drifts that supply local trade during the winter. Development has always been slight and has been confined for the greater part to the vicinity of Athens and Revere, in the northern part of the county.

Athens.—The McKee coal banks (N. W. ¼ N. E. ¼ Sec. 6, T. 66 N., R. 7 W.) have produced considerable coal from several drifts high up in the hills north of Cedar creek. In one drift a measurement of 23 inches of coal was taken; in another 25 inches. The roof is black shale, grading upward into drab. Mississippian limestone forms bluffs 25 feet high along Cedar creek and outcrops only a short distance below the coal. Shumard mentions the occurrence of an 18-inch coal bed two miles southeast of McKee's, in section 4. One mile northwest of McKee's (N. E. ¼ Sec. 36 and S. E. ¼ Sec. 25, T. 67 N., R. 8 W.) there have been many old drifts. The coal ranges from 15 to 30 inches in thickness, has a weak roof of black, brittle shale, and in places lies within five feet of the Mississippian limestone. Other coal beds have been worked a little in the past in sections 26, 23, and 14 of T. 67 N., R. 8 W. The Blue Jackett mine, located in Iowa one-eighth mile north of the Missouri line (S. E. ¼ N. W. ¼ Sec. 15, T. 67 N., R. 8 W.),

works a fairly large lens of thicker coal, shown in the following mine measurements:

		Feet.
1.	Shale, black, "slaty"	1 to 3
2.	COAL	0 to 1
3.	Sandstone, white, calcareous, fine-grained	1½ to 2
4.	Clay, white	2 to 3
5.	Shale, black, "slaty"	4 to 6
6.	COAL	4 to 5½
7.	Bone, with coal streaks	⅛ to ⅓
8.	Clay, grading below into sandstone	6

Revere.—East of Revere, near the bluff of the Des Moines river, are the Woods and the Davis coal banks (S. E. ¼ S. E. ¼ and N. E. ¼ N. E. ¼ Sec. 23, T. 66 N., R. 7 W.). A number of drifts have been opened at the same elevation on opposite sides of the ridge and some coal is taken out nearly every winter. The coal seam is 18 to 27 inches thick where seen and is overlain by 15 feet of shale that is sandy above and dark blue and "slaty" below. The Mississippian limestone outcrops only five feet below the coal at the Woods bank and appears at a higher level in the vicinity, showing that the coal lies in an isolated basin eroded in the lower formation.

Shumard notes the presence of five feet of cannel coal lying just above St. Louis limestone near Chambersburg (N. W. ¼ S. E. ¼ Sec. 16, T. 66 N., R. 8 W.), probably of very small lateral extent; and Winslow gives a section that includes 12 inches of pyritiferous coal outcropping on Fox river in the S. E. ¼ Sec. 1, T. 65 N., R. 8 W.

CLAY COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....29,732 TONS.

As in the region on the west and north there are no surface coals of importance in Clay county. The surface rocks beneath the glacial deposits in nearly the entire county belong to the Lansing formation and the Kansas City limestone. The Bethany Falls and the Hertha limestones at the base of the Kansas City formation and of the Missouri group, respectively, outcrop conspicuously in the bluffs of the Missouri river and the lower parts of its main tributaries. These limestone beds are useful markers for the coal horizons. Below the Hertha 75 feet or less of the shale and sandstone constituting the Pleasanton shale is exposed, the maximum being in the southern corner of the county.

The highest coal of importance is the Lexington, the bed so extensively worked in Ray county. At Missouri City it is 20 inches

*The geology of Clay county was first described by G. C. Broadhead (Rept. of Mo. Geol. Survey for 1872, pt. 2, pp. 315-326). Arthur Winslow briefly discusses the coal in the report for 1891 (pp. 112-114). The topography is shown on the Independence and Kansas City sheets of the U. S. Geol. Survey.

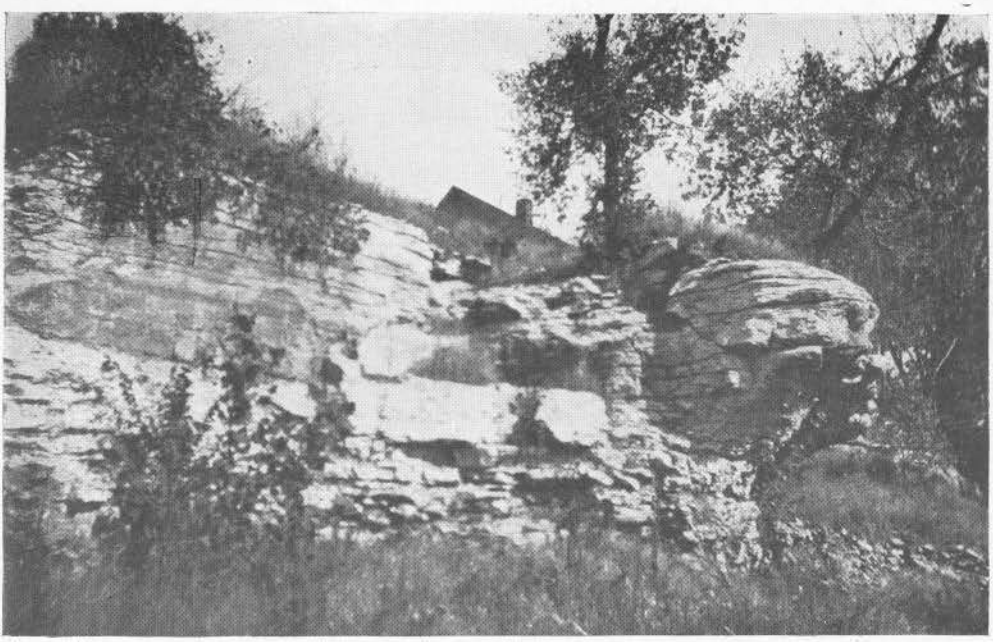

Fig. 1. Bethany Falls limestone at Missouri City, Mo.

Fig. 2. Mine of Missouri City Coal Co., Missouri City, Mo.

thick and is mined at a depth of 160 feet. It thins to the west, however, and is probably unworkable in all but the eastern part of the county. The next lower coal of importance is the Bevier, which lies 110 to 140 feet below the Lexington and 300 to 400 feet below the base of the Missouri group. It was formerly mined at Randolph, where it was 20 inches thick, at a depth of 420 feet, and it may be the horizon at which three-foot coal has recently been found at Smithville at a depth of 472 feet. Coal was found near this horizon six miles west of Kearney at 641 feet in a drilling on land higher than Smithville. The Bevier is a persistent bed that probably underlies much of the county, but is only exceptionally more than two feet in this part of the State. The depth to the Bevier horizon is greatest in the northwestern part of the county and least in the southeastern. Between the Bevier and the base of the Coal Measures there are about 350 feet, chiefly shales. In this interval there are coal beds, perhaps of workable thickness in many places, but irregular in distribution.

As very little prospecting has been done in the county, any estimate of its total coal resources must be very rough. The total amount of coal in the Randolph drillings (p. 152) is 92 to 108 inches, but only 50 inches of this is in beds of 14 inches or more. Fifty inches, which is probably a very fair average for the county, gives 1,953,600,000 tons as the total original tonnage for beds 14 inches or more in thickness.

DETAILED MENTION.

Missouri City.—On the west edge of Missouri City, beside the tracks of the Wabash railroad, is the shaft of the Missouri City Coal Company. The Lexington bed is reached at 160 feet and is worked longwall with a face track. Hoisting is done by steam power. The working face is 2,000 feet from the shaft on the north, east, and west. About 120 acres have been mined out. The product is sold chiefly to the railroad. The coal is clean and regular in occurrence, with only a few "slips" or "clays." A little pyrite may be seen in veins and streaks, and much white gypsum and calcite scale occurs in the joints. The roof is excellent; both timber props and "slate" pillars are used to support it behind the face.

LEXINGTON COAL BED AT MISSOURI CITY.

		Inches.
1.	Limestone	72
2.	Shale, black ("bat")	10
3.	Shale, black, "slaty"	8
4.	COAL	19 to 22
5.	Clay, black, with some coal streaks	4
6.	Clay, light	4 to 36
7.	Limestone, hard, reported	10

In the bluffs behind the town more than 10 feet of the Bethany Falls limestone outcrops, and 18 feet lower six feet of the Hertha lime-

stone forms the base of the Missouri group. In the shaft the Lexington coal is 226 feet below the base of the Bethany Falls limestone and 202 feet below the base of the Missouri group.

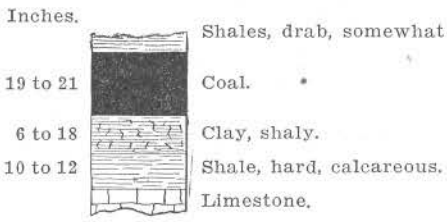

FIG. 27. The Bevier coal bed in old Randolph shaft.

Randolph.—Formerly a shaft 420 feet deep was in operation at Randolph. The Bevier bed was mined and was 20 inches thick. It was hard and broke with a sharp fracture, but was streaked with fine seams of pyrite ("sulphur") and shale. A modification of the long-wall system was necessitated by the poor roof. Two holes drilled near the shaft through all of the productive part of the Coal Measures of this region show very little workable coal. One of these, made near and about 30 feet below the level of the top of the shaft, shows the following record:

DRILLING NO. 2 AT RANDOLPH.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay and sand	29	....	29	....
Limestone, very hard	3	....	32	....
Shale, soft	13	....	45	....
Limestone	3	....	48	....
Sandstone	22	....	70	....
Shale	47	....	117	....
Sandstone	12	....	129	....
Shale	4	....	133	....
Clay, red	4	....	137	....
Sandstone	5	....	142	....
Shale, sandy	6	....	148	....
Sandstone, "petroleum"	4	....	152	....
Shale	12	....	164	....
Sandstone	3	....	167	....
Limestone	4	....	171	....
Sandstone	66	....	237	....
Shale, fossiliferous	5	....	242	....
Limestone	4	....	246	....
Shale, "slaty"	1	3	247	3
COAL (Lexington)	....	9	248	....
Shale and clay	9	....	257	....
Shale	20	....	277	....
Limestone	1	....	278	....
Shale, black, "slaty"	1	8	279	8
COAL (Summit)	....	10	280	6
Clay	10	6	291	....
Limestone	5	....	296	....
Shale, "slaty"	5	....	301	....
Shale, blue at top	28	....	329	....
Sandstone	3	....	332	....
Shale	17	....	349	....

DRILLING NO. 2 AT RANDOLPH—Continued.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Shale, "slaty"	4	....	353	....
Shale	8	....	361	....
Sandstone	11	....	372	....
Shale, drab, slightly sandy	14	8	386	8
COAL (Bevier), mined	1	9	388	5
Clay, black	1	7	390	....
Limestone	2	....	392	....
Shale	2	....	394	....
"Lignite"	1	....	395	....
Shale, sandy	12	....	407	....
Sandstone	8	....	415	....
Shale, sandy in lower part	14	....	429	....
Sandstone	6	....	435	....
Shale	16	....	451	....
Shale, "slaty"	4	....	455	....
COAL	....	5	455	5
Clay	2	7	458	....
Shale, "slaty," except at top	16	....	474	....
"Lignite"	....	8	474	8
Clay	4	4	479	....
Shale	11	8	490	8
COAL	....	4	491	....
Clay	6	....	497	....
Shale	6	9	503	9
COAL	1	1	504	10
Clay, black	1	....	505	10
Sandstone, "slaty," shale partings	25	2	531	....
Shale, "slaty"	3	6	534	6
COAL	1	2	535	8
Clay	1	4	537	....
Shale, lower two-thirds black and "slaty"	27	....	564	....
COAL	....	8	564	8
Clay	7	4	572	....
Shale, "slaty"	12	3	584	3
COAL	1	2	585	5
Sandstone	7	7	593	....
Shale, in part "slaty"	32	....	625	....
Sandstone	11	4	636	4
COAL	....	10	637	2
Sandstone	19	10	657	....
Shale	13	....	670	....
Sandstone, shale partings	32	....	702	....
Shale	20	....	722	....
Limestone, with a few clay partings (Mississippian, lower limit of coal)	138	....	860	....

According to Winslow the bed mined is nearly 400 feet below the Bethany Falls limestone, which is exposed in the bluff above the drill hole. The top of the Henrietta formation appears to have been removed by erosion during or just previous to Pleasanton time, a feature by no means uncommon in other localities.

Kearney.—A well drilled by A. W. Stubbs six miles west of Kearney† was carried to the Mississippian limestone, the lower limit of coal, at 1,022 feet. The drilling began at the top of the Lansing formation and reached the base of the Missouri group at 369 feet and the Lexington coal horizon at 567 feet. No careful attempt was made

†Record published by E. M. Shepard, Underground Waters of Missouri, Water-Supply Paper No. 195, U. S. Geol. Survey, 1907, p. 60.

to locate and measure coal beds, so that the record reveals little as to the coal resources of the district. A thin coal seam was identified at 623 feet and a coal (Bevier?) underlain by limestone at 641 feet.

Smithville.—A churn drilling was recently made at Smithville to a depth of 804 feet, stopping in white sandstone probably near the base of the Coal Measures. The only coal found was at 475 feet, and another drilling was made to investigate this. The second hole was made by a churn drill to 450 feet and by a diamond drill to the bottom. The record of the second hole, as furnished to the Survey, is as given below. Correlations are merely tentative, as additional geologic work is to be carried on in the district. The coal appears to be at or near the Bevier horizon.

	Thickness. *Feet.*	Depth. *Feet.*
Drift clay, gravel at bottom	50	50
Kansas City limestone—		
Limestone	10	60
Shale	10	70
Limestone	15	85
Shale	15	100
Limestone	10	110
Shale	10	120
Limestone	5	125
Shale	5	130
Limestone	30	160
Shale, black, "slaty"	5	165
Limestone (Bethany Falls)	20	185
Shale, black, "slaty"	15	200
Limestone (Hertha)	5	205
Pleasanton shale—		
Shale	110	315
Henrietta formation—		
Limestone	10	325
Shale	5	330
Limestone	10	340
Shale	20	360
Limestone	10	370
Shale	15	385
Limestone	10	395
Cherokee shale—		
Shale	43	438
Sandstone	4	442
Shale, light in lower half	16	458
Limestone	2	460
Shale, light	6	466
Shale, black	5½	471½
COAL	3	474½
Clay, sandy	4	478½
Shale, sandy	9½	488

CLINTON COUNTY.*

No coal has been mined in Clinton county. The surface rocks are barren of workable deposits, and lie 500 to 600 feet above the Lexington seam, which is probably the highest workable bed. The Stanton and Plattsburg limestones (see Lathrop drilling) outcrop along many

*The coal in Clinton county is briefly described by Arthur Winslow, Prelim. Rept. on Coal, Mo. Geol. Survey, 1891, pp. 103-104.

of the streams and form the rock floor of the glacial drift over most of the county. In a few places very thin streaks of coal outcrop, but have no value. The dip is so slight that the depth of the workable beds may, in general, be said to be dependent on the topography, though an anticline, which crosses the county from northwest to southeast, lifts the Lexington coal from 435 feet above sea level at Cameron to 535 feet above at Lathrop, through which it passes.

Drillings show the Lexington seam to be irregular in thickness and distribution, but they are not sufficiently numerous to show over how great an area it is workable. Coal below the Lexington has been explored in but one drilling—that at Stewartsville, where the record shows much limestone in the first 60 or 70 feet below the Lexington horizon, a feature found also in Callaway, Johnson, and a few other counties. The record at Lathrop may be considered typical of the beds above the Lexington.

In the Stewartsville drilling there are 28 inches of coal in beds of 14 inches or more. As this drilling did not penetrate the lower horizons known to be productive in Buchanan county and as the total coal does not include the Lexington bed, which is certainly workable in places, it may be conservatively considered that an average of 38 inches underlies the entire county. On this basis the total original tonnage is 1,521,216,000 tons.

DETAILED MENTION.

Plattsburg.—The depth to the various coal horizons is about the same at Plattsburg as at Lathrop. It is 40 or 50 feet less in the larger valleys.

Cameron.—Three diamond drill holes have been put down near Cameron, two in 1887. According to Winslow† the first started from the bottom of a shaft 430 feet deep and went to a total depth of 601 feet. The record shows:

	Thickness. *Inches.*	Depth. *Feet.*
COAL and shale	36	450
COAL	14	544
COAL	6	565
"Slate" and COAL	12	586

The second, drilled in 1887, recorded only 7 inches of coal at 648 feet, the bottom of the hole. Winslow says: "The discrepancies between these results are attributed, by the parties for whom the work was done, to careless drilling."

The third drill hole is east of town (S. E. ¼ N. E. ¼ Sec. 22, T. 57 N., R. 30 W.) at about the level of the depot.

†Winslow, Arthur, Prelim. Rept. on Coal: Mo. Geol. Survey, 1891. p. 104.

SUMMARY OF THIRD CAMERON DRILLING.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	46	....	46	....
Limestone and shale (to base of Kansas City limestone)	359	....	405	....
Shale (Pleasanton)	162	....	567	....
Shale and limestone	20	....	587	....
"Rock"	3	....	590	....
Shale, dark	3	....	593	....
COAL (Lexington)	1	7	594	7
"Rock"	2	....	596	7
Shale, dark	3	....	599	7
COAL	....	7	600	2

Stewartsville.—Following is the record of a diamond drill hole begun at a lower level, both topographically and stratigraphically, than the drillings at Cameron. The "rock" in the record is probably limestone:

STEWARTSVILLE DRILLING (N. ½ N. E. ¼ SEC. 20, T. 57 N., R. 32 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	169	2	169	2
Limestone and shale (to base of Kansas City limestone)	215	6	384	8
Shale, limestone and sandstone (with two 3-inch coal seams)	274	5	659	1
"Rock"	....	7	659	8
Shale, gray	....	11	660	7
COAL (Bedford?)	....	6	661	1
Shale, gray	4	3	665	4
COAL (Bevier?)	1	11	667	3
Clay, light	....	8	667	11
Rock	1	....	668	11
Shale, gray, very hard	21	3	690	2
COAL (Tebo?)	1	3½	691	5½
Clay, light	3	½	694	6
Shale, gray	....	5	694	11
"Rock"	1	6	696	5
Shale and "rock"	8	3	704	8
"Rock"	1	11	706	7
Shale, black	....	11	707	6
Shale, gray	1	3	708	9
COAL	....	7	709	4
Shale, gray	4	5	713	9
Shale and "rock"	77	9	791	6

Lathrop.—Two prospect holes have been drilled at Lathrop. The following was made in 1886 on a hill northwest of the Burlington depot and about 10 feet above it:

LATHROP DRILLING.	Thickness. *Feet.*	Depth. *Feet.*
Soil and drift	50	50
Lansing formation—		
Limestone (Stanton)	11	61
Shale	4	65
Limestone (Plattsburg)	25	90
Shale	28	118
Limestone	1	119
Shale, sandy	9	128
Limestone, hard	2	130
Shale, sandy	25	155
Limestone, hard	1	156
Shale	20	176

LATHROP DRILLING—Continued.

	Thickness. Feet.	Depth. Feet.
Kansas City limestone—		
Limestone	22	198
Shale	2	200
Shale, black, "slaty"	2	202
Shale	16	218
Limestone	9	227
"Clod," yellow	1	228
Shale, red	4	232
Shale, purple	8	240
Limestone	6	246
Shale	19	265
Limestone	8	273
Shale, with layers of limestone	12	285
Shale, dark	16	301
Limestone	25½	326½
Shale, bituminous	2½	329
Clay	1	330
Limestone	24	354
Shale, black, "slaty"	2	356
Shale, sandy	7	363
Limestone	13	376
Pleasanton shale—		
Shale, sandy, with streaks of coal	5	381
Clay	1	382
Shale, sandy	70	452
Sandstone	7	459
Shale, sandy	8	467
Sandstone	7	474
Shale, dark at top, sandy at base	19	493
Henrietta formation—		
Limestone	2	495
Shale, with layers of limestone	21	516
Limestone, hard	8	524
Shale, sandy	14	538
Limestone, hard	2½	540½
Cherokee shale—		
"Clod"	2¼	542¾
COAL (Lexington)	1¼	544½
Fire clay and black shale	2½	546
Sandstone	7½	554
Limestone	3	557
Shale, dark blue	5	562
Limestone	4	566
Shale	6	572
Limestone	7	579
Shale, blue	4	583
Limestone	1	584
Sandstone	1	585
Shale	4	589
Limestone	14	603

This drilling stopped only a short distance above the horizon of the Bevier and other coals that may be of value in this region. The Lexington coal was found in a near-by drilling, whose record follows:

	Thickness. Feet.	Thickness. Inches.	Depth. Feet.	Depth. Inches.
Interval to surface	575	8	575	8
Limestone	9	....	584	8
"Clod"	2	....	586	8
Slate	1	....	587	8
COAL	2	4	590	....
Fire clay	1	6	591	6

COLE COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....2,263 TONS.

A number of coal pockets have been found in Cole county, especially near Centertown and Elston, where they attracted much attention at an early date.

Considerable mining has been undertaken; yet it is safe to say that more money has been spent in prospecting for coal than has been made by mining it. Most of the deposits recently found gave only slight surface indications of their presence. The only recent development work has been at Hickory Hill and south of Elston.

Centertown.—Broadhead mentions a number of pockets worked within a few miles of Centertown, chiefly north of the town. Nothing is being done now; the most recent workings, according to reports of miners, were: (1) on the Leonard farm about two miles north of Centertown, where a pocket 200 feet in diameter, said to have consisted of 14 feet of cannel above four feet of bituminous coal, was worked for three years from a thirty-foot shaft; (2) the Bryant place, two miles northeast of Centertown, where 20 to 30 feet of cannel was mined by stripping and shallow shafting; and (3) on the Durham farm, 2½ miles north of Centertown, where a thirty-foot shaft reached nine feet of bituminous coal.

Elston.—Near Elston a large number of small pockets yielding a few bushels to several hundred carloads each have been found and exhausted. At present George Elston operates a fifty-foot shaft in the creek bottoms a quarter mile southwest of Elston. Under 10 feet of gravel and clay is said to be more than 40 feet of low-grade, light-weight bituminous coal that contains much zinc blende and breaks with irregular fracture.

One and one-half miles due south of Elston is the mine of S. and A. Bandelier in a pocket 250 feet wide from east to west and somewhat longer from north to south. The shaft is reported to have penetrated the following strata:

		Feet.
1.	Clay, white	20
2.	Bone coal	4
3.	Bituminous coal, soft	6
4.	Shale, black, "slaty"	10
5.	Cannel coal, bottom not reached	59

The coal at the outer walls of the deposit dips 80° away from them, but rapidly flattens and approaches horizontality near the center of

*Pockets known in earlier years are described by G. C. Broadhead (Cole County: Mo. Geol. Survey, 1873-1874, pp. 322-338). The topography is shown in the Jefferson City and Tuscumbia quadrangles of the U. S. Geol. Survey.

Fig. 1. Bandelier channel mine, south of Elston, Cole county.

Fig. 2. Shale, upper part of coal pocket; Dustless Coal Co. pit, Hickory Hill, Cole county.

the deposit. Surrounding the coal and separated from it by clay, are limestones much older than the Pennsylvanian. The clay walls act as a natural reservoir, and 6,000 barrels of water had to be pumped out when the mine was sunk, after which water gave no trouble. The coal mined is a very clean cannel, having a little pyrite and zinc blende near the outer walls; it cleaves readily parallel to the bedding, but has no regular fracture in other directions. Rooms are made about 18 feet wide and 35 feet high, no attempt being made to recover the coal in the top and bottom of the pocket. A small steamhoisting outfit is employed and most of the product is hauled to Elston and shipped to Jefferson City and neighboring points. About 400 carloads have already been shipped, and 45 more had been shot down and were ready for shipment when the mine was visited in May, 1911.

Mr. Carney Collett reports that another pocket, containing at least 86 feet of coal under 12 feet of soil and shale, has been drilled on the Stehlein farm, not far from the Bandelier mine. It is said to underlie over an acre, as shown by other drillings made to the top of the coal only.

Hickory Hill.—The Dustless Coal Company has constructed a spur seven miles long from Henley to its coal properties at Hickory Hill. A prospect shaft is reported to have penetrated 82 feet 9 inches of cannel coal bearing galena and zinc blende, and drillings are said to have shown a large pocket with its long axis southeast and northwest. Outcrops of limestone on at least two sides of the shaft indicate a number of small pockets rather than one of unusual dimensions. In a pit at the shaft mouth 10 feet of soil and clay and 8 feet of cannel are exposed. Pocket coal near Hickory Hill was worked in a very small way for many years and is mentioned by Broadhead.

COOPER COUNTY.*

A large outlier of Pennsylvanian rocks, separated from the main body in Howard county by the Missouri river valley, occupies the higher lands on the north-central border of Cooper county; and typical coal pockets are plentifully distributed throughout the remainder of the region. The outlier is composed of the lowest beds of the Coal Measures, including the section from the Lagonda shale and sandstone to the Mississippian, and bears at least two rather persistent coal beds which, however, are extremely variable in thickness and are not of great value. These two beds, as exposed west of Boonville, have been correlated by Swallow with the thick coal (Bevier) on Hinkson creek in Boone county

*The geology of Cooper county was first described by G. C. Swallow (Mo. Geol. Survey, First Report, 1855, pp. 86-87 and 187-190). The topography is shown on the Boonville quadrangle of the U. S. Geol. Survey.

and the thin seam (Tebo) next below it, a conclusion that appears to be correct. Several unimportant coals occur below the Tebo. Following is Swallow's section taken on the Missouri river bluffs about one mile below the mouth of the Lamine (Sec. 36, T. 49 N., R. 18 W.):

1. 30 feet, slope—nearly all bluff (loess).
2. 45 feet of brown friable micaceous sandstone.
3. 2 1-6 feet of coal (Bevier).
4. 10 feet, slope, covered by debris.
5. 3 feet of compact gray and blue hydraulic limestone.
6. 5 feet of bituminous shale.
7. 3 (?) feet of coal (Tebo).
8. 1 foot of bituminous shale.
9. 45 feet, slope (to Mississippian).

No. 5 of the above section is the most reliable marker in searching for coal; it is an irregularly bedded fine-grained rock, weathering on top to nodular forms, and in many places interstratified with clay or shale. It is practically the only Coal Measures limestone in Cooper county, and is easily distinguished from the Mississippian limestones by its lack of the more crystalline and massive appearance, characteristic of the latter.

In the above coal section both coal beds are much thicker than in most other portions of the outlier; in the greater part of the area the Bevier coal has been completely removed by erosion and the other beds are too thin to mine. The following section was measured by M. E. Wilson in Sec. 5, T. 48 N., R. 17 W., 3 ½ miles west of Boonville:

Number.		*Feet.*
1.	Limestone	3
2.	Shale, black, "slaty"	6
3.	Shale, drab	5
4.	COAL (Tebo)	¾
5.	Clay	1
6.	Sandstone, clayey, both massive and laminated	22

When the county was visited in the summers of 1910 and 1911 no mining was in progress. During the winters, however, small drifts are operated in the Tebo bed about one-half mile south of Boonville, where the following detailed section was measured by the writer on the land of W. F. Allen:

Number.		*Feet.*	*Inches*
1.	Sandstone, brown, weathers gray, thin-bedded	3	....
2.	Shale, gray, sandy	....	10
3.	Sandstone, like No. 1	5	6
4.	Limestone, dark bluish-gray, nodular	4	....
5.	Shale, calcareous, gray	2	....
6.	Concealed	10	....
7.	Slate, black	1	....
8.	Limestone, in thin ledge	....	7
9.	Shale, dark drab and black	6	....
10.	COAL, 5 inches, Clay, 1 inch, COAL, clean, light, 10 inches,	1	4
11.	Shale, yellowish gray, sandy, black streak near base	13	....

Coal Measures pockets are exposed near the heads of streams and along the river bluffs in nearly all the townships of the county. The coal contained in these is both cannel and bituminous and in some places is 30 feet or more in thickness. Some of the pockets contain considerable coal and one on the river bluffs three miles west of Boonville was extensively mined about 20 years ago,† yet it is improbable that any deposits of this sort will ever prove of sufficient extent to yield an adequate return on a large expenditure of money for mining equipment.

Roughly estimated, there is probably an average of 14 inches of coal in one bed over about 23 square miles, or three-fourths of the area underlain by the Pennsylvanian outlier. On the basis of 1,800 tons of coal per acre for every foot of coal, there are, therefore, 31,000,000 tons of mineable coal in this area, practically none of which has been utilized because of the thinness of the beds. In addition there are at least 500,000 tons of available coal still left in coal pockets, making a grand total of 31,500,000 tons in the county in beds of 14 inches or more. At the present time market conditions do not justify the exploitation of much of this thin coal; but there can be little doubt that at some future time the latent fuel resources will have an important effect upon the industries of the county.

CRAWFORD COUNTY.*

A number of small coal pockets in southern Crawford county, between Sligo and Keysville, have been known for many years. Among them may be mentioned those in the W. ½ Sec. 19, N. E. ¼ S. E. ¼ Sec. 21, N. E. ¼ N. W. ¼ Sec. 29, and N. E. ¼ Sec. 30, all in T. 36 N., R. 4 W. The pocket in section 19 is described in notes by Winslow as being 40 feet thick. Nason† discusses a V-shaped outcrop of coal 8 feet thick that has been shafted 3 miles from Cook's Station, on the Sligo branch railroad. Most of these deposits have been worked at irregular periods, but their slight extent and their crushed and disturbed condition make most of them of doubtful value.

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†Winslow, Arthur, Preliminary report on coal: Geol. Survey of Missouri, 1891, p. 170

*Shumard, B. F., Crawford County: Mo. Geol. Survey, Rept. for 1855-1871, pp. 255 256. The topography of the northern part of the county is shown in the Sullivan quadrangle of the U. S. Geol. Survey.

†Nason, F. L., Iron Ores: Mo. Geol. Survey, vol. 2, 1892, p. 139.

DADE COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....4,151 TONS.

Aside from outliers containing chiefly sandstone and occupying the higher lands in various parts of the region, the Coal Measures occupy only about 30 square miles in the northeast corner of Dade county. The principal constituent of the Pennsylvanian is sandstone, though it includes interbedded shales and one or more coal beds. The total thickness of these strata does not exceed 100 feet.

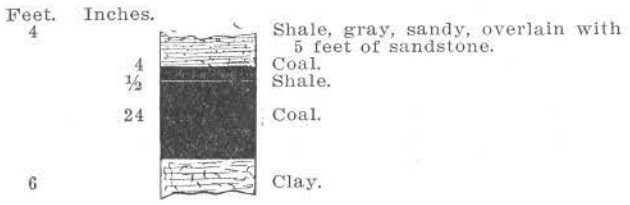


FIG. 28. Coal bed at Sylvania.

A coal field at Sylvania produces considerable fuel for a large territory and is capable of a larger output were shipping facilities available. The coal lies near the top of the divide on which Sylvania stands, and is limited topographically to an area extending from a point one mile east to a point one mile west of the village and from a point 1½ miles south of it to an unknown distance north. At Sylvania are the 20-foot shaft of J. R. Seaton, the 25-foot shaft of O. H. Hickman, and the slope of C. F. Woodridge. One to 1½ miles south and southeast of the village are the 30-foot shaft of Geo. Conklin, the slope of L. V. McCluey and the 25-foot shaft of W. A. Stout. Hoisting is done by horse-power and mining on the room and pillar system, the bed being undercut in the clay and wedged down. Few props are required, as the roof is excellent except where it is weakened by small "slips." There are very few "horse-backs" or "rolls." The coal is of fair quality, though it contains considerable pyrite in thin streaks. The bed is uniform, the section varying very little from the following:

	Feet.	*Inches.*
Sandstone, with shale partings, in places lies on the coal	20	....
Shale, bluish-gray, sandy	0 to 6	....
COAL	....	3 to 4
Shale	....	½
COAL	....	23 to 30
Shale, carbonaceous	....	0 to 8
Clay, soft at top, hard and sandy below, more than	3	....

*The coal in Dade county is mentioned by Arthur Winslow, Prelim. rept. on coal: Mo. Geol. Survey, 1891, pp. 160-161. The topography is shown in the Greenfield, Carthage, Nevada and Stockton sheets of the U. S. Geol. Survey.

This coal bed lies about 50 feet above the Mississippian limestone and flint, and is strikingly similar to that mined near Jerico, in Cedar county, and east of Milford, in Barton county. North of Sylvania the country is a flat prairie on which there are few outcrops. No coal is exposed in this region, though it is reported that the Sylvania bed has been found by drilling on the divide north of Sylvania. The Milford coal is exposed beside the road a short distance east of the northwest corner of Dade county (S. W. ¼ S. W. ¼ Sec. 24, T. 33 N., R. 29 W.) where it is mined by R. J. Taylor. It is only a few feet below the prairie level and dips to the west. The section here is:

	Feet.	*Inches.*
Sandstone	10	....
COAL	....	10
Shale	....	6
COAL, bottom 4 inches dirty	1	3
Clay	....	....

Excluding all beds or parts of beds less than 14 inches in thickness, the total original tonnage of Dade county may be roughly estimated as 33,380,000 tons.

DAVIESS COUNTY.*

There are now no coal mines in Daviess county, but producing mines are located a few miles north, east, and south of the county line. No coal of workable thickness is known to outcrop at the surface. The county lies near the eastern limit of the limestones at the base of the Missouri group, which are about 185 feet above the horizon of the Lexington bed, the highest important coal, and about 280 feet above the Bevier coal bed. These limestones outcrop along Grand river as far up as Pattonsburg, so that drillings in the flood plain should reach the Lexington horizon at less than 185 feet. The coal horizons below the Bevier, shown to be productive at Cainesville (see report on Harrison county), may also be important in this region, though we have little information concerning them. In the southwestern and northeastern parts of the county, the more important horizons are 200 to 300 feet deeper than on Grand river, as the surface is considerably higher. Several years ago the following core drilling was made at Gallatin, and shows very well the coal-bearing rocks which underlie the region:

*The geology of Daviess county was described by G. C. Broadhead: Mo. Geol. Survey, Rept. for 1873-1874, pp. 312-321. Brief mention is made of coal by Arthur Winslow: Prelim. Rept. on coal, Mo. Geol. Survey, 1891, pp. 99-100.

DRILLING AT GALLATIN (S. E. ¼ S. E. ¼ SEC. 17, T. 59 N., R. 27 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Loose earth and stone	7	....	7	....
Kansas City limestone—				
Limestone, hard (Bethany Falls)	11	11	18	11
Shale	2	9	21	8
Shale, black, "slaty"	1	10	23	6
Limestone	1	3	24	9
Shale	1	....	25	9
Limestone (Hertha)	8	7	34	4
Pleasanton shale—				
Shale and sandstone	158	9	193	1
Henrietta formation—				
"Conglomerate" (limestone?) and shale	20	5	213	6
Cherokee shale—				
Shale, black, "slaty"	4	11	218	5
COAL (Lexington), good	1	3	219	8
Shale	1	5	221	1
"Conglomerate" (limestone?)	4	1	225	2
Shale and sandstone, with several layers of "conglomerate" near top	68	8	293	10
Sandstone	2	5	296	3
COAL (Bedford), soft	1	8	297	11
Clay	1	7	299	6
Shale and sandstone	18	1	317	7
COAL (Bevier)	....	6	318	1
Shale and clay	3	2	321	3
Limestone	3	....	324	3
Shale and sandstone, with several thin layers of limestone near top	71	5	395	8
Shale, black, "slaty"	4	3	399	11
COAL, good	1	7	401	6
Clay	3	....	404	6

If the "conglomerate" at 213 and 285 feet is nodular or rough-bedded limestone, such as is found in places at this horizon and often called "conglomerate" by drillers, the coal at 219 feet is without much doubt the Lexington, as it is at the proper depth below the Hertha limestone. The Lexington has been mined at Hamilton, in Caldwell county, and at Melbourne, in Harrison county, though it is irregular in thickness at both places. It appears to be but 7 inches thick at Gentryville, Gentry county, and absent at Gilman City and Trenton. Little is known about the probable areal extent of the Bedford coal shown in Gallatin drilling. The Bevier coal, like the Lexington, was found at Gentryville, where it is apparently 26 inches thick. It is a persistent bed in nearly all parts of the state and is in many places of workable thickness.

The total thickness of coal in beds of more than 14 inches in the Gallatin drilling is 54 inches. If this represents a fair average for the county, the total reserve tonnage is 2,752,704,000 tons.

DeKALB COUNTY.

No coal crops out in DeKalb county except a few thin and unimportant streaks Grindstone creek and near Union Star. The surface is from 500 to 900 feet above the horizon of any workable coal seam, but the results of drilling at Stewardsville, Cameron, and Gentryville, and elsewhere in neighboring counties, make it seem very probable that the Bevier and possibly other coal seams underlie the entire county. The lowest point in the county, stratigraphically, is where Grindstone creek crosses the eastern border. Here the horizon of the Bevier coal is about 500 feet deep. The westerly dip and higher altitude of the beds at the surface in the northwest corner of the county increase this depth to about 900 feet in that region.

Evidence gathered in surrounding territory indicates that there is an average of 30 inches of coal in beds 14 inches or more thick under all of DeKalb county. If this estimate is correct the total reserve tonnage of the county is 1,209,600,000 tons.

GENTRY COUNTY.*

Coal has been mined in Gentry county, but work was long ago abandoned and for many years there have been no developments. The surface rock is buried beneath a thick covering of drift except near some of the larger streams, particularly Grand river, and little can be said of the depth of workable seams that do not outcrop. Where Grand river leaves the county the horizon of the Lexington coal is about 300 feet below the surface; but in the higher parts of the county it is probably 700 or 800 feet below. The distances from the Lexington to important lower horizons are indicated in the report on Harrison county. In the greater part of the county the highest Pennsylvanian is composed of the thick shale and sandstone beds constituting the Douglas shale, and it is in this that the rather unimportant outcropping coal of the county occurs. Broadhead† reports 4 to 10 inches of coal in the extreme southwest corner of the county. What is probably the same seam or another in the Lawrence shale was worked many years ago near Ellenorah‡ (N. E. ¼ N. E. ¼ Sec. 18, T. 64 N., R. 30 W). The thickness was reported to be 18 inches. About 1905 another shaft sunk at this place passed through 20 feet of red clay into a sandy blue shale. In this shaft the coal was reported to be 18

*The coal in Gentry county is mentioned by Arthur Winslow: Prelim. rept. on coal, Mo. Geol. Survey, 1891, p. 100.

†Idem, p. 100.

‡Buehler, H. A., Report on petition from Albany: Bien. Rept. State Geologist to Forty-third Gen. Assem., 1905, pp. 27-29,

or 19 inches thick, but about one-third of this was very soft, possibly due to proximity to old workings. According to Buehler, "A similar seam of coal was passed through in a well just north of Chalk Run on the land of James H. Hill, one mile south of the McNeese outcrop. The coal occurs at the same level, but the exact thickness of the bed is not known. The strata at this point lie approximately level, and in all probability the coal bed is continuous between the two places."

The only detailed record of deeper beds is that of the core drilling at Gentryville on Grand river (N. E. ¼ S. E. ¼ Sec. 36, T. 62 N., R. 31 W.), made in 1886 by A. Burdick. This penetrated in descending order 29 feet of glacial drift, 177 feet of the Kansas City limestone, 104 feet of the Pleasanton shale, 73 feet of the Henrietta formation, and 113 feet of the Cherokee. The Lexington coal with a 15-inch limestone cap-rock six inches above it and a seven-foot limestone bottom-rock under three feet of clay was found at 384 feet, but it was only seven inches thick. What is probably the Bevier bed was found at 477 feet; it contained 26 inches of coal. Aside from these two beds no coal was found, but the drilling was not sufficiently deep to explore the horizons below the Bevier that are so productive in Harrison and Mercer counties.

At Stanberry a prospect hole was put down in 1890 about three miles east of town. The drift was found to be 28 feet thick; some coal was reported at 600 feet and 30 inches at 720 feet.§ Whether this lower bed is the same as the 26-inch seam at Gentryville can not be definitely ascertained, but the Stanberry drilling started at a higher level both topographically and stratigraphically than that at Gentryville, so that there is at least a possibility that the two are the same.

An estimate of the total original tonnage of the county based on the assumption that 28 inches of coal, the average of the thicker beds in the Gentryville and Stanberry drillings, underlies the entire county, is very conservative, as no account is then taken of the possibility of coals lower than the Bevier. On this basis there are 1,280,496,000 tons of coal beneath the county.

GRUNDY COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....16,939 TONS.

Although Grundy has figured modestly as a coal producing county for many years, it has at present only one mine, that at Trenton. Formerly a little coal was produced at Spickards, Galt, and Laredo. The possibilities of the region have never been adequately tested by

§Eng. and Min. Jour., Vol. 49, 1894, p. 622.

*The coal of Grundy county is briefly described by Arthur Winslow: Prelim. rept. on coal, Mo. Geol. Survey, 1891, pp. 96-98.

the drill and the heavy covering of drift conceals in most of the region many strata which might otherwise outcrop.

The uplands in the southwest and narrow strips on the outer borders of the northwest quarter of the county are capped by thick basal limestones and interbedded shales that form the base of the Missouri group and that are useful markers for the coal beds that lie below them.

In most of the county the highest formation beneath the drift is the Pleasanton, which consists of about 150 feet of sandstone and shale with a few thin coal beds, none of which are known to be workable except for purely local purposes. The next lower formation is the Henrietta, which in most parts of the State contains rather prominent limestone beds. In this region both the limestones and the formation itself are very thin, and outcrop only along Medicine creek south of Laredo, and in a small area on Grand river on the south edge of Trenton. The Lexington coal, a few feet below the base of the Henrietta formation, has been found in the northern part of the county at Spickards and also at Melbourne in Harrison county. At these places it is rather variable in thickness ("faulty"), though it may be more constant at other localities in the northwestern part of the county. The lowest outcropping beds are seen on Medicine creek near the south county line and lie near the top of the Cherokee. The rest of the Cherokee is shown in the deep drillings at Trenton, where the vertical distance from the base of the Missouri group to the base of the Coal Measures is about 585 feet and the productive Cainesville and other horizons near the base of the Cherokee are barren. There can be little doubt that important coal deposits exist in the Cherokee in some part or parts of Grundy county, but these can be found only by thorough prospecting.

The average thickness of workable coal in the Trenton drillings, which penetrate all the chief coal horizons, is 30 inches, and to consider that amount to underlie the entire county in beds of 14 inches or more is very conservative. In addition, the Lexington horizon, which is barren or not represented at Trenton, contains, perhaps, an average of 18 inches in 100 square miles in the northwest corner of the county. On this basis the county contains a total coal reserve of 1,416,960,000 tons.

DETAILED MENTION.

Spickards.—On the west side of Grand river, near Spickards (S. E. ¼ N. W. ¼ Sec. 16, T. 63 N., R. 24 W.), two shafts have been sunk to the Lexington coal bed, but have not been worked for a number of years. One shaft was 100 feet deep, the upper 30 feet being reported as penetrating sandstone and shale and the lower 70 feet as showing

much limestone. The other shaft was located a short distance up a small branch and was 115 feet deep. The coal lies 165 feet below the Hertha limestone, which is exposed at the base of the Missouri group a short distance west. The bed was reported as 12 to 36 inches thick, separated into two benches by 2 inches of clay, the variation in thickness being due to the irregularity of the upper bench. The coal was overlain by a few inches of shale, over which was a limestone cap-rock, and was underlain by 3 feet of clay resting on a limestone bottom-rock. Only about one acre was mined out. The Cainesville horizon, at which coal was found near Princeton, lies about 300 feet below the Lexington bed and may possibly carry coal in this part of Grundy county.

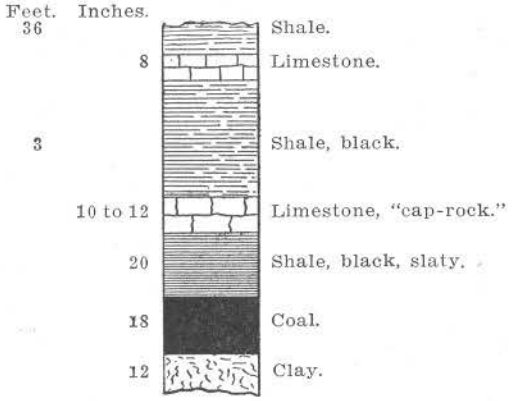


FIG. 29. Coal bed mined at Trenton.

Trenton.—For many years mining has been carried on at Trenton, chiefly to supply the city with fuel, about 385 acres having been mined out. The present mine, operated by the Trenton Mining Company, is the fourth to be sunk and is within the city limits (N. W. ¼ N. W. ¼ Sec. 16). The bed mined lies at a depth of 225 feet, or at an altitude of about 600 feet above sea level. An electric hoist is employed and production continues steadily throughout nearly the entire year. The bed is very uniformly 18 inches thick, and the coal is hard and clean and of excellent quality. Below the bed is 18 inches of rather soft clay and above it 2 feet of black "slaty" shale, lying below a 10-inch limestone cap-rock, making an excellent roof for longwall mining. In places, however, 40 inches or less of soft light shale or a dark calcareous shale full of shells ("black bat") intervenes between the "slaty" shale and the coal and causes some trouble in the workings. About 2,000 tons of coal are recovered per acre and 500 to 700 tons lost in mining through the production of slack and other causes.

The bed is undulatory, varying in level as much as 37 feet in the Trenton field. It thins north of town, but has never been explored far from Trenton. Fifteen feet below the coal in the mine is another bed

6 to 24 inches thick, with a poor roof formed by the clay and limestone "boulders" between it and the bed worked, and with a floor of "slaty" shale. Two or more coals found at higher levels are not considered workable. The bed mined lies about 265 feet below the Hertha limestone, the base of the Missouri group, exposed in the bluffs west of town. Because the limestone beds of the Henrietta formation, which serve as markers for lower beds in many of the Missouri coal fields, appear to be absent in the drillings made at Trenton, the correlations of beds are not made with any degree of certainty. Several factors indicate, however, that the bed mined is the Tebo, and it will be so considered in this report. The following churn drill records, kindly furnished by Robert Allardice of the Trenton Coal Company, show the relationships of the beds above the Tebo:

DRILLING IN NORTON PASTURE, WEST OF FAIR GROUNDS (N. W. ¼ N. W. ¼ SEC. 16).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	109	6	109	6
Sandstone, hard	5	....	114	6
Shale	8	6	123	....
Sandstone	4	....	127	....
Shale	5	....	132	....
Sandstone	15	....	147	....
Shale, gray	4	....	151	....
Limestone	1	6	152	6
Shale, gray	23	....	175	6
Shale, black, "slaty"	1	....	176	6
COAL (Mulky)	....	8	177	2
Clay	2	4	179	6
Shale, hard in lower part	23	6	203	....
Sandstone	14	....	217	....
Smut (Bevier)	....	6	217	6
Shale, gray	2	....	219	6
Limestone	....	4	219	10
Shale, with 5 layers of limestone 3 to 14 inches thick	13	2	233	....
Shale, black, "slaty"	1	....	234	....
Limestone	....	8	234	8
Shale, black, "slaty"	2	10	237	6
COAL (Tebo), mined	1	5	238	11
Clay	2	6	241	5

DRILLING EAST OF FAIR GROUNDS (N. E. ¼ N. E. ¼ SEC. 16).

Horizon of coal.	Thickness. *Inches.*	Depth. *Feet.*
Mulky	11	196
Bevier	6	217
Tebo	20	237

DRILLING AT NORTH END OF MABEL STREET.

	Thickness. *Inches.*	Depth. *Feet.*
Mulky	4	115
Bevier (COAL, 29 inches; Smut, 9 inches; COAL, 7 inches)	36	152
Tebo (COAL, 8 inches; Clay, 6 inches; COAL, 4 inches)	12	177

DRILLING SOUTHWEST CORNER PERRY FARM (S. W. ¼ S. W. ¼ SEC. 9).

	Thickness. *Inches.*	Depth. *Feet.*
Mulky	20	133
Bevier	10	157
Tebo	12	179

DRILLING IN THOMAS PASTURE, EAST OF ROCK ISLAND RAILROAD IN NORTH PART OF TRENTON.

		Thickness. *Inches.*	Depth. *Feet.*
Mulky	COAL, 8 inches, "Slaty" shale, 50 inch. COAL, 2 inches,	10	107
Bevier	COAL, 11 inches Dirt, 6 " COAL, 6 " Dirt, 14 " COAL, 6 " Shale, 60 " COAL, 4 "	27	148
Tebo		20	178
No name		18	200

OLD SHAFT NEAR RAILROAD STATION.†

	Thickness. *Inches.*	Depth. *Feet.*
Mulky	18	120
Bevier	14	145
Tebo	18	210
No name	6 to 24	225

An oil and gas well drilled in 1911 due west of Trenton, on the bank of Grand river, is said to have penetrated no coal, though rather thin beds might easily have been overlooked. The Mississippian limestone, the lower limit of coal, was struck at 640 feet. The following drilling also reached the Mississippian and found no workable coal:

CORE DRILLING IN OLD COAL SHAFT AT TRENTON.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Depth of shaft	....	....	234	5
Clay, sandy	1	5	235	10
Shale, black	6	6	242	4
Clay, shale and sandstone	15	3	257	7
Shale, blue, sandy	12	....	269	7
Shale, black, bituminous	7	9	277	4
Shale, brown and black	67	11	345	3
COAL	....	2	345	5
Clay and sandy shale	8	6	353	11
Shale, black	16	6	370	5
Limestone, with thin sandy shale partings	9	9	380	2
Shale, black at top, rest brown and sandy	23	11	404	1
Sandstone, micaceous	28	....	432	1
Shale, bituminous, sandy	4	....	436	1
Sandstone, micaceous	2	....	438	1
Shale, black, sandy in upper part	22	3	460	4
Sandstone, micaceous, with one-inch layers of black shale	44	11	505	3
Sandstone, coarse, friable	50	....	555	3
Limestone, cherty (Mississippian)	41	5	596	8
Limestone, crystalline (Mississippian)	9	2	605	10

†Winslow, op. cit., p. 97.

Galt.—Two shafts have been operated near Galt, one near the Quincy, Omaha & Kansas City railroad station and the other one-half mile west, but only a few acres were mined out before the field was abandoned. The bed mined was 18 to 22 inches thick and lay at a depth of 210 feet. The roof was a "soapstone" shale and the floor a sandy clay. Prospecting at the Medicine Valley shaft is said to have revealed a second bed 17 feet below the one mined and consisting of 20 inches of coal with an 8-inch parting of "black bat." A third bed, 42 inches thick, is reported at 257 feet. Both lower beds are said to have roofs of laminated shale and the third to have a 3-foot limestone cap-rock about 30 inches above the coal. The accuracy of these reports could not be verified, nor could it be ascertained which one of the three beds, if any, is the same as the bed mined at Trenton.

Laredo.—Several prospect holes are said to have been put down at Laredo to depths of 200 or 300 feet and coal 2 to 3 feet in thickness found, but these reports have never been verified. South of Laredo, along Medicine creek, the thin Mulberry coal outcrops near the base of the Pleasanton formation and has been stripped for local use in a number of places on both sides of the creek. About 2½ miles south (N. W. corner Sec. 30, T. 60 N., R. 22 W.) the following section was measured:

		Feet.	*Inches.*
1.	Shale, black, "slaty"	....	1
2.	COAL (Mulberry), hard, shiny	....	10
3.	Fire clay, with rock at top, about	2	6
4.	Limestone, gray, uneven on top	1 to 2	....

HARRISON COUNTY.

No coal beds more than 13 inches thick outcrop in Harrison county, but recent developments have revealed very important deep-lying deposits. The most conspicuous outcropping beds are those of the Kansas City limestone, at the base of the Missouri group. These may be seen on Big creek, notably at Bethany, and along Grand river and its tributaries. On the higher lands west of Big creek are the limestones and shales of the Lansing formation, and in the northwestern corner of the county the shales of the Douglas probably underlie the heavy cover of drift. The shales of the Pleasanton, with a thin coal bed (Ovid) near the top, appear below the Missouri group along Grand river and at Melbourne. In general the strata lie nearly horizontal, dipping slightly to the southwest, but there are minor anticlines (arches) and synclines (troughs) trending northwest-southeast and causing local irregularities. Along a line connecting Trenton, Melbourne, Bethany, and Denver, certain beds lie higher than in surrounding areas. The axis of a syncline in which they are relatively lower extends from south of Princeton to north of Cainesville and exerts an influence at Cainesville itself. Near the State boundary, north of

Cainesville, there is a notable rise, and farther north, at Leon, Iowa, lower beds are relatively near the surface.

DETAILED MENTION.

Cainesville.—In 1910 a shaft was sunk on the edge of the Grand river bottoms, on the south side of Cainesville (N. W. ¼ N. W. ¼ S. E. ¼ Sec. 13, T. 65 N., R. 26 W.), to a depth of 480 feet. Shortly after-

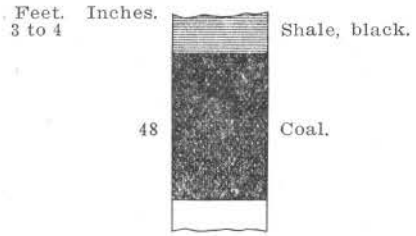


FIG. 30. The Cainesville coal bed at Cainesville.

wards a modern all-steel tower and tipple, self-dumping cages, hopper scales, shaker screens, and a powerful hoisting engine were placed in position and one of the best-equipped mines in the State was started by the Grand River Coal and Coke Company. The coal is of excellent appearance, being bright and so hard that hand work is difficult. Some white gypsum scale and a little pyrite occurs in small vertical and horizontal lenses, but the bed as a whole is clean. The bed is 44 to 60 inches thick, with an average of 4 feet. The roof is a hard, drab to black shale with a slightly wavy undersurface. The entries are timbered only at the pit bottom. A few unimportant "rolls" and "horsebacks" are present. The mine is dry and the floor a very hard sandy clay, almost a sandstone. The beds undulate slightly, but show no regular dip. Mining conditions appear to be very good, and it is confidently expected that Cainesville will soon be one of the principal mining centers of the State.

The top of the shaft is 9 feet below the Hertha limestone at the base of the Missouri group and 24 feet below the Bethany Falls limestone. The coal bed mined is, therefore, 489 feet below the Hertha and is the same as the thick bed in the Princeton drillings. The following diamond drill record shows the typical succession for the region:

DRILLING NEAR CAINESVILLE HOISTING SHAFT.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	24	....	24	....
Pleasanton shale—				
Shale, blue, sandy	76	....	100	....
Shale, light gray	36	....	136	....
Shale, blue, sandy at top, with limestone nodules below	20	....	156	....

DRILLING NEAR CAINESVILLE HOISTING SHAFT—Continued.

	Thickness.		Depth.	
Henrietta formation—	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Limestone (Pawnee)	4	....	160	....
Shale, black and bituminous at top, blue below	4	....	164	....
Limestone	5	....	169	....
Shale, gray, nodular	15	....	184	....
Shale, black and bituminous at top, blue below	7	....	191	....
Limestone	5	....	196	....
Shale, black, sandy	4	....	200	....
Limestone	2	....	202	....
Cherokee shale—				
Shale, black, bituminous	3	....	205	....
COAL (Lexington)	1	....	206	....
Clay shale, black	7	....	213	....
Shale and sand	21	....	234	....
Sandstone	9	....	243	....
Shale, black, sandy	8	....	251	....
Shale, blue, with limestone nodules	13	....	264	....
COAL (Mulky)	1	6	265	6
Shale, black, sandy in upper part	29	....	294	6
COAL (Bedford)	1	3	295	9
Shale, light	8	....	303	9
Shale, dark blue	1	....	304	9
COAL (Bevier)	....	6	305	3
Shale, blue at top, rest black	33	....	338	3
Shale, sandy	3	....	341	3
COAL (Tebo)	....	9	342	....
Shale, blue, sandy	7	....	349	....
Shale, dark blue	10	....	359	....
COAL	....	6	359	6
Shale, gray, sandy	13	....	372	6
Shale, blue	7	....	379	6
Shale, black, bituminous	3	....	382	6
COAL	1	8	384	2
Shale, light	6	....	390	2
Shale, black, bituminous	6	....	396	2
COAL	1	2	397	4
Shale, blue, sandy	3	....	400	4
COAL	....	6	400	10
Shale, blue, marly	18	....	418	10
Shale, blue	3	....	421	10
COAL	1	....	422	10
Shale, blue, upper half sandy	47	....	469	10
Shale, black, bituminous	6	....	475	10
COAL (Cainesville), mined	4	4	480	2
Shale, gray, sandy	17	....	497	2
Shale, blue, sandy	17	....	514	2
Shale, black, bituminous	2	....	516	2
COAL	2	2	518	4
Shale, light blue	4	....	522	4
COAL	3	6	525	10
Shale, light blue	5	....	530	10
Shale, dark and light blue	12	7	543	5
Sandstone and shale, black and gray	9	....	552	5
Shale, blue	1	6	553	11
COAL	1	6	555	5
Shale, blue, sandy	9	3	564	8
Shale, gray, sandy	2	....	566	8
Shale, dark blue	8	....	574	8
COAL	....	6	575	2
Shale, blue, sandy	5	....	580	2
Sandstone	34	4	614	6

According to a rather poorly identified churn drilling near Cainesville, 232 feet of limestone forming the top of the Mississippian series

and the lower limit of coal was struck at 858 feet, or about 375 feet below the horizon of the Cainesville coal. In the above record there are 205 inches of coal in beds of 14 inches or more. It is a notable fact that practically the only limestones mentioned in this record are those of the Henrietta formation, and the same is true of other records. The following coal summaries of beds over 14 inches thick show the considerable size of the productive area already tested:

AIR SHAFT OF CAINESVILLE MINE.

Horizon of coal—	Thickness. *Inches.*	Depth. *Feet.*
Mulky	16	264
Bedford	19	296
Tebo	21	358
No name	18	377
Cainesville	48	480
Depth of shaft	....	484
Total coal	122	

DRILLING IN S. ½ S. ½ S. W. ¼ SEC. 18, T. 65 N., R. 25 W.

	Thickness. *Inches.*	Depth. *Feet.*
Mulky	24	267
No name	19	371
Cainesville	54	485
Bottom of drilling	....	511
Total coal	97	

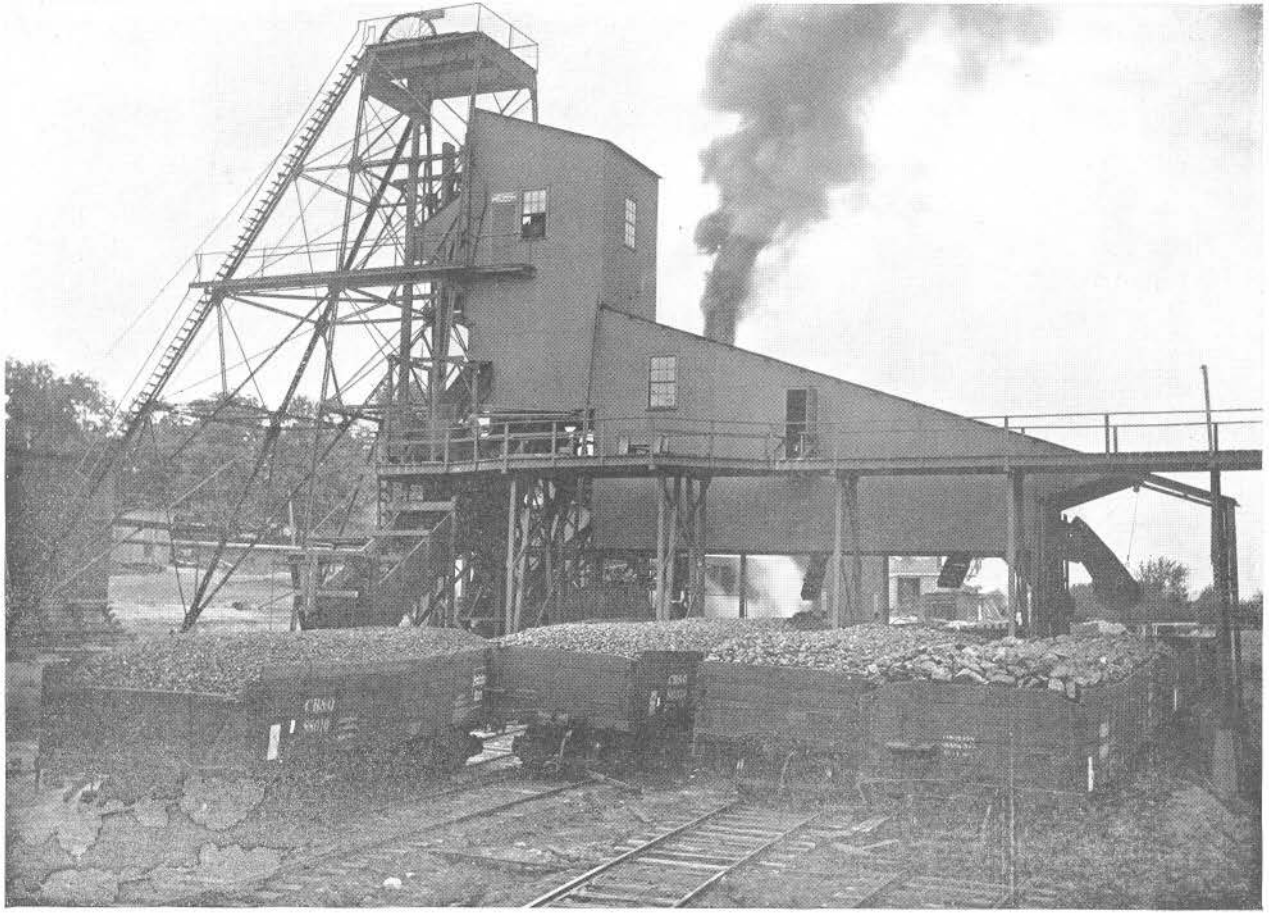
DRILLING AT SOUTHWEST CORNER OF SEC. 14, T. 65 N., R. 26 W.

	Thickness. *Inches.*	Depth. *Feet.*
Mulky	30	276
No name	18	351
Cainesville	54	500
Bottom of drilling	....	508
Total coal	102	

DRILLING AT SOUTHWEST CORNER OF SEC. 24, T. 65 N., R. 26 W.

	Thickness. *Inches.*	Depth. *Feet.*
No name	15	382
No name	28	401
Cainesville (?)	50	532
Bottom of drilling	....	538
Total coal	93	

The average thickness of coal in these records is 124 inches, but it is to be noted that, with the possible exception of the last, only the drilling near the Cainesville hoisting shaft penetrated the thick beds below the Cainesville coal. If beds less than 14 inches in thickness are included, the total thickness of coal is 22 to 64 inches greater (average 39 inches). Evidently there is a large reserve of coal near Cainesville, though the limits of the basins have not yet been determined. Very much the same succession of strata has been found at Princeton, in Mercer county, and coal beds that may correspond to some of those



Grand River Coal and Coke Co., Cainesville, Mo.

at Cainesville were penetrated in deep drillings at Leon, Iowa, north of Cainesville.*

Mount Moriah.—A drilling for oil and gas north of Mount Moriah (S. W. ¼ N. W. ¼ Sec. 12, T. 64 N., R. 26 W.), a few feet above the bottom lands of Grand river, reached a depth of 997 feet after penetrating 517 feet of Mississippian and possibly older rocks. The only coal beds reported were one 12 inches thick at 465 feet and another 30 inches thick at 431 feet, but the strata were not carefully identified. The base of the Coal Measures, which at Cainesville is about sea level, is here about 340 feet higher, probably owing in part to an ancient highland near Mount Moriah around which the Coal Measures were deposited, and in part to folding after the formation of the Pennsylvanian. According to the best evidence obtained from outcrop observations, the coal bed at 431 feet in the drilling is the Cainesville.

Ridgeway.—The Murphy schoolhouse oil and gas drilling, about 4 miles east of Ridgeway (Sec. 5, T. 64 N., R. 26 W.), was carried to a depth of 1,610 feet, reaching the base of the Coal Measures at 710 feet, or about 150 feet above sea level. Details were not carefully noted and the only coal reported was 4 feet at 95 feet. The depth given would place the coal in the Pleasanton shale and thus casts extreme doubt on the reported thickness, as no thick coal bed has been found in the Pleasanton in this part of the State.

Bethany.—In 1885 a hole was drilled to a depth of 654 feet one mile west of Bethany (Sec. 16, T. 63 N., R. 28 W.), on the bank of Big creek. Although five beds of coal were penetrated, the only one more than 9 inches thick was one of 15 inches at 370 feet.† It is not known how accurately coal beds were noted. As the basal limestones of the Missouri group are exposed at about the level of the top of the well, the bottom of it is certainly below the horizon of the Cainesville bed.

Gilman City.—Reports as to the thickness of coal found in a drilling at Gilman City in 1911 are somewhat conflicting. The following is a record kindly furnished by York Brothers, drillers:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Surface	8	....	8	....
Limestone, with shale partings	70	....	78	....
Shale, black	3	....	81	....
Sandstone, soft	90	6	171	6
Shale, various colors	85	6	257	....
Limestone	17	....	274	....
Shale	8	....	282	....
Sandstone	139	....	421	....
Shale, blue	15	10	436	10
COAL	4	8	441	6
Clay	1	....	442	6

*Hinds, Henry, Coal deposits of Iowa: Ia. Geol. Survey, Vol. XIX, 1909, pp. 247-253.

†For complete record, see Shepard, E. M., Underground Waters of Missouri, Water-Supply Paper No. 195, U. S. Geol. Survey, 1907, p. 61. His correlations appear to be somewhat in error.

The coal given in the record appears to lie between the Tebo and Cainesville horizons, at a stratigraphic level at which no thick bed has been reported in other districts. The extent of the basin should be determined by additional drilling before development work is attempted.

Melbourne.—The Lexington coal was recently mined at Melbourne by the Trenton Mining Company from a shaft a short distance east of the depot and north of the railroad (S. W. ¼ N. W. ¼ Sec. 25, T. 62 N., R. 26 W.). The bed varied in thickness from 30 to 41 inches where normal, but was "faulty" and contained a thin parting near the middle. It is well adapted to the longwall method employed. As determined by outcrop observations in the vicinity, the Lexington lies about 170 feet below the base of the Missouri group. The following record of the shaft was furnished by Messrs. C. F. Oram and J. S. Moore of Melbourne:

RECORD OF SHAFT AT MELBOURNE.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay	20	....	20	....
Sand	28	4	48	4
Pleasanton shale—				
Sandstone and shale	43	8	92	....
Henrietta formation—				
Limestone	2	3	94	3
Shale, hard and soft	12	4	106	7
Limestone, white	3	....	109	7
Shale, hard and soft	7	7	117	2
Limestone, mottled, hard	4	1	121	3
Limestone, shaly	1	4	122	7
Shale	6	5	129	....
Limestone	1	3	130	3
Shale	2	9	133	....
Limestone	3	....	136	....
Cherokee shale—				
Shale ("clod")	....	8	136	8
COAL (Lexington), with 2-inch parting one foot from top	....	30 to 41	140	....

As accurate deep drillings have been made only in the Cainesville district, it is very difficult to determine the coal reserve of the county. At Cainesville the average total thickness of coal is more than 10 feet, but at Mount Moriah it is only 30 inches and at Bethany 15 inches. Records at Gilman City and Melbourne affect only one bed, though the former record indicates an absence of coal at the Tebo and higher horizons. As there is considerable coal at Leon, Iowa, and at Princeton, in Mercer county, and a fair amount at Trenton, in Grundy county, 4 feet of coal in beds of 14 inches or over is considered a conservative estimate for the entire county. This places the total coal reserve at 3,363,840,000 tons, on the basis of 1,800 tons per acre-foot.

HENRY COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....152,377 TONS.

While the thick Mammoth coal bed at Lewis and the coal of the Deepwater basin were being actively developed, Henry ranked well up in the list of coal-producing counties. After the exhaustion of the Mammoth trough and the abandonment of the larger Deepwater mines, production decreased for a time, but was revived by the discovery and development of the Bowen trough near Windsor. Shipping mines are now confined to the vicinity of Bowen, Lewis, and Deepwater, but small local mines and strip-pits are exceedingly numerous in all parts of the county.

Three formations of the Coal Measures are recognized in Henry county. Of the upper, the Pleasanton, only a little of the lower shale caps a few hills on the northern edge of the county. The middle division, the Henrietta, extends farther south and also forms large mounds in the western part of the county. It is found only on the higher lands and does not reach south of the Missouri, Kansas, and Texas railway. The formation is 70 to 80 feet thick, and its outcrop is rendered conspicuous by several beds of resistant limestone near its base and one at its top. The lowest division is the Cherokee, which is the only outcropping formation in most of the county, and which appears in the main valleys in all parts of it. It consists chiefly of shale and sandstone, but includes several persistent limestones in its upper part. The Mississippian limestone and flint, which lies below the lower limit of coal, outcrops in the valley of Tebo creek to within five miles of Calhoun and along Grand river to north of Brownington. The southeast corner of the county contains almost no Coal Measures, and along the eastern edge they are very thin. Details of the stratigraphy are shown in the following generalized section compiled by F. C. Greene:

PENNSYLVANIAN OF HENRY COUNTY.

	Feet.
Pleasanton shale—	
Shale and sandstone	30
Henrietta formation—	
Limestone, gray	5
Sandstone and shale	50 to 60
Limestone, gray, thin-bedded	4
Shale, with "slaty" layer in upper part	8 to 15
Limestone, biue, weathers drab, blocky	1 to 2

*Two detailed reports by C. F. Marbut cover most of Henry county (Geology of the Clinton sheet; and, Geology of the Calhoun sheet: Mo. Geol. Survey, Vol. XII, pt. 2, 1898, pp. 20-191). The geologic and topographic maps and plates of cross sections are republished in revised form in this report, and much information has been utilized without further acknowledgment. The topography of the northern edge of the county is shown on a small scale on the Warrensburg atlas sheet of the U. S. Geol. Survey; that of the northwestern corner on the Harrisonville sheet; that of the western edge on the Butler sheet; and that of the remainder of the county on the Clinton sheet.

PENNSYLVANIAN OF HENRY COUNTY—Continued.

	Feet.
Cherokee shale—	
Shale, light at top, black and "slaty" at base, and with large concretions.	3 to 5
COAL (Lexington)	1 to 1½
Clay and shale	8 to 10
Limestone	1
Shale and sandstone, with thin and irregular coal bed at base	25 to 50
Limestone, gray, weathers rough on top, in places a foot or more of blue limestone at base	0 to 15
Shale, "slaty"	4 to 5
COAL (Mulky)†	0 to 1½
Shale, blue	20 to 40
COAL (Bevier)	0 to 2
Clay, shale, and sandstone	3 to 12
Limestone, variable	0 to 6
Shale, light at top, black and "slaty" below, locally with large concretions	0 to 8
COAL (Tebo)	0 to 3
Shale and sandstone, with basins of coal distributed irregularly both stratigraphically and geographically, including the Mammoth coal bed 40 feet and the Jordan coal 70-100 feet below the Tebo horizon	80 to 230

The southern continuation of the Warrensburg channel is filled with beds that can not be included in the above table. They are chiefly sandstone, with some shale, and they cut out many of the regularly bedded deposits along a strip one mile or less in width extending from Post Oak in Johnson county east of south across the headwaters of Sand creek and down the western side of that stream to the latitude of Calhoun.

The highest coal bed, the Lexington, lies near the top of the Cherokee formation and is less than 14 inches thick in much of the comparatively small territory it occupies. In parts of the eastern and northeastern portions of the county it is as much as 16 inches thick and furnishes a small quantity of fuel of excellent quality for local consumption. It is the same bed that is mined so extensively in Lafayette and Ray counties. Because of the "slaty" shale roof and the limestone cap-rock it can easily be mined longwall, and it is persistent in its occurrence, though thin, wherever its horizon is exposed.

The next lower bed, the Mulky, is also too thin to be of much importance, and is mined only for local use on Honey creek, near Lewis, and at a few other localities. It lies at an average of 50 feet below the Lexington, though the interval varies considerably.

About 30 feet below the Mulky is the Bevier bed, which has a rather thick shale roof and is therefore in many places concealed in outcrops. It is only locally workable, except in the northeast quarter of the county, where it averages 22 inches over considerable territory and is mined in a small way at a number of places near Windsor and on Sand creek.

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†Called the Honey Creek by Marbut and here correlated with the Mulky of Lafayette county. The irregularity in thickness of the limestone next above this coal apparently led earlier workers to confuse it with the Lexington in some places and with the Bevier in others.

About 20 feet below the Bevier is the Tebo bed, one of the most important in the county. It is in greater part persistently 24 to 30 inches thick and has above it two to three feet of black laminated ("slaty") shale, upon which rests a compact, massive limestone cap-rock. Although commonly little more than one foot thick, the resistant character of this cap-rock causes it to stand out prominently in outcrops and furnishes a marker for the coal beneath it. Longwall mining is rendered easy by the nature of the roof and other factors, and operations on the Tebo bed would be very successful were it not for the numerous lenticles of pyritiferous shale and other impurities found in most parts of the bed. The lack of railroad facilities in much of the field is also a detriment. The foreign matter can be picked out, however, and railroad spurs can be built at comparatively little cost whenever market conditions justify.

Two closely associated fields of Tebo coal lie within Henry county. In the southwestern quarter of the county the bed underlies all but the lower parts of the valleys as far east as LaDue and as far north as the valley of Grand river, but has not been recognized in outcrops west and northwest of Hartwell. The other field included nearly all of the county lying north of grand river and of the Missouri, Kansas, and Texas railway, back of the outcrop lines shown on the maps.

In the immediate vicinity of Clinton the coal is absent, and a short distance south of the railroad between Clinton and Calhoun it is entirely replaced by shale. Similarly, east of the longitude of Calhoun it is not typically developed. The Bowen trough lies in the stratigraphic position of the Tebo, but its coal in no way resembles the typical Tebo. Probably the Bowen coal was deposited before the Tebo, although lying at about the same distance below higher well-marked horizons, and is of the same age as the Mammoth bed of the Lewis district.

Below the Tebo bed the Coal Measures deposits are very irregular and lie in basins separated by barren areas of greater or less extent. The most important series of basins are those containing the Jordan coal. At one time the Jordan furnished a large amount of coal in the Deepwater district and even today its yield is of importance. The beds vary in thickness but average about three feet of good steam coal. The territory in which the basins have been found best developed is bounded by a line drawn from the southwest corner of T. 40 N., R. 26 W., northeast to Clinton, thence east to Alberta, and southwest through Brownington to the county line. Within this territory there are many barren areas, however, and outside of it there are many basins about which little is known. The Jordan coal of the Deepwater district probably lies 70 to 100 feet below the Tebo horizon, but as the higher bed has been removed by erosion in that territory the interval between the two cannot be definitely determined. The Jordan coal

lies in places very close to the base of the Coal Measures. It is possible that the Mammoth bed and the coal of the Bowen trough are contemporaneous with the Jordan, though it is more likely that these troughs and basins of comparatively thick coal are distributed irregularly through the lower part of the Cherokee formation. Prospectors should remember the basin and trough-shaped character of these lower coal beds and should make their investigations correspondingly thorough. Two dozen holes were drilled in the neighborhood of the Bowen trough without striking it, and it was not until later years that it was discovered. Similar deposits undoubtedly exist elsewhere in the county, more particularly where shales are more plentiful than sandstones among the lower beds. Drilling should be carried to the heavy limestone and flint beds of the Mississippian, in order that none of the lower basins may be missed.

Estimates of the amount of coal in the ground in Henry county are necessarily very rough. On the basis of 1800 tons per acre-foot, the total original tonnage in beds more than 14 inches thick is as follows:

TOTAL ORIGINAL TONNAGE OF HENRY COUNTY.

Beds.	*Tons.*
Lexington	21,600,000
Mulky and Bevier	252,000,000
Tebo	559,120,000
Jordan and other basin deposits	1,000,000,000
	1,832,720,000

DETAILED MENTION.

Urich.—At Urich sandstone and shale are the only rocks exposed, and a well sunk at the mill passed through 42 feet of sandy and argillaceous shales. Coal beds might be found at lower levels, as there are several at Creighton, near the county line northwest of Urich.‡ Two miles and more north of town a 16-inch coal that much resembles the Lexington is stripped by J. A. Shideler (S. W. ¼ S. E. ¼ Sec. 22, T. 43 N., R. 28 W.) and drifted by W. F. Lear (S. E. ¼ N. W. ¼ Sec. 15). At both places the output is small and is sold locally. The coal is of good quality and the bed is easily mined.

EXPOSURE AT LEAR DRIFT.

		Feet.	*Inches.*
1.	Limestone, light gray	6	....
2.	Concealed, about	10	....
3.	Limestone, buff, blocky	1	....
4.	Shale, upper half light, lower black, "slaty" and blocky	5	6
5.	COAL (Lexington)	1	4
6.	Concealed, about	20	....
7.	Sandstone, reddish brown, thin-bedded	6	....
8.	Shale	15	....

‡See report on Cass county.

Four miles south of Urich (Sec. 33, T. 42 N., R. 28 W. and vicinity) the Lexington coal, 14 to 18 inches thick, outcrops well up on a divide and is stripped for local use. The same bed is also stripped farther east, southwest of Hartwell (Secs. 26, 33, 35 and 36, T. 42 N., R. 28 W.). A lower bed consisting of one foot of cannel coal lying on one foot of bituminous coal was once stripped, a little north of the last (N. E. ¼ N. E. ¼ Sec. 26). All coal beds exposed in this area are thin.

	Inches.
Limestone (cap-rock)	14
Shale, black, "slaty", with hard, calcareous layers in places	36
Coal.	34
Shale, clayey, black.....	2
Clay	20

FIG. 31. The Tebo coal bed in western Henry county.

Montrose.—East and northeast of Montrose, high up in the valley of Bear creek (see map of Clinton quadrangle), and farther north in the valley of Deepwater creek and its tributaries, the Tebo coal bed outcrops and is stripped for local use. It is a very persistent bed 24 to 30 inches thick, overlain with about three feet of black laminated shale, over which is a very resistant limestone 12 to 15 inches in thickness. The limestone outcrops prominently in many places. Near the northwest corner of Montrose (N. E. ¼ Sec. 14) a bed only 16 inches thick (Bevier ?) lies apparently about 20 feet above the Tebo. This coal is not of much importance, but it may be safely assumed that the Tebo underlies all the divides between the outcrops mapped. Near the top of a large mound two miles west of Montrose, a 14-inch coal bed outcrops at the Lexington horizon. West of Germantown strippings show a lower coal, probably the Tebo. Southeast of Montrose, on the upper part of Marshall creek, a 30-inch coal bed is probably the Tebo. The following record is important, if accurate:

DRILLING TWO MILES SOUTHEAST OF MONTROSE (N. W. ¼ N. W. ¼ SEC. 31, T. 40 N., R. 27 W.).

		Feet.
1.	Not reported	8
2.	COAL	2
3.	Not reported	75
4.	COAL	5
5.	Sandstone, etc	36

LaDue.—In the northern part of LaDue a drill-hole was sunk 90 feet without striking more than a few inches of coal. The Tebo coal

is probably concealed beneath the soil cover a short distance north of and slightly higher than the village. Numerous small strip-pits are found on the outcrop of the Tebo between Grand river and Deepwater creek in T. 41 N., R. 27 W. (See map of the Clinton quadrangle.) Among them are: (1) G. N. Angle, N. W. ¼ S. W. ¼ Sec. 3, reported 36 inches thick; (2) O. Steward, N. E. ¼ S. E. ¼ Sec. 4, reported 32 to 36 inches; (3) S. E. ¼ S. W. ¼ Sec. 8, reported 24 inches; (4) D. M. Coe, N. W. ¼ S. W. ¼ Sec. 11, 30 to 36 inches; (5) S. W. ¼ N. E. ¼ Sec. 13, reported 18 inches; (6) J. Turk, N. E. ¼ N. W. ¼ Sec. 15, 22 inches; (7) J. Armstrong, S. W. ¼ S. E. ¼ Sec. 20, 26 inches; (8) S. W. ¼ S. W. ¼ Sec. 22, 24 inches. In places two feet or less of black, impure limestone lies upon the coal. Three to four feet above the coal is a bluish gray, compact limestone cap-rock a foot or more in thickness. Between the cap-rock and the black limestone or the coal is two to four feet of shale that is black and "slaty" in the lower half and light and argillaceous in the upper. If mining were conducted on a large scale, conditions would probably be favorable. At one locality one foot of coal, probably one of the benches of the Bevier bed, was found 18 feet above the Tebo. A drilling made in the branch near the Coe pit encountered only barren shales and sandstones to a depth of 110 feet.

The Lexington bed is stripped by W. H. Alexander at the top of a small mound four miles northwest of LaDue (N. W. ¼ N. W. ¼ Sec. 10, T. 41 N., R. 27 W.). A section from this pit to Angle's is as follows:§

OUTCROP AT ALEXANDER PIT.

		Feet.	*Inches.*
1.	Slope, with many limestone fragments	15	....
2.	Shale	5	....
3.	Limestone, bluish gray, compact, weathers to a clay	....	10
4.	Shale, light	1	....
5.	Shale, black, "slaty"	3	....
6.	COAL (Lexington)	1	6
7.	Concealed	8	....
8.	Limestone, sandy	1	....
9.	Shale and sandstone	36	....
10.	Dark streak	1	....
11.	Concealed (shale?)	30	....
12.	Limestone	1	....
13.	Shale, light	1	....
14.	Shale, black, "slaty"	1	8
15.	Limestone, dark	....	8
16.	COAL (Tebo)	2	6

Two miles southwest of LaDue, in the bed of Bear creek (N. E. ¼ N. W. ¼ Sec. 10, T. 40 N., R. 27 W.), a three-foot coal bed lies lower than the Tebo. Above it only sandstone and shale are exposed.

Hartwell.—Two or more small shipping mines have been operated in the Tebo bed beside the railroad one mile southeast of Hartwell, but

§Modified from Marbut (Mo. Geol. Survey, Vol. XII, pt. 2, 1898, p. 49). Owing to a westward thinning of the limestone above the Mulky (Honey creek) coal, Marbut apparently mistook the Lexington for the Mulky in the western part of the Clinton quadrangle.

are now abandoned. The coal was 32 to 34 inches thick, and contained considerable pyrite ("sulphur") in thin lenses that had to be picked out before the coal could be marketed. Above the coal is three feet of black laminated shale capped with a compact limestone 18 inches thick. A thinner limestone bed lies three feet above the cap-rock and a few inches of coal (Bevier) lies 10 or 12 feet above the Tebo.

The Tebo coal has not been found in the valley of Grand river west of Hartwell, and south of town it evidently rises. A drilling one mile west of town (N. W. ¼ Sec. 18) failed to find coal in 35 feet, but so shallow a drilling is of little value. In a bluff on the river (Sec. 30, T. 42 N., R. 27 W.), three thin and non-persistent coal beds, the thickest measuring only 16 inches, are separated by thin shales lying below the Tebo horizon.

No persistent coal bed lower than the Tebo outcrops on Grand river above the outcrops south of Clinton, though basins of workable coal may exist in parts of the valley. More than a mile north of Hartwell (N. E. ¼ N. E. ¼ Sec. 7) a shaft was once sunk 35 feet to 32 inches of coal, probably the Tebo, and 10 feet lower to 10 inches. One mile northeast of town (N. W. ¼ Sec. 16) four feet of coal is said to have been found in both a dug and a drilled well at 61 feet. Less than half a mile east of town (near center Sec. 17) 14 inches was struck at 10 feet, 36 inches at 40 feet (Tebo), and 14 inches at 73 feet. The lowest bed in the last drilling possibly corresponds to the four-foot bed in the wells, showing its lenticular character.

Maurine.—Near Maurine the Tebo and lower horizons lie below drainage levels, the former being only a few feet below the water surface of Big creek. Near the bridge southeast of the village (S. W. ¼ Sec. 29) the Bevier coal is 15 inches thick and the laminated shale above the Tebo outcrops. On the higher lands north and northwest of the town the Lexington bed outcrops, but averages only one foot. A lower bed, either the Mulky or the Bevier, shows in places near water level on the branches of Honey creek. At one of these, on land belonging to J. E. Gilliam (S. E. ¼ N. W. ¼ Sec. 13, T. 43 N., R. 27 W.), there is 18 to 20 inches of coal. At a drift owned by W. A. Witt (N. W. ¼ S. E. ¼ Sec. 18, T. 43 N., R. 26 W.) the section is:

		Feet.	*Inches.*
1.	Limestone	....	....
2.	Shale, "slaty"	....	10
3.	COAL	....	4
4.	Shale, hard and drab at base	8	6
5.	COAL	....	18–30

Due east of Maurine, on Honey creek (N. W. ¼ N. W. ¼ Sec. 25, T. 43 N., R. 27 W.), the Mulky, 17 inches thick, is stripped. The roof is four feet of laminated shale with an 18-inch limestone cap-rock.

Aside from these surface beds, which constitute important local supplies of fuel, there are probably lower beds concealed beneath the

surface, as indicated by developments at Chilhowee and elsewhere in southern Johnson county.

Garland.—A short distance northwest of Garland the Tebo coal outcrops in a branch of Honey creek and is mined in a slope on the Covington estate by Perry and Devine, the product being raised to the surface with a horse-gin and sold locally. Except where the upper bench is partly cut out by limestone concretions ("niggerheads") the coal bed is 27 to 31 inches thick and bears two half-inch partings of pyritiferous clay.

SECTION AT COVINGTON SLOPE (S. W. ¼ N. W. ¼ SEC. 12, T. 42 N., R. 27 W.

		Feet.	*Inches.*
1.	Shale, black at base	8	....
2.	Limestone, black, impure	....	6
3.	COAL (Bevier)	....	1
4.	Shale, black	2	5
5.	Limestone	1	7
6.	Shale, dark at top, black and "slaty" in lower part	3	....
7.	COAL (Tebo)	2	7
8.	Clay, hard, with pyrite	....	....

About a mile southwest of Garland the Tebo is reached by an abandoned shaft, 18 feet deep, and a short distance farther southwest the same bed is stripped at its outcrop by T. Cheatham on land of J. Owen (N. W. ¼ S. W. ¼ Sec. 14, T. 42 N., R. 27 W.). Here the coal is 30 inches thick, without clay partings; 26 inches of shale bearing concretions lie between it and the limestone cap-rock. The same thickness of coal was formerly mined two miles southeast (N. W. ¼ S. E. ¼ Sec. 24) in an 18-foot shaft and in a drift one mile farther southeast, near Field creek (S. E. ¼ S. E. ¼ Sec. 19). The Tebo outcrops at intervals for several miles up Field creek and probably underlies nearly all of the divide between that stream and Big and Honey creeks. A churn drilling made at Garland is said to have found the Tebo 38 inches thick at a depth of 50 feet, overlain with 30 inches of laminated shale upon which rests 20 inches of limestone. Fifty feet below the Tebo and separated from it by clay, shale, and white sandstone, is 10 inches of coal, followed, in descending order, by 20 feet of shale and 140 feet of white sandstone with no coal seams.

Four miles northeast of Garland, near Field creek, the Mulky coal is stripped, though it is only one foot thick. A neighboring well shows the relationships of several beds:

SPANGLER WELL (S. W. ¼ SEC. 34, T. 43 N., R. 26 W.).

		Feet.
1.	Undetermined	11
2.	Limestone	4
3.	Shale, black	5
4.	COAL (Mulky)	1
5.	Shale	30
6.	Limestone	1
7.	COAL (Bevier)	1
8.	Indeterminate	18
9.	COAL (Tebo)	2½

Clinton.—The only rocks exposed on Town creek, on the west side of Clinton, and in railroad cuts west of the city, are 50 feet or more of barren sandstones and sandy shales, which probably lie just below the level of the Tebo bed, though attempts to trace the coal to them were unsuccessful. The Tebo outcrops, however, on the upper courses of Field, Rose, Town, and Deer creeks, as shown on the geologic maps. Three miles northwest of the city, on a small tributary of Field creek, is the drift of M. E. Lane on land of the Britts estate (N. E. ¼ N. E. ¼ Sec. 29, T. 42 N., R. 26 W.) and the slope of Wiles and Todd on land of H. F. Taylor (N. W. ¼ N. W. ¼ Sec. 28). A short tramway leads from the Britts mine to a tipple on the Frisco railroad. The product is hauled up the Taylor slope by steam power. Longwall is the plan of working, but the coal sticks to the roof and is shot down. The bed contains two regular half-inch pyrite ("sulphur") bands and considerable pyrite in irregular lenticles.

TEBO BED AT TAYLOR AND BRITTS MINES.

		Feet.	*Inches.*
1.	Limestone, in even layer	....	4
2.	Shale	....	10
3.	Limestone, in one layer, "cap-rock"	1	6
4.	Shale, with calcareous lenses, black and "slaty" at base	3	4
5.	COAL (Tebo)	2	6
6.	Clay, hard, and with pyrite next coal	3	6

Two miles north of Clinton (N. W. ¼ N. W. ¼ Sec. 26) a stripping in the Tebo shows coal 34 inches thick, and another farther northwest (S. E. ¼ N. W. ¼ Sec. 22), shows it 32 inches thick. Closer to the city (S. E. ¼ Sec. 34) 28 inches of coal with a parting of two inches of bone, probably representing a bed lower than the Tebo, is mined from a 25-foot shaft by Neil and Wallace. Northeast of Clinton the Tebo has been stripped (N. W. ¼ N. W. ¼ Sec. 24 and N. E. ¼ N. E. ¼ Sec. 36, T. 42 N., R. 26 W.) and has been found to be about 34 inches thick.

South and southeast of Clinton a number of small mines supply local and city trade from the northern extension of the Jordan bed mined near Deepwater. Although the area of workable coal in this basin is by no means continuous, it is nearly so as far north as the latitude of Clinton and as far east as Sparrow Foot creek. In the Walter Owens mine, operated by Lucas and Damron not far from the southeast corner of the city (S. E. ¼ N. E. ¼ Sec. 11, T. 41 N., R. 26 W.), the coal is 25 inches thick, including three inches of dirty coal ("rash") at the bottom and one-half inch of bone five inches from the top. The bed is clean and regular and without "slips" or other troublesome features. The roof is a very hard, sandy, and calcareous shale 10 feet or more in thickness. The coal is shot off the solid and is hoisted 30 feet with a horse-whim. Near by are a number of small abandoned shafts. On the east (N. W. ¼ S. E. ¼ Sec. 12) coal is

now hoisted 30 feet by a horse-whim on land of F. M. Groff from a mine operated by T. A. Pharis. The bed worked and the roof are in all respects the same as those at the Owens mine. At least 20 feet of shale overlies the coal. On the opposite side of the road, on the Beck place, a shaft is being sunk to the same seam by James Damron (N. E. ¼ S. E. ¼ Sec. 12).

An exposure north of this on Deer creek (N. E. ¼ Sec. 12) shows three feet of coal beneath limestone 10 feet below the Jordan bed mined at the Groff shaft. This may be the bed formerly operated at one shaft two miles southeast (S. E. ¼ Sec. 18, T. 41 N., R. 25 W.), at another, one mile farther east (S. W. ¼ S. E. ¼ Sec. 17), and at others in the vicinity, though it is more probable that the Jordan bed is worked at all the places where the overlying material is more than commonly calcareous. This bed is variable in thickness and the coal is of excellent quality. Similar strata overlie the coal at the J. England stripping (N. W. ¼ N. E. ¼ Sec. 17) and in the drift of J. L. Shorter on land of Frank Brown (S. W. ¼ N. E. ¼ Sec. 17), where the following section was measured:

EXPOSURE AT BROWN DRIFT.

		Feet.	Inches.
1.	Limestone, white ("cottonrock"), compact, in three layers, very sandy.	4	....
2.	Shale, drab	5	....
3.	Shale, black and "slaty" in upper half	2	6
4.	Iron-bearing concretions	....	6
5.	Clay, very soft, mined before coal is shot	....	4
6.	COAL, 12 inches Bone, 2 " COAL, 22 "	3	....
7.	Shale, black, "slaty," very hard	....	8
8.	Sandstone, white	1+	....

Many other small mines in coal four feet or less in thickness have been operated in the southwestern quarter of T. 41, R. 25.* Three miles south of Clinton, near Grand river, an exceptionally pure coal is worked at a small slope operated by Robert Day and a thirty-foot shaft by Mr. Holt, both on land of T. D. Hodges (S. W. ¼ N. W. ¼ Sec. 24, T. 41 N., R. 26 W.). The bed is about two feet thick, but there are many barren areas in the district. The same bed (Jordan) outcrops in the river at Gilkerson's old ford (N. W. ¼ Sec. 26), where it is three feet thick.

SECTION AT HODGES MINES.

		Feet.	Inches.
1.	COAL	....	9
2.	Shale, very sandy, hard, in places with intercalated beds of red sandstone	18	....
3.	COAL, 4 inches Bone, 1 inch COAL, 19 inches	2	....
4.	Shale, black, carbonaceous ("rash")	....	3
5.	Clay, light blue, sandy, hard	2+	....

*For details see C. F. Marbut, Geology of the Calhoun sheet: Mo. Geol. Survey, Vol. XII, pt. 2, pp. 133-141.

Deepwater.—The Deepwater district became a very important coal producer soon after the construction of the Kansas City, Clinton and Springfield railway, but is now better known as one of the principal clay products manufacturing centers of the country. The coal mined is the Jordan bed, the thicker basins of which are now exhausted, so that present mines are not of large size. Much of the coal is consumed locally, although most of the clay plants use oil or gas for fuel. The principal producing area has been between Deepwater and Brownington, and north of Deepwater between Deepwater creek and Grand river. Mines now operating south of the creek, east and south of Deepwater, are (1) Crescent, S. E. ¼ Sec. 13, T. 40 N., R. 26 W., shaft 35 feet, horse-whim hoist, coal 36 to 42 inches; (2) James England, N. W. ¼ N. E. ¼ Sec. 13, shaft 31 feet, horse-whim hoist, coal 20 to 31 inches; (3) John Hurst, S. E. ¼ N. W. ¼ Sec. 13, shaft 55 feet, steam hoist, tramway to railroad spur, coal 6 to 37 inches, average 35; (4) H. T. Damaree, S. W. ¼ N. E. ¼ Sec. 12, drift, coal 28 inches; (5) Kennedy and Thompson, N. E. ¼ N. W. ¼ Sec. 23, shaft 19 feet, horse-whim

FIG. 32. The Jordan coal bed near Deepwater.

hoist, coal 28 inches; (6) Kansas City Paving Brick and Tile Co., S. W. ¼ N. W. ¼ Sec. 18, T. 40 N., R. 25 W., stripping, coal 36 to 40 inches.

A persistent seam of bone, one to two inches thick, lies four to ten inches below the top of the coal, and a variable layer of dirty coal or carbonaceous shale ("rash") may be found under the coal in many places. The roof is a blue to drab shale that is not strong and is overlain by a hard shale that grades in some places into an argillaceous and calcareous sandstone and in others into a sandy, impure limestone. Where the hard rock lies near the coal, the underlying shale falls and the roof then stands firmly. Where the hard rock is sandy and lies on the coal the roof is good, but rolls cut out much of the coal. In most places the hard rock lies 10 feet or more above the coal and on some properties the shale (and the coal below it) are obtained by stripping for use at the clay plants. Strata are so variable in this district that detailed sections are of little value, though the presence

of numerous fine leaf impressions in the shale indicates that the coal lies a few feet below. Aside from the hard rock already mentioned, itself commonly a shale, a considerable thickness of shales of various types overlies the Jordan horizon. Shales and thin sandstones lie between the coal and the Mississippian limestone, the lower limit of coal, their thickness varying from 20 to 70 feet or more.

The Jordan coal basin extends south and southeast of Deepwater to the county line, though coal is not continuous in that area, and near the southern limit of the county the Mississippian projects up through the Jordan horizon in places. Considerable prospecting has been done near Deepwater by coal and clay companies, so that important deposits would have been exploited had they been found. The first known occurrence of the Jordan coal west of Deepwater is at the small Reese drift (S. E. ¼ S. E. ¼ Sec. 17, T. 40 N., R. 26 W.), where the coal is in two benches of 10 inches each, separated by nine inches of shale; yellowish red sandstone rests on the coal. The same bed also occurs in the next quarter south; in the next one east, however, it was absent in a well, and a conglomerate of flint pebbles, evidently forming the base of the Coal Measures, was found about 50 feet below its horizon. Northwest of this locality a small basin containing two feet of coal has been stripped (N. E. ¼ Sec. 7) and penetrated in a well 18 feet deep (S. W. ¼ S. E. ¼ Sec. 6). Four miles south of this is the W. H. Rusk shaft (N. W. ¼ N. E. ¼ Sec. 31, T. 40 N., R. 26 W.), where the product is hoisted 27 feet by horse-power. The coal, which is of good quality, is sold locally. The bed is 30 inches thick, including one to two inches of bone in the center, but excluding eight inches of very dirty coal (''rash'') at the base. The roof is a strong, very sandy shale 10 feet thick, overlain by eight feet of hard sandstone. Mr. Rusk concludes from the evidence furnished by drillings and other shafts on the property that the coal basin is about 100 acres in extent. The surrounding country is flat and without clear-cut outcrops, so that other basins between Deepwater and Montrose might easily remain undiscovered.

The variability in the occurrence of the Jordan coal in the Deepwater district is well shown in the following records furnished by the Central Coal and Coke Co.:

T. 41 N., R. 26 W.:

S. W. ¼ S. E. ¼ Sec. 25; drilled 110 feet; 11 inches coal at 95 feet.

N. W. corner S. E. ¼ S. E. ¼ Sec. 26; 21 in. at 31 feet.

S. W. ¼ S. E. ¼ Sec. 26; stopped in sandstone at 65 feet; no coal.

S. E. ¼ N. E. ¼ Sec. 35; 3 in. at 31 feet, 16 in. at 42 ft.; stopped in sandstone at 81 feet.

S. E. ¼ S. W. ¼ Sec. 36; stopped in sandstone at 88 ft.; no coal over five inches.

S. W. corner S. E. ¼ Sec. 36; 30 in. at 77 ft.

T. 40, R. 26:

Center W. ½ N. E. ¼ Sec. 1; 35 in. at 70 ft.

E. ½ S. W. ¼ Sec. 12; 37 in. at 45 ft.

N. side S. E. ¼ N. E. ¼ Sec. 14; 33 in. at 57 ft.

N. E. ¼ S. E. ¼ Sec. 14; 24 in. at 62 ft.

E. side N. W. ¼ S. E. ¼ Sec. 14; stopped in sandstone at 49 feet; no coal.

N. edge S. E. ¼ S. E. ¼ Sec. 14; 18 in. at 50 ft.

N. E. corner S. E. ¼ S. E. ¼ Sec. 14; 21 in. at 40 ft.

N. E. ¼ S. W. ¼ Sec. 14; 32 in. at 35 ft.

N. E. ¼ N. W. ¼ Sec. 14; 4 in. at 53 ft.

S. E. ¼ S. W. ¼ Sec. 14; 20 in. at 31 ft.

N. ½ N. E. ¼ Sec. 23; east end 28 in. at 62 ft., west end 30 in. at 51 ft.

S. E. ¼ N. E. ¼ Sec. 23; stopped in flint rock at 72 ft.; no coal.

N. W. ¼ N. W. ¼ Sec. 23; stopped in rock at 32 ft.; no coal.

N. side S. E. ¼ N. E. ¼ Sec. 24; stopped in sandstone at 45 ft.; no coal.

S. E. ¼ N. W. ¼ Sec. 24; 6 in. at 22 ft.

S. W. ¼ S. W. ¼ Sec. 25; 20 in. at 55 ft.

Brownington.—East and northeast of Brownington very little coal has been found, and the Mississippian outcrops in Grand river. Three miles northeast (S. E. ¼ N. E. ¼ Sec. 9, T. 40 N., R. 25 W.) W. W. Miller recently stripped 30 inches of coal of good quality. One-fourth mile north of this, however, the coal was much thinner, and good outcrops elsewhere in the vicinity show only black shale at the coal horizon, with 40 feet of sandstone and shale above it. This basin is, therefore, rather small. Three miles farther northeast coal 16 inches thick was formerly stripped (S. W. ¼ N. W. ¼ Sec. 1), and a bed 22 inches thick was found in a shallow excavation near the center of Sec. 1. Other basins probably exist in this part of the county. Three miles north of Brownington, in a bluff on Grand river, a drift was once driven on 30 inches of coal under a roof of 15 feet of drab shale. Under the coal are exposed 50 feet of clay shales to about the level of the Mississippian in the bed of Grand river.

Colesburg.—Two miles south of Colesburg is the stripping of S. B. Parks (S. E. ¼ N. W. ¼ Sec. 31, T. 41 N., R. 24 W.), in which 33 to 48 inches of coal, resting on hard bone coal or black laminated shale, lie beneath two feet of black "slaty" shale. From the fact that the coal dips from both sides toward the position of the thickest coal, it is probable

that this is a trough-shaped deposit of unknown extent. Five miles southeast of Colesburg, at Glenrock Store (center Sec. 36, T. 41 N., R. 24 W.), are some strippings and a drift operated by David Pierce. The coal at and near the drift is reported to be four to five feet thick, in a prospect shaft a short distance north five feet seven inches thick, and 200 yards northeast six feet thick. One-fourth mile north of the drift, in the stripping now worked (S. W. ¼ N. E. ¼ Sec. 36), the coal is 30 to 52 inches thick with one to two inches of shale 14 inches from its base. There is some other evidence for thinking that the coal may lie in a trough of sufficient size to be of considerable importance. It lies only a few feet above the Mississippian, however, and heavy red sandstone lies 10 feet above it, both features indicating that the thick coal may not occupy much territory.

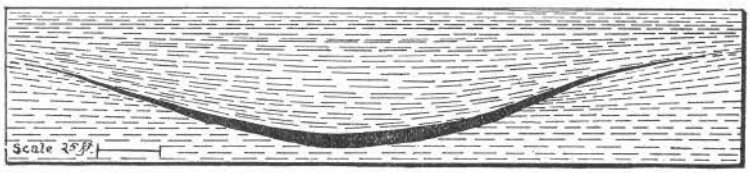

FIG. 33. Cross section of Mammoth coal bed. (Marbut.)

Lewis.—Soon after the completion of the Missouri, Kansas, and Texas Railway operations were actively begun on what is known as the Lewis or Mammoth coal bed, a trough-shaped deposit with axis lying N.W.-S.E. and extending from the northeast corner of Sec. 17, T. 42 N., R. 25 W. to the middle of the east line of Sec. 25. The position of the deposit is now marked by a line of abandoned shafts and near its southeastern end by strippings from which some coal is still taken. The coal in the center of the trough was four to five feet thick; laterally it rose and thinned, as did also the overlying "slaty" shale. Lateral work was abandoned when the thickness of the coal bed decreased to two feet, and the average width of the basin mined out was only 140 to 400 feet. The following record shows the stratigraphic position of the bed:

OLD BOWEN SHAFT (N. W. ¼ SEC. 17, T. 42 N., R. 25 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Limestone	2	....	2	....
Shale, light drab	1	8	3	8
Limestone, concretionary, with ochre	....	4	4	....
Shale, black at top, white at bottom	13	6	17	6
Shale, black, bituminous	2	....	19	6
COAL	....	6	20	....
Clay and shale, sandy at base	23	....	43	....
Limestone, blue, hard	2	6	45	6
Shale, calcareous	3	....	48	6
Shale, bituminous	2	....	50	6
COAL (Tebo)	2	6	53	....
Clay and shale	9	....	62	....

OLD BOWEN SHAFT (N. W. ¼ SEC. 17, T. 42 N., R. 25 W.)—Continued.

	Feet.	Inches.	Feet.	Inches.
	Thickness.		Depth.	
Shale, black	....	6	62	6
COAL, with pyritiferous concretions	3	....	65	6
Shale, light, sandy	12	....	77	6
Shale, dark, bituminous	7	....	84	6
COAL, extra good quality	....	6	85	....
Shale, bituminous	7	....	92	....
COAL (Mammoth)	5	3	97	3
Shale, pyritiferous	3	....	100	3

After the exhaustion of the part of the Mammoth bed that lay within reach of rail communication, operations near Lewis were transferred to the Tebo bed, which underlies practically all of the territory west of Calhoun, and north and a short distance south of the railroad (see outcrop line on map). The Tebo is now mined by the Lewis Coal Company (Pigg & Co.), one mile north of Lewis (N. W. ¼ Sec. 9). The product is taken to the surface through both a shaft and a drift and hauled to the railroad over a half-mile tramway down Westfork to Tebo creek. A new 25-foot shaft, where hoisting is done by horse-

Inches.
Limestone (cap-rock) 18
Shale, sandy and pyritiferous, gray 18
Shale, black, "slaty".....20
Coal, with 1 to 2-inch pyrite band near middle.....30
Clay, dark, hard..... 6
Clay, white, ("mining")....10

FIG. 34. The Tebo coal bed at the Pigg drift.

power, has been sunk by the Calhoun Coal Company 1½ miles northeast of Lewis, beside the railroad (N. E. ¼ N. W. ¼ Sec. 10). At these and former mines near Lewis the Tebo is almost uniformly 30 inches thick and is overlain with two to four feet of black laminated shale, above which is a compact limestone cap-rock about 14 inches thick. The coal contains numerous pyritic lenses, though it is otherwise excellent as a steam producer. Because of its cover of laminated shale and its cap-rock, the bed is easily worked longwall. About 18 feet above the Tebo is a coal bed (Bevier) 18 inches or less in thickness.

Calhoun.—Search for workable coal under Calhoun itself has been unsuccessful. A drilling just east of the city (N. E. ¼ N. W. ¼ Sec. 31) struck 28 inches at 30 feet, but the roof was too soft to permit profitable mining. A little more than a mile north of the city (S. ½ N. W. ¼ Sec. 30) a coal bed lying beneath a shale roof and separated

into an upper bench of one foot and a lower of three feet by nine inches of shale was once mined. These and other coal beds east and northeast of Calhoun lie below the horizon of the Tebo bed and are of small lateral extent. Marbut noted several occurrences in the southern half of T. 43 N., R. 24 W., viz.: (1) N. E. ¼ Sec. 27, coal 30 inches; (2) S. E. ¼ S. E. ¼ Sec. 33, coal 38 inches; (3) S. W. ¼ N. W. ¼ Sec. 22, coal 24 inches. A stripping four miles east of Calhoun shows 44 inches of coal in one place, and one foot more, rather dirty, in another. Several abandoned strippings show no visible coal.

West of Calhoun, on the west side of Tebo creek, the horizon of the Tebo bed outcrops. The coal itself, however, has not been found within a mile of the city. A drill hole near the railroad and Tebo creek, begun at about the level of the Tebo bed, found no coal in 75 feet. Two miles farther up Tebo creek (Secs. 22 and 23) the Tebo coal is about 24 inches thick. A short distance above the mouth of Sand creek a line of old drifts in the Tebo and the A. F. Parks drift (N. E. ¼ N. E. ¼ Sec. 34, T. 43 N., R. 25 W.) now produce coal that is hauled to the railroad for shipment and is sold in Calhoun. The bed is three feet thick, is fairly clean, and is overlain with 40 inches of black, laminated shale, above which is a 17-inch limestone cap-rock. Two miles farther up Sand creek (N. W. ¼ Sec. 28) the Whitcomb local slope operates a coal bed thirty inches thick and higher than the Tebo; above it are several feet of clay shale. The Lexington bed, still higher than the last named bed, was found at a depth of 30 feet in the old Thornton well (center Sec. 28), but was only one foot thick. None of the beds above the Tebo appear to be more than 14 inches thick except in small areas in this district. On the west side of Sand creek as far south as the latitude of Calhoun, a channel of Warrensburg sandstone cuts out the regular coal beds and the associated strata. Mines near the Whitcomb had to be abandoned, because their coal was cut off on the southwest by this sandstone.

South and southeast of Calhoun the Tebo coal thins out, but the Mulky and other higher beds are exposed near the hilltops, in Secs. 8, 16, 17 and adjacent lands of T. 42 N., R. 24 W. At the drift operated by Charles Crabb on land of R. Kirkpatrick (N. W. ¼ N. W. ¼ Sec. 8) 20 to 22 inches of coal (Bevier) lie beneath a shale roof. Under it are 13 inches of black shale bearing thin layers of coal and lying on more than one foot of clay. A thirty-inch coal bed with black laminated shale roof is said to be 30 feet below the one mined. The Bevier bed is also mined by W. E. Odell from a 14-foot shaft 1½ miles south (N. E. ¼ S. W. ¼ Sec. 17), where it is of the same thickness and character as at the Kirkpatrick drift. Hoisting is done by horse power and the product is sold locally. Over the coal is shale, and 26 feet above it is a blue argillaceous limestone eight feet thick. Southwest

of Odell's is the drift of Daniel Griffith (S. W. corner Sec. 22) in coal 26 to 30 inches thick underlying shale that is black and laminated ("slaty") at base and softer above. An old stripping near by showed four feet of coal that thinned laterally. Shaly coal at the same horizon was found in a drill hole and shaft 1½ miles to the east. These deposits are considerably lower than the Bevier on the hills to the northwest and are not far above the base of the Coal Measures. They lie in basins of small areal extent, but might, when thoroughly prospected, become important sources of fuel.

Windsor.—The Bowen Coal Co. is developing near Bowen, on the county line northwest of Windsor, a trough of thick coal very similar in many respects to the Mammoth coal of the Lewis district. The position of the center of the trough is indicated by the distribution of the shafts, viz.: (1) Shaft No. 5, 90 feet deep, S. W. ¼ N. W. ¼ Sec. 29, T. 44 N., R. 24 W.; (2) No. 3 (abandoned), 75 feet deep, S. E. ¼ S. E. ¼ Sec. 29; (3) No. 2, 72 feet deep, N. E. ¼ N. W. ¼ Sec. 33; (4) No. 4, 90 feet deep, N. W. ¼ N. E. ¼ Sec. 34; (5) No. 1 abandoned), N. W. ¼ S. W. ¼ Sec. 35. All of the working mines have substantial top works, steam hoists, and other modern machinery. Coal is shot off the solid. The product is large and is sold to the

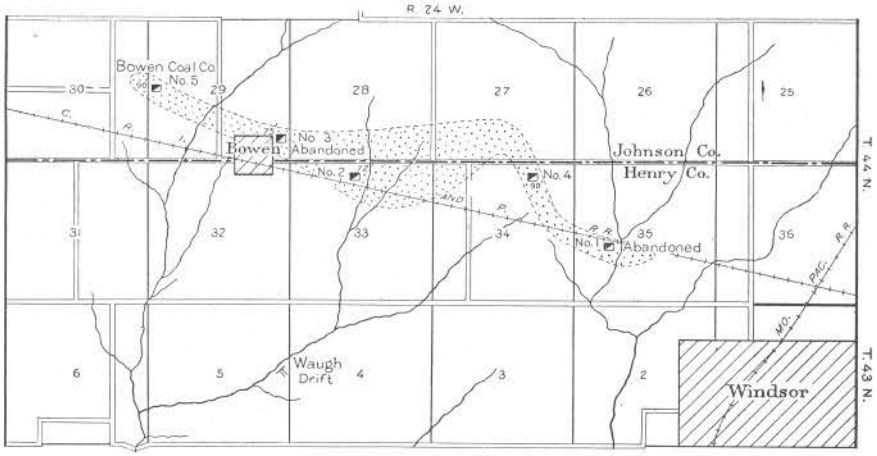

Fig. 35. The workable part of the Bowen trough near Windsor.

Rock Island railroad. The coal is hard and a good steam producer. Mine No. 5½ is small; it works with horse-power hoist on the edge of the trough near No. 2.

In the center of the trough the coal is 4 to 6½ feet thick, averaging 4½ where worked. A thin, persistent band of pyritiferous clay lies about 18 inches below the top of the bed; otherwise there is little "sulphur" except in the bottom of the bed. The bottom 12 to 18

inches of coal is dirty, containing much shale and pyrite, and in many places is left down. Over the coal are seven feet or less of black laminated shale, above which is an impure limestone of very variable thickness that helps support a very good roof. Out from the axis of the trough on either side, the bed rises and the top coal thins. The laminated shale above the coal also thins on the edges of the trough, and the limestone layer disappears, so that in places the top coal must be left up to support the roof. In many places, because of the poor roof on the outer edges, coal four feet thick is abandoned and left in the ground. The workable part of the trough was found to be widest, one-half to three-fourths mile, at Mine No 2; at No. 4 it is only 900 feet, and in other places only 700. The stratigraphic position of this coal with relation to higher rocks corresponds to that of the Tebo, but the conditions under which it was deposited were evidently far different from those governing the formation of the Tebo in the Lewis and Montrose districts.

Another bed of coal lies at an average of four feet below the bed mined and is one to 4½ feet thick. An attempt was made to mine both beds together, but the clay between them contains so much pyrite and so many thin seams of coal that it took fire when gobbed and caused much trouble. This lower bed will, therefore, never be recovered. No lower coals have been found, nor was the base of the Coal Measures reached in a drilling carried to a depth of 200 feet between mines Nos. 4 and 1. A regular and persistent bed of coal lies 20 feet or more above the thick coal described above, and is one to two feet in thickness, averaging 22 inches. The stratigraphic position of this bed is somewhat doubtful, but the best evidence available shows that it is the Bevier, the Mulky being absent and its cap-rock exceptionally thick. The following average section for the Bowen field shows its relation to the thicker coal below it:

		Feet.	*Inches.*
1.	Limestone, minimum 4 feet, maximum	15	....
2.	Shale, black, "slaty"	1	....
3.	Shale, drab	35	....
4.	COAL (Bevier)	1	10
5.	Shale, sandy	18	....
6.	Limestone, nodular, sandy	2	....
7.	Shale, black, "slaty"	5	....
8.	COAL, mined at Bowen	4	8
9.	Shale	4	....
10.	COAL	3	6
11.	Shale, sandy	50	....

At its eastern end the Bowen trough rises and has been removed by erosion. At Windsor itself there is a great development of sandstone, and borings 137 feet deep near the Missouri, Kansas & Texas depot passed through practically nothing but that material without reaching the base of the Coal Measures or finding any but very thin

beds of coal. A small trough, similar to that at Bowen, and probably a part of it separated from the main body by erosion, lies with its axis N. W.-S. E. across the county line 1½ miles southeast of Windsor. It is one-fourth mile long and 300 feet wide. Many small shafts, slopes, and strippings have nearly exhausted the supply of fuel, the only mine now working being the small shallow shaft of A. W. Stickrod on the Benton county side of the line (S. W. ¼ N. W. ¼ Sec. 18, T. 43 N., R. 23 W.). The mine is on the edge of the trough, where the roof is weak. The bottom coal of the bed mined is very dirty and is often not used. There are two bands of pyritiferous clay, one-half to three inches thick, one eight inches from the bottom and the other 30 inches higher. In the center of the trough black laminated shale lay on the coal, but it is absent on the edges. Five feet below the bed mined is another of nearly equal thickness that can not be profitably extracted. All of these characters correspond very closely with those of the Bowen trough. The following section of the overlying strata near the Stickrod mine discloses further similarity:

		Feet.
1.	Limestone, light gray, weathers nodular	5
2.	Shale, drab	4
3.	COAL, mined	5
4.	Clay	5
5.	COAL, reported	3

West of Windsor the coal bed (Bevier) lying next above the thick coal of the Bowen trough is mined in a small way at a number of places. Beds as high as the limestone cap-rocks of the Lexington coal are exposed on the tops of mounds in Secs. 5, 8, and 10, and on lower lands the Bevier coal is exposed 85 feet below them. Three miles southwest of the town are a number of strip-pits and also a new shaft operated by the Landers brothers.

SECTION AT LANDERS SHAFT (N. E. ¼ S. E. ¼ SEC. 9, T. 43 N., R. 24 W.).

	Feet.	*Inches.*
Soil, clay and sand	11	6
Shale, drab and blue	8	6
Shale, black, soft	....	4
COAL (Bevier)	1	10
Clay, in sump	4	....

The above section is typical for the thickness and associations of the Bevier in the district. At Snyders coal bank (N. W. corner Sec. 8) the coal is 28 inches thick. As shown in other exposures (e. g., S. W. corner Sec. 5) there is 18 to 24 inches of hard, blue limestone eight feet, more or less, below the Bevier, and under that 25 feet of shale that is drab at top and black and bituminous at base. Little or no coal was found at the Tebo or Mulky horizons. Three miles west of Windsor, Thomas Belcher is operating a drift on the land of Geo. Waugh (S. E. ¼ N. E. ¼ Sec. 5). The bed worked appears to be one

of the lower coals, but its exact stratigraphic position is doubtful. It is 21 inches thick and has over it 10 feet of shale that is black and laminated at the base. Four inches or less of black limestone lies on the coal in places. Eleven fee below, and separated from it by clay and shale, is another coal bed which is 20 inches thick.

HOLT COUNTY.*

The surface formations of Holt county are the Shawnee and Douglas, the former covering the greater part of the county. The Oread limestone, at the top of the Douglas shale, the lowest outcropping rock in the region, is found only low down in the valley of Missouri and Nodaway rivers near the mouth of the latter. It is evident, therefore, that the principal coal horizons lie at great depths. The only outcropping coal beds are the Elmo in the upper member of the Shawnee formation and the Nodaway, about 100 feet lower.† The Elmo coal is one foot or less in thickness and is of practically no importance. The Nodaway coal outcrops from the vicinity of Forest City to the north line of the county along the valley of Nodaway river. Where observed it also is too thin to mine, though it may thicken under cover to the north. At Forest City it measures six inches or less and in the northeast corner of the county only 10 inches. In the northwest corner it may be workable, however.

A drilling one mile north of Corning (near center Sec. 18, T. 63 N., R. 40 W.) shows the following section:

	Thickness. *Feet.*	Depth. *Feet.*
Shale, blue in adjacent outcrop	4	4
Limestone	2	6
Shale, sandy, with limestone 4 feet from base	74	80
COAL (Elmo), a few inches	....	80
Shale, etc., with limestone at base	99	179
COAL	....	....

Another drilling, sunk on the flood plain, where the surface is about 30 feet lower, found 16 inches of coal (Nodaway) at 150 feet.

The only reliable data concerning deep-lying coals are contained in the carefully kept record of the core drilling near Forest City.‡ According to this drilling there is no coal that could be mined under present market conditions.

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*The geology of Holt county is described by G. C. Broadhead (Iron Ores and Coal Fields, pt. 2, Mo. Geol. Survey, 1873, pp. 88-92, 128-134, 359-375). The topography of the southern portion is shown on the Atchison sheet of the U. S. Geol. Survey.

†For general section of outcropping rocks see report on Nodaway county.

‡A more complete record of this drilling is published in Water Supply Paper No. 195, U. S. Geol. Survey, 1907, pp. 62-64. A detailed record with correlations will be given in a publication now in preparation.

COAL SUMMARY, FOREST CITY DRILLING.

Horizon of coal bed—	Thickness. *Inches.*	Depth. *Feet.*
Ovid, near top of Pleasanton shale, poor quality	6	731
Lexington, at top of Cherokee, fair quality	4	889
No name, in upper part of Cherokee, inferior quality	4	986
Bedford (?), inferior quality	14	995
Bevier, fair quality, good roof and floor	15	1,039
Tebo, inferior quality	12	1,058
No name, inferior quality, considerable pyrite	9	1,070
No name	9	1,141
No name	5	1,252
No name	3	1,263
No name	3	1,286
No name	5	1,385
No name	10	1,390
No name	2	1,530
Thick limestone (Mississippian), lower limit of coal	....	1,620

The Bevier bed, the best shown in the drilling, is the one now extensively mined at Leavenworth, Kansas, and at many places in central Missouri. Its persistent character over large areas indicates that it probably retains an average of 15 inches in at least two-thirds of Holt county. The Bedford is persistent, though in a smaller degree, and probably averages 14 inches under half the county. Beds lower than the Bevier very likely thicken locally, though no evidence exists on this point. Since the beds dip north of west and the drilling was made on some of the lowest land in the county, any given horizon lies farther below the surface over the greater part of the region than it does at Forest City.

The total original tonnage of Holt county in beds of 14 inches or more is as follows:

Bed.	*Area.*	*Tonnage.*
Nodaway, 15 inches	50 square miles	72,000,000 tons
Bedford, 14 "	230 " "	309,120,000 "
Bevier, 15 "	307 " "	442,080,000 "
		823,200,000 tons

Broadhead§ describes a drilling one mile east of Oregon, which reached a depth of 656 feet, or to just below the Winterset limestone of the Kansas City formation. Eighteen inches of coal is reported at 204 feet, six inches at 344 feet, one inch at 374 feet, 15 inches at 440 feet, and 54 inches at 656 feet. Broadhead states, however, that the highest coal is probably chiefly bituminous shale and that examinations of specimens made by him indicated that the lowest bed of 54 inches was only bituminous shale with a few intercalated coal seams. Certainly it would be very surprising to find thick coal at the horizon at which this bed is reported.

§Iron Ores and Coal Fields, pt. 2, Mo. Geol. Survey, 1873, p. 371.

HOWARD COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....6,883 TONS.

Although settled at an early date and containing several beds of coal which, even if in greater part too thin for commercial purposes, might be extensively utilized for local consumption, Howard county has never produced much coal, a fact explained by the abundant supply of native timber and the proximity of the productive Higbee district of Randolph county. The only shipping mines ever operated are at Russell, whence the product is sent southwest over the Missouri, Kansas & Texas railway. The northeast quarter of the county really deserves more attention, for it contains what is for Missouri a fairly thick coal bed that could be easily reached by shafts on the prairie lands or by drifts in places on Bonne Femme, Salt Fork, Hungry Mother, and Moniteau creeks. The northern part of the county is in greater part prairie, but the remainder is cut by streams into numerous valleys from which most of the coal beds can be readily explored.

Broadly considered, the strata of the region are horizontal, though

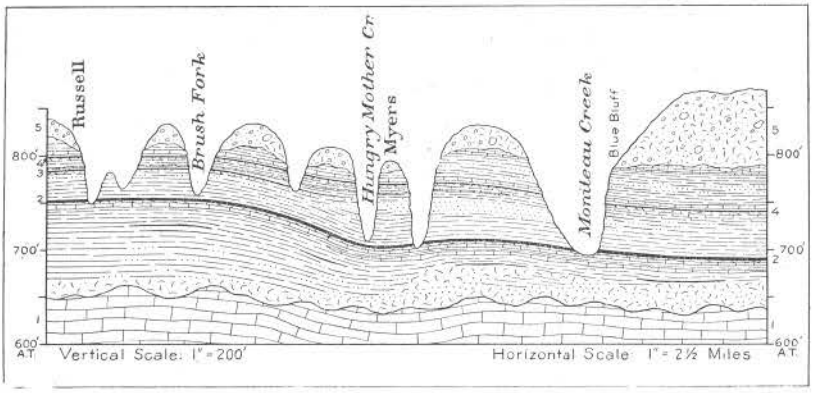

Fig. 36. Cross-section in northeastern Howard county. (1) Mississippian limestone. (2) Bevier coal. (3) Mulky coal. (4) Summit coal. (5) Glacial drift.

disturbed locally by sharp folds and in larger areas by a few low anticlines or arches. Thus at Blue Bluff, Myers, and Russell, the strata are slightly elevated by one or more of these arches. At Glasgow the Coal Measures extend below river level, but rise in the river bluffs

*In describing Howard county considerable aid was derived from the report by G. C. Broadhead and C. J. Norwood (Missouri Geol. Survey, Rept. for 1873-1874, pp. 179-221). As will be more fully explained in a report on "The Pennsylvanian of Missouri," now in preparation, errors were made by Norwood in compounding sections at Sebree, so that the general county section given here differs from his in important particulars. For a map of the geology and topography of part of the northern area see the Huntsville sheet, republished in this volume in connection with the Randolph county report. The topography of nearly the entire county is shown on the Glasgow and Moberly sheets of the U. S. Geol. Survey.

north of Richland creek so that the Mississippian limestones beneath them are exposed. The rise continues to a point two miles north of Lisbon, where the base of the Coal Measures is nearly 150 feet above the Missouri, and is then replaced by a dip to the south that causes Pennsylvanian sandstone to appear in the creek bed one mile east of Lisbon. At and east of New Franklin the Mississippian is again high in the bluffs and the outcrops up Bonne Femme and Salt creeks to within a few miles of Fayette. At Rocheport, also, only pockets of Coal Measures are found, the Mississippian forming the bluffs and outcropping far up Moniteau creek. A line drawn from Rocheport or New Franklin to a point just south of the mouth of Richland creek would probably correspond to the axis of another arch.

The Coal Measures of Howard county include four regular coal beds and strata from lowest Pleasanton to the base of the Cherokee, as shown in the general section given below. In this section the portion above the Mulky coal bed is as in the Armstrong and Burton districts, and the portion from the Mulky to the Mississippian is at Myers and near Sebree.

GENERAL SECTION.

Pennsylvanian series in Howard county.

Number.	*Stratum.*	Thickness. *Feet.*	Total from top. *Feet.*
Pleasanton shale—			
1.	Shale, sandy, with layers of sandstone	30	30
Henrietta formation—			
2.	Limestone, gray, rough bedded, impure, with specks of calcite	2	32
3.	Shale, light buff, with small round nodules	3	35
4.	COAL, streak	....	35
5.	Shale, drab, calcareous at top	11	46
6.	Limestone, blue, weathers drab, rough on top, in one layer	2	48
7.	Shale, drab, with thin lenses of limestone	1	49
8.	Limestone, dark blue to dove, irregularly bedded above, massive below	6	55
Cherokee shale—			
9.	Shale, coal streaks at top (horizon of Lexington coal bed)	3	58
10.	Limestone, weathers dove-color, irregularly bedded, (the "Chaetetes Limestone" of Broadhead)	7	65
11.	Shale, drab	18	83
12.	Limestone, dark to grayish blue, in two layers that break into slabs with square sides, forms pavements in creek beds	3	86
13.	Shale, drab at top and black below, "slaty"	2½	88½
14.	COAL (Summit)	1½	90
15.	Clay, with nodules and beds of limestone in lower part	6	96
16.	Limestone, weathers drab, in one layer	1½	97½
17.	Shale, dark, "slaty" at base, with small limestone concretions	2	100
18.	COAL (Mulky)	½	100½
19.	Clay and shale, with thin beds of sandstone	37	137½
20.	COAL (Bevier), thin clay parting in lower part	3	140½
21.	Clay	1	141½
22.	Limestone, dark blue to gray, irregularly bedded, numerous clay partings in upper part	2½	144
23.	Shale, with limestone layers and nodules	4	148

GENERAL SECTION—Continued.

Number.	*Stratum.*	Thickness. *Feet.*	Total from top. *Feet.*
24.	Limestone, dove to bluish gray, compact and almost massive	3	151
25.	Shale, sandy	3	154
26.	Shale, black, "slaty," with thin limestone layer below the center	8	162
27.	COAL (Tebo)	1½	163½
28.	Clay, various light shades, includes some sandstone and irregular coal beds	24	187½
Mississippian series—			
29.	Limestone, thick-bedded, coarse-grained	....	....

The above section will not hold exactly true for every locality in the county, as individual members are subject to local variations in thickness and character, but the part above the Bevier sump-rock is fairly regular. The lower members were laid down on or near the uneven upper surface of the Mississippian limestone under changeable conditions of deposition, this being especially the case with beds below the Tebo horizon. For this reason non-persistent coal beds and pockets, such as those found near Boonesboro and Rocheport, are not included in the table. Numbers 1 to 9 of the general section are found only near Armstrong and Roanoke, but the "Chætetes Limestone" (No. 10) outcrops conspicuously in ledges or tumbled masses near the ridge tops in nearly all of the remainder of the coal-bearing area north of Twp. 49, furnishing an excellent marker for the prospector. In the northern part of the county, drift, 50 feet or more in thickness, conceals the stratified rocks under the prairies; farther south it is not so abundant, although near the Missouri river it forms a thick mantle of fine sandy clay known as loess.

The highest regular coal bed is the Summit, which lies about 25 feet below the "Chætetes Limestone," and is easily located by its resistent cap-rock (No. 12), called by Broadhead the "Rhomboidal Limestone" because of its perpendicular fracture. The coal seam is very irregular in thickness, though persistent in occurrence, and appears to best advantage east of Fayette and north of Sebree. The Mulky coal bed is absent in most of the county, though about 18 inches

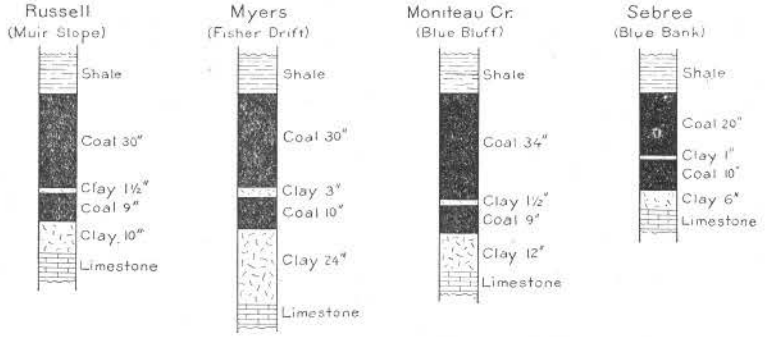

Fig. 37. The Bevier coal bed in Howard County.

thick near Russell. The Bevier coal bed, which is about 50 below the Summit, is the most important in the region. It underlies the entire northwestern quarter of the county as a bed 30 to 45 inches thick with a two-inch clay parting in its lower portion. It is seen at its best on Moniteau creek east of Myers. Whether the Bevier horizon bears much thick coal south and west of a line drawn through Sebree, Burton, and Roanoke is a question that cannot be answered. A coal that appears to be the Bevier is about three feet thick north of Boonesboro and east of Fayette, and it is highly probable that similar deposits will be located elsewhere at the Bevier horizon. The lowest regular coal bed, the Tebo, which lies only a short distance below the Bevier, is very rarely more than 15 inches in thickness and is very thin or lacking in many places. Whether it is present in the northern part of the county, where no streams have cut down sufficiently to expose it, is unknown, though the probabilities are that if present it is not of minable thickness. Coal beds lower than those mentioned above may exist as large or small basins under the prairie lands, but no regular beds lie at those levels.

The following table, a considerable modification of one made by Broadhead, is only a rough estimate of the amount of coal in the county. In it beds or parts of beds less than 14 inches thick are not included except when thin portions of a certain bed are combined with thicker portions to form an average for a township. There are considered to be 1,800 tons to the acre-foot:

Township.	Range.	Thickness of beds.	Area in square miles.	Tons of coal.
52 N.	14 W.	Mulky 18 inches, Bevier 40 inches	6	33,408,000
52 N.	15 W.	Mulky 16 inches, Bevier 30 inches	17	75,072,000
52 N.	16 W.	Bevier 24 inches, Tebo 14 inches	28	102,088,000
52 N.	17 W.	Bevier 18 inches, Tebo 18 inches	14	48,384,000
51 N.	14 W.	In part Summit and in part Mulky 14 inches, Bevier 40 inches, Tebo 14 inches	29	189,312,000
51 N.	15 W.	In part Summit and in part Mulky 14 inches, Bevier 30 inches	36	152,064,000
51 N.	16 W.	Bevier 24 inches	36	82,944,000
51 N.	17 W.	Bevier 18 inches, Tebo 14 inches	12	36,864,000
50 N.	14 W.	Summit 18 inches, Bevier 34 inches, Tebo 15 inches	13	83,616,000
50 N.	15 W.	Summit 18 inches, Bevier 24 inches, Tebo 14 inches	31	166,650,000
50 N.	16 W.	Summit 14 inches, Bevier 14 inches, Tebo 14 inches	32	129,024,000
50 N.	17 W.	Summit 14 inches, Bevier 20 inches, Tebo 14 inches	26	119,808,000
49 N.	14 W.	Tebo 17 inches	2	3,264,000
49 N.	15 W.	Tebo 14 inches	16	21,504,000
49 N.	16 W.	Tebo 14 inches	7	9,408,000
49 N.	17 W.	Tebo (?) 18 inches	10	17,280,000

The above estimate places the amount of coal in the regular beds at 1,270,690,000 tons. In addition there are probably about 10,000,000

tons in pockets and basins like those two miles east of Armstrong, near Boonesboro and Rocheport, and concealed beneath later deposits in various districts, making the total original coal reserve of the county 1,280,690,000 tons. As the recorded production is only 84,505 tons and the unrecorded output in early years and from small mines about as much more, it is evident that nearly the entire original content is still in the ground.

DETAILED MENTION.

Russell.—Russell, a flag station on the Missouri, Kansas and Texas Railway, is the only locality in Howard county in which shipping mines have been operated. The only mine now open was installed in 1910, one-half mile northeast of Russell (S. E. ¼ N. E. ¼ Sec. 25, T. 52 N., R. 15 W), by John Muir. The Bevier coal, 40 inches thick, lies 30 feet below the level of the railroad and is reached by a short slope up which cars are hauled by steam power. Near the slope mouth the roof over the coal seam is a soft clay shale that probably becomes stronger farther back under the hill. Drillings a short distance east are said to show a firm sandstone roof that will make longwall operations practicable.

In the abandoned shipping mines at Russell the Bevier coal bed lay at the level of Salt fork and is said to have become thinner and to have had a weaker roof at the west end of the workings. Drillings one to two miles west of Russell are reported to have reached no workable coal, but as no detailed information could be obtained it is impossible to say definitely that the western limit of thick coal was located. Southeast of Russell the Bevier bed holds its full thickness to the county line and beyond. The Mulky coal bed is 18 inches thick and of excellent quality; though the Summit bed in most places measures less than 14 inches. The Mississippian is said to lie 110 feet below Salt fork at Russell and consequently an equal distance below the Bevier horizon. South from Russell Bevier coal may reach 35 feet above Salt fork but again dips below water level north of Burton.

Burton.—On Bonne Femme creek, two miles west of Burton, the Bevier coal bed is 30 inches thick and outcrops 11 feet above water level. It is occasionally worked winters for local trade. Norwood states that one mile southwest of Burton the Bevier bed outcrops low down in Salt fork valley with the Summit cap-rock 60 feet and the "Chætetes Limestone" 89 feet higher. At and above Burton the "Chætetes Limestone" is conspicuously developed high in the bluffs, the Summit coal is mined in a very small way up some of the larger tributaries, and the Bevier coal is just below the level of Salt fork. In a draw in section 10, two miles northeast of Burton, is the following section;

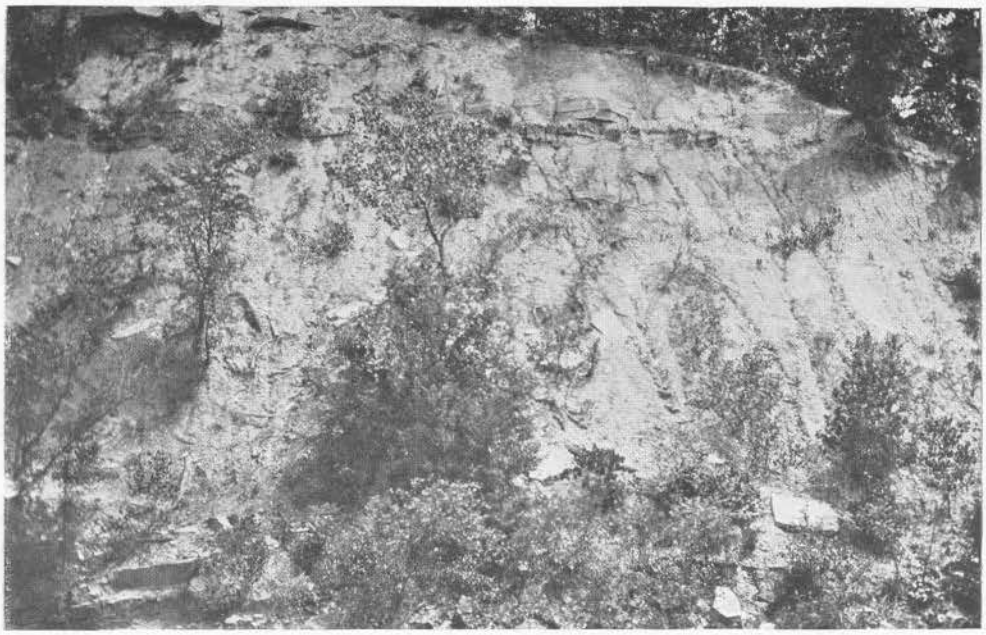

Fig. 1. Blue Bluff on Moniteau creek, Howard county, showing Summit and Bevier coal beds.

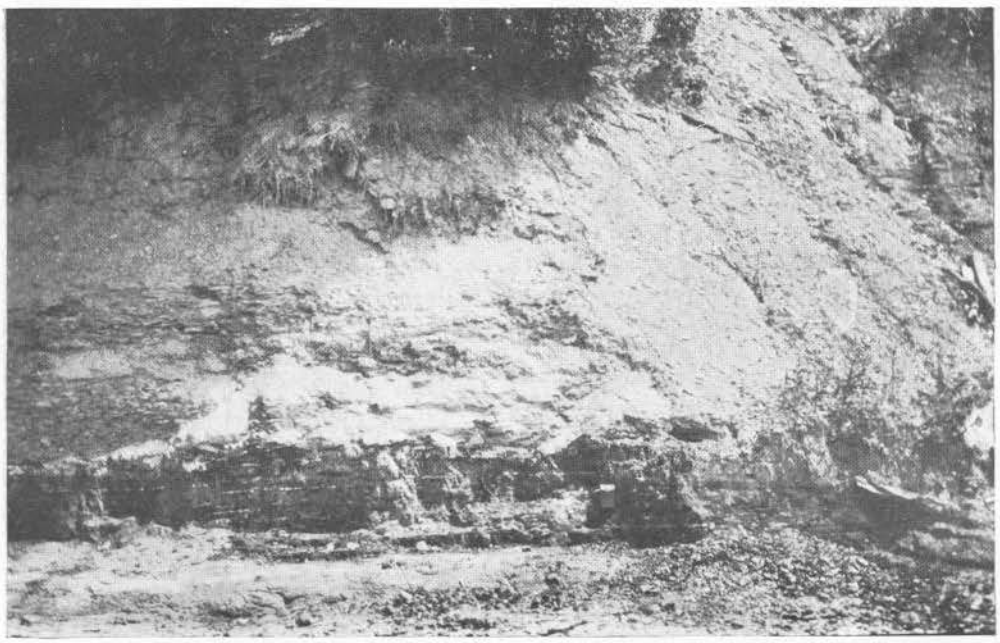

Fig. 2. A closer view of the Bevier bed at Blue Bluff.

		Feet.	Inches.
1.	"Chaetetes Limestone"	2	....
2.	Concealed	18	....
3.	Limestone, dark blue, weathers grayish drab, massive, compact	3	....
4.	Clay	....	6
5.	Shale, blue, "slaty"	1	6
6.	COAL (Summit), reported to be 18 inches in neighborhood	....	9
7.	Clay	2	....
8.	Limestone, small nodules in clay matrix	2	....
9.	Limestone, thin-bedded	5	....

Myers.—In the valley of Hungry Mother creek, near Myers (Bunker Hill), the position of the Summit coal, here 17 inches thick, shows that the Bevier lies at or just below creek level. In the valley on the east side of Myers a slight anticline or monocline brings the Bevier above water level and it is mined in a small drift on the land of J. D. Fisher (N. E. ¼ N. W. ¼ Sec. 17, T. 51 N., R. 14 W.). South for several miles outcrops are few and it is probable that the Bevier dips below Hungry Mother creek. The strata near the Fisher drift are:

		Feet.	Inches.
1.	"Chætetes Limestone"	....	....
2.	Shale, sandy	26	....
3.	Limestone, dark blue	3	....
4.	Shale, black, "slaty"	2	6
5.	COAL (Summit)	1	5
6.	Clay	2	....
7.	Limestone, nodules in clay matrix	4	....
8.	Limestone, brownish blue, weathers drab, compact (Mulky cap-rock)	1	5
9.	Shale, calcareous	4	....
10.	Sandstone, light buff, thin-bedded	21	....
11.	Concealed, about	17	....
12.	Shale, light drab, clayey, a fair mine roof	1	....
13.	COAL, 2 feet, 6 inches Clay, 0 " 3 COAL, 0 " 10 } (Bevier)	3	7
14.	Clay	2	....
15.	Limestone, dark blue, weathers brownish drab, concretionary on top, compact	1+	....

A short distance north of the road from Myers to Rucker, Moniteau creek has carved out a conspicuous topographic feature known as Blue Bluff, which furnishes the following excellent exposure:

		Feet.	Inches
1.	"Chætetes Limestone," dove color, irregularly bedded	2+	....
2.	Concealed, probably shale, about	8	....
3.	Sandstone, light red, thin bedded, in part a very sandy shale	12	....
4.	Interval, in all or greater part shale	10	....
5.	Limestone, dark blue, weathers bluish gray, upper 4 inches laminated, parting in center, very firm and compact	3	....
6.	Shale, black, "slaty"	2	6
7.	COAL (Summit)	1	10
8.	Interval, containing limestone nodules at base	10	6
9.	Shale, light gray, very sandy	19	....
10.	Shale, light blue above, dark drab below, a good mine roof	18	....
11.	COAL, 2 feet, 10 inches Clay, 0 " 1½ " COAL, 0 " 9 " } (Bevier)	3	8½
12.	Clay	1	....
13.	Limestone, light gray, concretionary on top	2	6

It may be seen from this section that the Summit coal bed in this district is 20 inches thick, with an ideal roof, and that the Bevier bed is nearly 4 feet thick and carries coal of excellent quality. The entire northeast corner of Howard county is an important and neglected coal field that will some day yield largely. From Blue Bluff down Moniteau creek to Sebree the Bevier coal outcrops at intervals, but up the stream it dips, so that in most places the Summit is the lowest bed exposed. One-half mile below the Randolph county line the following section shows the Mulky cap-rock. Both the Mulky cap-rock and the Mulky coal are absent at Blue Bluff and throughout Boone county, though typically developed at Russell and farther north.

		Feet.	*Inches.*
1.	"Chætetes Limestone," as at Blue Bluff	10	....
2.	Shale, sandy, light buff above and separated from darker shale below by red sandstone	21	....
3.	Limestone, dark blue, weathers bluish gray to drab, compact, parting in center, forms pavements in creek bottoms	3	....
4.	Shale, black, "slaty"	2	8
5.	COAL (Summit)	1	8
6.	Clay	3	....
7.	Interval containing limestone nodules in clay and also some beds of limestone	14	....
8.	Limestone, dark blue, weathers dark grayish drab, compact, massive (Mulky cap-rock)	2	6

Sebree.—Near Sebree three workable coal beds outcrop, and the two lower underlie all of the higher lands of the district. The Summit bed is 20 inches thick, the Bevier 30 inches, and the Tebo very variable, ranging from a mere streak to 20 inches. Both the Summit and Bevier could be easily and profitably mined if transportation facilities were adequate. The Summit coal, which is separated from its limestone cap-rock by two feet of "slaty" shale, lies 40 feet above the site on which Sebree stands. The Bevier coal is well exposed at Blue Bank, one mile northeast of Sebree, where it is intermittently worked by small local drifts at the bottom of a narrow valley.

SECTION AT BLUE BANK.

		Feet.	*Inches.*
1.	Sandstone, thin-bedded, and sandy shale	15	....
2.	Shale, light drab, rather sandy	14	....
3.	Shale, light blue above, very dark blue below	12	....
4.	COAL, 1 foot, 8 inches Clay, 0 " 1 " COAL, 0 " 10 " (Bevier)	2	7
5.	Clay	....	6
6.	Limestone, dark blue, weathers light gray, irregularly bedded, partings of clay most numerous in upper part	2	6
7.	Concealed	3	....
8.	Limestone	....	....

The lowest Coal Measures rocks are exposed in an old railroad cut and in Moniteau creek, one mile northwest of Sebree, as shown in the following section:

		Feet.	Inches.
1.	Limestone, bluish gray, weathers brownish gray, irregularly bedded, many thin clay partings, especially in upper part, same as No. 6 of Blue Bank section	2	6
2.	Interval, shale with some concretionary limestone	4	....
3.	Limestone, bluish gray, weathers light dove, massive except for parting in center	3	2
4.	Shale, sandy	3	....
5.	Shale, black, somewhat "slaty"	5	.....
6.	Limestone, dark blue, weathers red and yellowish drab, semi-crystalline	....	6
7.	Shale, black, "slaty"	2	6
8.	COAL (Tebo)	1	7
9.	Clay, yellowish and bluish white	12	....
10.	Sandstone, gray to brown, poorly exposed	6	....
11.	Clay, variegated, extends to water in Moniteau creek	6	....

About a quarter mile up Moniteau creek from this cut Mississippian limestone forms the stream bed and outcrops under number 11 of the above section at intervals for a mile farther up. In one of these exposures one foot of dirty coal appears three feet above the Mississippian limestone, under six feet of thin-bedded sandstone that probably corresponds to number 10 of the section. Two miles northeast of Sebree the Tebo coal is merely a three-inch streak.

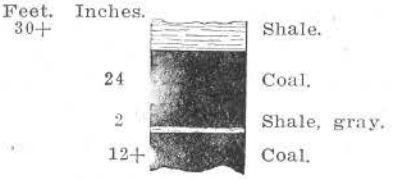

FIG. 38. The Bevier coal bed at old Gilvin drift.

Winslow† mentions the old Gilvin drift (in Bevier coal) in the bottom of a hollow about three miles northeast of Sebree and adds that another coal bed (Summit) outcropped in the hill about 40 feet higher. The following section, measured by M. E. Wilson in the small eastern tributaries of Moniteau creek in this vicinity, shows the relationship of the coal beds:

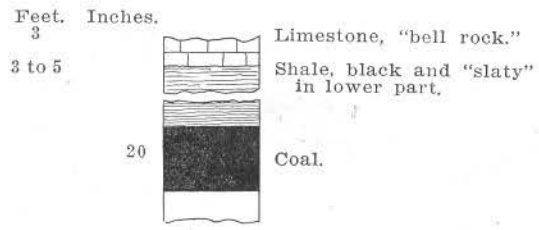

FIG. 39. The Summit coal bed at old Gilvin drift.

†Preliminary report on coal: Mo. Geol. Survey, 1891, p. 89.

		Feet.	Inches.
1.	Limestone, light colored, irregularly bedded, clay parting 4 feet from base ("Chætetes Limestone")	10	....
2.	Concealed, about	25	....
3.	Shale, brown, sandy	3	....
4.	Limestone, compact	3	....
5.	Shale, black, "slaty"	2	....
6.	COAL (Summit), probably a local thickening	2	6
7.	Limestone and clay containing limestone nodules, about	10	....
8.	COAL (Mulky)	....	6
9.	Shale, sandy	20	....
10.	COAL (Bevier), not the full thickness	2	....
11.	Clay, brownish, sandy	2	....
12.	Limestone, top weathers unevenly	2	6
13.	Shale, and concealed	8	....
14.	Limestone, hard	2	6
15.	Shale, and concealed	2	....
16.	Shale, black, "slaty"	3	3
17.	Shale, drab, sandy	3	....
18.	COAL (Tebo)	....	6
19.	Clay	5	....

Fayette.—All of the coal beds found near Fayette are thin, though containing coal of good quality and though having excellent roofs, and are mined only for the city trade by a few small drifts near town. Two miles east of Fayette are drifts on the land of L. Marshall (N. W. ¼ S. E. ¼ Sec. 7, T. 50 N., R. 15 W.), Mrs. Elkins (S. E. ¼ N. E. ¼ Sec. 7) and J. D. Fisher (N. W. ¼ S. W. ¼ Sec. 8). Three miles farther east and two miles south is the W. H. Collins drift. Two miles south of Fayette, near the Bonne Femme bridge on the Rocheport road (S. W. ¼ N. W. ¼ Sec. 24, T. 50 N., R. 16 W.), is a new drift at the level of the creek bottoms. All of these mines, with the possible exception of the last, work the Summit coal on the longwall system, wedging it down. White calcite and gypsum films appear in the joint planes, but pyrite is not abundant. The shale between the coal and its cap-rock is 30 inches thick at the mines east of the city and 40 inches at the drift on the Rocheport road. The coal itself is 18 to 20 inches thick. It outcrops in a great may places in this part of the county, commonly

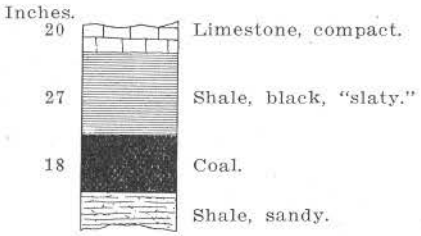

FIG. 40. The Summit coal bed at Elkin's drift.

well up in the valleys. Its relations to other strata are shown in the following measurement made on the county road beside the Marshall drift:

		Feet.
1.	"Chætetes Limestone," dove-color, irregularly bedded	4
2.	Shale, sandy above, clayey below	22
3.	Limestone, dark gray, compact, massive	1½
4.	Shale, gray	1
5.	Shale, bluish black, "slaty"	2
6.	COAL (Summit), worked in drifts	1½
7.	Clay and shale, slightly sandy, contains nodules of limestone	6
8.	Limestone, light gray, weathers drab, massive (Mulky cap-rock)	2
9.	Shale, light gray, sandy	18

An old shaft near the Marshall drift worked a three-foot coal said to lie 40 feet below the Summit bed, and Mr. Collins reports a similar bed 45 feet below the one now mined by him. This thicker coal is presumably the Bevier bed as found at Sebree and may underlie nearly all of central Howard county. That it is not more generally known may be explained by the fact that for the most part it lies too low to outcrop and that few wells on the ridges are sufficiently deep to reach it.

In the southwest corner of Fayette, at the pit of the Fayette Brick and Tile Company, 18 inches of excellent coal, attaining in places a thickness of 26 inches, has been much drifted in a small way in the neighborhood. It is overlain by at least seven feet of drab and black shale and its position low down in the valley indicates that it is one of the non-persistent beds lying at or just below the Tebo horizon. The limestone cap-rock of the Summit coal may be seen under the armory at Central College and on the sides of the ridges in most of the county northwest and southwest, the "Chætetes Limestone" outcropping above it. Over much of this territory, however, the Summit coal is too thin to be of importance. The following section is now exposed on Dr. Beck's land, four miles southwest of Fayette (Sec. 29, T. 50 N., R. 16 W.):

		Feet.	Inches.
1.	Limestone, in fragments, resembles "Chætetes Limestone"	....	....
2.	Concealed	20	....
3.	Limestone, nodular on top, impure	2	....
4.	Shale, drab	1	6
5.	Limestone, blue on fresh fracture, bedded	1	8
6.	Shale, black and "slaty" at base	5	....
7.	COAL (Summit?)	.. 1	2
8.	Clay	....	8

Four miles south of Fayette, on land of I. C. Darby (S. W. ¼ Sec. 35, T. 50 N., R. 16 W.), a little stripping has been done in a bed that lies about 70 feet below the ridge tops and only eight feet above the Mississippian limestone. The coal is reported to be two to three feet thick and has a roof of slaty shale. It is probably not a blanket seam underlying a large area, yet it is highly probable that other basin deposits of similar type are common.

Rocheport.—The bluffs at Rocheport are composed of massive Mississippian limestones, the regular beds of the Pennsylvanian appearing only on the high lands back from the river. Here and there along

the bluffs, however, numerous pockets of coal, some of them thick, are found filling ancient ravines in the older formations.

Five miles and more northwest of Rocheport an eighteen-inch coal bed has been mined by stripping and drifting. In the S. E. ¼ Sec. 16, T. 49 N., R. 15 W., a strip-pit shows 14 to 18 inches of coal overlain by black and drab shale beneath a very thin limestone band. Coal 18 inches or less in thickness has also been mined in a small way in sections 5, 18, 19 and 28 of T. 49 N., R. 15 W. The correlation of these exposures is slightly uncertain, though the probabilities are that the coal in most of them is the Tebo. Mr. Wilson found a thicker coal bed, perhaps only a pocket, about seven miles north of Rocheport (N. W. ¼ Sec. 34, T. 50 N., R. 15 W.), where he measured:

		Feet.	*Inches*
1.	Limestone	....	7
2.	Shale, drab, clayey	8	....
3.	Shale, dark, "slaty"	2	2
4.	COAL	1	4
5.	Concealed	20	....
6.	COAL	6	....

Boonesboro.—Several small strip-pits and drifts in the vicinity of Boonesboro mine a coal bed 18 to 24 inches thick. The limestone cap-rock, separated from the coal by a thin "slaty" shale, is much like the Summit cap in the northern part of the county; it also resembles the limestone above the Tebo coal, however, and may be identical with it. The coal in the outcrops close to the village is more like the Summit coal than is that in the outcrops farther southeast, where the coal lies only 20 feet above the flint conglomerate at the base of the Coal Measures. Broadhead and Winslow describe a coal bed more than 6 feet thick three miles west of Boonesboro (S. E. ¼ Sec. 6, T. 49 N., R. 17 W.), near the base of the Coal Measures; but it is likely that this thick coal is confined to a basin of very small extent. A more regular bed is exposed on the Whiten place, two miles southeast of Boonesboro (N. W. ¼ Sec. 15, T. 49 N., R. 17 W.), where it is 14 to 22 inches thick, and farther north on the J. Jones farm (Sec. 10), where the following section shows the nature of the associated rocks:

		Feet.	*Inches*
1.	Sandstone, both massive and thin-bedded	35	....
2.	Concealed	3	....
3.	Coal streak	....	....
4.	Limestone, very nodular	2	....
5.	Concealed, about	4	....
6.	Limestone, dark blue on fresh fracture, rather massive	3	....
7.	Shale, black, "slaty"	4	....
8.	Shale, dark, clayey, very irregular in thickness, here	....	6
9.	COAL	1	2

Close to Boonesboro the following is exposed at one coal bank:

		Feet.	*Inches*
1.	Limestone, 3-inch clay parting in center	3	....
2.	Shale, "slaty," with large limestone "niggerheads"	2	6
3.	COAL, 18 inches to	1	10
4.	Clay and shale	4	4
5.	Limestone, bluish, upper surface rough	1	8
6.	Clay, blue, with crystals of gypsum	2	....

Northeast of Boonesboro, in a small tributary of Sulphur creek (S. E. ¼ Sec. 23, T. 50 N., R. 17 W.), what may be the Mulky bed appears as a thin coal of little importance underlain by more than 30 feet of sandstone and sandy shale. At a lower level, in the bed of Sulphur creek, a bed that has been stripped at several places in the vicinity has the association shown below:

		Feet.	Inches.
1.	Limestone, blue, firmly cemented, in fragments	....	....
2.	Shale, black, "slaty," with "niggerheads"	2	6
3.	Clay, black	....	6
4.	Shale, drab ("soapstone")	7	....
5.	COAL	1	6

Four miles north of Boonesboro, on the land of J. A. Jackson (N. W. ¼ N. E. ¼ Sec. 21, T. 50 N., R. 17 W.), is an important occurrence of coal shown in the accompanying figure. The bed dips gently to the north down Copperas branch and outcrops at intervals for 1½ miles down stream, with an average thickness of about 28 inches. It

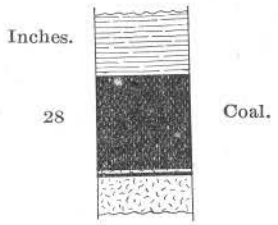

Fig. 41. Coal bed at Jackson pit.

is possible that this thick coal seam underlies a considerable territory, for 30 feet or more of clay shale similar to that overlying the coal outcrops in several ravines between Boonesboro and Richland creek. That this is the Bevier coal bed is indicated by the nature of the deposit and by the overlying material observed on the Boonesboro-Glasgow road, near the Jackson strip-pit, as shown in the following section:

		Feet.
1.	Limestone, dark blue when fresh, bluish drab when weathered, massive	1½
2.	Shale, black, "slaty," with many small flat concretions and a few limestone "niggerheads"	3
3.	Interval, chiefly shale	20
4.	Shale, bluish drab, darker below	15
5.	Concealed (horizon of thick coal?)	3
6.	Limestone, dove-color, irregularly bedded (type of Bevier sump-rock)	2
7.	Shale, light drab	3

Glasgow.—No coal sufficiently thick to justify mining under modern conditions is known to outcrop near Glasgow. Low in the bluffs, as shown in sections published in Broadhead's Howard county report, is one foot of coal at or near the Tebo horizon. This bed is only a short but somewhat variable distance below a conspicuous limestone stratum and was observed in an excavation recently made below the level of

the railway track just north of the Wabash depot. On the south side of the mouth of Hurricane creek, nearly 60 feet of red micaceous sandstone forms prominent bluffs containing no coal. The tops of the ridges on either side of Greggs and Hurricane creeks bear outcrops of the "Chætetes Limestone," with higher formations near the heads of the streams. The Summit coal, which is less than one foot in thickness, lies 30 feet below the "Chætetes" and about 50 feet above the rather thick limestones lying just below the Bevier horizon. The strata between the Summit coal and the lower limestones consist chiefly of sandy shale.

Armstrong.—So far as known little coal of importance underlies the Armstrong district. Two miles east of town the old Briggs (S. W. ¼ N. E. ¼ Sec. 25) and Beech (N. E. ¼ S. E. ¼ Sec. 25) coal banks formerly mined a few tons from drifts and from a shallow shaft; the thickness of coal at the Briggs bank is reported as 30 inches and that at the Beech bank as over four feet. There is no doubt, however, that these mines worked in a basin of coal that underlies a very small area. The beds lie just above part of the Henrietta formation and form part of the base of a channel deposit, tributary, perhaps, to the main Moberly channel shown on the Huntsville sheet.

The two coal beds next lower in the section, the Summit and the Mulky, outcrop in nearly every sharply cut stream valley, but are only one foot or less in thickness over most of the northwest part of the county. It is highly probable that outlying basins of coal exist at the Bevier horizon, which lies 50 feet below the Summit bed and about 110 feet beneath the level of Armstrong; for the Bevier coal measures three feet on Finnel branch two miles north of the Howard county line, two feet near the extreme northwestern corner of the county, 41 inches near Yates, and 30 inches on Bonne Femme creek two miles west of Burton. It is also probable that coal exists at the Tebo horizon in most of the district, though it varies greatly in thickness. On the south side of Doxies creek at Rattlesnake spring, about 1½ miles east of the Chariton county line, the following section was measured at a small abandoned drift:

		Feet.	*Inches.*
1.	Coal smut (Bevier)	....	....
2.	Clay, with limestone nodules in lower half	2	....
3.	Limestone, dove-color, very roughly bedded in upper part	3	....
4.	Shale	1	6
5.	Limestone, dove-color	....	6
6.	Shale	....	10
7.	Limestone, light blue with dark blue spots, irregularly bedded at top	1	8
8.	Shale, black, "slaty"	4	....
9.	Clay, drab	....	6
10.	COAL (Tebo), reported	1	6

In the extreme northwest corner of the county several small drifts are now working the same bed for local supplies. The following sec-

tion was made on the land of Chas. Eiring (N. E. ¼ Sec. 2, T. 52 N., R. 17 W.), below thin limestones corresponding to the Bevier sumprocks:

		Feet.	*Inches.*
1.	Shale, black, "slaty," with a few "niggerheads"	2	9
2.	Clay, fairly firm, a local thickening	3	4
3.	COAL (Tebo), hard, some white scale, pyrite in fine streaks, thickness 16 to 30 inches, average	1	8

JACKSON COUNTY.*

Coal was formerly mined in Jackson county at the Brush Creek mine, a few miles southeast of Kansas City, but at present the county is not a producer.

The Kansas City, the formation of thick limestones and interbedded shales so conspicuously exposed in the bluffs at Kansas City, is at the surface over most of the county. In the northern and eastern portions of the region, especially along the Little Blue and Sniabar, the lower limestones of this formation cap a rather steep escarpment. On the slopes below them Pleasanton shale is exposed. In a few places along the lower course of the Sniabar the uppermost limestones of the Henrietta formation appear. All the more important coal horizons of the State therefore lie below the surface in all parts of the county.

The unexposed portion of the Coal Measures is well shown in the Randolph record contained in the Clay county report and less exactly in the records contained in this report. The highest important coal horizon is that of the Lexington, the bed so extensively mined in Lafayette and Ray counties. About 140 feet lower is another persistent coal, the Bevier, the bed now mined at Leavenworth and formerly at Randolph. The probable depth, thickness, and character of the Lexington bed in northern Jackson county may be best judged from its known occurrences at Randolph and Missouri City in Clay and Orrick in Ray county, and in eastern Jackson from the descriptions of mines near Napoleon, Greenton, and Odessa in Lafayette county. Aside from information derived from the mine and records at Randolph, the only data that is at all reliable in regard to coal beds lower than the Lexington are contained in records at Kansas City and Independence.

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*The section at Kansas City was first described by G. C. Broadhead: Mo. Geol. Survey, Rept. for 1872, pt. 2, pp. 95-98, 104-108. In a forthcoming report of this Bureau the geology of the county will be described in detail. The coal is mentioned by Arthur Winslow: Prelim. Rept. on Coal, Mo. Geol. Survey, 1891, pp. 116-117. The quarry products are described by E. R. Buckley and H. A. Buehler: Mo. Bur. Geology and Mines, Vol. II, second ser., 1904, pp. 227-242. The lime and cement materials are discussed by H. A. Buehler: Mo. Bur. Geology and Mines, Vol. VI, second ser. 1907, pp. 142-147. The topography is shown on the Kansas City, Independence, Harrisonville and Olathe sheets of the U. S. Geol. Survey.

In the absence of accurately kept drill records it is impossible to estimate accurately the coal resources of the county. The information available indicates that the total average thickness of coal in beds not less than 14 inches thick is three feet, which would make the total original tonnage of the county 2,097,792,000 tons.

DETAILED MENTION.

Kansas City.—The only large mining venture in the county was the Brush Creek shaft, sunk near the creek of that name, two miles southeast of the city limits, and abandoned in 1904. Reports differ as regards depth and thickness of the coal, but all agree that there were two beds of sufficient thickness to mine. The following is a partial record of the shaft:

SHAFT AT BRUSH CREEK MINE.

	Thickness. *Feet.*	Depth. *Feet.*
Not reported	40	40
Shale, clayey	35	75
Limestone	8	83
Shale, sandy	59	142
Clay, red	5	147
Shale, sandy	17	164
Shale, clayey	3	167
Limestone	4	171
Sandstone, soft	66	237
Shale, fossiliferous	5	242
Limestone	4	246
Shale, bituminous	2	248
COAL	1	249
Shale, fossiliferous	4	253
Clay	6	259
Shale, clayey	17	276
Limestone	2	278
Shale, black, "slaty"	2	280
COAL (mined)	2	282
Clay	10	292
Not reported	95	387
COAL (Bevier?), mined	2	389

The upper bed mined is said to be 16 to 18 inches thick and at a depth of 280 to 320 feet. A "slaty" shale roof permitted mining on the longwall plan, but inflammable gas caused much trouble. The underclay was rather hard to pick. The lower bed is stated by different authorities to be 80 to 160 feet below the upper. Apparently it is the same bed as the one formerly mined at Randolph. Winslow gives the following section of beds lying at a depth of 400 feet in a shaft sunk on Blue river, about half a mile below the mouth of Brush creek:

	Feet.	*Inches.*
Limestone	4	....
Shale, gray	1	6
Shale, black	3–4	....
COAL	....	18–20
Clay	2	....

Broadhead gives the following somewhat imperfect record of a drilling near the old Union Station at Kansas City:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	37	....	37	....
Kansas City limestone—				
Limestone, bluish, fine-grained (Bethany Falls)	21	....	58	....
Clay, light blue to dark	5	....	63	....
Limestone, gray (Hertha)	13	....	76	....
Pleasanton shale—				
Shale, dove-colored	100	....	176	....
Clay, bituminous, sandy	4	....	180	....
Clay	84	....	264	....
Henrietta formation—				
Limestone, brown, bituminous	4	....	268	....
Shale, argillaceous	5	....	273	....
Limestone	18	....	291	....
Clay, drab, sandy	4	....	295	....
Limestone, light buff	23	....	318	....
Cherokee shale—				
Shale, dove-colored, clayey to sandy	47	....	365	....
Clay, dark and shelly, COAL	5	....	370	....
Shale, dark blue, micaceous	25	....	395	....
Sandstone, very dark blue, fine-grained	37	....	432	....
Shale, dark	1	....	433	....
COAL	....	4	433	4
Clay	10	....	443	4
Clay and limestone	5	8	449	....
Shale, dark, "slaty," and COAL, lower six inches dense and bright	2	....	451	....
Clay and limestone	16	....	467	....
Sandstone, gray, coarse to fine-grained	22	6	489	6
Clay, blue	3	6	493	....
Shale, argillaceous	7	....	500	....
Shale, dark, dove-colored, sandy	119	....	619	....
Shale, black	3	....	622	....
COAL	1	....	623	....
Shale, sandy	50	....	673	....
Shale and dark clay, thinly laminated	6	....	679	....
Shale, black, bituminous	3	....	682	....
COAL	1	8	683	8
Shale and clay	51	2	734	10
Sandstone, dark, mottled, crystalline	10	2	745	....
Limestone, vitreous, crystalline (Mississippian, lower limit of coal)	13	....	758	....

Independence.—On the Salisbury farm 2½ miles east of Independence (Sec. 6, T. 49 N., R. 31 W.) a drilling found 26 inches of coal at a depth of 248 feet, and it is currently reported that a shaft will be sunk to it. The record is given below:

DRILLING TWO AND ONE-HALF MILES EAST OF INDEPENDENCE.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil and clay	27	....	27	....
Pleasanton shale—				
Shale	74	....	101	....
COAL	....	6	101	6
Clay	1	6	103	....
Shale	7	6	110	6
Sandstone	8	....	118	6
Shale	7	6	126	....
Shale, black, "slaty" at top, dark below	11	10	137	10

DRILLING TWO AND ONE-HALF MILES EAST OF INDEPENDENCE—Continued.

	Thickness.		Depth.	
Henrietta formation—	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Limestone	3	4	141	2
Shale, black	4	6	145	8
Sandstone	13	6	159	2
Shale, light	9	6	168	8
COAL	1	....	169	8
Shale, black at top	9	....	178	8
Limestone	3	6	182	2
Shale	4	....	186	2
Limestone	10	....	196	2
Cherokee shale—				
COAL (Lexington) and black shale	2	6	198	8
Limestone	4	6	203	2
Shale	19	....	222	2
Shale, hard, sandy	1	....	223	2
Shale, black, "slaty"	1	6	224	8
Shale	1	6	226	2
COAL (Summit)	1	....	227	2
Clay	3	6	230	8
Limestone	1	....	231	8
Clay	3	8	235	4
Shale	10	8	246	....
Shale, black, "slaty"	2	....	248	....
COAL (Mulky)	2	2	250	2
Clay	2	7	252	9

Another drilling in the vicinity found the Mulky 24 inches thick, with a 3-foot limestone cap-rock separated from the coal by 6 inches of slaty shale.

JASPER COUNTY.*

Coal mining has been intermittently carried on in Jasper county since its settlement, but the largest annual production reported was 633 tons, the output in 1891. The Pennsylvanian of the county consists of the southern margin of the main body of the Coal Measures in the northwest corner and small outliers and pockets scattered irregularly over the remainder of the area. For the former, Norwood† gives the following generalized section:

GENERAL SECTION OF PENNSYLVANIAN OF JASPER COUNTY.

		Thickness.	
		Feet.	*Inches.*
1.	Slope, lower part covered with fragments of curiously ripple-marked sandstone	55	....
2.	Sandstone	3	6
3.	Conglomerate, not always present	....	0–10
4.	COAL, good	1	4
5.	Clay, potters'	4	....
6.	Interval	15–20	....

*The Pennsylvanian series in Jasper county was first described by C. J. Norwood, Rept. for 1873-1874: Mo. Geol. Survey, 1874, pp. 92-96. The region around Joplin is described by W. S. T. Smith and C. E. Siebenthal, Joplin folio (No. 148), Geol. Atlas U. S., U. S. Geol. Survey, 1907. The topography is shown on the Joplin and Aurora Special topographical sheets and the Carthage and Joplin sheets of the U. S. Geol. Survey.

†Op. cit. p. 95.

GENERAL SECTION OF PENNSYLVANIAN OF JASPER COUNTY—Continued.

		Thickness. Feet.	Inches.
7.	Shale, sandy	5	....
8.	COAL	....	12–18
9.	Shale, blue	2	....
10.	Shale, semi-bituminous	14	....
11.	Sandstone	5	....
12.	Interval	4	....
13.	Sandstone	2	6
14.	Shale, sandy, semi-bituminous	5	6
15.	COAL	1	2
16.	Interval	25	....
17.	Limestone, Mississippian	....	....

From the foregoing it will be seen that the thickest coal in the area is not more than 18 inches. Norwood believed the coal beds to be the same as certain beds in Barton county, and if this is true, they will probably be found persistent over the northwest corner of Jasper. According to Smith and Siebenthal‡ the pocket coal is sometimes found much thicker. "In many of the hollows and sink holes eroded in the surface of the Boone and filled by the Cherokee, coal pockets were found, the thickness of coal accumulated being in places very great," though in some deposits it is all, or in large part, cannel coal. These pockets are usually rounded in outline, synclinal in structure, and thin abruptly toward the margin. The quality is good as a rule, but the quantity is limited. The following pockets are among those reported:

1. Just west of the railway on the south side of Sec. 19, T. 29 N., R. 33 W., 200 feet in diameter, 6 feet in thickness in center and thinning abruptly at the margin.

2. A mile and a half east of south of Carl Junction, coal 3 to 4 feet thick.

3. Just west of road leading south from Neck, coal 5 to 9 feet in thickness in the middle, rising and thinning out toward the sides of the more or less circular deposit.

4. Next 40-acre tract to west, a similar deposit ranging from 2½ to 8 feet in thickness.

5. South of Carterville, on the Homestead Company's ground, coal 6 feet thick.

6. West ½ lot 2, Sec. 2, T. 29 N., R. 31 W., coal 18 inches.

Other pockets doubtless exist in many localities, but their importance is hardly sufficient to justify detailed description.

If beds or parts of beds less than 14 inches in thickness be omitted there may be conservatively considered to be an average of 15 inches of coal in 65 sq. miles in northwestern Jasper county, or 93,600,000 tons. In addition there is at least sufficient fuel in the pockets to bring the total coal reserve of the county to 100,000,000 tons.

‡Op. cit. pp. 19-20.

JOHNSON COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....17,046 TONS.

Although Johnson county possesses a greater coal reserve than any other county in Missouri, the coal-mining industry within its borders is practically quiescent. More than 40 years ago mining was actively pursued in the vicinity of Montserrat and later near Knobnoster, but was later abandoned because of the inferior quality of the coal. Except near Bowen there are at present no shipping mines in the county, though strip-pits and small local mines may be found almost anywhere in the eastern half. Until recently shipping mines were in operation at Sutherland, Chilhowee, and Denton, and it is very probable that these will be reopened in the near future.

All the divisions of the Des Moines group are represented in Johnson county, and the heavy limestones at the base of the Missouri group appear on ridges in the northwest corner. The highest division of the Des Moines, the Pleasanton shale, includes about 175 feet of shales and sandstones, with one or two thin beds of limestone and a few beds of coal. So far as known the Pleasanton of Johnson county contains no coal sufficiently thick to be workable on even a small scale. A very little coal has been taken from a bed (Mulberry) only one foot thick near the base of the formation in the vicinity of Holden. The Pleasanton is the surface formation on the western border of the county and on all the higher lands in the western half of the region.

Below the Pleasanton is the Henrietta formation, consisting of about 69 feet of interbedded limestone and shale. The Henrietta outcrops along the main streams in the western part of the county and on the higher divides and mounds in the eastern, where its resistant and persistent limestones form conspicuous ledges. The following is a typical section of the formation near Sutherland:

HENRIETTA FORMATION IN JOHNSON COUNTY.

		Feet.
1.	Limestone, gray, massive, with flint	7 to 10
2.	Shale	30
3.	Limestone, gray, thin-bedded, with flint	3
4.	Shale, "slaty" in upper part	15
5.	Limestone, buff	2½
		59

Below the Henrietta formation is the Cherokee shale, which is the surface formation over the greater part of the county. It consists

*The geology of the part of Johnson county adjacent to the Missouri Pacific Railroad, together with a few other localities, was first described by G. C. Broadhead (Iron Ores and Coal Fields: Mo. Geol. Survey, pt. 2, 1873, pp. 32-36, 166-195). Coal mines were briefly described by Arthur Winslow (Prelim. rept. on coal: Mo. Geol. Survey, 1891, pp. 128-132). The topography of the county is shown on the Warrensburg and Harrisonville sheets of the U. S. Geol. Survey.

chiefly of shale and sandstone, with a number of coal beds and several thin limestones, some of which thicken greatly in the southeast quarter of the county, as shown in the section given later for the Leeton district (p. 232). Owing to variations in the thickness of the shales and sandstones and owing more especially to the uneven upper surface of the Mississippian upon which the Cherokee rests, the formation varies from 220 to 350 feet in thickness. The succession of strata is shown in numerous detailed sections which follow. A general section applicable to a large district may be constructed by combining the Montserrat No. 1 shaft record with the general section for Bristle Ridge.

Massive sandstones and some sandy shale belonging to the Henrietta, and possibly to the lower part of the Pleasanton, replace the beds of the upper Cherokee in an old channel known as the Warrensburg. The channel is one to 3 miles wide, is in places more than 90 feet deep, and extends north and south across the entire county, through Fayetteville, Warrensburg, and Post Oak. It is deepest in the center and thinner on the borders, and contains no workable coal.

The highest coal bed of importance is the Lexington at the top of the Cherokee formation. It is very persistent in occurrence, but in the greater part of the region it is less than 14 inches thick and is available only for local fuel supplies in places where stripping is particularly easy. In some districts, however, as near Holden and elsewhere, it is somewhat thicker and might become an important producer. Over it are 2 to 8 feet of black slaty shale on which rests a compact limestone cap-rock. It could be very easily mined longwall, mining conditions being much the same as in the large producing fields at Lexington and Higginsville.

The next lower important coal is the Mulky, 40 to 80 feet below the Lexington. In the Warrensburg district another coal lies only a

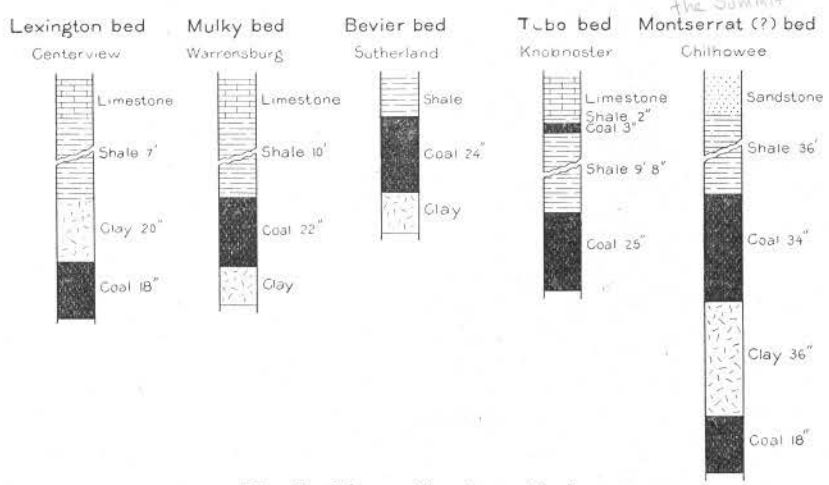

Fig. 42. Johnson County coal beds.

short distance above the Mulky, though it is only very locally developed. The Mulky is of good quality and is mined for local and city use near Warrensburg, on Bristle ridge, and elsewhere. It is absent in the southeastern corner of the county, but where normally developed averages about 20 inches in thickness. It also has a strong limestone cap-rock under which is black "slaty" shale; but in many places a "soapstone" shale wedges in between the two in places separating them by as much as 15 feet. In a few localities the Mulky is 36 inches thick.

About 15 to 30 feet below the Mulky horizon is the Bevier bed, which is characterized over a large area by a thin layer of black limestone, full of shells, that lies directly upon it. Above the limestone are sandy and argillaceous shales. At Sutherland, on Bristle ridge, near Knobnoster, and elsewhere in the eastern part of the county, the Mulky averages about 2 feet in thickness, though in some places thin and in others reaching 30 inches or more.

From 10 to 20 feet below the Bevier is the Tebo coal, with a limestone cap-rock that is also the bottom-rock of the Bevier. This bed is very similar to the Mulky in thickness and associations, though its cap-rock is thicker and more irregularly bedded. It is mined at many small pits near Knobnoster. The quality of the bed is made variable by shale partings that appear in certain localities.

Fifty feet below the Tebo and separated from it by shale and more or less massive sandstone is the Brushy Hill coal, whose thickness is very variable, though commonly less than 36 inches. It is seldom utilized because it lies too low to outcrop, except in small areas.

Between the Brushy Hill and the Montserrat coal, which lies 50 feet below it, are shales and clays interbedded with three thin coal beds, all of which, so far as known, are too thin to be workable. The Montserrat is the bed formerly extensively mined near Montserrat, where it was 7 feet or less in thickness but was in part very dirty. West of Montserrat it thins but is of good thickness at least as far east as Knobnoster. The Chilhowee coal may be at the same horizon. The Montserrat lies too low to outcrop except in a very few localities, such as on Clear fork near Burtville, where it contains 36 inches of coal. As it can be found only by drilling and as very little drilling has been done except near the railroads, it is very possible that important deposits of better quality than those formerly mined will yet be found at this horizon.

The flint and heavy limestone beds at the base of the coal-bearing formations lie 35 to 150 feet below the Montserrat horizon. Few drillings have penetrated to this base, so that little is known of their coal reserves. In prospecting, it should be remembered that all coal beds below the Tebo are very variable in thickness and irregular in distribution, although in certain basins thicker than any of the higher coals.

The failure to find workable lower coals at one locality is not, therefore, a certain indication that adjacent areas are barren. Deposits like the Bowen trough, on the line between Johnson and Henry counties, indicate the desirability of thoroughly prospecting so promising a region as this.

Though, when broadly considered, the strata lie almost horizontal in Johnson county, a comparatively few minor sharp dips cause changes in level of 100 feet or less within short distances. These disturbances are connected with anticlines (arches) and closely associated synclines (troughs) apparently trending northwest-southeast. One of the most notable of the former is at Montserrat (p. 226). At the railroad bridge over Clear fork the Montserrat coal is nearly 100 feet higher than it is only one-half mile south. Up Clear fork from the latter point, the strata gradually rise to the axis of another anticline that lies along a line from Burtville to a point a few miles north of Windsor. Southwest of the last-named anticline, at Sutherland, is a syncline in which strata are relatively depressed.

On the basis of 1800 tons per acre-foot the total coal reserve in beds more than 14 inches in thickness may be roughly estimated as follows:

TOTAL ORIGINAL TONNAGE OF JOHNSON COUNTY.

Beds.	*Tons.*
Lexington	337,500,000
Mulky	600,000,000
Bevier	640,000,000
Tebo	960,000,000
Brushy Hill, Montserrat and other lower coals	2,922,500,000
	5,460,000,000

DETAILED MENTION.

Dunksburg.—About 1½ miles south of Blackwater river and one mile west of the Pettis county line near Dunksburg a stripping on the land of E. C. Strickland and a drift on that of G. W. Strickland are operated in a small way for local trade. The bed mined is non-persistent, hard, and clean, and contains only a moderate amount of sulphur in the form of thin vertical pyrite veins associated with much white gypsum scale. It is 24 to 27 inches thick, with an additional 6 inches of dirty coal at the bottom. The underclay is dark and very hard. Lying on the coal is 18 inches of dark clay-ironstone, above which are 2 feet of black laminated shale, overlain by 20 feet of sandy drab shale, containing limestone concretions and beds and lenses of sandstone. Massive sandstone at least 8 feet thick appears in the hills about 20 feet above the coal.

Three miles southwest of the above the Lexington coal, only 8 inches thick, outcrops about 40 feet below the top of a low mound (N. W. ¼ Sec. 15 and N. E. ¼ Sec. 16, T. 47 N., R. 24 W.). One mile

farther west (N. W. ¼ N. W. ¼ Sec. 17) a small stripping shows the following section:

		Feet.	Inches.
1.	Limestone, with 6 inches shale in center	2	2
2.	Shale, drab, soft	1	....
3.	Shale, black, "slaty"	2	9
4.	COAL (Mulky)	1	2

The Mulky is poorly exposed on the Blackwater-Walnut divide for a considerable distance, and a lower coal was utilized years ago at a few points in the valleys.

Fayetteville.—The Warrensburg sandstone channel, one to three miles in width, extends north and south on the east side of Fayetteville, cutting out at least the higher coal beds. East of the channel the horizons of the principal coals outcrop. The Lexington is too thin to be workable, and the Mulky is variable and not of very much importance. Lower beds are shown in the following section, measured on and near the road on the west line of Sec. 14, T. 47 N., R. 25 W.:

		Feet.	Inches.
1.	Sandstone and sandy shale	7	....
2.	Shale, drab at top, slate-blue at base	7	....
3.	COAL	1	....
4.	Shale, dark drab	1	....
5.	Limestone, nodular, more than	....	6
6.	Shale, drab	1	....
7.	Limestone, dark blue, in one layer	....	8
8.	Shale, light	....	9
9.	Limestone, in two layers	....	8
10.	Shale, light above, dark below	2	....
11.	COAL	....	9
12.	Concealed	21	....
13.	Shale, light drab	8	....
14.	Shale, black, "slaty," with five rows of ferruginous concretions	6	6
15.	COAL	1	10
16.	Impure coal and shale	....	6
17.	Clay	2	9
18.	Limestone, nodular, more than	....	9
	To Blackjack Creek	10	....

It is reported that in sinking the piers of the wagon bridge 3 feet of coal a few feet below the base of the above section was struck. Four miles southeast of Fayetteville and along Blackjack creek the Mulky and its typical cap-rock may be seen on the low divides. Two lower coals are reported in wells. At one stripping (S. E. ¼ N. E. ¼ Sec. 31, T. 47 N., R. 25 W.) the Mulky is 22 inches thick; at another (N. E. ¼ S. E. ¼ Sec. 30) the following section is exposed:

		Feet.	Inches.
1.	Limestone	1	....
2.	Clay, with 3 inches limestone in upper half	1	9
3.	Shale, black and "slaty" at base	5	....
4.	COAL (Mulky)	1	6

According to the record of a well (S. E. ¼ N. W. ¼ Sec. 32) drilled east of the site of the above section the next lower coal bed lies about 80 feet below the Mulky and is 18 inches thick. Its roof,

which consists of 6 feet of black "slaty" shale overlain with 3½ feet of a blue limestone that weathers yellow, indicates that it is the Tebo.

On the west side of the Warrensburg channel, near Fayetteville, the Henrietta formation outcrops everywhere except in the deeper valleys, and the chief coal horizons are under cover. A well dug and drilled on a high ridge southwest of the village gives a section of part of the Coal Measures of the region. In it no coal was found at the Lexington or Mulky horizons, and it was not sunk sufficiently deep to reach the horizons of thicker coal in the lower part of the Cherokee.

WELL THREE MILES SOUTHWEST OF FAYETTEVILLE (S. W. ¼ S. E. ¼ SEC. 20, T. 47 N., R. 26 W.).

	Thickness. *Feet.*	Depth. *Feet.*
Soil and clay	12	12
Limestone, white	13	25
Shale, hard	12	37
Limestone, white	2	39
Shale, black, "slaty" (horizon of Lexington coal)	6	45
Shale, very calcareous in lower half	10	55
Limestone	2	57
Shale, blue, "slaty"	4	61
Sandstone, hard	3	64
Shale, gray, with thin layers of limestone	80	144
COAL (Bevier)	1	145
Limestone, white	2	147
Shale, calcareous	4	151
Limestone, black, fossiliferous	2	153
Shale, black, "slaty"	4	157
COAL (Tebo)	1½	158½
Clay	10	168½

Five miles northwest of Fayetteville (S. W. ¼ N. W. ¼ Sec. 6, T. 47 N., R. 26 W.) the Lexington coal is mined by Henry Thorp in a small drift on land of Henry Jackson. The bed, which is 12 to 14 inches thick, underlies 3 feet of shale, black and "slaty" at base, that is overlain by 5 feet of limestone. Under it are 2 to 3 feet of clay lying on a 3-foot limestone.

Columbus.—Though strata as low as the Mulky bed outcrop in the main valleys of the northwest corner of Johnson county, most of the surface rocks belong to the Henrietta and higher formations. No coal of importance outcrops in the region. The Lexington is irregular in thickness and is commonly very thin. An 18-inch bed of low grade coal (Mulberry ?), evidently in the lower part of the Pleasanton, has been stripped in Secs. 14, 15 and 25 of T. 47 N., R. 28 W. It has a shale ("soapstone") roof and overlies limestone. Similar deposits probably exist at other points.

Holden.—Except in Blackwater valley the outcropping rocks near Holden are higher than the Lexington horizon and, aside from very thin seams in the Pleasanton formation near the city, are not known to contain coal. According to a poor drill record, the base of the Coal

Measures lies at a depth of 500 feet. On Blackwater river and its branches, a few miles northeast of Holden, the Lexington bed outcrops high above the river for several miles down stream. Between the coal, which is 6 to 18 inches thick, and its limestone cap-rock is 5 to 9 feet of shale that is in greater part black and slaty. Broadhead† cites the following rather unusual occurrence of a coal that may be the Lexington on the south side of Blackwater river in T. 46 N., near the line between Rs. 27 and 28 W.:

		Feet.	*Inches.*
1.	Limestone	3	....
2.	Shale, bituminous	8	....
3.	COAL, cannel	1	6
4.	COAL, bituminous	....	6
5.	Calcareo-pyritiferous bed	1	....
6.	COAL, bituminous	....	6

At the small mines of Chas. Manford and R. Brownleigh in Sec. 27, T. 46 N., R. 27 W., the same bed is 16 to 18 inches thick. The Thompson drift and slope (N. W. ¼ Sec. 28) and the Deal mine (N. E. ¼ S. E. ¼ Sec. 36, T. 46 N., R. 28 W.) also work the same bed. The section at the Manford drift (S. E. ¼ S. W. ¼ Sec. 27 N.) is as follows:

		Feet.	*Inches.*
1.	Limestone, weathers buff	2	....
2.	Shale, light at top, black and "slaty" in greater part and with large concretions	7	....
3.	Clay, black, very hard	1	8
4.	COAL	1	6

At the Cunningham drift (N. E. ¼ S. W. ¼ Sec. 15, T. 46 N., R. 27 W.) the Lexington (?) coal is 14 to 16 inches and has over it about the same strata as at the Manford drift.

Much lower in the bank of Blackwater river, at the wagon bridge (N. E. ¼ N. E. ¼ Sec. 15), the Bevier coal is well exposed, though only 12 inches thick. Certain associations, which enable the prospector to recognize this bed, are well shown at the outcrop, whose section is as follows:

		Feet.	*Inches.*
1.	Shale, light, sandy in upper part	24	....
2.	Shale, black, "slaty," with very thin concretionary layers of reddish limestone	6	1
3.	Limestone, black, with many shells	....	7
4.	COAL (Bevier), dirty at top	1	....
5.	Clay, dark	1	6
6.	Limestone, rough on top	1	2

Warrensburg.—Extending north and south through Warrensburg is the Warrensburg channel, filled with massive sandstone that is extensively quarried‡ north of the city. The width of the channel is one

†Mo. Geol. Survey, Rept. for 1872, pt. 2, p. 190.

‡Buehler, H. A., The quarrying industry of Missouri: Mo. Bureau Geol. and Mines, Vol. II, second series, 1904, pp. 272-277.

to 2 miles and its boundaries at Warrensburg correspond approximately with the east and west limits of the city. At the quarries drillings show 75 feet of sandstone overlying 100 feet of dark sandy shale. Three hundred yards east of the Warrensburg railroad station the channel contains at least 87 feet of sandstone. It is evident that only the lowest coal beds can be present under the main part of the channel, though at its outer edges it is much thinner and higher beds underlie it. Thus a drilling made on the ridge 300 yards south of the Normal School (N. W. ¼ Sec. 25), showed in descending order 78 feet of channel sandstone with a thin conglomerate at the base, 42 feet of shale, and 18 inches of coal. In an old shaft one mile east of town, near the edge of the channel, the conglomerate was found at 63 feet, one foot of coal at 65 feet, 2 feet at 78 feet, and 14 inches at 127 feet; the lowest coal had the characteristics of the Montserrat bed and shows that the latter thins to the west. One mile southeast of Warrensburg (S. E. ¼ S. E. ¼ Sec. 30, T. 46 N., R. 25 W.), beyond the edge of the channel, there is one foot of coal at a depth of 40 feet, 2 feet at 53 feet, 6 inches at 57½ feet, and no more to at least 86 feet. Although the lowest part of the Coal Measures was not explored in these borings, there appears to be little probability that very thick coal occurs in the vicinity.

The Mulky coal outcrops on both sides of the channel near the city and is mined at several places. Along Potts branch it was formerly mined in many drifts, and was 18 to 26 inches thick. One mile northeast of the city (N. E. ¼ N. E. ¼ Sec. 24), a slope formerly reached it at a depth of 20 feet. The bed was 22 inches thick and the coal of fair quality; above it was 5 feet of shale, black and "slaty" at top and blue and heavy at base, underlying a 15-inch cap-rock of blocky limestone. The same coal has been mined in drifts to the south. At a ford over Blackwater creek (S. W. ¼ Sec. 7, T. 46 N., R. 25 W.), the horizon of either the Mulky or the Tebo lies just below water level and 22 inches of coal was found in a shallow shaft in the vicinity. Near the hilltops and east of the ford, the Lexington coal, 14 inches thick and at least 65 feet above the coal last mentioned, is stripped at a number of places. Above the coal is black "slaty" shale capped with 7 feet of limestone, containing a very thin shale parting. On land of Geo. Burkhart two shafts (Geo. Burkhart, N. W. ¼ S. E. ¼ Sec. 19, 35 feet deep, and M. B. Miley, S. W. ¼ N. E. ¼ Sec. 19, 20 feet deep), are now hoisting by horse power one mile east of Warrensburg. Miners in this vicinity recognize two coal beds called the "slate vein" and the lower "soapstone vein" (Mulky), the latter being the one mined at the shafts. Following is the record at one of the Burkhart shafts:

		Feet.	Inches.
1.	Timbered	3	....
2.	COAL	1	....
3.	Clay	1	....
4.	Limestone, in two layers	2	....
5.	Shale, black	2	8
6.	Limestone, concretionary	....	9
7.	Shale, blue	10	8
8.	COAL (Mulky), hard, good quality	1	10
9.	Clay, hard	5	....

In the upper part of the other Burkhart shaft there are 20 feet of white sandstone, probably in the eastern edge of the Warrensburg channel. Until recently the J. Sullivan slope mined 18 inches of coal with a "soapstone" roof (N. W. ¼ S. W. ¼ Sec. 18, T. 46 N., R. 25 W.). None of these mines produce much coal, though there is a considerable demand for fuel in the neighboring city.

Coal also outcrops on the west side of the Warrensburg sandstone channel. Northwest of the city 18 to 24 inches has been mined in small drifts and shafts (Secs. 11 and 23, T. 46 N., R. 26 W.). What appears to be the Mulky, 20 inches thick, is still mined at the Post Oak mine on land of J. W. Flanders, northwest of the cemetery and at the edge of the Warrensburg channel. In a well farther northwest (S. E. ¼ S. W. ¼ Sec. 17), 16 inches of coal was found at 44 feet and 20 inches at 66 feet, other strata to a total depth of 109 feet being only shale and clay. Considerable coal has been mined in a small way near the southwest corner of Warrensburg from a bed that outcrops low in the valley and is probably the Mulky. The Pritchard and Witt drift on land of W. Harrison (N. W. ¼ S. E. ¼ Sec. 27), and the Chas. Carter drift (S. W. ¼ S. W. ¼ Sec. 26), were found in operation. Outcrop measurements in the vicinity show:

		Feet.	Inches.
1.	Shale, with brown ferruginous concretions	10	....
2.	COAL	....	8
3.	Limestone, gray, concretionary	2	....
4.	Concealed	5	....
5.	Limestone, drab, weathers buff, with one foot shale parting near base	2	4
6.	Shale, dark at base, soft	1	7
7.	Shale, black, "slaty"	1	2
8.	Shale, drab ("soapstone"), absent at Harrison drift	4	4
9.	COAL (Mulky?), mined	....	14–20
10.	Clay	2	2
11.	Limestone, very hard	....	8

A lower coal has been mined in the neighborhood and more than one lower bed is reported in places, reports being somewhat conflicting. Mr. Carter gives the following section as that of a drilling at his mine:

		Feet.	Inches.
1.	Limestone (No. 11 of last section)	....	....
2.	Shale	27	....
3.	COAL (Bevier?)	....	2
4.	Shale	10	....
5.	Rock (limestone?)	1	....
6.	Shale, "slaty"	3	....
7.	Rock, very hard (limestone?)	2	6
8.	Interval	16	....
9.	COAL (Tebo?)	2	3

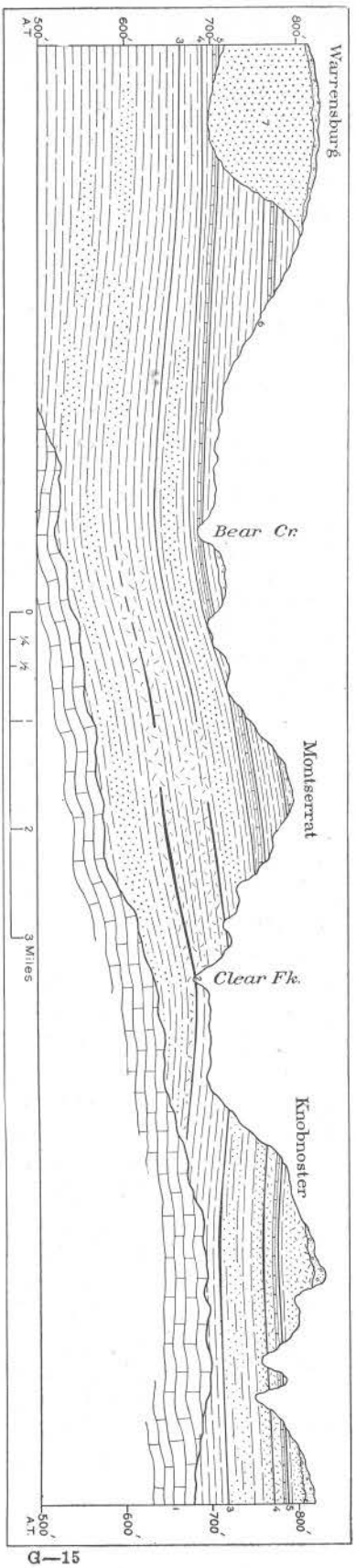

Fig. 43. Cross-section along Missouri Pacific Railroad from Warrensburg to Knobnoster. (1) Mississippian limestone. (2) Montserrat coal. (3) Brushy Hill coal. (4) Tebo coal. (5) Bevier coal. (6) Mulky coal. (7) Warrensburg channel.

The Lexington coal bed outcrops on the higher lands near Centerview and along the upper courses of Post Oak creek. Although very thin in most places, in others it is apparently as thick as in the Lafayette county fields where it is mined so extensively. Broadhead cites an occurrence 4 miles southwest of Warrensburg (Sec. 9, T. 45 N., R. 26 W.), where it is 23 inches thick, the upper five inches being a "slaty" cannel and the remainder bituminous coal of good quality. Above the cannel is 8 inches of bituminous shale below 56 inches of limestone that would make an excellent roof.

Montserrat.—In the early days of coal mining in Missouri a number of fairly large shipping mines were operated along the railroad near Montserrat, the best known being May No. 5, one mile west, and Montserrat No. 1, one-half mile east of town. Other shafts were worked near Clear fork, up which a short spur was constructed from the main line. The coal mined was 4 to 7 feet in thickness, the lower 30 inches being a good steam coal, but the upper portion being so dirty that much of it was discarded, only to cause additional trouble by its tendency to take fire in the gob. The amount of "sulphur" and other impurities in the

bed and the lack of good markets caused the abandonment of this field. The relations of the thick coal to other beds is shown in the following record:

SHAFT AND DRILLING AT MONTSERRAT NO. 1.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Shale, and surface material	20	....	20	....
COAL (Tebo)	2	6	22	6
Shale	17	6	40	....
Sandstone	11	....	51	....
Shale, black, not quite "slaty"	15	....	66	....
COAL (Brushy Hill)	1	3	67	3
Clay	5	....	72	3
Shale	8	....	80	3
COAL	....	8	80	11
Clay	4	....	84	11
Shale	12	....	96	11
COAL	1	....	97	11
Clay	6	....	103	11
Shale	9	....	112	11
COAL	....	4	113	3
Clay	4	....	117	3
Shale, black, "slaty," present in places	....	....	117	3
COAL (Montserrat)	5	....	122	3
Clay, sandy	10	....	132	3
Shale, sandy	10	....	142	3
Shale, black	15	....	157	3
Sandstone, hard, thin-bedded	20	....	177	3
"Flints" (base of Coal Measures)	20	....	197	3
Limestone (Mississippian)	....	....	....	....

The three thin coals above the Montserrat are unimportant but are fairly persistent. The Brushy Hill bed is rather variable; in a railroad cut one mile east of Montserrat it is only one foot thick, but it is probable that it is the same bed that is 32 inches thick in a small drift up a little draw near the railroad bridge over Clear fork (N. E. ¼ N. E. ¼ Sec. 19, T. 46 N., R. 24 W.); dips are so variable and irregular as to be very confusing. On the west side of Mine No. 1 a strong easterly dip indicates that the depth of the Montserrat bed below the railroad depot is about 160 feet. A drill hole 325 feet deep one-eighth mile west of the depot, however, failed to strike any coal below the Tebo, which lay at a depth of 40 feet. That the barren strip is not wide is shown by the occurrence of coal at May No. 5.

On the sharp topographic feature known as Bristle ridge, which extends from Montserrat south for 5 or 6 miles, coal beds higher than those in the Montserrat shaft are exposed and are stripped at many places. Near Bristle Ridge postoffice a number of small drifts in the Mulky bed are operated for the greater part of the year and the product is hauled across country to Warrensburg. The ridge owes its existence to the heavy limestone cap-rocks of the Lexington coal that form its present summit. Beds as low as the Brushy Hill coal outcrop along the deeper streams. A generalized section of the rocks on the ridge and in neighboring territory follows:

BRISTLE RIDGE GENERAL SECTION.

		Feet.	Inches.
1.	Shale and thin beds of limestone, alternating	20	....
2.	Limestone, weathers yellowish-buff	2	....
3.	Shale, soft and clayey at top, black and "slaty" at bottom	3	....
4.	COAL (Lexington)	....	8 to 10
5.	Clay, with nodular limestone at base	3	8
6.	Shale, yellow	10	....
7.	Interval, chiefly shale, very variable, average	20	....
8.	Limestone, dark gray, compact, breaks in blocks	2	6
9.	Shale, in part "slaty"	4 to 12	....
10.	COAL (Mulky), excellent quality	....	15 to 36
11.	Interval, chiefly shale	10	....
12.	Shale, with a few thin limestone bands at top	16	....
13.	Shale, black, "slaty," with small nodules	5	....
14.	Limestone, bluish-black, full of shells	0 to 1	6
15.	COAL (Bevier)	....	18 to 30
16.	Clay, white	4 to 5	....
17.	Limestone, irregularly bedded	3	....
18.	Shale	½ to 4	....
19.	COAL (Tebo), with shale partings in places	....	8 to 30

North of Montserrat, in and near the valley of Clear fork, are several poor outcrops of the coal beds lying between the Mulky and the Montserrat coals. Little besides shale and sandstone are associated with the coal and exact correlations are impossible. Two miles north of the town (S. E. ¼ N. E. ¼ Sec. 1, T. 46 N., R. 25 W.), the following section is exposed in the road and in old strippings:

		Feet.	Inches.
1.	Sandy shale and sandstone	10	....
2.	Sandstone, brown, at least	2	....
3.	Shale, drab	6	....
4.	Limestone, impure, with shells	....	4
5.	Shale, drab	6	....
6.	COAL, not fully exposed	....	6
7.	Shale, blue and yellow, three coal streaks near base	20	....
8.	COAL, good except upper 6 inches	2	8

Northwest of the above section (middle north line Sec. 1 and S. W. ¼ Sec. 25), the upper coal (No. 6) is about 18 inches thick. A drilling near one of the exposures (S. E. ¼ S. W. ¼ Sec. 36, T. 47 N., R. 25 W.) struck at 96 feet a bed resembling the Montserrat, but only 15 inches thick. By the iron bridge over Clear fork (S. W. ¼ N. E. ¼ Sec. 31, T. 47 N., R. 24 W.) is the following excellent exposure of the bed:

		Feet.	Inches.
1.	Sandstone, in part massive, in part thin-bedded	12	....
2.	Concealed	16	....
3.	Sandstone and sandy shale	6	....
4.	Sandstone, reddish-brown, massive	3	....
5.	Shale, very coaly	....	10
6.	COAL, dirty, 20 inches Bone, 3 " COAL, fair, 12 "	2	11
7.	Shale, coaly	....	3
8.	Shale, drab, bottom lies 10 feet above Clear Fork	6	....

One mile south, near the edge of Clear fork, the coal of the last section is 35 inches thick. In a well on higher ground to the north

(N. E. ¼ N. E. ¼ Sec. 30, T. 47 N., R. 24 W.), the first coal encountered was 20 inches at a depth of 91 feet. One mile southeast of the well (middle east line, Sec. 29), on a tributary of Walnut creek, the Bevier coal has been mined; it is 24 to 30 inches thick, is overlain with calcareous coaly shale, and is underlain with 30 inches of clay that rests on 2 feet of rough-bedded limestone.

Knobnoster.—The limestones lying just above the Lexington coal form the top of the high knob from which Knobnoster takes its name, their base being about 110 feet above the Bevier coal bed. Both the Bevier and Tebo coals outcrop well up on the sides of the valleys surrounding the town and are stripped in several localities. The characteristics of these beds are well shown in the following section from a place one mile northwest of Knobnoster (N. E. ¼ Sec. 17) where there are several large strippings:

		Feet.	*Inches.*
1.	Shale, light at top, dark at bottom, with reddish concretions	3	....
2.	Limestone, dark blue, with shells	0 to 2	....
3.	COAL (Bevier)	....	18 to 24
4.	Concealed	8	....
5.	Limestone, light blue, irregularly bedded, rough on top	2	6
6.	Shale	....	2
7.	COAL	....	3
8.	Shale, drab, with streaks of coal	6	....
9.	Shale, black	3	8
10.	COAL (Tebo)	....	20 to 30

In the bank of Clear fork near the above section (S. W. ¼ Sec. 8), 12 feet of shale below 4 feet of sandstone rests on the Brushy Hill coal, here only one foot thick. One mile east (N. W. ¼ S. E. ¼ Sec. 9), the Bevier is reported 22 inches thick at some old strippings and the Tebo is burned to a red ash along its outcrop. The Bevier and Tebo beds appear at intervals for many miles up and down the valley of Walnut creek. Near the Missouri Pacific bridge, 3 feet of coal is stripped in two places, and one mile farther up the valley (N. E. ¼ N. E. ¼ Sec. 24, T. 46 N., R. 24 W.), the Bevier is one foot thick and the Tebo 30 to 36 inches. A slight dip to the north causes these beds to outcrop for a mile or more farther south. Less than a mile southeast of Knobnoster, the Bevier is 20 inches and the Tebo 15 inches thick. A well dug just east of Knobnoster shows the following section of these two beds and of the next lower one:

DUDLEY DUG WELL (NORTH LINE N. W. ¼ N. E. ¼ SEC. 22, T. 46 N., R. 24 W.).

	Thickness. *Feet.*	Depth. *Feet.*
Soil and shale	6	6
Clay	20	26
Sandstone	12	38
Shale, "slaty"	3½	41½
COAL (Bevier)	1	42½
Clay	3½	46

Fig. 1. Strip pit one mile northwest of Sutherland, Mo.

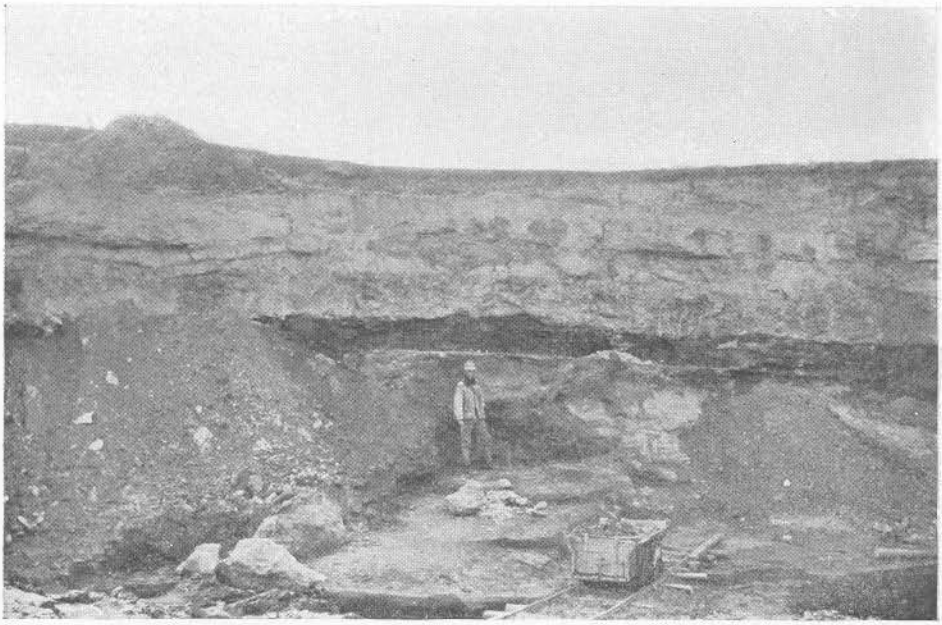

Fig. 2. Coal in J. K. Boyd & Son's clay pit, Knobnoster, Mo.

DUDLEY DUG WELL (NORTH LINE N. W. ¼ N. E. ¼ SEC. 22, T. 46 N., R. 24 W.)—Continued.

	Thickness. *Feet.*	Depth. *Feet.*
Limestone, very hard	4	50
Clay	9	59
COAL (Tebo)	2	61
Shale	3	64
Sandstone	7	71
Shale, "slaty" at top, soft at bottom	5	76
Sandstone	4	80
Shale, "slaty"	7	87
"White rock"	7	94
Slaty shale and rock, mixed	13	107
Shale, black, "slaty"	4	111
COAL (Brushy Hill)	2½	113½
Shale, black, "slaty"	12	125½
Gray rock	3	128½
Flint (base of Coal Measures?)	....	....

One mile southwest of Knobnoster (N. W. ¼ N. W. ¼ Sec. 28), a lower coal 42 to 48 inches thick was formerly mined by Boyd & Co. at a depth of 67 feet. It underlay a blue shale, only the lower foot of which was soft, and overlay "slaty" shale and "rock." It contained rather large amounts of sulphur in balls, plates, and grains of iron pyrites and a number of bony lenses irregularly placed. The coal was the Montserrat bed, but without the troublesome dirty top coal found in the mines on the other side of Clear fork. A drilling here failed to find any coal below the Montserrat, but 13 feet above it, is 10 inches, 20 feet above it, 14 inches, and 36 feet above it, 18 inches of coal.

Just west of Knobnoster, near the railroad (N. E. ¼ N. W. ¼ Sec. 21), two thin coal beds, evidently lying only a short distance above the Montserrat coal, are interbedded with clays and shales in the Boyd shale pit. Across the road to the southwest 4 feet of coal is reported at the Montserrat horizon with only 35 feet of clay between it and the Mississippian. At one end the rocks exposed dip strongly 30° N. Near this place the Boyd Brick Co. obtains fuel for its brick plant and for a small local trade from a bed 42 inches thick with a shale roof and hard clay floor; the upper 6 inches of coal is separated from the lower portion by one foot of gray shale bearing particles of pyrite and thin streaks of coal. The product is hoisted 32 feet by steam power.

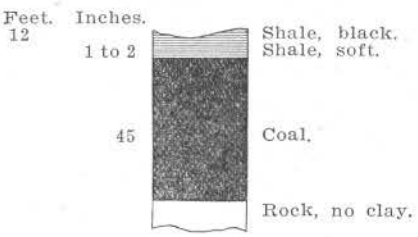

FIG. 44. The Montserrat coal bed at former Boyd shaft.

On the east bank of Clear fork, southwest of Knobnoster (S. W. ¼ N. W. ¼ Sec. 20, T. 46 N., R. 24 W.), there is an unmistakable exposure of the Tebo coal and rocks associated with it. This is very surprising, as rocks stratigraphically nearly 100 feet higher are exposed at the same level on the opposite side of the creek, less than half a mile northwest. Evidently there is in this vicinity a sharp fold or fault, probably trending northwest-southeast and associated with the heavy grades encountered in the old shipping mines east of Montserrat. At and south of this cut-bank exposure the thick coal of the Montserrat horizon lies, therefore, at a much greater depth below the creek than it does near the railroad. Up Clear fork for several miles from this locality, the strata gradually rise slightly more than does the stream, so that exposures in the cut-banks show the lowest rocks farther south. A combined section of these exposures from the outcrop mentioned in Sec. 20 to that in the S. E. ¼ Sec. 31, T. 46 N., R. 24 W., is as follows:

		Feet.	*Inches.*
1.	Limestone, slate-blue, rough on upper surface, irregularly bedded	2	4
2.	Shale, in part "slaty"	....	6
3.	COAL	....	6
4.	Clay and dark gray shale	6	....
5.	COAL (Tebo), 2-inch clay parting near top, dirty	2	9
6.	Clay and shale, soft at top	11	6
7.	Sandstone, massive	8	....
8.	Shale, sandy at top and bottom, black in places	13	....
9.	Sandstone, shaly	6	....
10.	Shale, black, sandy at top, "slaty" at bottom, iron concretions in thin streaks	7	3
11.	Shale, black, soft, with nodules of coal	2	....
12.	COAL (Brushy Hill)	2	2
13.	Shale and sandstone	10	....

Burtville.—The southerly rise of the strata noted above continues up Clear fork, so that within a mile of the mouth of Copperas creek, east of Burtville, two of the thin coal beds lying between the Brushy Hill and Montserrat coals outcrop. Just north of this (N. W. ¼ S. W. ¼ Sec. 18, T. 45 N., R. 24 W.) may be seen 3 feet of coal at what Broadhead considers to be the Montserrat horizon. About a mile west of Burtville (Sec. 14, T. 45 N., R. 25 W. and north and south), the limestones above the Lexington coal occur on the ridge, showing that most of the important coal horizons of the county outcrop between the ridge and Clear fork. Some mining for local use has been done in these beds northeast of Burtville and elsewhere.

Henrietta.—Near Henrietta, the Lexington coal, though very thin, is stripped a little. Over it are 3 to 5 feet of black slaty shale upon which rests 4 feet of limestone that weathers buff. About 15 feet above it is a light gray limestone at least 5 feet thick. One mile north of Henrietta old drifts in the Bevier coal, low down in a small valley, show the following section. Limestone No. 3 is the cap-rock of the Mulky coal (which is here absent), and is exceptionally thick in this region:

		Feet.
1.	Lexington horizon	....
2.	Interval, chiefly shale	40
3.	Limestone, gray, irregularly bedded, more than	8
4.	Shale	3
5.	Limestone, buff	1
6.	Shale, black at top, drab at bottom	18
7.	COAL (Bevier)	1⅔

Sutherland.—On the divide near Sutherland the full thickness of the Henrietta formation is present, and the Lexington coal, less than 14 inches thick, is stripped at many places a mile or more from the village. One-half mile east of Sutherland, beside the Missouri Pacific tracks, is the shaft of the Sutherland Coal Co., temporarily abandoned at the time it was visited. Mr. J. B. Scott kindly furnished the following record, in which all the "rock' is probably limestone:

SUTHERLAND SHAFT (S. W. ¼ N. W. ¼ SEC. 21, T. 44 N., R. 24 W.).

	Thickness. Feet.	Depth. Feet.
Soil	9	9
Henrietta formation—		
Rock	8	17
Shale	20	37
Shale, "slaty"	3	40
COAL	1	41
Clay	2	43
Rock	11	54
Shale, black at top	16	70
Rock	4	74
Cherokee shale—		
Shale, "slaty"	3	77
COAL (Lexington)	1⅛	78
Shale, clay and "boulders"	61	139
Rock (Mulky cap-rock)	14	153
Shale, "slaty"	2	155
Shale	12	167
COAL (Bevier)	2	169

Northeast and east of Sutherland the rocks dip strongly southwest, so that lower strata are exposed near the eastern edge of the county and on the divide between Copperas and Muddy Creeks than at similar altitudes at Sutherland. Three miles northeast of the village (N. E. ¼ N. E. ¼ Sec. 9, T. 44, R. 24) a stripping is reported to show the Bevier bed 25 inches thick and considerably higher in elevation than at the Sutherland shaft. Two miles farther east (S. W. ¼ N. E. ¼ Sec. 11), at a 30-foot, horse-whim shaft, known as the Keyes mine, the coal is 30 inches thick, is overlain with 6 feet or more of sandy shale, and lies stratigraphically below the Bevier bed, though probably no lower in elevation.

Bowen.—The important coal deposits near Bowen are described under Henry county, as much of the Bowen trough lies in the latter county. (See p. 193.)

Leeton.—Not much coal is exposed near Leeton. The Lexington bed, only about one foot thick, is exposed near the heads of branches on

all sides of the town. The Muddy cap-rock shows remarkable development in this region, as indicated by the following outcrops on Mineral creek, 1½ miles north of Leeton:

		Feet.
1.	Lexington coal horizon	....
2.	Interval, chiefly shale	25 to 40
3.	Limestone, gray, with flint	4
4.	Concealed	21
5.	Limestone, weathers buff, thin-bedded, and with thin shale partings near base	11
6.	Shale, black, "slaty" at top and bottom, thin layers of limestone and streaks of coal near base	6½
7.	Clay, white	5
8.	Limestone, gray, thin and irregularly bedded at base, more massive and with flint at top	7

Post Oak.—At Post Oak itself shales of the Pleasanton formation appear, but less than half a mile west the sandstones of the southern continuation of the Warrensburg channel outcrop. This channel is here about one mile wide and cuts out the regular coal measures to a considerable depth.

Chilhowee.—New Chilhowee is built on the lower part of the Pleasanton formation. The Lexington coal, only about one foot thick, outcrops in the upper valleys of streams not far distant. After the completion of the Rock Island Railroad, two shafts were sunk beside it by the Chilhowee Coal Co. one mile northwest of the station. Both shafts, No. 1 (S. E. ¼ S. W. ¼ Sec. 14, T. 44 N., R. 27 W.), and No. 3 (S. W. ¼ S. W. ¼ Sec. 14), are 223 ft. deep to the top of the coal mined, and are connected for ventilating and other purposes. Steam hoists and complete tipples are included in the equipment, and the product has been shipped to Kansas City and other places. At the time they were visited the mines had been closed for some time. According to reports, the coal is in two benches, separated by 3 to 4 feet of clay, the upper bench being 34 inches thick and the lower 18 inches. Three feet of "slaty" shale intervene between the top of the coal and 20 feet of hard sandstone. The coal lies nearly 200 feet below the Lexington horizon, and is probably either the Brushy Hill or the Montserrat. A drilling carried to a depth of 370 feet near Chilhowee†, struck one foot of coal at 42½ feet, 18 inches at 86½ feet, 24 to 30 inches at 155 feet, 30 inches at 195 feet, 42 inches at 206 feet, 24 inches at 250 feet, and the white flint at the base of the Coal Measures at 346 feet.

Denton.—The Chilhowee Coal Co. sank its mine No. 2 at Denton. The coal was reached at 242 feet and was found to be the same as that mined at Chilhowee.

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†A complete record is published in the 19th Annual Rept. of the Mo. Bureau of Mines and Mine Inspection for 1905, p. 120, but the identification of strata was evidently not exact in all particulars and correlations cannot be made with certainty.

KNOX COUNTY.*

The general remarks made concerning Lewis county apply also to Knox. The drift cover is thick, so that outcrops are few, but the highest indurated rocks of nearly the entire region are of Mississippian age. It is probable, however, that small outliers and pockets of Pennsylvanian shale and sandstone will be found at many places, and that the attenuated eastern edge of the main body of the Coal Measures occupies a narrow strip along the western border of the county. Coal is undoubtedly interbedded with some of these deposits, yet it is doubtful whether any of the beds will yield returns on more than very small outlays of capital.

LAFAYETTE COUNTY.**

AVERAGE ANNUAL PRODUCTION, 1901-1910.....625,270 TONS.

Mining began in Lafayette county very early in the history of the State, being carried on before the Civil War chiefly by slaves. During the last thirty or forty years mining has been actively prosecuted on a large scale near Lexington, Wellington, Corder, and Higginsville, and more recently at Waverly. There are small mines at many places in the county and coal is shipped in large quantities to Kansas City and points in Kansas and the neighboring parts of Missouri.

The bed mined at all of the shipping plants, except those at Waverly, and at most of the smaller ones is the Lexington. Although the bed is only 14 to 22 inches thick in the producing fields, the coal is of exceptionally good quality for domestic use and is very easily mined. The bed outcrops along the Missouri river bluffs from Waverly nearly to Wellington except where replaced by the Warrensburg channel, and along many smaller streams, so that it may be reached without difficulty. The coal is hard and bright, contains very little visible pyrite, has commonly considerable white gypsum scale on the well developed quadrangular cleavage joints, and stands shipping and stocking exceptionally well. Nearly everywhere there is a parting of pyritiferous shale or clay less than one inch in thickness and three to five inches from the bottom of the bed. East of Lexington a top

*The topography of most of Knox county is shown on the Edina and Atlanta quadrangles of the U. S. Geol. Survey.

**Scattered references to Lafayette county are given by G. C. Swallow: 1st Rept. Mo. Geol. Survey, 1855, and by G. C. Broadhead: Rept. Mo. Geol. Survey for 1872, pt. 2, 1873. The topography and geology of the greater part of the county are described in great detail by Arthur Winslow, The Higginsville sheet: Mo. Geol. Survey, Vol. IX, 1896 (also in folio form, 1892), and by C. F. Marbut, The Lexington sheet: Idem, Vol. XII, pt. 2, 1898 (map republished in revised form in this volume). Considerable information is here taken from the detailed reports without further acknowledgment. The topography of the whole county is shown on a small scale on the Lexington, Independence, Warrensburg, and Harrisonville sheets of the U. S. Geol. Survey.

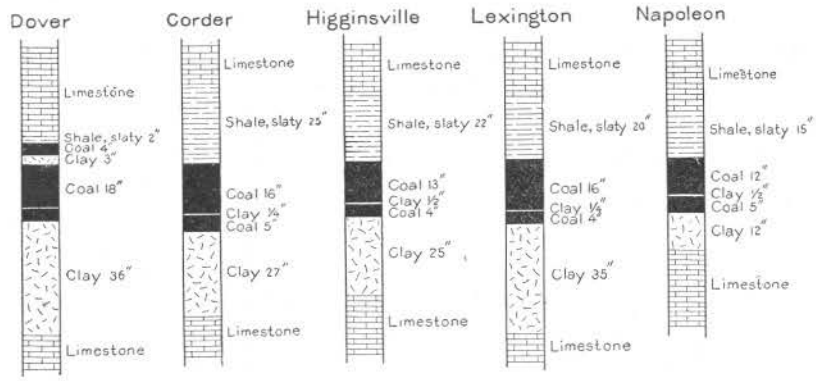

Fig. 45. The Lexington coal bed in Lafayette County.

coal comes in, separated from the lower by two or three inches of clay and very impure coal. Under the coal is a thin layer of pyritiferous clay, known as "sulphur," which is so hard that machines are forced to do their undercutting in the softer clay beneath it. In some mines operated by pick work the mining is done in the lower coal and an inch or two of fairly soft clay between it and the "sulphur." In places the underclay contains nodules of impure limestone that interfere with the machines. One to five feet below the coal is a limestone bottom-rock with an uneven upper surface.

The nature of the rocks overlying the Lexington makes it an ideal bed for longwall mining, the only system in vogue. The coal is commonly overlain by one to two feet of black, "slaty" shale, but east of Lexington, especially near Dover and Hodge, the shale is very thin and in places absent. In the main producing fields this shale is divisible into three parts, an upper, known as the "roof slate", a middle, the "block slate", and a lower, the "band slate". The "roof slate" has very poor vertical jointing and stays up after the coal falls. The "block slate" has a more feebly developed horizontal cleavage than the "roof slate", and much better vertical jointing, so that it forms rectangular blocks. It comes down with the coal and is used in building gob walls and pillars, little or no timbering being required. The "band slate" is only a few inches thick, contains much pyrite and in places many shells, and tends to stick to the coal. The "block" and "band slate" and the "sulphur" make considerable gob to handle, especially where machines are used. Above the "slaty" shale is a strong limestone cap-rock, commonly about seven feet thick. It parts along two or three planes, the upper being 2½ to three feet from the base and known as the "mule parting". In the larger mines the "roof slate" and limestone as far up as the "mule parting" are shot down to make room in the entries. The roof thus formed is very strong and requires little or no artificial support.

The Lexington coal underlies in workable condition a large area

in Lafayette county, being at its best in the northwestern and central portions. In the southwestern and northeastern quarters it is too thin and irregular to be of much importance, and along the southern and eastern edges it has been removed by pre-glacial erosion in many areas. It is also absent along the Warrensburg channel. Details in regard to its occurrence may be found in the descriptions of the different mining districts which follow.

The Mulky coal bed lies about 50 feet below the Lexington and is too low to outcrop except in the eastern part of the county. It is very similar to the Lexington in thickness and character and like it has a covering of black "slaty" shale and a limestone cap-rock. It may be distinguished from the Lexington by: (1) the absence of a well developed limestone bottom-rock, (2) the presence of concretions and lenses of rock in the overlying shale, (3) the greater thickness and differences in minor detail of the shale, and (4) the absence of other limestone beds a short distance above the cap-rock. The Mulky is at its best on both sides of Davis creek and south of the divide on which Concordia stands. Its characteristics may be learned by consulting the descriptions of the Alma, Aullville, and Concordia districts. Where it outcrops along the bluffs near Waverly and Hodge it is too thin to work and drill holes at Corder and elsewhere indicate that it is not persistent in at least part of the area in which it is concealed beneath the surface.

There are a few thin coal beds higher than the Lexington, most of them non-persistent, and there is a persistent bed between the Lexington and the Mulky, but all of these are too thin to be workable. The presence of extensive workable beds beneath the Mulky is in much doubt. Few drillings have been made to determine the question. Outcrops in Johnson county on the south reveal much coal in the lower part of the section and some is more or less doubtfully reported in drillings at Odessa, Lexington, Aullville, and elsewhere. The lower coal beds, except the Bevier and Tebo, lie in basins of no great lateral extent, but in places contain thicker coal than the higher and more persistent beds. Numerous drillings are therefore necessary to show their presence or absence as workable deposits over large areas. The Tebo was formerly shafted at Hodge, where it is 15 inches thick. The Bevier appears to be thin in the same locality.

Important beds lower than the Mulky occur only at Waverly, where a bed lying 200 feet below the Lexington has been mined from shafts for some time. This bed is three to four feet thick and has a shale roof of fair stability. The Waverly coal or others closely associated with it may underlie considerable territory, but little is known as to the actual acreage. Winslow estimates it as 60 square miles.

The following table is prepared on the basis of 1,800 tons of coal per acre-foot:

TOTAL ORIGINAL TONNAGE OF LAFAYETTE COUNTY.

Horizon of coal.	*Average thickness.*	*Area.*	*Tons of coal.*
Lexington	17 inches	280 square miles	456,960,000
Mulky	18 "	80 " "	138,240,000
Waverly	24 "	60 " "	138,240,000
Tebo and others	15 "	100 " "	144,000,000
			877,440,000

According to the best available statistics the amount of coal mined to 1911 was 13,427,000 tons, nearly all from the Lexington bed. In the Lexington field, where the coal is 20 inches thick, about 2,500 tons are recovered per acre, showing a loss of 500 tons per acre through the production of slack, the leaving of unmined corners, and other factors. The amount of coal mined therefore represents an actual exhaustion of 16,592,400 tons or 1.9 per cent of the total original tonnage.

The following is a generalized section of the beds exposed within the county, compiled by the writer from the reports of Winslow and Marbut. Sections measured at different localities will vary much in detail, but be so similar in general characteristics that various horizons may be easily identied. The limestones of the Henrietta formation constitute the most satisfactory markers.

	Feet.
MISSOURI GROUP.	
Kansas City limestone†—	
Limestone	10
Shale	10
Limestone	3
Shale	6
Limestone	2
DES MOINES GROUP.	
Pleasanton shale—	
Shale and sandstone, variable	160
Henrietta formation—	
Limestone	5
Sandstone and sandy shale	25
Limestone	5
Limestone, argillaceous, thin-bedded above, more thickly bedded below, with shale partings	5
Limestone, cap-rock of Lexington coal	5
Cherokee shale—	
Shale, black, "slaty"	1
COAL (Lexington)	1½
Clay	4
Limestone, bottom-rock of coal	3½
Shale	18
Limestone	1½
Shale	4
COAL (Summit)	½
Clay, blue	6
Limestone	3
Shale, drab	2
Limestone	2
Shale, clayey at top, black and "slaty" and with concretions at bottom	7
COAL (Mulky)	1½
Clay	4
Shale, gray	26
Sandstone, micaceous	5
Shale, drab	10
COAL (Bevier)	½

†The grouping and naming of the formations are the writer's.

DES MOINES GROUP—Continued.

Cherokee shale—Continued.	Feet.
Clay	1
Limestone, compact	2½
Shale, in part drab, in part black and "slaty"	15
COAL (Tebo)	1
Clay and shale	22

The rocks between the bottom of the above section and the Waverly coal are shown in a record of the Waverly shaft on a following page. The thick Mississippian limestone, which marks the lower limit of workable coal, lies about 325 feet below the Lexington coal horizon, though this interval may differ by 100 feet in different localities.

In addition to the rocks listed above there are massive and thin-bedded sandstones that do not fit into the general section or other parts of the county, in a narrow strip running north and south through the central part of the county. These deposits fill the ancient Warrensburg channel, which was eroded during Pennsylvanian time in the older Coal Measures rocks. On the Missouri river this channel is six miles wide, but farther south it is only two miles wide or less. The nature and thickness of the rocks that filled the channel are shown in the Higginsville deep well record. These deposits underlie the towns of Berlin, Dover, Page City, Higginsville, and the country just east of Tebo. The economic significance of the channel lies in the fact that in the territory it traverses the Lexington, Mulky, and many or all other coal beds that may have once been deposited are no longer present.

DETAILED MENTION.

Area east of Warrensburg channel.

Waverly.—The deepest and thickest coal bed known in the county is mined at Waverly in the northeastern corner. The stratigraphic position of this bed could not be exactly placed, though at Waverly it appears to be about 200 feet below the Lexington coal horizon.

TRIAL SHAFT ON RIVER BANK, NEAR RAILWAY STATION AT WAVERLY.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil (10 feet below railway level)	14	....	14	....
Sand	4	....	18	....
Shale, greenish, with concretions	3	6	21	6
Shale, black, hard	....	2	21	8
COAL	....	1	21	9
Shale, black, soft	....	3	22	....
Shale, gray	8	....	30	....
Limestone, dark gray	2	....	32	....
Shale, gray	8	....	40	....
COAL	....	1	40	1
Clay	....	2	40	3
Shale	17	3	57	6
Limestone	4	6	62	....
Shale, dark brown, black and with coal streaks near bottom	10	....	72	....
COAL (Waverly), mined	3	....	75	...
Clay	....	....	....	...

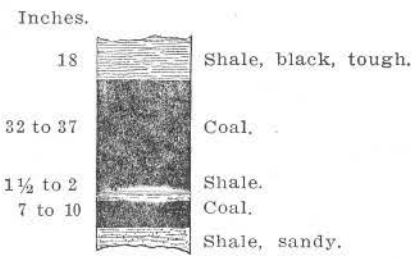

FIG. 46. The Waverly coal bed at Waverly.

At present two shafts—those of the Steamboat Coal and Mining Company and the Waverly Brick and Coal Company—are operating at the foot of the bluffs. The shaft of the Steamboat Coal and Mining Company is one-fourth mile east of Waverly and 102 feet deep. Five very thin coals were found above the Waverly and 30 feet of barren shale below it. The only work done in 1910 was the pulling of pillars in the east workings and the driving of an exploratory entry through an ancient channel in which the coal is replaced on the south by clay shale and cross-bedded sandy shale. When visited the entry had been driven south 300 feet without finding the coal. In the mine the coal is three to four feet thick and is overlain with 18 inches of dark shale, above which are 10 feet of light sandy shale. The roof requires careful timbering. Three-fourths of a mile west of the railroad station is the shaft of the Waverly Brick and Coal Company, 120 feet deep. A modern tower and tipple with shaker screens, self-dumping cages and geared, double hoisting engine has recently been installed and the mine bids fair to become an important producer. If sufficient of the black shale is left up, the roof is fairly good and the requisite height can be obtained in the roadways by taking up the underclay. The coal is shot off the solid on the room and pillar method. A little inflammable gas is found in places and necessitates careful watching. The bed contains considerable pyrite (''sulphur'') in streaks and lenses. On the south its thickness decreased to three feet. The main workings show the following section:

	Feet.	*Inches.*
COAL	....	6
Clay, white	6	....
Shale, black, tough, with stringers of coal	6	....
COAL, 37 inches Clay, 1½ " (Waverly) COAL, 10 "	4	½
Clay, dark gray, hard, more than	2	....

Little could be learned of the areal extent of the Waverly bed, but it is probable that it is rather irregular in thickness and that workable basins are separated by areas nearly or completely barren. In the Catron well, four miles south of Waverly (S. E. ¼ S. E. ¼ Sec. 4, T. 50 N., R. 24 W.), 18 inches of coal (Mulky) were found at 71

feet and 36 inches (Waverly?) are reported at 252 feet. Other wells in the district did not go deep enough to reach the Waverly horizon. The Mulky was formerly stripped one mile west of the Catron well but is said to have been only one foot thick.

Hodge.—All the coal beds (including the Lexington and Mulky) exposed in the bluffs between Waverly and Hodge (formerly Edwards Station) are too thin to be workable. On the range line, four miles from Waverly, coal more than 15 inches in thickness was dug from the river bed many years ago. All beds dip to the west. The Lexington appears 100 feet above the railroad east of Hodge and gradually approaches lower levels as far as Dover. In 1889 a shaft was sunk to a depth of 93 feet at Hodge and for a time operated in the coal lying 70 feet below the railroad and about 170 feet below the Lexington horizon. The coal mined appears to be higher than any of those in the trial shaft record at Waverly, and to correspond in stratigraphic position with the Tebo bed, which is well developed in Johnson, Henry, Linn, and other counties. The interval between it and the Lexington is somewhat greater here than in other localities.

SHAFT AT HODGE.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Surface material	15	....	15	....
Shale	15	....	30	....
COAL	....	6	30	6
Shale, sandy and micaceous	40	....	70	6
COAL (Bevier), "slaty"	....	6	71	....
Clay	3	....	74	....
Limestone (?)	3	....	77	....
Shale and clay	3	....	80	....
Limestone (?), clayey, pyritiferous	1	8	81	8
Shale, black, calcareous in center, lower 2 feet "slaty"	4	10	86	6
COAL (Tebo), mined	1	3	87	9
Clay	4	6	92	3

Two miles west of Hodge (S. W. ¼ S. E. ¼ Sec. 9, T. 51 N., R. 25 W.) is the small Rockholt drift, operated by Peter Bartley. This appears to be the eastern limit along the Missouri bluffs of really workable coal in the Lexington horizon. Even here the bed is very irregular, being affected by rolls in the roof and floor.

LEXINGTON BED AT ROCKHOLT DRIFT, WEST OF HODGE.

	Inches.
Limestone	.....
COAL, upper bench	0 to 6
Clay	2
COAL, lower bench	3 to 20
Clay, light	48

In the bluffs one-half mile farther west (west line, Sec. 9) and 75 feet above the railroad is the W. E. Bear drift, operated by W. R. Bynum for local trade. The Lexington is much the same as at the Rockholt drift, the upper bench being commonly absent and the lower

12 to 20 inches thick, averaging 15 inches. Four inches or less above the coal is more than 11 feet of limestone with intercalations of shale in the upper part.

Dover.—Just above the railroad, in the bluffs one mile northeast of Dover Station, is an old shipping mine now operated by the Dover Coal Company. The working face is one-half to one mile from the mouth of the drift. Here, also, the Lexington bed is greatly impaired by rolls in the roof, the upper bench being cut out in much of the mine. Because of the thinness of the shale above the bed it is difficult to obtain sufficient material suitable for building gob walls. The coal contains a large percentage of moisture and "sulphur" and a moderate percentage of ash.

LEXINGTON BED AT DOVER COAL CO. DRIFT, NORTHEAST OF DOVER.

	Feet.	*Inches.*
Limestone	4	.....
Shale, black, "slaty"	.....	0 to 3
COAL	.....	0 to 8
Clay	.....	3
COAL	1	6
Clay, dark, top, lighter below	2 to 5	.....
Limestone	.....	.....

At the town of Dover itself and for a mile north, east and south and a greater distance west, the Lexington bed and probably most of the lower coals have been removed and replaced by the sandstone of the Warrensburg channel. A well near the wagon road, one-fourth mile southwest of the town, found no coal in a depth of 80 feet. The Phillips well, two miles east of Dover (N. W. ¼ Sec. 27), however, is beyond the eastern limit of the channel and penetrated 24 inches of coal (Lexington) at 60 feet and 22 inches (Mulky) at 100 feet. Where it outcrops half way between the Phillips well and the Dover Coal Company drift, the Lexington is much the same as in the neighboring river bluffs. Along one of the main branches of Tebo creek, southeast of Dover, both the Mulky and the Lexington outcrop, and a very promising prospect in the latter has been opened in a side draw on land of Albert Gattung (S. E. ¼ S. W. ¼ Sec. 4, T. 50 N., R. 25 W.).

LEXINGTON BED AT GATTUNG SLOPE, SOUTHEAST OF DOVER.

	Inches.
Limestone, compact	42
Shale, black, tough	11
COAL, with two inches very impure	7
Shale, very carbonaceous	2
COAL, excellent, clean, hard, bright, weathers well	19
Clay	24
Limestone	....

Alma.—The Lexington coal outcrops on the west side of Salt creek, west of Alma, but has not been found at the town itself. A drilling 58 feet deep in the northeast corner of town was barren; another, one-

half mile south of the railroad, struck coal at 100 feet. South of Alma, near the headwaters of the tributaries of Davis creek, the Mulky bed outcrops in workable condition and has been mined in a small way at several points. Three miles southeast (south side, N. E. ¼ Sec. 3, T. 49 N., R. 24 W) the Mulky is 18 inches thick and separated from the limestone cap-rock by five to six feet of black, "slaty" shale.

Corder.—Several shipping mines formerly in operation near Corder have exhausted and abandoned their territories. According to the record‡ of a shaft just west of town, the Lexington was 96 feet deep and 20 inches thick. Above it were two thin unimportant coal beds. A drilling that explored 230 feet of strata below the bottom of the shaft found that the Mulky horizon is barren and penetrated only two coal beds, one 10 and the other 5 inches thick in the entire distance, but allowance must be made for inaccuracies inherent in a churn drill record.

The Lexington bed in the Corder field is thicker than at Higginsville, though not quite so regular. There are a few "horsebacks", where the "slaty" roof shale is replaced by softer material without rectangular cleavage, and the top coal is thin, dirty, or absent. These, however, affect only a small proportion of the working faces. At present the only shipping plant is the Wilson mine of the Diamond Coal Company, on a spur running one-half mile southeast from Corder. The shaft is 60 feet deep and hoisting is done by a first-motion, double engine. A rock crusher prepares the limestone shot down in the roads for concrete and other uses. In 1910 the circular face was about 700 feet from the shaft. The largest "horseback" affects 140 feet of face; five others encountered affect only 25 to 40 feet each. A pre-glacial channel cuts out the coal east of this mine. One mile south of Corder (S. W. ¼ N. W. ¼ Sec. 35) is the 38-foot shaft of Bishop and James on land of Nathan Corder. Hoisting is done by horse-power and a part of the output is hauled to Corder and shipped. A few "horsebacks" were noted. Several miles south of the town, on the headwaters of the northern tributaries of Davis creek, the Lexington coal outcrops and has been mined for country trade at many points. The only mine found in operation was the drift of M. W. Summers (S. W. ¼ S. W. ¼ Sec. 6, T. 49 N., R. 24 W.). One-half mile northeast and northwest, respectively, from Corder are two small mines hoisting by horse-power: (1) Anton Stolin, shaft 52 feet, S. E. ¼ S. W. ¼ Sec. 23, and (2) Hohenwald Bros., shaft 45 feet, S. W. ¼ S. E. ¼ Sec. 22. There are a few "horsebacks" in the latter and one in the former that cuts out all or part of the coal on one side of the mine.

The coal and associated rocks are much the same at all of the Corder mines.

‡Mo. Geol. Survey, Vol. IX, 1896, p. 40.

LEXINGTON BED IN CORDER FIELD.

	Feet.	Inches.
Limestone	3	....
Shale	2	....
Limestone, "cap-rock"	7	....
Shale, "roof slate"	....	0 to 18
Shale, "block slate"	....	10 to 13
Shale, pyritiferous and carbonaceous, "black jack"	....	1 to 10
COAL, upper bench	....	14 to 19
Shale	....	¼
COAL, lower bench	....	4 to 5
Clay	....	4 to 60
Limestone, "bottom-rock"	....	....

Higginsville.—Higginsville itself is situated on the Warrensburg channel, which has cut out all coal beds originally deposited there. The nature of the Warrensburg strata is shown in the record of a deep well bored 200 feet northeast of the Missouri Pacific depot in 1898.

HIGGINSVILLE DEEP WELL.	Thickness. Feet.	Depth. Feet.
Earth and clay	68	68
Sandstone, saturated with asphaltum at base	120	188
Shale, "slaty"	5	193
Shale, dark	147	340
Shale, light	10	350
Sandstone	20	370
Limestone (Mississippian, lower limit of coal)	....	....

The well was carried to a total depth of 1,507 feet, the strata below those given above being chiefly limestone.§ Probably the base of the channel deposits was reached at 188 feet, but it may be that all beds above the Mississippian should be included. The lateral limits of the channel are one-half mile from the city on the west and one mile on the east, though it is much thinner on the edges than in the record cited. It extends north and northwest to the Missouri and south to the county line, as shown on the map of the Higginsville quadrangle and those included in this volume. The large mines for which Higginsville is famous are west of the channel and will be described later. East of the channel are a number of small drifts that supply a local trade and haul to the city, and also a shipping mine on the Alton Railroad, owned by the Bonanza Coal Company. The Bonanza shaft is two miles east of the city (N. E. ¼ S. W. ¼ Sec. 32) and is 72 feet deep. Hoisting is done by horse-power. The lower three feet of cap-rock is shot down in the entries and crushed for concrete and road material in a plant recently installed. The working face is 1,000 feet east and 1,700 feet south of the shaft. Near the Bonanza (N. E. ¼ S. E. ¼ Sec. 32), is the small drift of Herman Freth, one mile south (N. E. ¼ S. W. ¼ Sec. 5), the 35-foot shaft of J. C. Wagner, and nearly a mile farther south (N. E. ¼ N. W. ¼ Sec. 8), the 18-foot shaft of W. M. Freth. The Lexington bed outcrops in the upper portions of the valleys south of the railroad and has been mined at a num-

§Complete record given by E. M. Shepard, Underground waters of Missouri: Water Supply Paper, No. 195, U. S. Geol. Survey, 1907, p. 87.

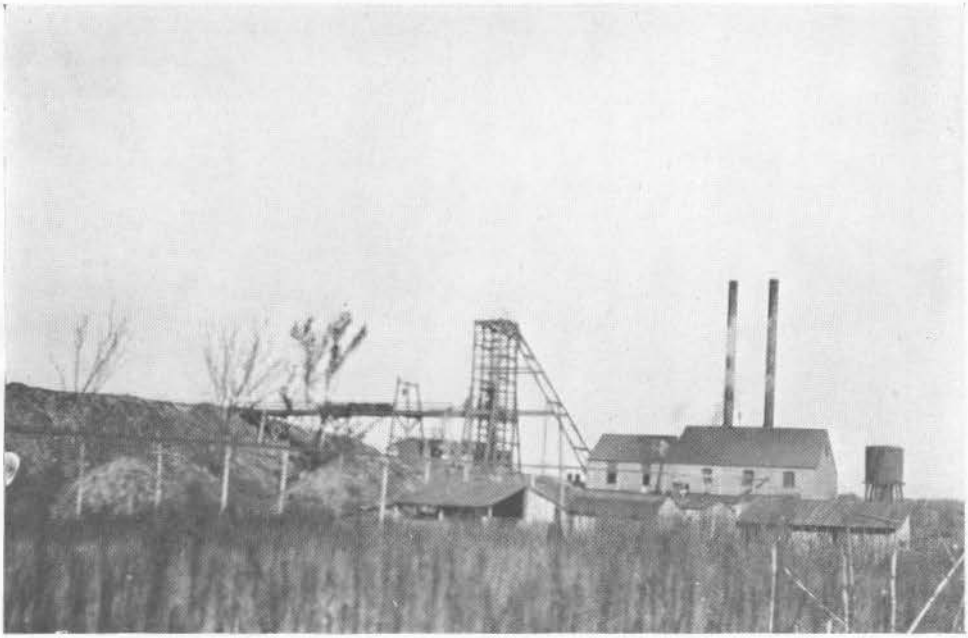

Fig. 1. South mine of Western Coal and Mining Co., 4 miles south of Lexington, Mo.

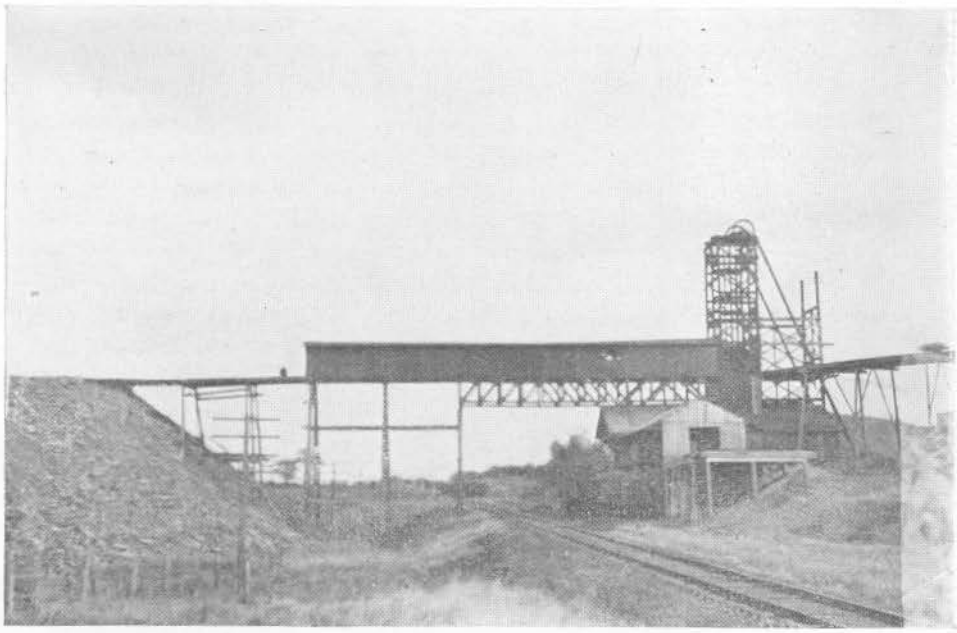

Fig. 2. Mine No. 1, Farmers Coal Co., Higginsville, Mo.

ber of small drifts. The coal is much the same in all the mines in the district.

LEXINGTON BED EAST OF HIGGINSVILLE.

	Feet.	*Inches.*
Limestone	6	....
Shale, with thin beds of limestone	8	....
Limestone, with natural rock partings about 1, 2, and 3 feet from base	6	....
Shale, "roof slate"	....	7
Shale, "block slate"	....	10
Shale, pyritiferous at base, "band slate"	....	6
COAL	1	3
Shale	....	½
COAL	....	4
Clay	....	8 to 48
Limestone	....	....

Aullville.—Near Aullville the Lexington bed is found only on those higher lands on which it has not been replaced by drift. In a railroad cut one mile southeast of town it is 16 inches thick, but the upper four inches is impure. Near a hilltop one mile west of town it is 19 inches thick, and is separated from a thick limestone cap-rock by two feet of "slaty" shale. A more important bed in this part of the county is the Mulky, which outcrops along the lower courses of the tributaries of Davis creek. It is worked for local trade at a number of places. Two miles southeast of Aullville, at the level of the railroad, is the drift of W. M. Shelton on the Taubman estate (S. W. ¼ S. W. ¼ Sec. 35, T. 49 N., R. 25 W.) and not far distant (N. W. ¼ N. W. ¼ Sec. 2) is the 20-foot shaft of G. E. Neece on land of Herman Alewel. The Mulky coal is 20 to 23 inches thick, is underlain with hard drab clay and overlain with six feet or more of black "slaty" shale containing lenses and "niggerheads" of impure limestone. The same bed is mined north of Davis creek (N. E. ¼ N. E. ¼ Sec. 24, T. 49 N., R. 25 W.) by Jacob Martens.

MULKY BED AT MARTENS SLOPE.

	Feet.	*Inches.*
Limestone	1	8
Clay, light	1	....
Shale, bluish-black, "slaty," lithified in places, a few disc-shaped "niggerheads"	6	....
COAL	....	18 to 22

Two miles northeast of Aullville the Lexington bed may be seen at the Thomas Payne (N. W. ¼ N. E. ¼ Sec. 22) and Wm. Clapper

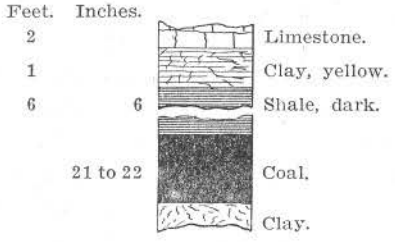

FIG. 47. The Mulky coal bed near Concordia.

(N. E. ¼ S. E. ¼ Sec. 15) drifts. The coal is 19 inches thick, with 26 inches of black "slaty" shale between it and a limestone cap-rock. Unlike that over the Mulky coal, the shale above the Lexington is made "blocky" by a strong rectangular cleavage.

A hole drilled at Aullville penetrated the Mulky at 30 feet and also 28 inches of coal at 203 feet that is correlated with the Waverly bed by Winslow. No other information regarding the deeper coal beds of the district is available.

Concordia.—The Mulky coal is exposed well up in the valleys both north and south of Concordia and is mined intermittently for local use. One and one-half miles northeast of town (S. W. ¼ S. W. ¼ Sec. 34) is the shaft of August Lohman, where a small gasoline engine is employed to hoist 20 feet. The Mulky is here 19 inches thick, overlain with more than six feet of "slaty" shale that is lithified at the base, and underlain with four feet or more of yellowish drab clay. The same bed may be seen along Panther creek southeast of Concordia, and is now mined in the shallow shaft of Peter Miller on the Ziegler land (S. E. ¼ N. E. ¼ Sec. 15, T. 48 N., R. 24 W.). The coal is 25 inches thick where normal, but about one-fourth of the working face is reduced by rolls in the roof and floor. The underclay is at least six feet thick, though it heaves only a few inches. The Mulky is also exposed on Peavine creek and is mined three miles southwest of town at the Henry Temming drift (N. E. ¼ S. W. ¼ Sec. 13), the short slope of W. M. Rust (N. W. ¼ S. W. ¼ Sec. 13), and the shallow shaft of Chas. Guyman.

MULKY BED SOUTHWEST OF CONCORDIA.

	Feet.	*Inches.*
Limestone, blue, compact	1	10
Clay	....	10
Shale, black, "slaty"	7	6
COAL	....	17 to 25
Clay, very hard, more than	2	....

Area west of Warrensburg channel.

Higginsville.—Deposits at and east of Higginsville have already been described. On the west side of the Warrensburg channel, two miles and less southwest of the city, is a field that has produced and shipped to Kansas City and other points large amounts of coal. Most of the mines are on a coal spur connected with both the Chicago & Alton and the Missouri Pacific railroads and known as the Rocky Branch Railroad. Although the Lexington, the bed mined, is only 14 to 18 inches thick here, the ideal longwall mining conditions afforded by its excellent roof and floor and the regularity and exceptional quality of the coal have encouraged development. Three grades are recognized by the trade: (1) the Farmers, a black, glossy coal containing very little gypsum or pyrite; (2) the Excelsior, a "white coal" with a moderate amount of gypsum scale on the joints, and (3) the

Planters, which is much like the Excelsior, but has slightly inferior stocking qualities and a little more pyrite. Pyrite is moderate in all the grades, appearing only in very fine streaks or associated with the gypsum in thin films.

The largest company operating in the field is the Farmers Coal Company, their mines being: (1) No. 1, shaft 80 feet, N. E. ¼ S. W. ¼ Sec. 1; (2) No. 3, shaft 40 feet, N. W. ¼ S. W. ¼ Sec. 12; (3) No. 6, shaft 26 feet, N. E. ¼ N. E. ¼ Sec. 11; and (4) No. 7, drift, N. E. ¼ S. W. ¼ Sec. 11. These mines have exhausted more than 400 acres and most of them have been in operation for more than 20 years. Geared steam hoists are used at the shafts, motor haulage in Nos. 1 and 3, and Goodman mining machines at Nos. 1, 3, and 7. Other mines in the district are: (1) Ruff and Belt, drift, opposite No. 7; (2) Chas. August on land of C. Hader, shaft 18 feet, near No. 3; (3) Snieder and Gladish, short slope, N. E. ¼ N. W. ¼ Sec. 11; and (4) Canterbury and Griffith, slope, S. E. ¼ S. W. ¼ Sec. 36. A short distance southwest and south of the main producing district are several smaller mines that supply city and country trade: (1) S. G. Emerson, drift, S. W. ¼ N. E. ¼ Sec. 15; (2) J. Wright, drift, N. W. ¼ S. E. ¼ Sec. 15; (3) T. J. Clay on land of S. Schooling, drift, S. E. ¼ S. E. ¼ Sec. 15; and (4) F. Boedeker on land of E. Boedeker, short slope, S. W. ¼ S. E. ¼ Sec. 14. The coal and other strata are the same in all parts of the district.

LEXINGTON BED SOUTHWEST OF HIGGINSVILLE.

	Inches.
Limestone, with bedding partings about 12 and 30 inches from base	....
Shale, "roof slate"	7 to 10
Shale, "block slate"	9 to 13
Shale, "band slate"	2 to 4
COAL	11 to 14
Clay	¼ to ¾
COAL	3 to 5
Clay, black, pyritiferous, hard, "sulphur"	0 to 6
Clay, light, softer	0 to 48
Limestone, upper surface uneven	....

Mayview.—On the west side of Mayview, beside the railroad, is a shaft operated by B. F. Cary. Coal is hoisted 128 feet by a geared engine and the product shipped to Slater and other points. White gypsum scale is rather abundant on the joints. Small "horsebacks" of the Corder type are present. The working face is about 700 feet from the shaft.

LEXINGTON BED AT MAYVIEW.

	Inches.
Limestone	....
Shale, "roof slate"	6
Shale, "block slate"	12
Shale, pyritiferous	1½
COAL	10
Clay	¼
COAL	5½
Clay	36
Limestone	....

The rocks above the coal are well shown in the record of the Strasburg shaft, formerly operated one mile northeast of Mayview.

OLD STRASBURG SHAFT.

	Thickness. *Feet.*	Depth. *Feet.*
Soil and clay	24	24
Limestone, gray	⅔	24⅔
Shale	20⅓	45
Limestone, yellowish	11	56
Shale, yellowish, bluish at base	17	73
Limestone, bluish, hard	9	82
Shale, black, "slaty"	1⅓	83⅓
COAL (Lexington)	1⅔	84⅝
Clay	3	....

North, east, and southeast of Mayview the Lexington coal outcrops along the branches of Tebo creek and has been mined at a number of places for country use. Two miles north (N. W. ¼ N. W. ¼ Sec. 6) is the H. Smith drift, operated by W. N. Alcorn in coal 16 inches thick and under conditions like those at Mayview. Three miles farther north (N. W. ¼ S. E. ¼ Sec. 19, T. 50 N., R. 26 W.), is the C. G. Lyons drift, operated by J. Burns, where the coal is 19 inches thick and the overlying material the same as at Mayview. Very little mining is now done south of Mayview, as the coal is rather thin in the southern part of the county. On Wooden creek, seven miles south of Mayview, are the local drifts of W. H. Littlejohn (N. E. ¼ S. W. ¼ Sec. 18, T. 48 N., R. 26 W.) and the Stockton Brothers (N. W. ¼ S. W. ¼ Sec. 18).

LEXINGTON BED ON WOODEN CREEK.

	Feet.	*Inches.*
Limestone, blue, weathers gray, more than	4	....
Shale, black, "slaty," clayey at top	1	10
COAL	....	15 to 18
Shale, dark, hard, pyrite at base	....	7
Clay	3	....

Odessa.—The surface formation at Odessa is the Pleasanton shale, with the basal limestones of the Missouri group exposed on the high ridges near town. Rather conflicting records of several wells drilled near the town are given in full by Marbut. The Hatch well (S. W. ¼ Sec. 31, T. 49 N., R. 27 W.) penetrated 21 inches of coal at 70 feet, 17 (Lexington?) at 117 feet, and 17 at 169 feet, the total depth being 198 feet. The Lee well (N. W. ¼ Sec. 1, T. 48 N., R. 28 W.) reached 18 inches at 266 feet and 23 at 301 feet. At the Wayman well, eight inches were reported at 42 feet, 12 at 61, 15 at 91, and 30 inches at 100 feet. None of these wells, except possibly the Lee, were carried sufficiently deep to explore the more productive lower horizons.

The Lexington coal is 16 inches thick where exposed on Owl creek, northwest of Odessa (N. E. ¼ Sec. 27). About five miles southwest of Odessa three small mines are supplying a local trade: (1) Thomas

Perry, drift, N. W. ¼ N. W. ¼ Sec. 17, T. 48 N., R. 28 W.; (2) S. Davis, drift, one mile southwest of Perry; (3) I. B. Hudson, operated by R. B. Gann, drift, one mile southeast of Perry. In this district the Lexington bed is of good quality but is very irregular in thickness. In many places the top bench is cut out in whole or in part by "horsebacks" of the Corder type. Where the full thickness of the coal is found the section averages as follows:

LEXINGTON BED SOUTHWEST OF ODESSA.

	Inches.
Limestone, gray, more than	48
Shale, blue, soft, "blue john"	7
Shale, black, "block slate"	10
Shale, pyritiferous, carbonaceous	1
COAL	10
Shale, pyritiferous	¼
COAL	5
Clay, dark, hard, "sulphur band"	6
Clay, light	12
Limestone	....

Greenton.—The Lexington bed outcrops in the valleys west of Greenton and is drifted by P. E. Oliver on land of J. A. Chamberlin (N. E. ¼ S. W. ¼ Sec. 1, T. 49 N., R. 28 W.), and by Wilson Brothers on land of H. T. Robinson (S. W. ¼ N. W. ¼ Sec. 15). The coal is only 13 inches thick at these mines, and is separated from its limestone cap-rock by 12 to 20 inches of black, "slaty", shale. The usual layer of hard pyritiferous clay is found next the bottom of the coal. Down Sniabar creek from this locality to Wellington the Lexington is at or just below stream level and no mines or prospects were found.

Lexington.—Since the earliest days of the settlement of the region, when coal was mined to supply steamboats and pioneers with fuel, Lexington has been an important producing center. Formerly there were a number of shafts along the railroad east of the city and drifts in the bluffs for five miles below Myrick, but these are now abandoned.* At Riverton the top bench of coal, found in places northeast of Dover, is four inches thick and separated from the cap-rock by six inches of "slaty" shale. Otherwise the bed is much the same as in the district west and south of Lexington, where the top bench is absent. Drillings in Secs. 23, 25, and 26, T. 51 N., R. 27 W., showed that the coal was replaced by drift along a channel one-fourth mile wide. Elsewhere in this locality the rock cover above the coal is thin and fractured, so that water entered the workings. Operators state that all of the territory east of Lexington and north of the Lexington branch of the Missouri Pacific railroad as far east as Dover is mined out, unworkable, or barren. Just south of the railroad, however, two

*For shaft records and more detailed descriptions of these mines see Marbut, Mo. Geol. Survey, Vol. XII, pt. 2, 1898, pp. 217-220, 235-237.

miles east of the city (S. E. ¼, S. W. ¼ Sec. 36), the Gaffin mine of the Aull Coal Co. is now operated. The product is pulled up a short slope to the surface by a small engine attached to a cable. The working face is more than a half mile south of the entrance. There are a few "horsebacks" and "slips." The coal is as follows, much like that in the Riverton district:

LEXINGTON BED EAST OF LEXINGTON.

	Feet.	*Inches.*
Limestone	4	....
Shale	3	....
Limestone	7	2
Shale, black, "slaty," lower two inches pyritiferous	1	2
COAL	....	2
Clay, black, very carbonaceous	....	4
COAL	1	5
Clay	....	¼
COAL	....	3
Clay, dark, pyritiferous, "sulphur"	....	4
Clay, light	2 to 4	....
Limestone	....	....

In the deep ravines on the south side of Lexington are four mines that supply a large city trade: (1) Plattenburg Coal Co., drift, face 1400 feet south of entrance; (2) Bell and Greer, drift, face 1900 feet southwest of entrance; (3) C. C. Sipe, shaft 26 feet, horse-whim hoist; and (4) Frank Crane, shaft 25 feet, horse-whim hoist. The largest companies operating are the Western Coal and Mining Co. and the McGrew Coal Co. The Western mines were sunk during and after 1900 on a spur that extends three miles south from Lexington and are: (1) Valley mine, shaft 87 feet; (2) Midway mine, shaft 140 feet; (3) Summit mine, shaft 160 feet; and (4) South mine, shaft 180 feet. The equipments are modern and complete in every detail. Large first-motion steam hoists are used. There are electric lights at the pit bottoms, and electric power stations at the Midway and South mines. Twenty electric mining machines are employed. About 780 acres have been mined out, chiefly from the mines nearest the city.

The McGrew mines Nos. 1 and 2 were opened in 1886 in the river bluffs three miles southwest of Lexington. The Graddy, another old mine, is now operated by the same company. All three drifts are connected and have continuous faces that lie more than one-half mile from the bluffs. They have mined out about 300 acres. They are exceptionally well managed, use 14 mining machines and five motors with a central power plant and repair shop at No. 1, and have double-tracked haulage lines in the main entry. At McGrew No. 2 the Lexington coal bed is only a few feet above the river flood plain, while one mile farther up the railroad it is 25 feet lower and there are no mines in operation. From the Graddy mine to Myrick, however, the

bluffs are pitted with abandoned drift openings and the Macey drift is still in operation, the face being nearly one-half mile from the bluffs.

The coal and associated strata are much the same at all the mines west and south of Lexington, the only noticeable change being a very slight thinning of the coal to the south.

LEXINGTON BED WEST AND SOUTH OF LEXINGTON.

	Inches.
Limestone, with bedding-plane partings 1 and 2 feet from base	80
Shale, "roof slate"	3 to 5
Shale, "block slate"	10 to 11
Shale, "band slate"	2 to 7
COAL	16 to 17
Clay	¼
COAL	3 to 4
Clay, fairly soft, "mining clay"	0 to 6
Clay, dark, very hard, "sulphur"	1 to 6
Clay, light, softer	20 to 48
Limestone	....

The nature of the strata above the coal near the bluffs is shown by the following record:

NEW AIR SHAFT OF McGREW MINES.

	Thickness. *Feet.*	Depth. *Feet.*
Surface clay	26	26
Sandstone	16	42
Shale	22	64
Limestone	5	69
Shale	20½	89½
Limestone	8½	98
Shale, "slaty" at base	7	105
Limestone, blue, cap-rock	7	112
Shale, black, "slaty"	1⅓	113⅓
COAL (Lexington)	1⅔	115

Although the strata closely associated with the coal are very persistent in character and thickness, those above the cap-rock are rather variable. This is shown by the following drillings made south of Lexington:

DRILLING ONE MILE SOUTHEAST OF VALLEY MINE (200 FEET NORTH AND 800 FEET WEST OF CENTER OF SEC. 10, T. 50 N., R. 27 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay and gravel, very tough	55	....	55	....
Shale, yellow	12	6	67	6
Limestone, white	7	....	74	6
Shale, yellow	17	4	91	10
Limestone, white	12	1	103	11
Shale, black	....	6	104	5
Limestone, cap-rock	7	8	112	1
Shale, black	....	10	112	11
COAL (Lexington)	1	9	114	8
"Sulphur"	....	6	115	2
Clay to limestone bottom-rock	4	....	119	2

DRILLING IN RAVINE SOUTHWEST OF SUMMIT MINE (ON LINE BETWEEN SECS. 9 AND 16, T. 50 N., R. 27 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay and shale	6	3	6	3
Shale, blue at top, copper-color at bottom, sandy	23	9	30	....
Clay, very soft	1	11	31	11
Limestone, white, fine-grained, very hard	4	....	35	11
Shale, black, very bituminous in lower part	11	11	47	10
COAL, absent farther north	....	10	48	8
Clay	2	....	50	8
Limestone, very hard	1	6	52	2
Clay, with sand	2	3	54	5
Limestone, white, fine-grained	11	7	66	....
Shale, black, bituminous	5	10	71	10
Limestone, blue, cap-rock	6	2	78	....
Shale, black, "slaty"	....	10	78	10
COAL (Lexington)	1	8	80	6
"Sulphur"	....	4	80	10
Clay, to limestone bottom-rock	3	6	84	4

DRILLING ONE MILE SOUTHWEST OF SOUTH MINE (NEAR CENTER SEC. 21, T. 50 N., R. 27 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay	10	5	10	5
Rock (sandstone?)	4	....	14	5
Shale, sandy near center	38	6	52	11
Limestone, white	3	8	56	7
Shale	25	6	82	1
Limestone, white	6	....	88	1
Clay and blue shale	5	6	93	7
Limestone, blue, cap-rock	7	6	101	1
Shale, black, "slaty"	....	8	101	9
COAL (Lexington)	1	6	103	3
"Sulphur"	....	6	103	9
Clay, to limestone bottom-rock	4	4	108	1

The coals below the Lexington bed in the Lexington field are very little known. A hole drilled near the railway at the mouth of Wilmot branch found 20 inches of coal at 135 feet below the Lexington bed. Above the coal was 20 inches of black shale overlain with light shale. This bed, which is probably the Bevier, is persistent under considerable territory. It is said that four feet of coal was reported in a drilling at the Lexington brewery, but that part of it may have been black shale.

Wellington.—The Lexington coal bed lies about 40 feet below the railroad at Wellington, and was formerly mined from a shaft on the east side of the town. It is said that the mine was abandoned because of a poor roof. One mile east of town the coal rises so high that for a short distance it is as much as 15 feet above the railroad and can be mined by drifting. The Lanning and Harris Coal and Grain Co. operate the Daisy drift here (N. W. ¼ S. E. ¼ Sec. 14), shipping over the Missouri Pacific to Kansas City and points in Kansas. The working face is 3300 feet south and 2200 feet southeast of the entrance and 120 acres have been mined out. Three motors haul from the face and are

supplied with power by a plant at the mine. The main entries are double-tracked, with electric lights at the partings and switches. In places there are three tracks side by side and the roof above them has stood for years without timbers. Six Goodman mining machines are employed. The details of the coal and associated strata are practically the same as given in the general section for the district west and south of Lexington.

Although the Lexington coal lies below the level of Big Sniabar creek for several miles from its mouth, the bed outcrops for four miles up Little Sniabar, and there is a group of small drifts on that stream about three miles southeast of Wellington. These supply local trade and are: (1) Edward Fallman land, Virgil Ball operator; (2) John McFadden; (3) C. Goodloe; and (4) August Anderson. Mining is done by hand in the bottom coal or in a few inches of "black jack" found in places above the "sulphur". The average of sections measured is:

LEXINGTON BED IN LITTLE SNIABAR CREEK.

	Inches.
Limestone	48
Shale, "roof slate"	4
Shale, "block slate"	11
Shale, "band slate"	1
COAL	13
Clay, pyritiferous	½
COAL	4
Clay, "sulphur"	5
Clay, softer, to limestone bottom-rock	18

Not quite two miles west of Wellington (N. W. ¼ S. W. ¼ Sec. 16) is the steam-power shaft, 76 feet deep, of the Labor Exchange mine. The mine was temporarily closed when visited, but the details of the coal are said to be much the same as at the Daisy drift. Marbut gives the following record of an old shaft near the Labor Exchange:

OLD HARTMAN MINE, TWO MILES WEST OF WELLINGTON.

	Thickness. *Feet.*	Depth. *Feet.*
Soil and clay	12	12
Sandstone	2	14
Clay, red	4	18
Limestone, blue	4	22
Shale, colored	20	42
Limestone, white	7	49
Shale, white and blue	20	69
Limestone	7	76
Shale, black, "slaty"	1	77
COAL	1½	78½
Clay	5	83½
Limestone	3½	87

Napoleon.—The Independence Coal Co. operates a 50-foot shaft beside the railroad one mile east of Napoleon (N. E. ¼ N. E. ¼ Sec. 24, T. 50 N., R. 29 W.), hoisting by steam power. The Lexington coal

lies 40 feet below the railroad level and is in much the same condition, though thinner, as in the Lexington field. The bed is but little disturbed in most of the mine, but in the west workings there is a real fault said to trend northwest-southeast. The coal has dropped down about 44 inches on the west side of the fault. In an old mine west of this one work toward the east was stopped by a fault with a downthrow of about the same amount toward the east.

LEXINGTON BED AT NAPOLEON.

	Feet.	Inches.
Limestone	6	....
Shale	3	6
Limestone, partings 10 and 40 inches from bottom	7	10
Shale, "roof slate"	....	3
Shale, "block slate"	....	10
Shale, pyritiferous	....	2
COAL	....	12
Clay, with pyrite and coal streaks	....	½
COAL	....	5
Clay	0 to 2	....
Limestone	½ to 2	....
Shale	8	....

LEWIS COUNTY.*

Lewis county cannot be considered an important potential coal producer, although from time to time a small amount of coal has been mined in it for local use. In by far the greater part of the county the highest rocks beneath the drift cover are the barren limestones of the Mississippian series. A thin veneer of Pennsylvanian Coal Measures, consisting of shale and sandstone and possibly a few thin coal beds, is found on the ridge on which Williamstown stands, and isolated pockets of the same formation are scattered through the remainder of the county. These were evidently formed in depressions in the upper surface of the Mississippian and were protected from the action of post-Carboniferous erosion by the resistant limestone beds surrounding them. Coal has been recently taken from a number of these outliers and has excited considerable local interest. Material so obtained may be of local importance but it is not likely that the county contains coal beds with adequate cover and of sufficient extent and thickness to justify the expenditure of large sums for development. Mention of a few of these outliers is made below.

Monticello.—A small slope was operated for local trade during recent winters one-half mile east of Monticello (N. W. ¼ N. W. ¼ Sec. 5, T. 61 N., R. 7 W.), but when visited in August, 1910, was caved and inaccessible. The exposure at the slope is:

*The topography of Lewis county is shown on the Kahoka and Palmyra quadrangles, U. S. Geol. Survey.

		Feet.
1.	Sandstone, yellowish buff	5+
2.	Shale, carbonaceous, in places coaly	6
3.	COAL (reported thickness)	4
4.	Shale, black and drab, carbonaceous	10
5.	Limestone (Mississippian)	....

About 25 feet of yellow and buff sandstone, with no trace of shale, occur a few hundred feet north of the slope and perhaps cut out the coal in that direction.

Where exposed the coal is somewhat bony and contains abundant pyrites. The deposit appears to be a small outlier or pocket, as Mississippian limestone outcrops at higher levels in neighboring hills.

Lewistown.—Several years ago a few hundred bushels of coal were mined two miles north of Lewistown (S. E. ¼ Sec. 5, T. 61 N., R. 8 W.) by a slope and shallow shaft. This coal is reported to be 24 to 30 inches thick and to be overlain with a fair roof of "slaty" shale and underlain with sandstone.

LaBelle.—Several small deposits of coal occur near LaBelle. The following drill record shows that there is a considerable thickness of Pennsylvanian three miles northeast of that town:

DRILLING IN SEC. 27, T. 62 N., R. 9 W.

		Thickness. Feet.	Depth. Feet.
1.	Soil	3	3
2.	Clay (drift)	93	96
3.	Slate	2	98
4.	COAL	4	102
5.	Shale ("soapstone")	10	112
6.	Sandstone	53	165

LINCOLN COUNTY.*

The Coal Measures in Lincoln county are very small outliers and pockets, the surface rock of the remainder of the county belonging to older formations. Very thin outliers of Pennsylvanian, one bearing two feet of coal, are found on the higher ridges in areas aggregating less than five square miles. As mapped by W. B. Potter outliers occur in parts of sections 21, 27, 28, 34, and 35 of T. 50 N., R. 3 W.; sections 13, 24, 25, 26, 27, and 36 of T. 49 N., R. 1 E.; and sections 19, 31, and 32 of T. 49 N., R. 2 E. In addition to these small patches of regularly startified material there are numerous pockets, which are most abundant on the upper branches of Coon creek, comprising only a few acres in extent and consisting of coal with a little shale and sandstone. As this coal is in many cases of exceptional thickness it has attracted much attention and was formerly mined from many small drifts and shafts.

*Potter, W. B., Geology of Lincoln County: Geol. Survey of Missouri, Iron ores and coal fields, 1873, pp. 217-289. The topography of Lincoln county is shown on the Louisiana, Hermann, and O'Fallon sheets of the U. S. Geol. Survey.

Those interested are referred to Mr. Potter's report for a very complete discussion of former operations. These deposits have the general characteristics of pocket coal in other parts of the State, and are too limited in areal extent and too inferior in quality to ever be of more than very local importance.

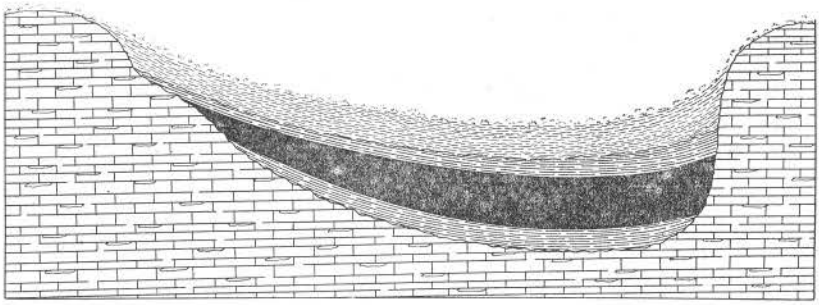

Fig. 48. A Lincoln County Coal Pocket. (After Potter.)

LINN COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....95,945 TONS.

Aside from very small drifts and shallow shafts southwest of Browning, Linneus and Laclede, mining has been confined to the southeastern part of Linn county. There are shipping mines at Marceline and one is planned for Bucklin. Several mines with large local trade operate near Brookfield. Shafts were once sunk at St. Catherine. In spite of this rather small development, the entire county is probably rich in coal deposits.

The formations exposed at the surface include the lower part of the Pleasanton shales and sandstones, all of the Henrietta shales and limestones, and that part of the Cherokee shale which lies above the Tebo coal bed. Practically all these rocks are shown in the Bucklin shaft record and most of them in the Brookfield and Marceline records, to which the reader is referred for a general section. The higher coal beds are not important in this area. There are basins of coal two feet or less in thickness in the bottom of the Pleasanton formation, but the Lexington and Summit horizons show no workable beds. The only coal at the Mulky horizon is in rather small basins, such as the one south of St. Catherine. The next lower coal is the Bevier, the one so extensively mined at Bevier and elsewhere in Macon county. Although this bed contains more than 3 feet of coal at Lingo, in Macon county, at Bucklin it includes only 22 inches, at Marceline 18, at St. Catherine 16, and at Brookfield 15. It has not been utilized in this

*The geology of Linn county was first described by G. C. Broadhead: Mo. Geol. Survey, 1873-1874, pp. 257-271. The writer is unable to agree with the part of his general section (pp. 222-226) below No. 61.

region. It is possible that it is thicker in some parts of the unexplored portion of the county, especially the northeastern quarter. From 50 to 75 feet below the Bevier is the Tebo coal bed, the one worked at all the principal mines. This bed is uniformly 26 to 30 inches thick

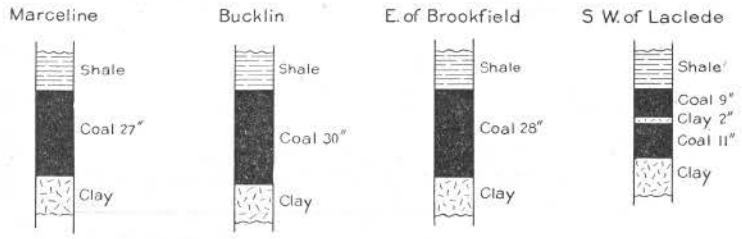

Fig. 49. The Tebo coal bed in Linn County.

in the southeastern quarter of the county, but it is only 20 inches thick in the southwestern. It is a good steam coal, though it contains considerable "sulphur", and has a fairly stable shale roof. From 70 to 100 feet below the Tebo is a bed that has been explored only with the drill. This is the Eureka, another bed with a shale roof. Where found near Bucklin, Marceline, St. Catherine, and Brookfield, it is about 32 inches thick. In the St. Catherine record a three-foot coal bed was struck 39 feet below the Eureka, though that is the only drilling in which more than one bed was found below the Tebo. The top of the Mississippian limestone, below which it is useless to search for coal, was reached at 233 feet at Marceline and 294 feet at Brookfield. The distance of the base of the Coal Measures below any given horizon varies within limits from place to place, because of the uneven upper surface of the Mississippian.

Broadly speaking, the strata dip gently to the south at an angle equal to the slope of the main valleys. At and near Bucklin and southwest of Browning the strata are slightly elevated by an arch, the continuation of the College Mound anticline of Macon county, which trends northwest-southeast. In the southwestern corner of the county the beds are similarly elevated and are greatly disturbed, so that southwest of Laclede may be seen the lowest beds outcropping in the county. Little is known about the amount of coal in the area north of the Burlington railroad, as the more productive horizons are concealed beneath the surface and practically no prospecting has been done with the drill. A useful guide to prospectors is the fact that from the Sullivan county line southward to the railroad, except at a few places, the horizon of the Summit coal lies close to the level of Locust, East Yellow, and West Yellow creeks. The distance from the Summit to the first important coal horizon, the Bevier, is about 50 feet, so that the distance to it and lower productive horizons may be roughly estimated in any locality

in northern Linn county, provided the elevations of the main creeks and the tract to be drilled are known.

The aggregate thickness of the coal found in the Coal Measures at Brookfield, St. Catherine, Bucklin, and Marceline, in beds 14 inches or more thick averages 86 inches, but some of the beds thin to the west and northwest; the lower ones lie in large basins only, and under certain areas near lower Locust creek there is little or no coal. The following table is made on the assumption that the beds contain 1800 tons to the acre-foot:

TOTAL ORIGINAL TONNAGE OF COAL IN LINN COUNTY.

	Average thickness of beds in inches.	Area in square miles.	Content of beds in tons.
Southeastern quarter	86	155	1,279,680,000
Southwestern quarter	24	155	357,120,000
Northern half	40	310	1,190,400,000
Totals		620	2,827,200,000

DETAILED MENTION.

Marceline.—Marceline owes its prosperity largely to the coal-mining industry that has flourished there for many years, the Tebo bed being the one mined. There are now two large shipping mines with short spurs from the Santa Fe railroad, both operated by the Marceline Coal and Mining Co., and one local mine operated by the Landreth Coal Co. All mines have steam hoists and other modern equipment. Much of the product not sold locally is utilized by the railroad. Mine No. 1 of the Marceline Coal and Mining Co. is 190 feet deep and is in the southeastern corner of the city, near the Chariton county line (S. E. ¼ S. W. ¼ Sec. 32, T. 57 N., R. 18 W.). Mine No. 2 is 130 feet deep and is just outside the city limits, 1¼ miles north of the depot. It is notable that the coal at the Landreth mine is about 40 feet higher in elevation than that at the shipping mines, indicating a strong dip. In the Landreth mine the dip is southeast; in No. 1 the dip is regularly 1½ per cent to the south; in No. 2 the dips are very irregular in the south workings and in places cause 10 per cent grades.

The bed mined is fairly regular at 27 inches in mine No. 1; at the Landreth mine it is 24 to 32 inches; at mine No. 2 it is very irregular, being 25 to 42 inches at the present working face. Variation in thickness is greatest where the coal is thickest. "Horsebacks" in the underclay and "rolls" in the roof decrease the thickness locally. The

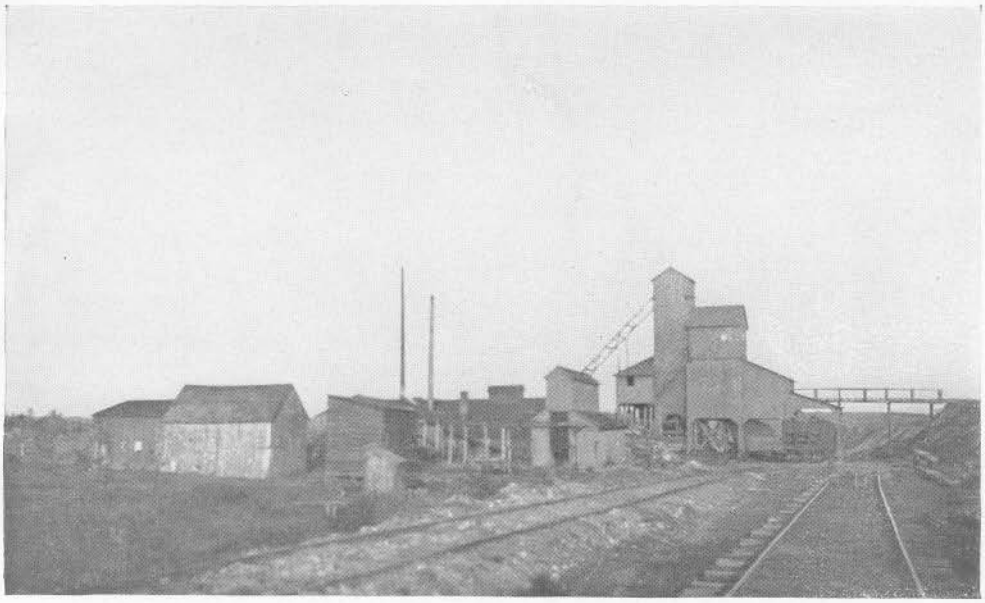

Fig. 1. Mine No. 1, Marceline Coal and Mining Co., Marceline, Mo.

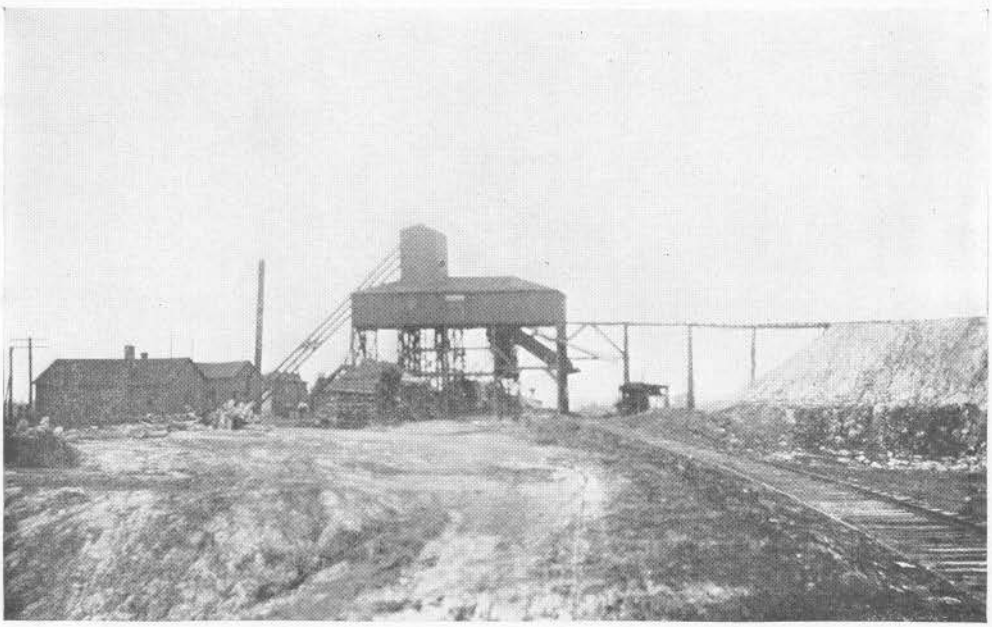

Fig. 2. Mine No. 2, Marceline Coal and Mining Co., Marceline, Mo.

quality of the bed is not of the best. Though it makes a good steam coal, it contains considerable sulphur in streaks of iron pyrites and in large lenticles of pyrite combined with shaly and calcareous material. The greater part of these impurities is picked out and discarded; some pyritiferous chunks weighing more than 100 pounds were seen on the dumps.

All the mines employ the longwall system. The roof is a drab, slightly sandy shale that makes a good longwall roof, though it will not stand machine mining and must be rather closely timbered on the main roads. In mine No. 2 there are two plies of draw shale aggregating in thickness about one foot; in No. 1 only one ply of 3 inches comes down with the coal. Under the coal is a thick clay containing numerous limestone boulders of various sizes. Locally these boulders may lie so close to the coal as to make it necessary to do the undermining in the coal itself. Where there is much rock and the top of the concretions forms a fairly even surface, like that of a regular limestone stratum, what is termed "rock bottom" is formed.

The rocks found in the Marceline district above the Tebo coal are well shown in the following record furnished by the superintendent of the Marceline Coal and Mining Co.:

RECORD OF DRILLING AT MINE NO. 1, MARCELINE.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
1. Drift clay	25	....	25	....
Henrietta formation—				
2. Shale	10	....	35	....
3. Limestone	5	....	40	....
Cherokee shale—				
4. Shale, dark above, light below	10	6	50	6
5. Limestone	5	2	55	8
6. Sandstone	19	....	74	8
7. Shale	9	....	83	8
8. Limestone, hard	3	....	86	8
9. Shale, black, "slaty" (horizon of Summit coal)	4	7	91	3
10. Clay	5	9	97	....
11. Limestone	2	3	99	3
12. Shale	1	....	100	3
13. Shale, black, with boulders (horizon of Mulky coal)	3	....	103	3
14. Clay	3	....	106	3
15. Shale, calcareous	2	....	108	3
16. Sandstone	13	....	121	3
17. Shale	16	....	137	3
18. COAL (Bevier)	1	6	138	9
19. Clay	3	....	141	9
20. Limestone	1	....	142	9
21. Sandstone, soft	6	....	148	9
22. COAL	....	4	149	1
23. Clay	2	....	151	1
24. Shale, sandy at top	10	4	161	5
25. Sandstone	15	....	176	5
26. Shale	13	....	189	5
27. COAL (Tebo)	2	4	191	9

The following record furnished by Mr. Landreth includes the strata penetrated by his shaft and a generalized section of lower strata

found by drilling in various parts of the district. The shaft section differs from the drill record at mine No. 1 chiefly in the detail of the Bevier bed and in the greater distance assigned to the interval between it and the Tebo:

LANDRETH SHAFT RECORD AND DRILLINGS, MARCELINE.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift	25	....	25	....
2.	Shale	25	....	50	....
3.	COAL (upper Bevier)	1	4	51	4
4.	Sandstone	4	....	55	4
5.	Shale, black, "slaty"	2	....	57	4
6.	COAL (lower Bevier)	....	2	57	6
7.	Clay	2	....	59	6
8.	Limestone, hard	1	10	61	4
9.	Sandstone	30	....	91	4
10.	Shale	35	....	126	4
11.	COAL (Tebo), mined	2	4	128	8
12.	Clay, with boulders	6	....	134	8
13.	Sandstone and shale	35	....	169	8
14.	Shale, black, "slaty"	4	....	173	8
15.	Clay	4	....	177	8
16.	Shale	22	....	199	8
17.	COAL (Eureka)	2	8	202	4

The gas drilling at Marceline, which was carried to a depth of 2004 feet, was bored near and at about the same level as the Landreth shaft. According to the record, the Mississippian limestone, the lower limit of coal, was reached at 233 feet, about 110 feet below the Tebo horizon. Little except shale was found in the lower part of the Coal Measures.

Bucklin.—Recently a single-compartment shaft was sunk 230 feet near the Burlington railroad, a short distance west of the Santa Fe crossing at Bucklin. The Tebo bed is being mined by a co-operative company of citizens and has proved so satisfactory that a larger shaft is to be sunk and direct connections made with both railroads. The coal is 28 to 32 inches, very hard and fairly clean. The roof is a dark drab shale that stands well with the longwall plan of mining pursued:

RECORD OF BUCKLIN SHAFT.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift	29	10	29	10
Pleasanton shale—					
2.	Shale	23	6	53	4
Henrietta formation—					
3.	Limestone	3	10	57	2
4.	Clay	3	1	60	3
5.	Limestone and shale	3	2	63	5
6.	Shale, black	1	2	64	7
7.	Limestone	2	5	67	....
8.	Shale, black	1	6	68	6
9.	Sandstone	3	3	71	9
10.	Limestone	7	....	78	9
Cherokee shale—					
11.	Clay, black (horizon of Lexington coal)	4	3	83	....
12.	Limestone	6	6	89	6
13.	Sandstone	13	6	103	....
14.	Shale	8	6	111	6
15.	Limestone	2	6	114	....

RECORD OF BUCKLIN SHAFT.

		Thickness.		Depth.	
Cherokee shale—Continued.		*Feet.*	*Inches.*	*Feet.*	*Inches.*
16.	Shale, black, "slaty"	2	11	116	11
17.	COAL (Summit)	....	7	117	6
18.	Clay, white	6	6	124	....
19.	Limestone	2	....	126	....
20.	Shale, dark brown, "slaty" (horizon of Mulky coal)	3	6	129	6
21.	Clay	3	....	132	6
22.	Sandstone	16	....	148	6
23.	Shale	17	....	165	6
24.	COAL, 19 inches Sandstone, 6 " COAL, 3 " (Bevier)	2	4	167	10
25.	Shale	1	8	169	6
26.	Limestone	6	7	176	1
27.	Sandstone	41	8	217	9
28.	Shale	10	....	227	9
29.	COAL (Tebo)	2	6	230	3

It is reported that the same amount of coal was found by drilling at points about a mile east and southeast of town and that 32 inches of coal (Eureka) was struck 70 feet below the Tebo. The strata dip slightly east, west, and south from Bucklin, showing that the axis of the anticline, or arch, mentioned in the report on Macon county as passing south of Lingo, trends northwest-southeast through Bucklin or its vicinity. The Tebo bed is about 25 feet higher at Bucklin than at Lingo or Marceline, and 40 feet higher than at Brookfield. North of Bucklin there is a slight southerly dip as far as the Sullivan county line.

St. Catherine.—More than thirty years ago mines were operated at St. Catherine, half way between Bucklin and Brookfield, the last worked (S. W. ¼ Sec. 35, T. 58 N., R. 19 W.) being 140 feet deep, and an older one near it 90 feet. The following record cited by Broadhead* shows several workable beds:

ST. CATHERINE SHAFT AND BORE.

		Feet.	*Inches.*
1.	Clay	14	....
2.	Shale, "slaty," rotten	6	....
3.	Sandstone, flinty	....	....
4.	COAL (Bevier)	1	4
5.	Clay	2	5
6.	Shale	22	....
7.	Limestone, hard	1	....
8.	Sandstone, blue	6	....
9.	Shale	40	....
10.	COAL (Tebo)	2	2
Bottom of shaft—			
11.	Clay	3	....
12.	Sandstone, flinty, hard	8	....
13.	Shale	60	....
14.	Shale, black, "slaty"	4	6
15.	COAL (Eureka)	2	6
16.	Clay	4	....
17.	Shale	35	....
18.	COAL	3	....

*Mo. Geol. Survey, 1873-1874, p. 267.

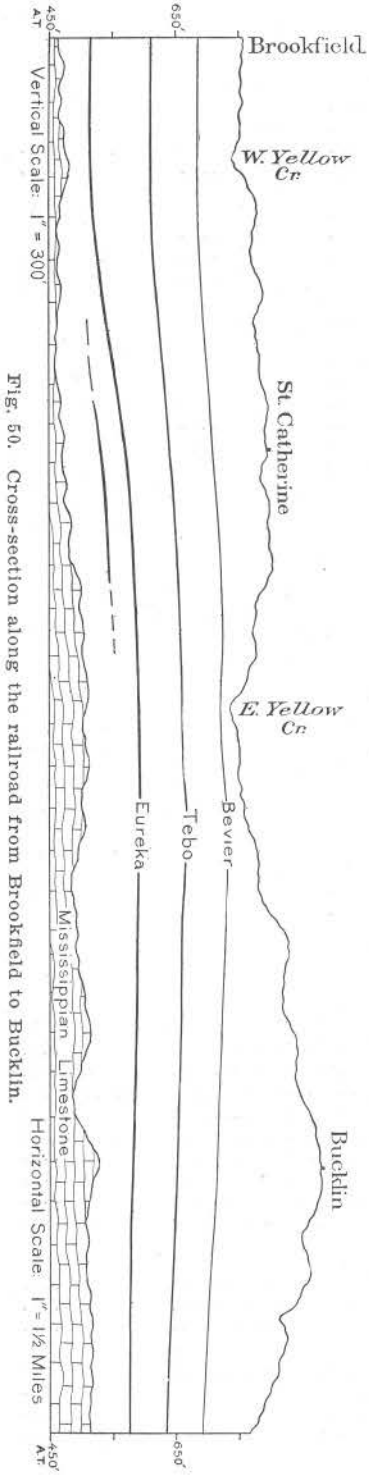

Fig. 50. Cross-section along the railroad from Brookfield to Bucklin.

Two miles south of St. Catherine (N. W. ¼ S. W. ¼ Sec. 12, T. 57 N., R. 19 W.) is the drift of S. Rosenthal in coal 18 to 24 inches thick, with a roof consisting of four feet of black "slaty" shale bearing large concretions ("niggerheads") and capped with five feet of drab to buff limestone. This coal is the Mulky bed, and it is only in this vicinity that it is known to be of workable thickness in southern Linn county. It is said that a short distance south the concretions cut down badly into the coal. The Summit coal is too thin to be utilized but is of importance as a marker for lower horizons. Near the railroad it is 25 feet above East Yellow creek, and two miles farther north it is at the water level. North of this it rises at about the gradient of the creek, keeping near the stream.

Brookfield.—Several attempts to obtain coal by shafting have been made on the west side of Yellow creek near Brookfield, but all have been unsuccessful because of the amount of water encountered and because the Tebo bed contains more impurities than farther east. One mine formerly operated at the east city limits reached at 155 feet the Tebo bed, consisting of 26 inches of coal divided in the center by three inches of shale that is said to thicken to the west. On the east side of Yellow creek, about 1½ miles east of Brookfield, is a group of mines that now supply fuel to the city. All hoist with horse-whims, have no shipping connections, and work longwall. The bed mined is the Tebo, which contains 24 to 32 inches of coal with a very thin streak of carbonaceous clay in the center. Iron pyrites ("sul-

phur'') is fairly plentiful, and in places rolls in the roof cut out half the coal or less. Mines in operation in 1910 were: (1) H. D. Burdall (N. E. ¼ N. E. ¼ Sec. 5, T. 57 N., R. 19 W.), shaft 140 feet; (2) H. F. Wine (S. W. ¼ S. W. ¼ Sec. 33, T. 58 N., R. 19 W.), shaft 151 feet; (3) J. Turpin (S. W. ¼ N. W. ¼ Sec. 4, T. 57 N., R. 19 W.), shaft 138 feet; (4) Crandall brothers (N. W. ¼ N. E. ¼ Sec. 9, T. 57 N., R. 19 W.), shaft 155 feet; (5) Walker and Scott (Sec. 16, T. 57 N., R. 19 W.), shaft 160 feet.

There is a thinner coal bed above the one worked and a slightly thicker one of doubtful quality below, as shown in the following record published by Broadhead†:

BROOKFIELD SHAFT AND BORE.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Surface	30	....	30	....
2.	Limestone, found in creek near by	1	10	31	10
3.	Clay and shale	41	....	72	10
4.	COAL (Bevier)	1	3	74	1
5.	Clay and shale, containing concretions near base	20	....	94	1
6.	Limestone	1	8	95	9
7.	Shale	52	8	148	5
8.	COAL (Tebo), mined	2	4	150	9
9.	Clay and shale	16	....	166	9
10.	Shale, with rock concretions	14	....	180	9
11.	Clay	10	....	190	9
12.	Sandstone	8	....	198	9
13.	Clay and shale	38	8	237	5
14.	Clay	4	....	241	5
15.	Shale	2	....	243	5
16.	COAL, 25 inches Clay, 5 " COAL, 6 " (Eureka)	3	....	246	5
17.	Clay and shale	15	....	261	5
18.	Sandstone	8	....	269	5
19.	Shale	21	2	290	7
20.	Rock concretions	4	....	294	7
21.	Hard rock (Mississippian?)	2	....	296	7

The Summit coal bed, which is about six inches thick and lies about 120 feet above the Tebo horizon, outcrops in the bank of West Yellow creek near the railroad bridge. It forms a useful marker and is characterized by a cap-rock of compact gray limestone that weathers into rhomboidal slabs and is separated from the coal by about three feet of black ''slaty'' shale. The Summit outcrops near the level of West Yellow creek five miles northeast of Brookfield (S. W. ¼ S. W. ¼ Sec. 10, T. 58 N., R. 19 W.) showing a slight rise of the strata toward the north.

Laclede.—Attempts to find coal at Laclede have not been successful. A drilling for water to a depth of 248 feet in the north part of town was barren of coal. Another, two miles southwest, found nothing over six inches thick in 137 feet, and one on Coal branch, only 1¼ miles north of the mining locality mentioned below, gave no results in 127 feet. The lack of coal at these localities may possibly be connected

†Mo. Geol. Survey, 1873-1874, p. 268.

with the presence of a sandstone-filled channel known to exist about three miles southwest of Laclede, in which case more productive territory may lay quite close to barren drillings. At Woodland Mills (N. E. ¼ Sec. 14, T. 57 N., R. 21 W.) there is a remarkable exposure in the bluffs of Locust creek, where strata geologically higher than any seen elsewhere in southwestern Linn county dip steeply down stream and are overlain unconformably with sandstone and shales similar to those described as the Moberly channel deposits in Chariton, Randolph, and other counties.

One mile southeast of Woodland Mills (N. ½ Sec. 24, T. 57 N., R. 21 W.) small drifts and shallow shafts have been worked intermittently for years. The bed mined is the Tebo, the same as the one worked at Brookfield and at the Turkey creek mine in Chariton county, but its elevation is considerably higher than in the former field. It probably underlies a considerable territory in this part of the county, though cut off on the north by sandstone. The coal is 20 inches thick, with two inches of clay in the center. Above it is 56 inches of blue shale, above which is two feet of black shale capped with one foot of limestone.‡ Below the coal is four feet of blue and yellow clay resting on sandstone.

Meadville.—It is reported that on a hill in the eastern part of Meadville a shaft was sunk 120 feet without finding coal. A shaft 100 feet deep reached 18 inches of coal about a mile northwest of town. On Locust creek, east of Meadville (Secs. 27 and 34, T. 58 N., R. 21 W.), a little mining has been done in 17 inches of coal that lies 20 feet above the creek. Above the coal is 20 feet or more of sandy shale. Below a parting of bituminous shale more than one foot thick is a lower bench of coal six inches thick and below this 15 feet of clay containing calcareous concretions and resting on a hard blue limestone that outcrops in the creek. The association of strata resembles that at the Bevier horizon, but such a correlation can be made only tentatively.

Linneus.—Beds outcropping near Linneus lie too high in the series to bear much workable coal, but indicate the depth at which the more important horizons may be reached. Just north of the city (Sec. 31, T. 59 N., R. 20 W.) are 15 feet of red shales lying near the base of the Pleasanton, the same as the highest rocks in the Bucklin shaft record. Descending to the west from this locality the rocks of the Henrietta formation may be seen, and in Locust creek (Sec. 34, T. 59 N., R. 21 W.) those just above and below the Summit coal horizon outcrop, the coal itself being represented only by black "slaty" (laminated) shale. Three miles north the place from the outcrop of the Summit coal is 20 feet above Locust creek, with a mere streak of coal exposed at the Mulky

‡Additional strata are described by Broadhead: Mo. Geol. Survey, 1873-1874, p. 261.

horizon below it. This dip to the south nearly equal to the gradient of the creek continues for a considerable distance up stream, so that west of Purdin (S. W. ¼ N. W. ¼ Sec. 11, T. 59 N., R. 21 W.) the "slaty" shale of the Summit horizon may again be found about 25 feet above Locust creek, and farther north (N. W. ¼ N. E. ¼ Sec. 2, T. 59 N., R. 21 W.) it is at the water level.

Browning.—Rumors of two to four feet of coal found in a drilling near Browning are persistent, though nothing definite could be ascertained. The principal coal horizons lie 130 feet or more below the town, as the outcropping strata in the vicinity are Pleasanton shales and sandstones. One mile west of Browning (N. E. ¼ N. W. ¼ Sec. 7, T. 60 N., R. 20 W.) a bed that lies in the Pleasanton and is only eight inches thick has been stripped a little, and west of this, on West Locust creek, the limestone a few feet below the top of the Cherokee formation outcrops. A short distance down stream (N. W. ¼ N. W. ¼ Sec. 14, T. 60 N., R. 21 W.) is a coal bed reported to be 14 inches thick, but not now exposed. Four miles southwest of Browning an arch, or anticline, brings above Locust creek rocks which are, according to F. C. Greene, stratigraphically lower than those outcropping elsewhere in northern Linn county.

BLUFF ON WEST LOCUST CREEK (S. E. ¼ S. W. ¼ SEC. 23, T. 60 N., R. 21 W.).

		Feet.	*Inches.*
1.	Sandstone, yellow	10	....
2.	Shale, dark, sandy	30	....
3.	Shale, black, "slaty"	2	4
4.	COAL (Bevier)	....	5
5.	Clay	1	5
6.	Limestone, gray, nodular	3	....

A short distance south (N. ½ Sec. 26) this coal is 9 to 16 inches thick, and a little was mined years ago. There is reported to be an eighteen-inch bed about 15 feet below it.

LIVINGSTON COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....1,528 TONS.

Many small mines are found in Livingston county, but all of them produce coal for local use only. Over most of the county the outcropping rocks belong to the Henrietta formation and Pleasanton shale. There is an area of Cherokee shale along Grand river, and high tablelands capped by the Bethany Falls and associated limestones in the southern and western parts of the county. A thickness of about 475 feet is exposed, with probably 200 feet of lower Pennsylvanian found only in drillings.

*The geology of Livingston county is described by G. C. Broadhead, Mo. Geol. Survey, Rept. for 1872, pt. 2, pp. 290-316. All references to Broadhead are from this report. The coal is very briefly described by Arthur Winslow: Prelim. rept. on coal, Mo. Geol. Survey, 1891, pp. 95-96.

GENERAL SECTION OF OUTCROPS IN LIVINGSTON COUNTY.

		Feet.	*Inches.*
		Feet.	*Inches.*
Kansas City limestone—			
1.	Limestone, thin-bedded and cherty in lower part, heavy-bedded in upper, maximum thickness about	20	....
2.	Shale, blue at top, black and "slaty" below	3	9
3.	Limestone, nodular at top, oolitic in places, with shale partings near base (Bethany Falls)	21	.. ..
4.	Shale, blue in greater part, black and "slaty" at base	6	6
5.	Limestone	....	10
6.	Shale and sandstone, 10 to 30 feet, average	20	....
7.	Limestone, ferruginous (Hertha, base of Missouri group)	7	....
Pleasanton shale—			
8.	Shale	14	....
9.	COAL (Ovid), maximum 20 inches	....	6
10.	Sandy shale and sandstone, about	80	....
11.	Limestone, blue or gray, hard or nodular	2 to 6	....
12.	Shale, drab	16	....
13.	COAL	....	4
14.	Shale, red and clayey, or sandy and with sandstone, about	70	....
15.	COAL (Mulberry), absent in southern part of county	0 to 2	....
16.	Clay and shale	0 to 20	....
Henrietta formation—			
17.	Limestone, gray, massive	4 to 5	....
18.	Shale, blue, red and green, with thin beds of limestone, limestone nodules near base	15 to 20	....
19.	Limestone, buff, with shale partings, about	8	....
Cherokee shale—			
20.	Shale, blue, with black layer (horizon of Lexington coal)	6	....
21.	Limestone, blue, weathering buff or brown	3 to 4	....
22.	Shale, clayey at top, sandy	20	....
23.	Limestone, hard, blue, even-bedded, generally in 2 layers	2	....
24.	Shale, black, soft at top, "slaty" and calcareous below	3 to 4	6
25.	COAL (Summit)	....	0 to 6
26.	Clay and shale	5	....
27.	Limestone, buff, nodular	2	....
28.	Shale, dark to black, with concretions of limestone and thin shreads of coal (horizon of Mulky coal)	....	3
29.	Shale, sandy, with thin coal seams and sandstone	50	....
30.	COAL (Bedford) cut out by sandstone in places	....	0 to 28
31.	Shale, sandy, with clay at top and black "slaty" shale below	14	....
32.	Limestone, black, pyritiferous, fossiliferous	....	0 to 10
33.	COAL (Bevier)	....	0 to 4
34.	Clay	2 to 4	....
35.	Limestone, gray, nodular at top	2 to 5	....
36.	Shale, argillaceous	7	6
37.	Limestone, drab, weathering brown	2	6
38.	Shale, blue above, darker below	14	....
39.	Limestone, dark blue, weathering buff	....	6 to 10
40.	Shale, black, "slaty," some clay at base	2	6
41.	COAL (Tebo)	....	16 to 20
42.	Clay and shale	5	....
43.	Limestone, bluish, nodular	1	....
44.	COAL	....	1
45.	Clay and shale	4+	....
46.	Interval to base of Coal Measures, not exposed, about	175 to 225	....

The distribution of the Kansas City, Pleasanton, Henrietta, and Cherokee formations is shown on the state geologic map. In general, the beds lie horizontal, but the geology of certain areas is complicated by low dips. A syncline, or trough-shaped area in which beds lie at relatively low levels, probably accompanied by a little faulting, appears to traverse the county in a northwest-southeast direction from

near Wheeling to the northwest corner. At Graham's Mill, Spring Hill, Utica and other places, irregular dips occur.

The Ovid Coal probably occurs under all the high land in the "Blue Mound" region, in the vicinity of Mooresville, and in the northwestern part of the county. It has been reported up to 20 inches thick, but its average thickness is probably not over 6 inches. It is of little importance.

The Mulberry Coal occurs in parts of the county covered by the Pleasanton formation, except the south row of townships. Its thickness ranges from 6 inches to nearly 2 feet. Its distribution is irregular and the character of the roof is changeable. It has been mined at Utica, north of Chillicothe, and northwest of Wheeling, and has been the source of most of the coal produced in the county.

The Bedford Coal outcrops in many places in the southeastern part of the county and has been mined near Bedford. Its thickness is variable because of the nature of the roof, being 28 inches in one place and little or nothing where the overlying sandstone cuts down into it. In many places the sandstone rests directly on the coal, but in a few places shale intervenes. This seam is thought to have been found near Chillicothe, where it varied from 0 to 33 inches, and at Utica, where it was 26 to 30 inches. The Bedford is probably the same as the upper Bevier bed of Chariton and Linn counties.

The Bevier Coal, where it outcrops, is not over 4 inches thick, but may possibly increase to the west, as it is a persistent horizon and commonly productive.

The Tebo Coal is exposed in a few places in the extreme eastern part of the county, where it has been mined. Its thickness ranges from 16 to 20 inches and it is generally overlain by clay that in places pinches out so as to permit the black "slaty" shale above to rest directly on the coal. The lower part of the bed contains considerable pyrite in places. Its extent north and west of the area of outcrop is unknown.

The absence of extensive mining developments in Livingston county makes an estimate of its total coal resources very difficult. It appears probable, however, that there is at least an average of 30 inches of coal in beds 14 inches or more in thickness. An estimate would make the total coal reserve of the county 1,532,160,000 tons.

DETAILED MENTION.

Southeast Corner.—The south bluffs of Grand river show many fine exposures of the various coal seams and the accompanying strata. Beginning on the road down the branch to the northeast corner of Sec. 11, T. 56 N., R. 23 W. a measurement made included all of the beds from Nos. 16 to 34 of the general section. All the coal beds are less than 6 inches thick except the Bedford, which is 14 to 18 inches,

is overlain with massive sandstone, and is underlain by a considerable thickness of clay and shale. The nature of the roof indicates that the thickness of the coal in this vicinity is variable. The coal is absent in places, but where it is overlain with shale, as it is locally, its thickness is more constant. Much coal has been mined for local use in the N. E. ¼ Sec. 11, T. 56 N., R. 23 W. At the slope of J. W. Kimber in the S. W. ¼ N. E. ¼ of this section the coal is reported to be 14 to 24 inches thick, averaging 18 inches. It was overlain with shale and underlain with clay.

West of Bedford, near Grand river (N. E. ¼ S. W. ¼ Sec. 31, T. 57 N., R. 22 W.) is the shaft of Wm. Kelly, abandoned at the time it was visited. The shaft is reported to be 33 feet deep and the coal (Bedford) to be 18 inches thick. The coal is exposed a short distance to the north in the following section:

	Feet.	*Inches.*
Shale, dark, "slaty"	15 +	....
Sandstone, gray, hard, calcareous, conglomeratic, in thin even layers, with shaly partings, 3 feet to	4	4
Shale, clayey	....	0 to 12
COAL (Bedford)	....	16
Clay, hard, white	1 +	....

Up the hill southeast of the shaft, Nos. 21 to 28 of the general section are exposed, the horizon of the Lexington coal lying 80 feet above the coal mined. About one-half mile west of this is Monroe Ford, near which is the stripping of John Plaster in a seam thought to be the Bedford (N. E. ¼ S. E. ¼ Sec. 36, T. 57 N., R. 23 W.). This coal is reported to be 3 or 4 feet thick, but the present stripping shows only 26 inches, the upper part of the bed having been removed by recent erosion and replaced by alluvium. The coal appears to be clean and free from "sulphur". The reported thickness is unusual for the Bedford seam. Fifteen feet south only sandstone and shale and two very thin coal beds are exposed for 50 feet above the creek, the thicker coal being probably a few feet below the water.

The Bedford coal has been mined near Bedford. The following section by Broadhead is more complete than any now exposed:

	Feet.	*Inches.*
Sandstone	10 +	....
Shales, sandy and argillaceous	5	....
COAL (Bedford), good	1	....
Fire clay, sandy	2	6
Shales, bituminous at bottom; contain several concretionary layers of iron carbonate	10	....
Limestone, deep-blue, pyritiferous	....	0 to 10
COAL (Bevier), has yellow "sulphur" in crustations	....	4
Fire clay	2	....
Limestone, nodular	4	....
Limestone, sandy, even layers, with bands of shales	3	....

Coal has been mined in the N. W. ¼ Sec. 18, T. 56 N., R. 21 W., but nothing is done now. Across the road, in section 13 near Grand river, the Bedford horizon appears to be barren.

In the N. ½ N. E. ¼ Sec. 29, T. 56 N., R. 21 W., Broadhead cites the occurrence of 20 inches of coal at the Tebo horizon. Above it are 30 inches of clay overlaid by the same amount of black, "slaty" shale capped with a thin limestone layer. At the mouth of Toe String creek he noted 18 inches of coal in the same bed, 10 feet above Grand river level. Here there are 6 feet of shale between the coal and its 6-inch limestone cap-rock, and 4½ feet between the coal and a thin limestone below it.

Of several thin coal beds in the southeastern corner of the county, only the Bedford (locally) and the Tebo are of workable thickness. Neither appears to be suitable for mining on a large scale, though the Tebo lies too low to outcrop nearly everywhere and may prove more attractive in undiscovered fields where it can be found only with the drill.

Wheeling.—In the N. E. ¼ N. W. ¼ Sec. 31, T. 58 N., R. 22 W., at the old Collier Mill, is the following:

	Feet.	*Inches.*
Sandstone, yellow	4+	....
Shale, black, "slaty"	4	....
COAL (Mulberry?), reported	....	6 to 16
Covered, with red and drab shale showing in places, about	5	....
Limestone, light buff to gray, very nodular at top, thin-bedded and with shale partings in middle	9	4
Shale, dark at top, drab below (Lexington coal horizon)	6	6
Limestone, gray, weathering buff, nodular on top	2	6
Shale, upper 3 feet clayey, sandy below, to water in Medicine creek	13	....

The coal was formerly mined by drifts at several places in this vicinity and reported to be of good quality. There is some question as to its correlation with the Mulberry, as the limestone at the top of the Henrietta formation and part of the shale below it were eroded away before the deposition of the coal. Farther northeast (W. ½ S. W. ¼ Sec. 29), the dip brings up the Summit coal, which, however, is only a few inches thick.

Halloween (Slagle's Mill).—Folding, apparently accompanied by faulting, has taken place in this vicinity. Just south of the bridge in the western part of Sec. 24, T. 58 N., R. 23 W., a section similar to that at Collier's Mill is exposed on the west side of the creek. To the north, in the N. W. ¼ of Sec. 24, the Lexington horizon is exposed a few feet above water level, and about 6 feet north of this the Mulberry coal outcrops at the same level. Up the branch through the middle of Sec. 23, the limestones at the base of the Missouri group dip strongly to the northeast and are not more than 25 or 30 feet above the flood plain of Medicine creek, indicating a vertical displacement of 100 feet or more. From the northwest corner of Sec. 24 along the west side of Medicine creek to the S. E. ¼ of Sec. 14, there are a number of drifts and shafts working the Mulberry seam.

The most important of these is the shaft of E. S. Inman on the land of Inman Bros. This is 48 feet in depth and the coal is reported to be 18 inches thick. Where Medicine creek crosses the north county line, the Summit horizon is exposed near water level and is barren of coal.

Chillicothe.—No coal has been mined very near Chillicothe. Just northwest of town in the southeast corner of Sec. 23, T. 58 N., R. 24 W., feeble attempts have been made to mine what is probably the Mulberry seam. Drillings for wells in the vicinity of Chillicothe report as much as 4½ feet of coal,† including, probably, much black shale. The most reliable data are the records of a drilling and shaft reported by Broadhead and Winslow. The record given by Broadhead shows 6 inches of coal (Summit?) at 155 feet, 20 inches of "black smut" at 175 feet and 24 inches of "black smut" at 197 feet, the latter probably at the Bedford horizon. The record of a shaft sunk‡ about 1 mile east of Chillicothe (east side of the N. W. ¼ Sec. 30, T. 58 N., R. 23 W.), is as follows:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil, clay, and sand, with blocks of limestone	70	....	70	....
Shale, bluish gray, with 3 to 4 feet of micaceous sandstone near middle	40	....	110	....
COAL	....	16 to 20	111	4
Clay	....	1 to 8	112	....
Sandstone, brown, shaly	20	....	114	....
Shale, gray	22	....	136	....
COAL, poor, "stony"	....	8	137	....
Shale, gray, clayey at top	23	....	160	....
COAL	1	....	161	....
Clay	3	....	164	....
Sandstone, clay, and thin seams of coal, with hard layer, probably iron carbonate. At 187 feet are 2½ feet of drab fusible clay, at 197 feet, 4 feet of same, and at 220 feet, 4 feet of same. At the bottom is sandstone	110	....	274	....
COAL	2	9	277	....
Drill hole, no coal	122	....	399	....

"A sandstone roof was found on the coal (lowest bed), of so undulating a character that it frequently almost cut out the coal entirely and, generally, materially diminished its thickness."

Coal is reported to have been formerly stripped 5 miles east of Chillicothe (Sec. 34, T. 58 N., R. 23 W.), and as found in a shaft was about 20 inches thick. This is thought to be the Mulberry seam.

Graham's Mill.—The Mulberry coal has been mined at several localities in the north-central part of the county and is exposed in a number of other places, but in most of them is too thin to be of importance. Near Graham's Mill, on the east side of Grand river, the

†Shepard, E. M., Water Supply Paper U. S. Geol. Survey, No. 102, 1904, pp. 389-440

‡Winslow, Arthur, Prelim. rept. on coal, Mo. Geol. Survey, 1891, p. 96, and notes in office.

coal was shafted and is reported 12 to 14 inches thick. It was not being worked when visited. About 5 miles north of Chillicothe (Sec. 2, T. 58 N., R. 24 W.), are the Cox mines. A number of drifts and shafts have been operated in the vicinity for over 40 years.

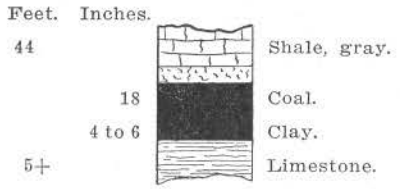

FIG. 51. The Mulberry coal bed at the Cox mines.

At the John Cox shaft (S. W. ¼ S. E. ¼ Sec. 11, T. 58 N., R. 24 W.), Mr. Cox gives the following record (from memory):

	Thickness. *Feet.*	Depth. *Feet.*
Clay	32	32
Sandstone	10	42
Shale, blue	43	85
COAL (Mulberry), average	1½	86½

The Mulberry coal at these mines, as at other places in the county, seems to be rather irregular both in distribution and thickness, varying between 14 and 24 inches. The roof is a shale containing remains of plants. Mining is done on a modified longwall method. The floor is in places a limestone, but in others as much as 4 feet of shaly clay lies between the bottom-rock and the coal. At the J. B. Cox mine (N. E. ¼ S. E. ¼ Sec. 11), like conditions prevail. The coal is hoisted by horse-power and consumed locally and at Chillicothe. A short distance north of the Cox mines the only rock exposed is sandstone.

Utica and Mooresville.—Coal has been mined at a number of places on the south bluffs of Grand river near Utica. Near the old mill site, the limestone at the top of the Henrietta formation outcrops about 15 feet above water. About 150 feet west it dips and disappears below water. Above the point of disappearance, the following is exposed:

	Feet.	*Inches.*
Shale, sandstone and talus to top of hill	140	....
COAL	....	12 to 18
Shale and sandstone, to water	22	10

This coal is stratigraphically higher than the Mulberry, and has been used at the brick yard, being stripped with the shale. Up the river the rocks again rise, and the Mulberry coal was formerly mined on the land of John Stone for a quarter of a mile or more along it. According to Broadhead the coal was only 9 inches thick.

About 1870 a shaft was sunk at Utica to a depth of 190 feet and the following is reported: at 25 feet from surface 12 inches of coal, at 80 feet 15 to 16 inches, and at 190 feet 26 to 30 inches. The latter seam was worked. Two miles north of Utica (S. E. ¼ N. E. ¼ Sec. 8, T. 57 N., R. 25 W.) is the shaft of Wm. Fullwood, on the land of G. T. Walters. The coal lies at a depth of 51 feet, and is reported to vary from 8 to 20 inches, with an average of 15 inches. The shaft starts about the level of the top of the Bethany Falls limestone and probably operates the Ovid seam. It is overlain by shale, underlain by clay, and worked longwall. Many small drifts, slopes, and shafts have been operated in this vicinity for many years and the product consumed mainly at Mooresville.

MACON COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....927,983 TONS.

Since 1899 and during several previous years Macon county has been the largest coal producer in the State, a distinction which it easily

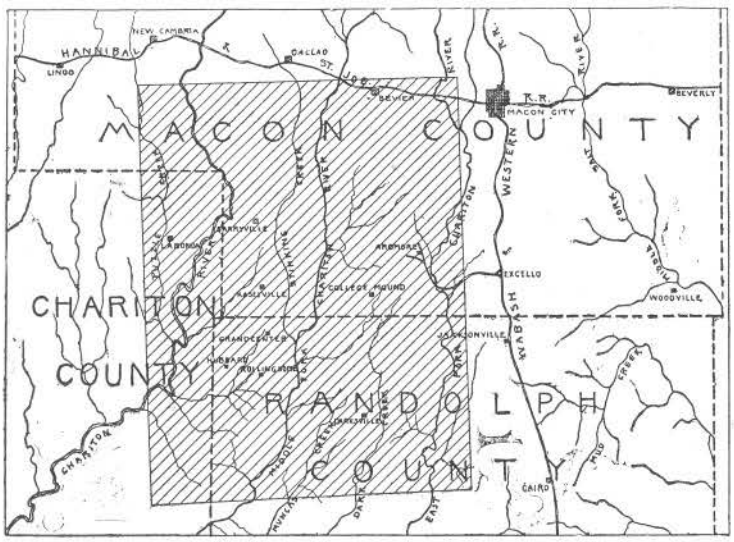

FIG. 52. Outline map showing position of the Bevier quadrangle.

*The thick coal of the Bevier field in Macon county was first mentioned by F. Hawn: Mo. Geol. Survey, Second report, 1855, p. 126. G. C. Broadhead briefly described the geology of the county: Mo. Geol. Survey, 1855-1871, pp. 74-92; while that of the Bevier quadrangle was fully discussed by C. H. Gordon, A report on the Bevier sheet: Mo. Geol. Survey, 1893 (also Vol. IX, 1896), pp. 1-75. W. J. McGee visited exposures near Macon City (Trans. St. Louis Acad. Sci., Vol. V, 1888, pp. 305-336), but the writer is unable to agree with his stratigraphic conclusions. Coal mines were briefly described by Arthur Winslow, A preliminary report on coal: Mo. Geol. Survey, 1891, pp. 62-67; and clays and shales by H. A. Wheeler, Clay deposits: Idem, Vol. XI, pp. 336, 347, 397, 546, et al. The topography of the eastern portion of the county is shown on the Macon and Atlanta quadrangles of the U. S. Geol. Survey, and that of the southwestern part on the Bevier quadrangle, republished in this report.

gained by reason of the quantity and availability of its coal deposits. Two of the largest coal-mining companies in Missouri now operate in the district between Bevier and Ardmore, and ship their product on the Hannibal and St. Joseph branch of the Burlington railroad to points west and northwest. A number of local mines are located near Macon City and in country districts near Salt river, East fork, and elsewhere. Before the large mines in the Bevier-Ardmore district were started considerable coal was shipped from Carbon, a camp near Salt river east of Macon, but now only small local mines operate in that vicinity. Until recently mining on a large scale was done at Lingo, a station a few miles east of Bucklin, but is now at least temporarily abandoned.

The drift is thick in Macon county, on many divides 100 feet or more, though exposures are fairly good along the lower courses of East fork and Salt river. Beneath the drift the highest formations are the lower Pleasanton, the Henrietta, and the higher Cherokee in the northern part of the county, and only the Cherokee south of the Burlington railway. Strata change somewhat from point to point, so no general section can be given that would represent the conditions in every district. The reader can obtain a good idea of the general stratigraphy, however, by combining the section of the upper strata measured by F. C. Greene and given in the description of rocks southwest of Hart, with the Eureka shaft record in the description of the Macon district. Between the lowest stratum of the Eureka record and the top of the Mississippian (the lower limit of coal) are shales, clays, and sandstones that average 30 feet in thickness, though the beds are extremely variable because of the uneven upper surface of the Mississippian. The only records that show the depth to the Mississippian are those of the deep drillings at Macon, Bevier, College Mound, and east of LaPlata, and perhaps of the Walker drilling at Elmer.

There are five coal-bearing horizons in Macon county, as follows:

1. Summit, average 12 inches.
   Interval, average 25 feet.
2. Mulky (Macon C'ty),† average 18 inches.
   Interval, 6 to 50 .eet.
3. Bevier, average where mined, 52 inches.
   Interval, 20 to 40 feet.
4. Tebo (Lower Ardmore),† average 14 inches.
   Interval, 55 to 90 feet.
5. Eureka, very variable.

†The coal beds termed Macon City and Lower Ardmore by earlier investigators have been correlated with the Mulky of Lafayette county and the Tebo of Henry county, respectively, and in this report are given the names by which they are known in the southwestern region.

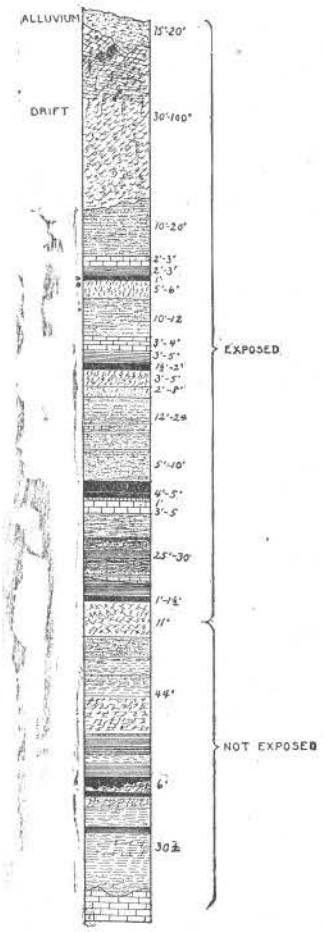

FIG. 53. General section of the rocks of the Bevier sheet. (After Gordon.)

Summit Coal Bed.—The highest coal, the Summit, is too thin to be of economic importance. It is capped by two to three feet of black "slaty" shale, free from large concretions, over which is a compact, massive ledge of limestone of about the same thickness. Below the underclay in most places is a limestone sump rock.

Mulky Coal Bed.—The Mulky coal bed is mined at several places near Macon, in the breaks of Salt river, where it is the only outcropping bed that has been utilized, near New Cambria, and in a few other localities. Though locally absent or thin, it is remarkably persistent at from 18 to 22 inches, is of good quality, and has a splendid roof of about five feet of shale which is black and "slaty" at base, grades upward into softer and lighter material, and contains rock concretions. Above this shale is a very hard, compact, massive limestone, three to five feet thick, which makes an ideal cap-rock. Below the

coal is a considerable thickness of clay. It is very difficult to distinguish the Mulky from the Summit horizon in outcrops, although certain differences may be detected by the trained observer. When the thicker coal at the Bevier horizon approaches exhaustion, the Mulky will become a prime factor in the commercial development of the region.

Bevier Coal Bed.—The most important coal horizon in the State is the Bevier, so named because of the outcrops and mines in the Bevier district. It is thickest under the divide between Middle and East forks, south of the Burlington, as described later. Between Middle fork and main Chariton it has been in most places removed by erosion; near the western edge of the county, at Lingo, its value is impaired by the thickness of the clay parting. This portion averages only two inches in the Bevier-Ardmore districts; east of East fork it thins gradually, so that on Salt river it cannot be considered exceptionally important. In the region north of the Burlington the horizon of the Bevier is in most places below the drainage levels and few prospecting records that throw light upon its occurrence are available. Where drilling has been done the results have not been encouraging, yet it appears probable that undiscovered deposits of importance exist somewhere in this area. Farther north, in the Novinger field of Adair county, conditions of deposition were very similar to those in the

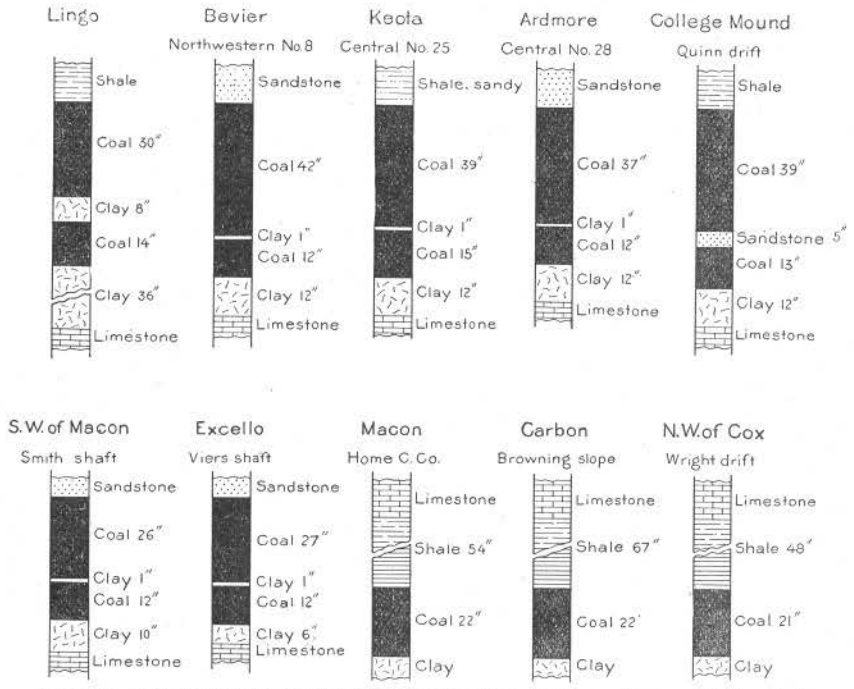

Fig. 54. Macon County coal beds. Bevier—first seven sections. Mulky—last three sections.

Bevier field, and the coal at the Bevier horizon is much the same as in southern Macon county. It is therefore natural to suppose that localities between these two fields contain similar deposits.

The material between the Mulky and Bevier horizons, as described in subsequent pages, is very irregular in character, though everywhere shale or sandstone or a mixture of the two. It is nearly 50 feet thick in the southwestern part of the county and thins toward the east, so that near Bevier it is 20 feet and near Salt river only 10 feet or less. Below the Bevier bed is clay that averages about one foot but is irregular because of the uneven upper surface of the limestone upon which it rests. This limestone is very persistent in occurrence, though it is very thin in the breaks of Salt river. Combined with the absence of a limestone cap-rock it serves to distinguish the Bevier from all other coal beds. It also is an important factor in mining, as it decreases the tendency to "squeeze," which is a serious drawback in some mines in the State, and in many places it affords a firm foundation on which props may be placed.

Tebo Coal Bed.—At the old Eureka shaft and a few other places this bed is two feet or more in thickness, though in general it is 18 inches or thinner. It was explored at the Eureka shaft, but operations in it were not continued. It is mined at Marceline and Bucklin, in Linn county, and was found at Lingo to be a split bed of 27 inches. Between it and the Bevier are 20 to 40 feet, chiefly of black "slaty" shales and drab shales; at the top of the interval are one or more beds of limestone forming the Bevier sump rocks and a very thin limestone commonly lies about six feet above the coal. The roof of black "slaty" shales bearing concretions and the limestone cap led McGee into the error of correlating the Tebo on East fork with the Mulky at Carbon. The underclay of this bed is exceptionally thick.

Eureka Coal Bed.—At the old Eureka shaft, west of Macon, a coal lying 55 feet below the Tebo was mined for a time, apparently not with great success. There were four feet of coal split by a very irregular clay parting, six inches to five feet thick. Between the Eureka and the Tebo are shales, clays, and sandstones, the interval being elsewhere slightly thicker and more sandy than at the Eureka shaft. The coal lies too low in the section to outcrop within the county, but drilling has shown its presence in many places, notably southeast of Macon and just across the county line at Bucklin. It is in most places too thin to be workable, but contains irregular basins or troughs of thicker coal that will at some future date be of importance. It is the lowest bed of coal yet found in this region.

In the following estimate of the quantity of available coal in the county only beds or parts of beds 14 inches or more in thickness are considered, and there are held to be 1800 tons per acre-foot. As very

little information is available in regard to the northern part of the county, detailed estimates cannot be made. However, it is believed that an average of 36 inches of coal in beds of 14 inches or more, in this region is a very moderate assumption.

TOTAL ORIGINAL TONNAGE OF MACON COUNTY.

Range.	Township.	Thickness of beds in inches.	Area in square miles.	Tons of coal.
13	56	Mulky 20, Bevier 24 in half of area, Tebo 15 in one-third of area, Eureka 18 in one-third of area	20	82,560,000
13	57	Mulky 22, Bevier 24 in half of area, Tebo 15 in one-third of area, Eureka 18 in one-third area	22	95,040,000
14	56	Mulky 22, Bevier 36, Tebo 16 in half of area, Eureka 18 in one-third area	34	235,008,000
14	57	Mulky 20, Bevier 24, Tebo 15 in half of area, Eureka 20 in half of area	35	208,320,000
15	56	Mulky 18 in one-third of area, Bevier 48, Tebo 16 in half of area, Eureka 18 in half of area	19	129,504,000
15	57	Mulky 18 in half of area, Bevier 48, Tebo 16 in half of area, Eureka 20 in half of area	22	158,400,000
16	56	Bevier, Tebo and Eureka combined 30	18	51,840,000
16	57	Mulky 18 in half of area, Bevier, Tebo and Eureka combined 36	36	155,520,000
17	57	Mulky 15 in one-third of area, Bevier 36, Tebo 24, Eureka 20	36	293,760,000
13 to 17	58 to 60	All beds in northern three tiers of townships, average 36	456	1,575,936,000
			698	2,985,888,000

The best available statistics indicate that to the end of 1910 21,100,000 tons of coal had been mined and utilized. This is only seven-tenths of 1 per cent of the original content, but in reality it represents greater loss, as much coal has been left in old workings and otherwise rendered unavailable. Computations based on old mine maps and the reports of production by the State Mine Inspectors show that the area mined out in the Bevier-Ardmore districts originally contained more than twice that actually sold. More specifically: the maps indicate that to 1910 nearly 50,000,000 tons have been used or rendered unavailable, whereas statistics show for the same period a production of only 20,500,000 tons, or only about 40 per cent of the coal originally in the ground. The companies now operating are much more economical in mining than the earlier ones, and perhaps leave only 20 per cent of the coal in the ground. Of the product hoisted, about 30 per cent is slack, part of which finds a ready sale.

Broadly considered, the rocks of Macon county dip very gently to the southwest, yet certain features have important local effects. Aside from minor undulations, there is a notable arch, called by Gordon the College Mound anticline, along which the rocks are at un-

usually high elevations. The axis of the anticline trends northwest-southeast, entering the county southeast of College Mound, passing south of Hammacks Mill and Lingo, and leaving near Bucklin. As may be seen on the map of the Bevier quadrangle, the Bevier bed is higher at and near College Mound than it is farther north or northeast. There is also a notable rise in level of the Bevier coal from Lingo to Rocky ford and from Lingo to Bucklin. Other less conspicuous anticlines and synclines parallel the College Mound flexure. On East fork, west of Atlanta, considerable disturbance is evident, and it may be that a strong anticline passes through that region, perhaps continuing northwest to Cardy. Its presence there would account for the apparent anomalies of the drill records.

DETAILED MENTION.

Northern Macon County.

LaPlata.—Drilling has been done at LaPlata, but records could not be obtained. The fact that no development work followed suggests that no important coal deposits were found. It is probable that the drift is thick and the Coal Measures thin in this district, but the absence of outcrops in the northeastern part of the county makes an analysis of the stratigraphy impossible. The following record of a churn drill hole six miles east of LaPlata (S. E. ¼ N. E. ¼ Sec. 7, T. 60 N., R. 13 W.) shows that the Pennsylvanian is very thin at that point and probably extends very little farther to the east:

		Feet.
1.	Drift clay	97
2.	Fire clay	13
3.	Limestone (Mississippian)	215

Cardy.—Three diamond drillings were made by York Bros. one to two miles west of Cardy near the Santa Fe railroad. Although these holes ranged in depth from 180 to 222 feet only a few very thin stringers of coal were penetrated. The only limestones were two very thin beds struck in one drilling, the remainder of the strata consisting of shale with some intercalated sandstones. These drillings do not appear to show a typical succession, and cannot be considered a fair criterion of what may exist in other parts of northern Macon county. Two miles north of Cardy, at the abandoned mine of David Vose, the following shaft record is reported from the memory of the operator:

RECORD OF VOSE SHAFT (W. ½ SEC. 7, T. 60 N., R. 15 W.).

		Feet.	*Inches.*
1.	Drift	18	....
2.	Sandstone	....	8
3.	Limestone	1	....
4.	Shale, "slaty"	4	6
5.	COAL	1	6
6.	"Dirt with sulphur balls"	36	....
7.	Shale	80	....
8.	COAL, three feet to	3	6

Gifford.—Two miles southwest of Gifford, at a ford over the Chariton (Sec. 17, T. 60 N., R. 16 W.), strata from the Summit cap-rock to the shale just below the Mulky (Macon City) sump-rock may be seen, but no coal occurs at these two horizons in this district. The horizon of the Bevier bed lies less than 50 feet below water level at the ford, and that of the Tebo a short distance lower. The thickness of coal at these horizons is not known. A hole drilled just over the line in Adair county (Sec. 33, T. 61 N., R. 16 W.) is said to have penetrated one foot of coal at 54 feet and 44 inches at 108 feet. Mr. Zimmerman, on whose land this boring was made, says that the amount of coal was overestimated.

Elmer.—At the small Perry mine, about two miles northeast of Elmer, there are 20 inches of coal capped by 2½ feet of "slaty" shale over which is eight inches of limestone. Nearer Elmer on Sand creek (N. E. ¼ S. E. ¼ Sec. 36, T. 60 N., R. 16 W.) there are 12 to 18 inches of coal overlain with 15 feet of blue sandy shale. The above two coal beds resemble respectively the Mulky and the Bevier, but this correlation is made with hesitation. A hole drilled 150 yards north of the Iowa and St. Louis station at Elmer, from about the level of the coal on Sand creek, passed through clay, shale, and sandstone, and encountered 10 inches of coal at 40 feet and traces at 60 feet. The record of the Walker shaft and drilling at the brick yard was furnished from memory and not from written records, but its importance justifies its insertion here:

WALKER SHAFT AND DRILLING (N. E. ¼ SEC. 1, T. 59 N., R. 16 W.).

		Feet.	*Inches.*
1.	Drift clay	18	....
2.	Shale	27	....
3.	COAL (Bevier?)	1	2
4.	Shale, very bituminous	....	8
5.	Shale and sandstone	99	....
6.	Rock, very hard (Mississippian?)	10	....

A mile and a half south of Elmer (N. E. ¼ Sec. 11, T. 59 N., R. 16 W.) there is one foot of coal overlain by 26 feet of shale and that in turn with a hard blue limestone one foot thick. This coal may be the Bevier. Farther south (N. E. ¼ Sec. 23, T. 59 N., R. 16 W.) there is an outcrop for 200 yards in a gully of 17 inches of coal, bearing numerous clay seams. Outcrops are very poor in all of this region, and the correlation of strata is correspondingly difficult.

Hart.—Along Mussel fork exposures are fairly good. Near New Boston the following section shows the position of the bed (Lexington) mined at Stahl in Adair county, and that all the important coal horizons lie below the level of the fork:

STRATA EXPOSED NEAR NEW BOSTON (N. W. ¼ SEC. 6, T. 59 N., R. 17 W.).

		Feet.
Pleasanton shale—		
1.	Shale, red and white	30
Henrietta formation—		
2.	Limestone, gray, weathers rough on top, heavy-bedded	3
3.	Shale, with thin layers of nodular limestone	13
4.	Limestone, in bed of creek (upper cap-rock of Lexington coal)	1+

The Lexington horizon contains little or no coal in Macon county. Southwest of Hart are excellent exposures in a big cut of the Santa Fe railroad near Mussel fork.

STRATA EXPOSED SOUTHWEST OF HART (N. W. ¼ SEC. 19, T. 58 N., R. 17 W.).

		Feet.	Inches.
Pleasanton shale—			
1.	Shale, red and white	5	....
Henrietta formation—			
2.	Limestone, gray, weathers buff, rough on top	3	9
3.	Shale, with a thin layer of limestone nodules in center	16	7
4.	Limestone, buff, clayey, nodular	2	6
5.	Shale, drab to buff, calcareous	2	8
6.	Limestone, gray, clayey, irregularly bedded	4	5
Cherokee shale—			
7.	Shale, dark (horizon of Lexington coal)	5	6
8.	Limestone, drab to deep brown, rough on top	4	....
9.	Clay, white	4	....
10.	Concealed, probably shale and sandstone	12	....
11.	Limestone, blue, in one layer	1	8
12.	Shale, black, "slaty"	2	6
13.	COAL (Summit), six inches to	....	8
14.	Clay, about	5	....
15.	Limestone, buff	2	....
16.	Shale, drab, sandy at base (horizon of Mulky coal)	10	6
17.	Sandstone and sandy shale	5+	....

According to this exposure none of the horizons above the Bevier, which lies only a short distance below No. 1 of the above section, bear coal of importance at this locality, though a short distance east (S. W. ¼ N. E. ¼ Sec. 20, T. 58 N., R. 17 W.) and down Mussel fork what may be the Mulky is 16 to 20 inches thick. The probability that thicker beds occupy the Bevier or Tebo horizons may be inferred from the deposits known to exist at Lingo and Bucklin.

Atlanta.—Some thin coal has been mined near Vienna and also about 3½ miles northeast of Atlanta. Both northeast and southeast of Vienna (N. W. ¼ Sec. 23 and S. E. ¼ Sec. 27, T. 59 N., R. 14 W.) the Lexington horizon lies near the level of Middle fork of Salt river, as shown by small exposures of the limestones associated with it.

West of Atlanta, on Long branch, is a very thin coal bed in the strata shown below. This coal may be either the Mulky or the Bevier.

LONG BRANCH SECTION.

		Feet.	Inches.
1.	Sandstone, flagging	3	....
2.	Shale, sandstone, and concealed	16	6
3.	Shale, black, "slaty"	2	8
4.	COAL, eight inches to	....	10
5.	Clay	5	....
6.	Limestone, greenish gray, in bed of branch	4	....

Near the bridge over East fork, due west to Atlanta, are several small abandoned drifts in what is probably the Mulky bed, here 15 to 24 inches thick and with a roof of two feet or more of black "slaty" shale overlain with a thin limestone cap-rock. A dip to the south or southwest carries this coal to the level of the water under the bridge over East fork, where it is stripped a trifle in dry seasons. There is a

little coal at the Summit horizon also, and rocks higher than the barren Lexington horizon are exposed south of the road. West of East fork (S. W. ¼ Sec. 24, T. 59 N., R. 15 W.) Daniel Tate's mine shows 20 inches of coal overlain with seven feet of "slaty" shale. A lower bed, perhaps the Bevier, was once reached by a shaft and is said to be 18 to 27 inches thick. The following record was kindly furnished by Mr. D. P. Branham:

RECORD OF BRANHAM SHAFT (S. W. ¼ SEC. 24, T. 59 N., R. 15 W.).

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift clay	25	....	25	....
2.	Limestone, blue	2	4	27	4
3.	Shale, black, "slaty"	2	....	29	4
4.	COAL	....	10	30	2
5.	Clay	7	....	37	2
6.	Limestone, white	1	6	38	8
7.	Clay	7	....	45	8
8.	Limestone, brittle, glassy	1	6	47	2
9.	Clay	7	....	54	2
10.	Sandstone, white	42	....	96	2
11.	Shale, "slaty", 2 inches coal at base	2	2	98	4
12.	Shale, sandy	16	....	114	4
13.	COAL (Bevier?)	1	8	116	....

Several miles up East fork, due east of Love Lake, the Lexington horizon is just above creek level, indicating that the important coal horizons of Macon county lie 50 feet or more below drainage level. About one mile northwest of this (N. E. ¼ S. E. ¼ Sec. 35, T. 60 N., R. 15 W.), however, 14 inches of coal under black "slaty" shales were utilized in a small way years ago and may lie in the Pleasanton formation above the Lexington horizon.

SOUTHERN MACON COUNTY.

Carbon.—Carbon is an abandoned mining camp which flourished on Middle fork of Salt river east of Macon before the development of the Bevier mines drove it out of business. A few small local mines still work the Mulky, a bed that outcrops low in the valley for a considerable distance and averages 22 inches in thickness. The coal is of excellent quality, hard and clean, and has a strong roof that adapts itself readily to longwall mining. Near the bridge across the fork, on the wagon road leading east from Macon (S. E. ¼ S. W. ¼ Sec. 18, T. 57 N., R. 13 W.), is the E. M. Browning slope, where the Mulky bed lies only a few feet above water level and is 22 inches thick. Over it are 67 inches of a shale which is drab and clayey at top but black and very calcareous and "slaty" in the lower and greater portion. Over the shale is a massive, compact, limestone cap-rock about 30 inches thick. The Hunt slope is in the same bed one-half mile south (S. W. ¼ N. E. ¼ Sec. 19), where there are 20 inches of coal. One mile farther down the valley, up a small tributary from the west (S. W. ¼ S. W. ¼ Sec. 30), is the R. Walker drift, where there are

24 inches of fine coal, seven feet of overlying "slaty" shale, and 3½ feet of compact limestone cap-rock. Many old workings in the Mulky bed may be seen in the valley of Salt river and the lower part of its tributaries for three miles above Carbon and for many miles below it. The bed appears to be very persistent and to underlie nearly all this part of the county.

The Summit coal has been removed by erosion in the greater part of the Carbon district, but remnants of it may be seen in places. Thus about one mile northeast of the Browning slope (S. E. ¼ S. E. ¼ Sec. 7, T. 57 N., R. 13 W.) it lies 22 feet above the Mulky coal, is 16 inches thick, and is separated from a thirty-inch limestone cap-rock by one foot of black "slaty" shale. About four miles north of this the Summit is said to be 12 inches thick and of poor quality. No coal outcrop has been found farther north, but drilling operations would probably uncover deposits similar to those of the Carbon district.

The Bevier bed, so important west of Macon, is much thinner and lies nearer the Mulky at Carbon, as shown by the accompanying sketch of the section* exposed at the first wagon bridge south of the railroad bridge over Salt river. Farther south the bed is irregular in thickness and locally thickens to as much as three feet, as in the following section measured by T. B. Marbut just above the level of low water in Salt river:

EXPOSURE THREE MILES SOUTH OF CARBON (N. W. ¼ S. E. ¼ SEC. 31, T. 57 N., R. 13 W.).

		Feet.	*Inches.*
1.	Shale, black	....	....
2.	COAL (Mulky), 20 inches to	2	2
3.	Clay and shale	5	....
4.	Limestone, gray, coarse-grained	1	....
5.	Clay, dark	1	....
6.	COAL (Bevier), probably	3	....
7.	Clay	1	6
8.	Limestone	2	....

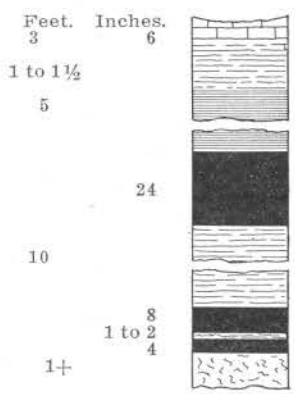

FIG. 55. The Mulky and Bevier coal beds near Carbon.

*Winslow, Arthur: Preliminary report on coal, Mo. Geol. Survey, 1891, p. 67.

A mile northwest of the above (S. E. ¼ S. W. ¼ Sec. 25, T. 57 N., R. 14 W.) a three-foot bed of coal is said to lie 8 to 12 feet below the Mulky, the latter having its usual associations and thickness of 22 inches.

Beds lower than the Bevier lie too low to outcrop and can be found only by boring. A few years ago about 30 drillings were made southeast of Macon; it is reported that workable coal was found at the Eureka horizon in a strip about three miles wide extending from three miles east of Macon east of south to about one mile northwest of Cox. One of the holes in which the thicker coal was found is given below. Although it is said to have been drilled on a ridge near which the Mulky seam has been mined, preglacial erosion had removed that bed at the point penetrated.

DRILLING NEAR CARBON (N. W. ¼ S. W. ¼ SEC. 18, T. 57 N., R. 13 W.).

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift	35	8	35	8
2.	Limestone (Mulky sump-rock)	1	10	37	6
3.	Shale, light-colored	9	....	46	6
4.	Sandstone	....	10	47	4
5.	COAL (Bevier)	....	2	47	6
6.	Sandstone	1	....	48	6
7.	Shale, light-colored, drab	5	6	54	....
8.	Shale, blue	6	....	60	....
9.	Sandstone	1	4	61	4
10.	Shale, black, "slaty"	1	4	62	8
11.	Shale, sandy	3	3	65	11
12.	COAL (Tebo)	1	4	67	3
13.	Clay	1	9	69	....
14.	Shale, sandy	17	....	86	....
15.	Sandstone	3	....	89	....
16.	Shale, light-colored, sandy	7	6	96	6
17.	Sandstone, shale partings	10	6	107	....
18.	Shale, light-colored, sandy	21	9	128	9
19.	COAL, 30 inches Clay, 5 " COAL, 9 " (Eureka)	3	8	132	5
20.	Clay	1	7	134	....
21.	Shale, light-colored, sandy	1	10	135	10

Cox.—In T. 56 N., R. 13 W. the Mulky coal bed outcrops low down in the valleys of Narrows creek, Hoover creek, and Salt river, as well as in several minor tributaries, and may safely be said to underlie the greater part of the township. This bed is very uniformly 22 inches thick and is mined at many points by drifting and stripping for local use. The bed has an excellent roof of hard black "slaty" shale five feet thick, overlain with four feet of compact limestone. On or near Narrows creek much coal has been removed along the outcrop, drifts recently in operation being those of Lewis Wright (N. W. ¼ S. W. ¼ Sec. 18, T. 56 N., R. 13 W.) and William Vancycle on land of J. H. Smith (N. E. ¼ N. W. ¼ Sec. 18). North of the

Vancycle drift, in Sec. 7, the same bed is reported to be 27 inches thick at one place (N. E. ¼ S. W. ¼) and 24 at another (S. E. ¼ S. W. ¼) where it is only a few feet above the bottom lands of Narrows creek. Farther east (N. W. ¼ S. E. ¼ Sec. 8) it is 18 inches, and the same or a few inches thicker near the mouth of Narrows creek, where it is about 30 feet above the water. At the Wright drift it is 21 inches and a short distance north (S. W. ¼ N. W. ¼ Sec. 18) 22 inches. A half mile east of this, on another tributary of Narrows creek, it is 24 inches thick. South and southwest of Cox (Secs. 29 and 30) the Mulky is 18 to 22 inches thick and only a few feet above the level of Greasy creek. Still farther south it is 18 inches thick and near the level of Hoover creek.

The Summit coal bed is less than 14 inches thick in most of this region and is eroded away in much of it. The limestone cap-rock and "slaty" shale above it are similar to those over the Mulky, though the shale is thinner. In Sec. 8, T. 56 N., R. 13 W. it is said to be 14 inches thick and 10 to 25 feet above the Mulky. These measurements probably approximate those at other places where the higher bed is present.

The Bevier bed lies only a few feet below the Mulky and appears to be irregular in thickness, though nowhere exceeding three feet. This bed lies too low to outcrop except in the main creeks, and the tendency of its overlying material to wash down obscures it even there. Northwest of the Vancycle drift (N. W. ¼ S. E. ¼ Sec. 8, T. 56 N., R. 13 W.) it is said to be three feet thick and to have a roof of light-colored sandy shale. West of this (N. E. ¼ S. W. ¼ Sec. 7) it is reported as having the same thickness and as lying 12 feet below the Mulky. A drilling farther north (S. E. ¼ N. W. ¼ Sec. 6) shows its thickness there to be only 19 inches. What may be the Bevier bed is 22 inches thick on Hoover creek, but a drilling at Cox shows only 12 inches at that horizon.

Broadhead* gives a section near Winn branch (N. W. corner Sec. 3, T. 56 N., R. 13 W.) including 18 inches of coal that apparently correlates with the Tebo, in which case it is evident that the strata are at higher levels than on Salt river. Drillings show little coal at the Tebo horizon at other points. The finding of coal at the Eureka horizon in the northwestern part of T. 56 N., R. 13 W. has been mentioned in the description of the Carbon district. This bed appears to be of irregular thickness and unworkable under present conditions in a number of places, although thicker in certain basins. Below are a few drill records, most of which do not report much coal, kindly furnished by Mr. David Moore of Macon.

*Mo. Geol. Survey, 1855-71, p. 88.

DRILLING THREE MILES SOUTH OF CARBON (S. E. ¼ N. W. ¼ SEC. 6, T. 56 N., R. 13 W.).

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift	77	8	77	8
2.	Limestone	3	....	80	8
3.	Shale, blue	1	....	81	8
4.	Shale, black, "slaty"	4	8	86	4
5.	COAL (Mulky)	1	6	87	10
6.	Clay	3	....	90	10
7.	Shale, light	5	2	96	....
8.	COAL (Bevier)	1	7	97	7
9.	Clay	....	9	98	4
10.	Sandstone	1	4	99	8
11.	Shale, light, sandy	2	4	102	....
12.	Limestone	1	2	103	2
13.	Shale, light, sandy, with thin sandstone layer	9	10	113	....
14.	Shale, dark	2	6	115	6
15.	Shale, blue at top, sandy at bottom	9	6	125	....
16.	"Rock," black	....	10	125	10
17.	Shale, dark, sandy	3	3	129	1
18.	COAL (Tebo)	....	11	130	....
19.	Shale, with thin sandstone layer near top	11	....	141	....
20.	Sandstone	12	4	153	4
21.	Shale, variegated, with thin sandstone layer near top	14	8	168	....
22.	Sandstone	8	4	176	4
23.	COAL, 12 inches Sandstone, 20 " COAL, 6 " (Eureka)	3	2	179	6
24.	Clay	....	6	180	....
25.	Shale, light, sandy	1	2	181	2
26.	Sandstone	27	10	209	....

DRILLING TWO MILES NORTH OF WOODVILLE (S. W. ¼ S. E. ¼ SEC. 15, T. 56 N., R. 13 W.).

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift	25	....	25	....
2.	Shale, light, sandy, thin sandstone layer near base	25	....	50	....
3.	Sandstone, with shale partings	9	6	59	6
4.	Shale, dark at top, remainder light and sandy	5	6	65	....
5.	Sandstone, with shale partings	23	....	88	....
6.	Limestone	3	1	91	1
7.	COAL	....	3	91	4
8.	Sandstone	4	8	96	....
9.	Shale, light, sandy in lower half	10	5	106	5
10.	COAL	....	7	107	....
11.	Clay	1	3	108	3
12.	Shale, light, sandy	3	9	112	....
13.	Sandstone	3	6	115	6
14.	Shale, light	1	10	117	4
15.	Limestone	2	4	119	8
16.	Shale, light, sandy, sandstone layers in middle	3	4	123	....
17.	Shale, dark, sandy	1	10	124	10
18.	COAL	....	9	125	7
19.	Clay	....	8	126	3
20.	Sandstone	3	9	130	....
21.	Limestone	3	1	133	1
22.	Shale, dark in center, light above and below	35	5	168	6
23.	COAL	....	8	169	2
24.	Clay	1	10	171	....
25.	Sandstone	5	3	176	3

DRILLING ONE AND ONE-HALF MILES NORTH OF COX (N. E. ¼ S. W. ¼ SEC. 17, T. 56 N., R. 13 W.).

		Thickness. Feet.	Inches.	Depth. Feet.	Inches.
1.	Drift	25	....	25	....
2.	Shale, light, sandy	8	6	33	6
3.	Shale, black in center, blue above and below	5	6	39	....
4.	Shale, light, sandy	3	5	42	5
5.	COAL (Tebo)	....	11	43	4
6.	Clay	1	8	45	....
7.	Shale, in part sandy	10	6	55	6
8.	Sandstone	9	4	64	10
9.	Shale, in greater part light and sandy	30	10	95	8
10.	Shale, blue	20	4	116	....
11.	COAL, 15 inches Sandstone, 14 " COAL, 9 " (Eureka)	3	2	119	2
12.	Clay	2	2	121	4

DRILLING AT COX (N. E. ¼ N. W. ¼ SEC. 29, T. 56 N., R. 13 W.).

		Thickness. Feet.	Inches.	Depth. Feet.	Inches.
1.	Bored well	60	....	60	....
2.	Sandstone	3	4	63	4
3.	Shale, broken	4	2	67	6
4.	"Hard stone"	2	6	70	....
5.	Shale, light at top, blue at bottom	10	9	80	9
6.	Limestone	4	1	84	10
7.	Shale, light at top, blue at bottom	2	2	87	....
8.	Shale, black, "slaty"	4	....	91	....
9.	COAL (Mulky)	1	3	92	3
10.	Clay	1	9	94	....
11.	Shale, light	5	....	99	....
12.	COAL (Bevier)	1	....	100	....
13.	Clay	1	6	101	6
14.	Sandstone	2	6	104	....
15.	Shale, blue, with one-foot sandstone layer	22	8	126	8
16.	Shale, black, "slaty"	1	6	128	2
17.	Shale, light, sandy	3	....	131	2
18.	COAL (Tebo)	....	8	131	10
19.	Clay	1	2	133	....
20.	Shale, light, sandy, one-foot sandstone layer near top	7	10	140	10
21.	Sandstone, with thin shale parting	11	2	152	....
22.	Shale, light, sandy in lower half	26	....	178	....
23.	Sandstone	3	6	181	6
24.	Shale, in greater part light and sandy	20	....	201	6
25.	Shale, blue	18	6	220	....
26.	COAL (Eureka)	1	8	221	8
27.	Clay	1	4	223	....
28.	Sandstone	2	8	225	8

DRILLING ONE MILE SOUTHWEST OF COX (S. E. CORNER SEC. 30, T. 56 N., R. 13 W.).

		Thickness. Feet.	Inches.	Depth. Feet.	Inches.
1.	Drift	28	....	28	....
2.	Shale, light, with eight-inch sandstone layer	11	....	39	....
3.	Shale, blue	11	7	50	7
4.	Limestone	....	9	51	4
5.	Shale, upper half blue, lower black and "slaty"	3	1	54	5
6.	COAL (Tebo)	1	....	55	5
7.	Clay	1	7	57	....
8.	Shale, light, sandy	11	4	68	4
9.	Sandstone	4	6	72	10
10.	Shale, light, sandy	24	6	97	4

DRILLING ONE MILE SOUTHWEST OF COX (S. E. CORNER SEC. 30, T. 56 N., R. 13 W.)—Continued.

		Thickness. Feet.	Thickness. Inches.	Depth. Feet.	Depth. Inches.
11.	Shale, blue	5	8	103	....
12.	COAL, 4 inches; Shale, blue, 20 "; COAL, 8 "; (Eureka)	2	8	105	8
13.	Clay	1	4	107	....
14.	Shale, light, sandy	4	9	111	9
15.	"Black rock"	1	5	113	2
16.	Sandstone	10	4	123	6
17.	Shale, light, sandy	5	4	128	10
18.	Sandstone	5	10	134	8
19.	Shale, in part sandy	20	4	155	....
20.	Sandstone, soft	7	6	162	6

Woodville.—At Woodville the regular coal beds and other strata have been removed by a large channel similar to the one described in Randolph and Monroe counties. As exposed in a gully northwest of the village, there are 40 feet or more of massive red sandstone and sandy shale, with several beds of conglomerate bearing pebbles of Coal Measures limestones firmly cemented in a calcareous matrix. At the bridge northeast of Woodville (center Sec. 26, T. 56 N., R. 13 W.) 16 feet of light sandy shale overlies 15 feet of massive sandstone. At and on both sides of the bridge due east of Woodville sandstone is also exposed. West of the village (S. E. ¼ S. E. ¼ Sec. 28) regular Pennsylvanian beds containing 17 inches of coal (Tebo?) outcrop on Hoover creek, but 200 feet down stream these are overlain with about six feet of the conglomerate. On this part of Hoover creek, dips are steep and irregular, and farther northwest (S. W. ¼ N. E. ¼ Sec. 28) sandy shales and sandstones of the channel deposits are again in evidence.

South of west from Woodville, on Hoover creek and its branches, the strata are undisturbed and a number of local drifts supply local trade from the Mulky bed, which outcrops in the hill sides. This bed contains fine clean coal 18 to 22 inches thick, with above it six to seven feet of shale, all but the top of which is hard, black, and "slaty." Over the shale is a limestone cap-rock with its usual characters. The only mines found in operation were the drifts of M. F. Switzer (S. E. ¼ N. E. ¼ Sec. 33, T. 56 N., R. 13 W.) and G. A. Burkhardt (N. E. ¼ S. E. ¼ Sec. 32).

Macon.—The Mulky (Macon City) coal bed is persistent in character and thickness under the divide on which Macon stands, and is mined both east and west of the city. The Bevier, however, is the bed utilized at most of the mines on the west, though its weak roof is a cause of an increasing tendency to abandon it for the Macon City. East of Macon the Bevier thins, as stated in the description of the Carbon district. The Tebo and Eureka do not seem to be of im-

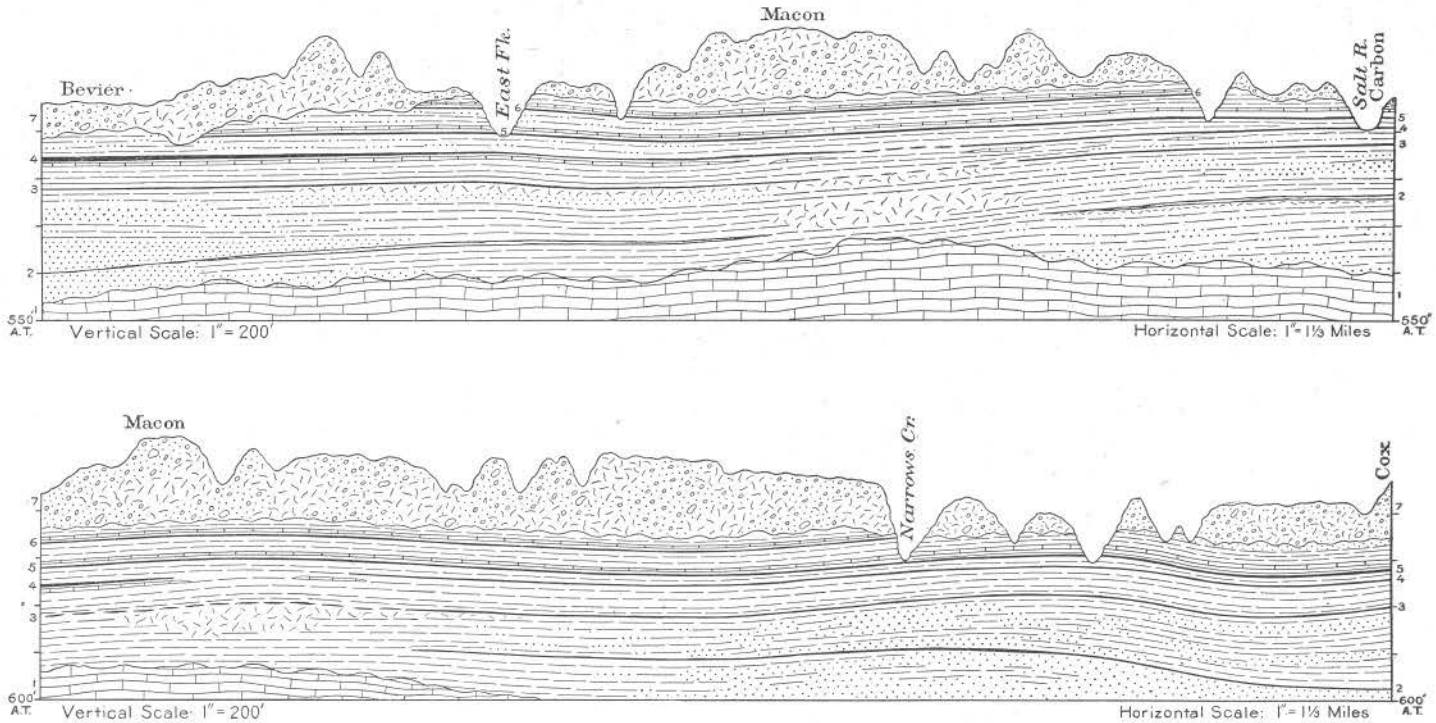

Fig. 56. Cross-sections through Macon City. (1) Mississippian limestone. (2) Eureka coal. (3) Tebo coal. (4) Bevier coal. (5) Mulky coal. (6) Summit coal. (7) Glacial drift.

portance under the city, though the Eureka is locally workable on both sides of it. No drill records were obtained of the higher lands north and south of Macon, so that the strata under most of the divide must be inferred from the outcrops visible in the breaks of the Chariton and Salt river drainages. It is known, however, that the drift is at least 100 feet thick in parts of the divide, a feature that renders prospecting expensive.

Near the Burlington railroad and the east corporation line of Macon (N. W. ¼ N. W. ¼ Sec. 22, T. 57 N., R. 14 W.) is a shaft of the Home Coal Co., 73 feet deep to the Mulky coal bed. Hoisting is done by steam power, mining on the longwall system, and the product is sold in the city or shipped to neighboring towns on the east. The thickness of the coal is uniformly 22 inches. There is a limestone cap-rock, under which is 4½ feet of hard, black, "slaty" shale, that is very calcareous and makes an excellent roof. In places lenses of very pyritiferous shale next the coal prevent it breaking down well. A few "clay slips," adjacent to which the coal is full of pyrite ("sulphur"), make longwall working difficult in small areas, but on the whole the bed is a clean one. The underclay is exceptionally thick and rests on a very thin layer of nodular limestone.

A deep drilling,* the details of the upper part of which are evidently slightly erroneous, was put down in the southeast portion of Macon (S. W. corner N. E. ¼ N. E. ¼ Sec. 21), not far from the Home mine. The only coal recorded was 13 inches at 49 feet and 22 inches at 75 feet, probably the Summit and Mulky beds. The Mississippian was reached at 185 feet. That no coal was recorded at lower horizons may have been due to imperfections in the drillers log.

A short distance southwest of Macon, in what is known as Coal Hollow, many small drifts, slopes, and shafts have explored the coal beds, chiefly the Mulky seam, which lies about 15 feet above East fork.

EXPOSURES SOUTHWEST OF MACON (SECS. 28 AND 29, T. 57 N., R. 14 W.).

		Feet.	*Inches.*
1.	Limestone, blue, compact	1	6
2.	Shale, blue, soft at top	2	1
3.	COAL (Summit)	1	....
4.	Clay and shale, with possibly a thin limestone	15	....
5.	Limestone, yellowish gray, compact	3	....
6.	Shale, soft at top, hard, black and "slaty" in greater part	5	....
7.	COAL (Mulky)	1	10
8.	Clay and shale, about	20	....
9.	COAL (Bevier)	2	3

South of Coal Hollow (center Sec. 32) all three coals outcrop, the Summit 11 inches thick, the Mulky 22 inches, and the Bevier 30 to 36 inches and 17 feet below the Mulky. One-half mile east the Bevier lies only seven feet below the Mulky, and in one place the two

*For complete record see Trans. St. Louis Acad. Sci., vol. V, 1888, pp. 327-328, or Water Supply Paper No. 195, U. S. Geol. Survey, 1907, p. 90.

beds are said to have so closely approached one another that they could be mined as one bed.

Two mines are now supplying the wagon trade from shafts between Macon and East Fork: (1) J. C. Brown, 40 feet deep (S. E. ¼ N. W. ¼ Sec. 20, T. 57 N., R. 14 W.), and (2) J. H. Dennis, 60 feet deep (N. W. ¼ S. E. ¼ Sec. 17). Both mine the Mulky bed, which is quite clean and uniform in thickness, on the longwall system and hoist with horse whims. Mr. Dennis attempted to work the Bevier bed at the same shaft, but gave it up because of its poor roof.

PARTIAL RECORD OF DENNIS SHAFT (N. W. ¼ S. E. ¼ SEC. 17, T. 57 N., R. 14 W.).

		Feet.	*Inches.*
1.	Limestone, massive, compact	4	6
2.	Shale, black, "slaty," with concretions	5	....
3.	COAL (Mulky)	1	10
4.	Clay, four inches to	1	2
5.	Limestone, two inches to	....	4
6.	Shale, soft	18	....
7.	COAL (Bevier), with two-inch clay parting	2	4

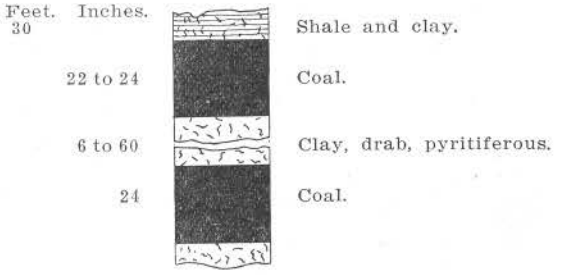

FIG. 57. The Eureka coal bed at the abandoned Eureka shaft.

Many years ago the Eureka shaft was sunk 172 feet beside the Burlington railroad two miles west of Macon. An attempt was made by the Macon Coal Co. to mine the Eureka bed, but was abandoned because of a poor roof and the amount of dirt in the coal; the Bevier bed was also operated at the same shaft. The shaft record furnishes so complete a section of the stratigraphic succession of the district that it is re-published below:

EUREKA SHAFT* (S. W. ¼ S. E. ¼ SEC. 18, T. 57 N., R. 14 W.).

		Thickness. *Feet.*	Depth. *Feet.*
1.	Drift	21	21
2.	Limestone	3	24
3.	Shale, black, "slaty"	3½	27½
4.	COAL (Summit)	1	28½
5.	Clay	7½	36
6.	Sandstone	2½	38½
7.	Shale	9½	48
8.	Limestone, hard, blue, known as "Bluestone"	3	51

*A report on the Bevier sheet: Mo. Geol. Survey, vol. IX, 1896, p. 14.

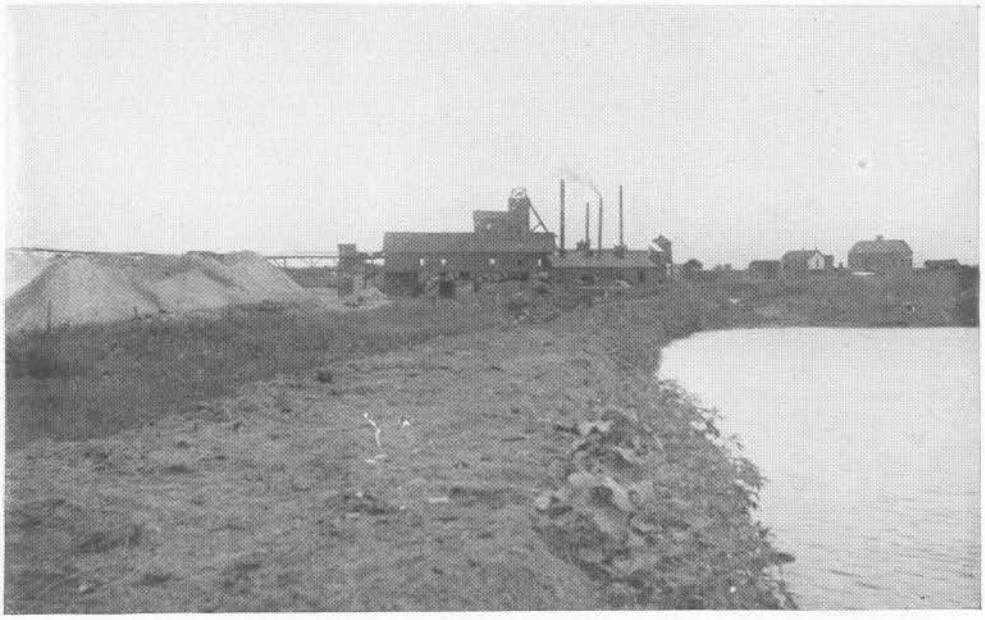

Fig. 1. Mine No. 61, Central Coal and Coke Co., Keota, Mo.

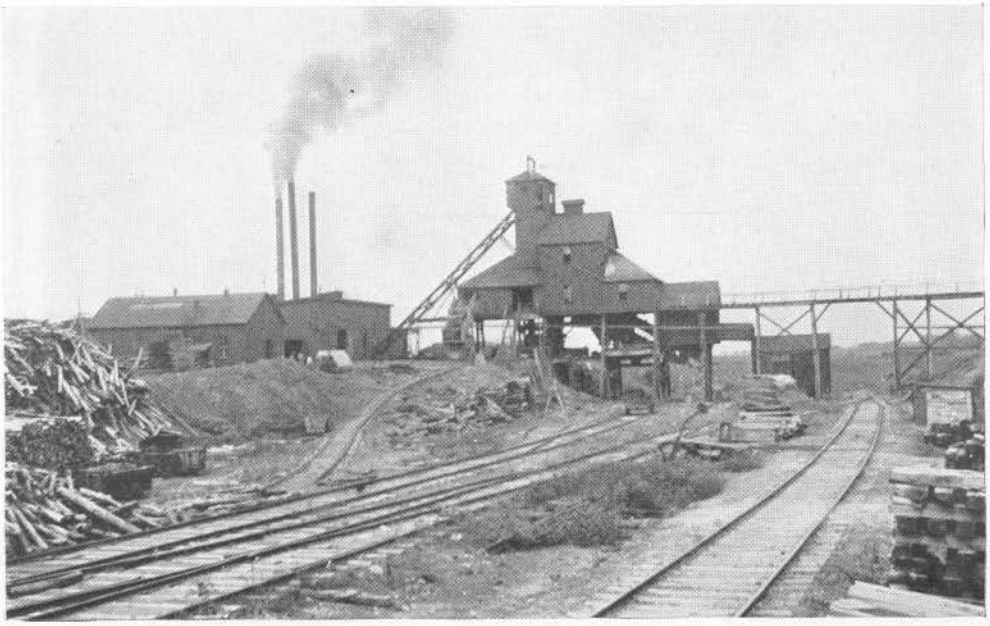

Fig. 2. Mine No. 8, Northwestern Coal and Mining Co., south of Bevier, Mo.

EUREKA SHAFT* (S. W. ¼ S. E. ¼ SEC. 18, T. 57 N., R. 14 W.)—Continued.

		Thickness. *Feet.*	Depth. *Feet.*
9.	Shale, black, "slaty"	4	55
10.	COAL (Mulky)	1½	56½
11.	Clay	5½	62
12.	Shale, sandy, with some sandstone	8½	70½
13.	"Cement rock"	2	72½
14.	Shale, sandy	3	75½
15.	COAL, 13 inches Clay, 1 inch COAL, 10 inches (Bevier)	2	77½
16.	Clay	½	78
17.	Limestone	3	81
18.	Shale	2½	83½
19.	Limestone, with six-inch shale parting	2	85½
20.	Shale, black, "slaty"	6	91½
21.	Limestone	½	92
22.	Shale, black in lower part	11	103
23.	Limestone	½	103½
24.	Shale, black	5½	109
25.	COAL (Tebo)	2	111
26.	Clay	11	122
27.	Sandstone	6	128
28.	Shale, with thin layers of limestone and sandstone	7½	135½
29.	Shale, black, "slaty"	5	140½
30.	Clay	12½	153
31.	Shale, black and "slaty" at top and bottom	13	166
32.	COAL, 24 inches Clay, 6 to 60 " COAL, 24 " (Eureka)	6	172

To top of Mississippian about 30 feet.

Excello.—Under this head are considered deposits in T. 56 N., R. 14 W., east of East fork. What underlies the divide on which Excello stands can be inferred only from the outcrops on Salt river drainage on the east, previously described, and those in the breaks of East fork on the west. The Summit is probably unimportant; the Mulky a persistent bed about 22 inches thick and with a good roof; the Bevier averaging perhaps 30 inches and with a weak roof; the Tebo in most places too thin to work; the Eureka locally workable, but only in restricted areas whose locations can be determined only with a drill.

Three miles northwest of Excello is the small shaft of A. W. Sexton, 25 feet deep, operated for local trade. A number of small mines have been operated in this vicinity.

SEXTON SHAFT (N. W. ¼ S. W. ¼ SEC. 8, T. 56 N., R. 14 W.).

		Feet.	*Inches.*
1.	Limestone	3	6
2.	Shale, black	4	....
3.	COAL (Mulky)	2	....
4.	Sandstone	11	....
5.	COAL, 23 inches Clay, 2 " COAL, 13 " (Bevier)	3	2
6.	Clay	1	....
7.	Limestone, impure	....	....

*A report on the Bevier sheet: Mo. Geol. Survey, vol. IX, 1896, p. 14.

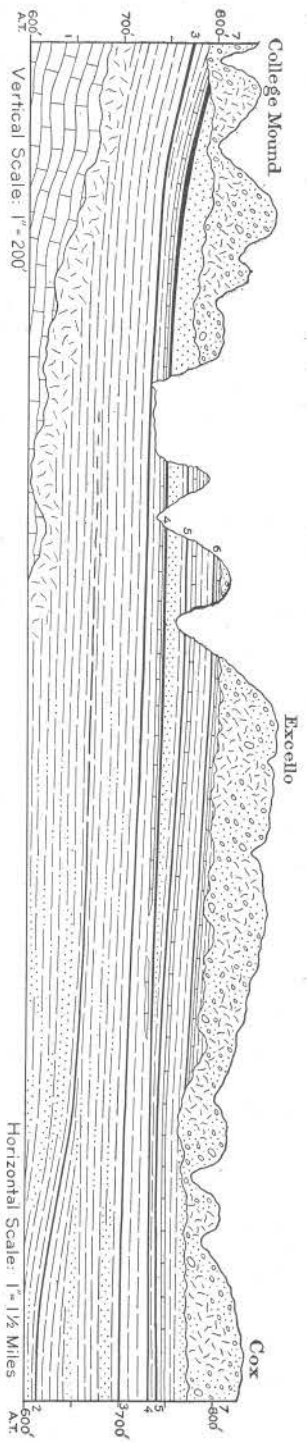

Fig. 58. Cross-section from College Mound to Cox. (1) Mississippian limestone. (2) Eureka coal. (3) Tebo coal. (4) Bevier coal. (5) Mulky coal. (6) Summit coal. (7) Glacial drift.

The sandstone above the Bevier has a slightly uneven lower surface. Where the roof is shale the coal is somewhat thicker. Near the railroad, west of the Sexton bank (Sec. 9), the Bevier is said to be only 30 inches thick and is slightly less farther north (Sec. 4).

Two miles northwest of Excello are two small mines. T. McGrath is opening a slope (S. W. ¼ S. E. ¼ Sec. 8, T. 56 N., R. 14 W.) to the Mulky bed, which is 21 inches thick and is overlain with 4½ feet of very hard and calcareous, dark gray, "slaty" shale, over which is a five-foot massive limestone cap-rock. Mr. McGrath formerly mined the Bevier bed, which is 30 to 36 inches thick and has a rather poor shale roof. The Summit is one foot in thickness near the slope. M. G. Viers hoists with a horse whim 58 feet from the Bevier, a bed that varies here from 30 to 48 inches because of a sandstone roof that cuts down into the coal in places.

VIERS SHAFT (N. W. ¼ S. W. ¼ SEC. 17, T. 56 N., R. 14 W.).

		Feet.	*Inches.*
1.	Drift	7	....
2.	Limestone, massive	1	6
3.	Shale, black, "slaty"	3	....
4.	COAL (Summit)	1	....
5.	Interval, mostly shale	25	....
6.	COAL (Mulky)	1	10
7.	Sandstone	19	....
8.	COAL, 27 inches Clay, ½ inch COAL, 12 inches (Bevier)	3	3
9.	Clay	....	6
10.	Limestone, rough on top, impure	3	6

Between Excello and East fork are a number of small country mines, the principal ones being: Frank Henry (S. W. ¼ S. W. ¼ Sec. 19), G. M. Brown (S. W. ¼ S. W. ¼ Sec. 29), A. J. Marsh (Sec. 29), Ernest Judy (Sec. 29), C. H. Herrington (S. E.¼ N. E. ¼ Sec. 30), and L. D. Craft (S. W. ¼ S. E. ¼ Sec. 30). All utilize the Bevier

bed, which has a shale or sandstone roof, is four feet thick, and has a two-inch clay band about 18 inches from the bottom. Near the Graft drift the Mulky bed is 18 inches thick and 12 to 18 feet above the Bevier, and the Summit is 13 inches thick and 23 feet above the Mulky. At the Ardmore bridge and at other points on East fork for a mile or more above and below it, the Tebo coal has been seen near water level. It lies about 20 feet below the Bevier, is about 18 inches thick, and overlain with black "slaty" shale; in one place* (S. W. ¼ N. W. ¼ Sec. 19, T. 56 N., R. 14 W.) the bed includes 30 inches of coal split in the center by a four-foot shale parting.

Bevier-Ardmore.—On the divide between Middle and East forks, south of Bevier, is the most important producing field in Missouri. On it have been and are the largest mines in the State and their present output forms a large proportion of that of the whole State. In former years the principal mines were located on or near the main line of the Burlington at Bevier and at Ardmore, a mining camp then connected with the Wabash by a spur from Excello. After the coal at these localities became exhausted, shafts were sunk on the divide between Bevier and Ardmore, the spur from Excello was abandoned, and a railroad constructed from Bevier to Ardmore. Many miners live at Ardmore and Keota, a new camp three miles south of Bevier, but the majority stay at Bevier, which is a prosperous town supported by the mining industry. The shipping mines are controlled by two companies and are among the best equipped in the State, using modern steam hoists, electric equipment for underground use, etc. In most of the mines the main haulage is by motors. The plan of working is room and pillar, and coal is shot off the solid, no mining machines being used. At Keota is the only coal washer in Missouri; screenings are washed during periods when there is little demand for the inferior unwashed article. The plant has proved its economy and from the conservationist's point of view is a move in the right direction.

SHIPPING MINES OF THE BEVIER-ARDMORE DISTRICT.

Name.	Location.	Depth of shaft.
		Feet.
Central Coal and Coke Co. No. 24...	N. W. ¼ S. W. ¼ Sec. 12, T. 56 N., R. 15 W..	120
" " " " " " 25...	N. W. ¼ S. W. ¼ Sec. 34, T. 57 N., R. 15 W..	Slope
" " " " " " 28...	S. E. ¼ S. W. ¼ Sec. 13, T. 56 N., R. 15 W..	82
" " " " " " 61...	N. W. ¼ N. W. ¼ Sec. 27, T. 57 N., R. 15 W..	124
" " " " " " 66...	N. W. ¼ N. W. ¼ Sec. 2, T. 56 N., R. 15 W..	57
Northwestern Coal and Mining Co. No. 8.....	N. W. ¼ S. E. ¼ Sec. 22, T. 57 N., R. 15 W..	140
Northwestern Coal and Mining Co. No. 9.....	S. E. ¼ S. W. ¼ Sec. 23, T. 57 N., R. 15 W..	106

*Gordon, C. H., A report on the Bevier sheet: Mo. Geol. Survey, vol. IX, 1896, p. 22.

The bed utilized at these mines, called by McGee and others the Bevier bed, outcrops on Middle and East forks and on Claybank creek and its lower tributaries. It lies less than 160 feet below the higher parts of the divide. The thickness of coal is one to six feet, with an average of nearly 4½ feet. There are two benches separated by an average of two inches of clay, the lower bench being quite uniform at 10 to 15 inches, and the upper more variable. The quality of the bed is shown in the chapter on analyses and fuel tests. There are three types of roof over the coal, of which the most common is what is known as the "soapstone," though it is in reality either a very clayey sandstone showing cross bedding or a very sandy shale; this makes a fairly stable roof if carefully watched, though it tends to slice off gradually when left exposed. About as common a roof is a hard, medium-grained sandstone that is stronger, but in places cuts down into the coal so as to decrease the thickness of the upper bench. A less common top is a black carbonaceous shale that lies over patches one to 40 acres in extent; under it the coal is slightly thicker than elsewhere, but it often generates fires and requires watching. Below the coal is clay, very irregular in thickness, but averaging little more than one foot; in the old mines at Bevier it is said to have been four feet thick and to have given much trouble through "heaving." Under the clay is a limestone sump-rock that is very hard, rough on top, and without good cleavage planes.

Aside from the large mines mentioned there are a number of smaller ones that supply local trade. A short distance north and northwest of Bevier are three: (1) J. H. Jones (S. W. ¼ S. W. ¼ Sec. 10, T. 57 N., R. 15 W.), shaft 107 feet, horse-whim hoist, coal four feet, roof shale and sandstone, the latter in places cutting down so as to reduce coal to 18 inches; (2) R. Thomas (S. E. ¼ N. W. ¼ Sec. 10, T. 57 N., R. 15 W.), shaft 130 feet, small steam hoist, coal averages four feet, roof a thin black "slaty" shale, above which is 30 feet or more of sandstone and sandy shale; (3) James Bros. (S. W. ¼ S. E. ¼ Sec. 9, T. 57 N., R. 15 W.), shaft 54 feet, horse-whim hoist, coal four to 4½ feet, roof sandstone. Southwest and south of Bevier, near Middle fork of Chariton river, and North fork of Claybank creek, are three small slopes where the coal and roof are as in the shipping mines: (1) Isaacson and Underwood (S. E. ¼ S. E. ¼ Sec. 20, T. 57 N., R. 15 W.), (2) J. Gates (N. W. ¼ N. W. ¼ Sec. 4, T. 56 N., R. 15 W.), and (3) T. A. Vestal (S. E. ¼ S. W. ¼ Sec. 4, T. 56 N., R. 15 W.). Mines on South fork of Claybank creek are mentioned in the description of the College Mound district. One-half mile northeast of Ardmore (S. E. ¼ N. W. ¼ Sec. 24, T. 56 N., R. 15 W.) Mr. Walters has two small drifts, one in the Bevier bed, which is four feet thick with a one-inch clay parting and a roof of gray sandy shale, and the other in the Mulky, which is 18 inches thick and is overlain with hard,

grayish black, "slaty" shale. Three miles southeast of Bevier are two mines that sell the Bevier coal locally and in Macon City: (1) H. J. Hurd (S. W. ¼ S. W. ¼ Sec. 19, T. 57 N., R. 14 W.), shaft 94 feet, horse-whim hoist, coal 31 inches, roof a soft sandy clay that is not very reliable; (2) G. E. Smith (S. W. ¼ N. W. ¼ Sec. 30, T. 57 N., R. 14 W.), shaft 72 feet, steam hoist, coal 38 inches, roof sandstone, underclay 10 inches. Half way between the Smith shaft and Ardmore (S. E. ¼ S. W. ¼ Sec. 6, T. 56 N., R. 14 W.) W. Phipps operates a slope where the Bevier is 3½ to 4½ feet thick and has an inch of clay 13 inches from the bottom; the roof is a sandstone with an uneven under surface to which the upper eight inches of coal sticks after shooting; the underclay averages one foot.

One feature that causes trouble in some of the mines and has prevented many areas being developed is the great thickness of the drift. This soft material is 100 feet thick on many of the higher lands and in places lies so near the coal as to make the mine roof very insecure. In some places preglacial erosion cut down so far as to remove even the Bevier bed itself, especially in the territory bordering Middle fork. Thus the horizon of the thick coal is found occupied by soft clays containing pebbles in the northwest workings of Central No. 61, and on the west side of Central No. 28, as well as in places drilled in Secs. 21, 28, 33, 34, and 35, T. 57 N., R. 15 W., and Secs. 2, 3, and 11, T. 56 N., R. 15 W. In the same way drift and alluvium have replaced the Bevier coal bed under the bottom-lands of Middle fork west of Bevier; of three drill records in Sec. 17, T. 57 N., R. 15 W., one shows 70 feet of drift (S. E. corner S. E. ¼ S. W. ¼) and two 109 feet (S. E. corner S. W. ¼ N. E. ¼ and S. W. corner N. W. ¼ S. E. ¼).

One of the puzzling questions yet to be solved is the nature of the Bevier bed in the region north of Bevier. There are no outcrops that can be studied and drill records are few. The old mines at Bevier and the small mines now working on the north side of the railroad near that town appear to have coal much like that in the large producing area south of Bevier, with the exception that there is more of the sandstone roof and therefore many rolls to reduce the thickness of the coal beneath. Some years ago, however, Mr. Watson sank a shaft about 1½ miles north of Bevier (S. E. ¼ N. W. ¼ Sec. 2) only to discover that the coal was unworkable except along a narrow trough. West of Bevier and north of the Burlington railroad the coal is said to be thin, apparently because a sandstone roof cuts into it. What little prospecting has been done north of Bevier township appears to have been unsuccessful, though more drilling must be done before it can be said that there are no valuable coal deposits between the Burlington and the Santa Fe railroads.

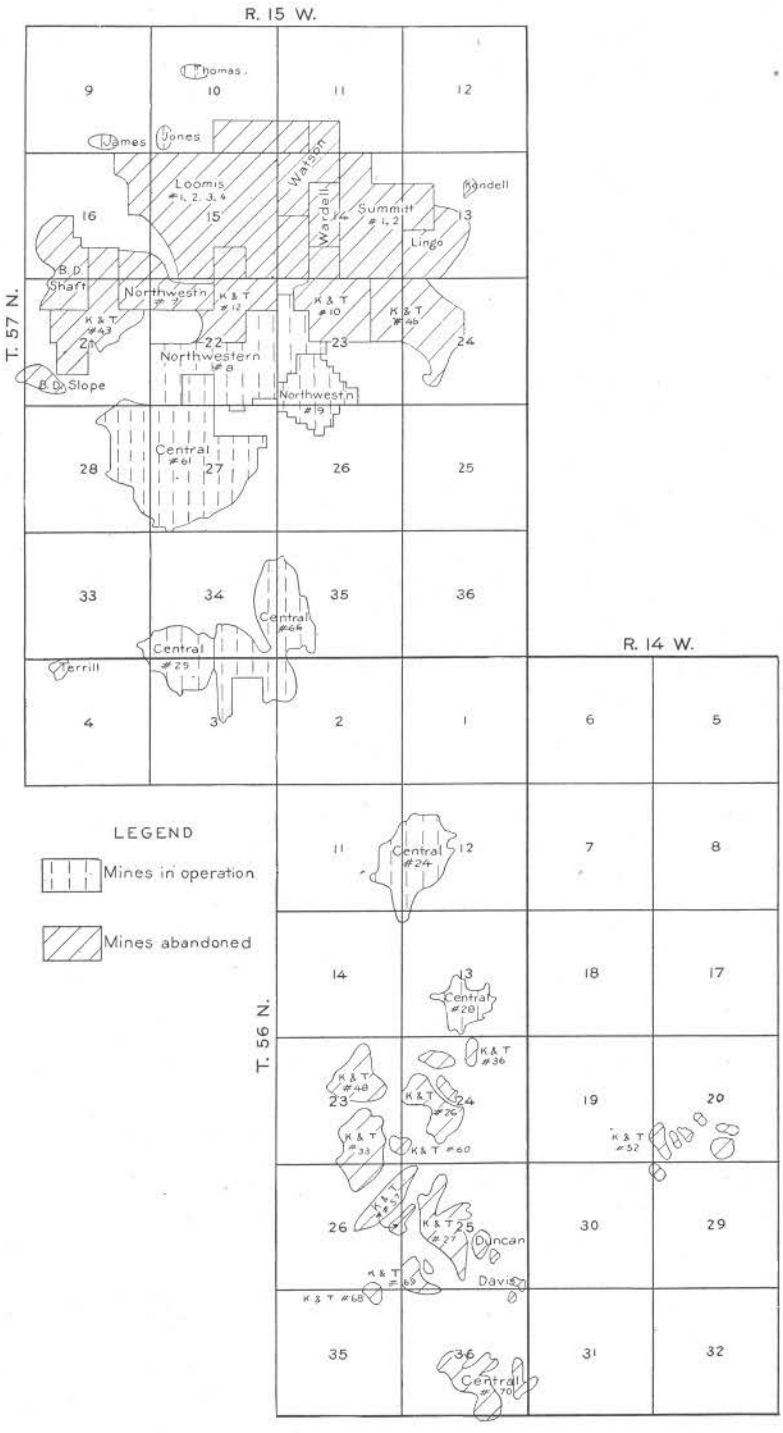

Fig. 59. Past and present mine workings in the Bevier-Ardmore area, 1910.

The first coal bed above the Bevier, the Mulky (Macon City), has been removed by preglacial erosion in much of the field and in small areas it was never deposited. North of Ardmore on the eastern side of the divide, however, the Mulky is commonly present as a bed averaging 18 inches and overlain with about four feet of shale that is black and "slaty" at the bottom and grades upward into softer and lighter material. Over the shale is a cap-rock of compact limestone three to four feet in thickness. The Mulky is separated from the Bevier bed below it by 10 to 25 feet of shales and sandstones that are very variable in composition. It is worked by a few small mines near East fork, of which the Walters drift near Ardmore has already been mentioned. The operators of the Hurd shaft (S. W. ¼ S. W. ¼ Sec. 19, T. 57 N., R. 14 W.) intend to abandon the Bevier and begin operations in the Mulky, which is said to lie 16 feet higher and to be 23 inches thick. Near the Phipps slope T. W. Gipson has a small drift in 19 inches of coal that lies at the Mulky horizon, 14 feet above the Bevier.

The Summit coal bed is replaced by drift nearly everywhere except east of Northwestern No. 9, near the Smith and Hurd mines, and farther north. The rocks overlying it much resemble those above the Mulky, but the coal is rarely as much as 14 inches in thickness and cannot be considered workable. It lies 20 to 30 feet above the Mulky seam. The following record shows the relationships of the three highest coal beds:

DRILLING SOUTHEAST OF BEVIER (CENTER N. W. ¼ SEC. 25, T. 57 N., R. 15 W.).

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift	103	....	103	....
2.	Limestone	2	....	105	....
3.	Shale, blue	1	4	106	4
4.	COAL (Summit)	....	8	107	....
5.	Shale, clayey	6	....	113	....
6.	Limestone	1	....	114	....
7.	Shale, blue	8	....	122	....
8.	Limestone	3	....	125	....
9.	Shale, black	5	....	130	....
10.	COAL (Mulky)	1	6	131	6
11.	Sandstone	19	6	151	....
12.	COAL, 34 inches Clay, 2 " COAL, 12 " (Bevier)	4	....	155	....
13.	Clay	1	....	156	....

The first coal horizon below the Bevier is the Tebo, and has already been mentioned as containing coal at the Eureka shaft, near Ardmore, and in the Carbon and Cox districts. From such drill records as are available, it appears to be a bed six inches to two feet in thickness, overlain with black "slaty" shale and underlain with a considera-

ble thickness of clay or soft shale. As it is not being mined and outcrops are very scarce, nothing can be said as to its quality. Between it and the Bevier are 20 to 35 feet of drab and black shales with a few thin beds of limestone interstratified. This bed was penetrated in drillings at Bevier, Northwestern No. 8, and between Keota and Ardmore; also two miles southeast of Bevier, where the Bevier coal has been replaced by drift as shown in the following record:

DRILLING SOUTHEAST OF BEVIER (N. W. CORNER N. E. ¼ N. E. ¼ SEC. 20, T. 57 N., R. 15 W.).

		Thickness.		Depth.
		Feet.	*Inches.*	*Feet.*
1.	Drift	79	....	79
2.	Limestone (Bevier sump-rock)	5	....	84
3.	Shale, soft	8	....	92
4.	Shale, dark	6	....	98
5.	Limestone	1	....	99
6.	Shale, blue	9	7	108½
7.	COAL (Tebo)	1	4	110
8.	Clay	1	1	111

The lowest coal bed is the Eureka, already mentioned as once mined at the Eureka shaft and as found in drillings east and southeast of Macon. It is a bed that is very variable in thickness, apparently lying in large basins separated from the Tebo by 50 to 90 feet of sandstone and sandy shale. Its value is in places impaired by a shale parting of variable thickness, though it is probable that in time better deposits will be discovered at this horizon under tracts of rather small area. The following drilling includes both the Tebo and Eureka coals:

DRILLING BETWEEN KEOTA AND ARDMORE (CENTER EAST LINE S. E. ¼ SEC. 2, T. 56 N., R. 15 W.).

		Thickness.		Depth.
		Feet.	*Inches.*	*Feet.*
1.	Drift	72	....	72
2.	Limestone	1	....	73
3.	Shale, gray	4	....	77
4.	Limestone	....	6	77½
5.	Shale, black, "slaty"	3	6	81
6.	COAL (Tebo)	1	1	82
7.	Shale, sandy at top	31	11	114
8.	Shale, dark	2	....	116
9.	Shale, sandy	16	....	132
10.	Shale, black, "slaty"	9	....	141
11.	COAL (Eureka)	2	3	143
12.	Clay	....	9	144

Two drillings made at and near Bevier and printed below show not only the three lowest coal beds, but also the top of the Mississippian, the lower limit of coal. A comparison of the records indicates the very variable character of Coal Measures deposits lower than the Tebo horizon.

DEEP DRILLING 300 YARDS EAST OF STATION AT BEVIER.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift clays, with sand at base	24	....	24	....
2.	Shale, light, sandy	1	10	25	10
3.	Sandstone	6	6	32	4
4.	Shale, light, sandy, with two thin sandstone layers	9	....	41	4
5.	COAL (Bevier)	2	11	44	3
6.	Clay	1	1	45	4
7.	Limestone	3	6	48	10
8.	Shale, light	2	2	51	....
9.	Sandstone, and light sandy shale	1	10	52	10
10.	Limestone	2	11	55	9
11.	Shale, light, with four inches of limestone at bottom	1	3	57	....
12.	Shale, dark at top, blue at bottom	7	....	64	....
13.	Limestone	....	3	64	3
14.	Shale, dark at top, blue at bottom	3	9	68	....
15.	Shale, black, "slaty"	3	....	71	....
16.	COAL (Tebo)	1	2	72	2
17.	Sandstone	....	3	72	5
18.	Clay in upper half, light sandy shale in lower	2	7	75	....
19.	Sandstone	4	10	79	10
20.	Shale, light, sandy in lower part	9	....	88	10
21.	Sandstone	12	10	101	8
22.	Sandstone, with shale partings	19	4	121	....
23.	Sandstone	37	....	158	....
24.	COAL (Eureka)	....	10	158	10
25.	Clay	....	7	159	5
26.	Sandstone	....	8	160	1
27.	Shale, black, "slaty"	....	6	160	7
28.	Sandstone	11	3	171	10
29.	COAL	....	2	172	....
30.	Sandstone	5	....	177	....
31.	Limestone (top of Mississippian)	19	8	196	8
32.	Sandstone at top, greenish at bottom	4	4	201	....
33.	Limestone	7	....	208	....
34.	Sandstone	25	....	233	....
35.	Limestone	7	6	240	6

DRILLING AT NORTHWESTERN NO. 8 (S. E. ¼ SEC. 22, T. 57 N., R. 15 W.).

		Thickness.		Depth.
		Feet.	*Inches.*	*Feet.*
1.	Drift	55	....	55
2.	Shale, gray, "slaty" (laminated)	51	....	106
3.	Sandstone	26	....	132
4.	COAL (Bevier)	4	....	136
5.	Clay	1	2	137
6.	Sandstone and shale	2	10	140
7.	Limestone, blue	4	....	144
8.	Shale	3	....	147
9.	Limestone	2	....	149
10.	Shale	8	....	157
11.	Shale, in part black and "slaty"	2	....	159
12.	COAL (Tebo)	....	6	159½
13.	Shale	26	6	186
14.	Limestone	2	6	188½
15.	Shale	24	6	213
16.	COAL (Eureka)	1	2	214
17.	Sandstone, blue	16	10	231
18.	Shale, gray and red	9	....	240
19.	Limestone, gray, hard (Mississippian)	16	....	256

College Mound.—Because of an arch, or anticline, with axis trending northwest-southeast, the strata at and near College Mound lie at higher levels than farther north, as is shown on the map of the Bevier quadrangle. Consequently, the Summit and Mulky beds were eroded

away before the region was covered with drift and in places even the Bevier itself is gone. This thinness of the solid cover over the Bevier is one of the factors that lessens the availability of the bed, although it contains three to six feet of good coal. A minor factor is the presence of a "bench rock" of clay or sandstone one to 10 inches in thickness; in some of the large mines formerly in operation south of Ardmore this parting was as much as 18 inches in small areas. On the South fork of Claybank creek, north of College Mound, small local mines have been operated for half a century and two were found open in 1910: (1) Mr. Smith (S. E. ¼ S. W. ¼ Sec. 22, T. 56 N., R. 15 W.), and (2) Alonzo Quinn (S. E. ¼ S. E. ¼ Sec. 22, T. 56 N., R. 15 W.). The coal at these mines is 52 inches thick, the lower third being separated from the upper bench by five to seven inches of hard, pyritiferous sandstone. The roof is a soft shale, drab at the Smith bank and black at the Quinn, and is not strong.

According to the record of an oil and gas prospect recently drilled on the hill-side near College Mound (S. E. ¼ S. E. ¼ Sec. 28, T. 56 N., R. 15 W.) to a depth of 953 feet, the drift is 55 feet thick at that point and replaces the Bevier; the Tebo is about two feet thick and at a depth of 67 feet; below the Tebo is 55 feet of shale under which is 20 feet of clay resting on thick Mississippian limestone. The top of the Mississippian, the lower limit of coal, is, therefore, only 144 feet below the surface and only about 95 feet below the Bevier horizon; and there is no coal recorded lower than the Tebo.

Callao.—The region between Chariton river and Middle fork is so heavily drift-covered that no exposures of Pennsylvanian rocks can be seen, even along the main streams. Some coal, evidently at a horizon lower than the Bevier, was found by drilling about one-half mile west of the station at Callao at a depth reported as 150 or 175 feet, but was not sufficiently thick to justify development. In the territory south of the Burlington railroad, the few drill records available indicate that preglacial erosion removed the Bevier coal and the strata above it. Thus, one boring one-half mile north of Kaseyville showed more than 65 feet, and another one-half mile farther north more than 100 feet of drift clay. Two and one-half miles south of Callao were found:

DRILLING SOUTH OF CALLAO (S. E. CORNER S. W. ¼ S. W. ¼ SEC. 19, T. 57 N., R. 15 W.).

		Thickness. Feet.	Thickness. Inches.	Depth. Feet.
1.	Drift	98	....	98
2.	Limestone (Bevier sump-rock)	3	6	101½
3.	Shale, light at top, blue and "slaty" at bottom	6	6	108
4.	Limestone	1	....	109
5.	Shale, "slaty," blue at top, black at bottom	8	....	117
6.	Limestone	1	....	118
7.	Shale, black, "slaty"	4	2	122
8.	COAL (Tebo)	1	7	124
9.	Clay	3	3	127
10.	Limestone	....	....	....

In a boring one mile northwest of the last, begun on ground about 40 feet lower, even the Tebo is removed by erosion, and lower strata were penetrated as follows:

DRILLING SOUTHWEST OF CALLAO (N. W. CORNER S. W. ¼ SEC. 24, T. 57 N., R. 16 W.).

		Thickness. Feet.	Inches.	Depth. Feet.
1.	Drift	127	....	127
2.	Shale, yellow at top, light below	14	....	141
3.	Shale, dark, and sandstone	2	4	143
4.	COAL (Eureka?)	....	7	144
5.	Clay	2	1	146
6.	Shale, black, "slaty"	1	....	147
7.	Shale, gray and dark	11	5	158
8.	COAL	....	1	158½
9.	Shale, dark blue	5	....	163½
10.	COAL, shaly	....	7	164
11.	Shale, black	5	5	169½
12.	Sandstone, dark	7	....	176½

New Cambria.—A shaft sunk at New Cambria (N. E. ¼ N. W. ¼ Sec. 12, T. 57 N., R. 17 W.) is said to have encountered 30 inches of coal at about 100 feet, and one foot more still lower; the upper bed is correlated by Gordon* with the Mulky (Macon City), in which case the lower is the Bevier. Four miles northeast of the town, near the Chariton bottoms, there have been a number of small mines in the Mulky bed, reported to be 30 inches thick at one place (W. ½ S. E. ¼ Sec. 27, T. 58 N., R. 16 W.). Broadhead gives the following section from this vicinity:

	Feet.	Inches.
Sandstone, brown and bluish drab, thin-bedded	12	....
Limestone, blue	1	4
Shale, dark blue, clayey	1	....
Shale, bituminous	2	6
COAL (Mulky)	1	....
Concealed to bottoms	10	....

Two miles southwest of New Cambria is the strip pit of Jesse Burns (N. W. ¼ S. W. ¼ Sec. 8, T. 57 N., R. 16 W.) and the drift of J. B. Noah on the Baldwin place (S. E. ¼ S. E. ¼ Sec. 7, T. 57 N., R. 16 W.). At these small local mines the Mulky coal bed is 18 to 24 inches thick, is underlain with more than three feet of clay, and overlain with four feet or more of shale that is soft and drab at the top and black and "slaty" next the coal. Large flattened oval concretions lie horizontally in the shale. South of this (Sec. 17) old drifts in the same bed may be seen about 20 feet above the Chariton bottoms. Broadhead found in Sec. 18 one foot of coal that may be at the Summit horizon. At Hammack's Mill there are exposed 43 feet of shale and brown sandstone just below the Mulky horizon and evidently only a few feet above the Bevier.

*A report on the Bevier sheet, pp. 35, 48. Notes by T. B. Marbut show that the depth of 196 feet to the thirty-inch bed, cited by Gordon on p. 48, is a typographical error for 96 feet and that the distance from the upper bed to the second may be 50 feet instead of 72.

Lingo.—Until recently a mine had been worked at Lingo station for many years, the product being shipped to Kansas City, St. Joseph and other points west. The shaft was 140 feet deep to the Bevier coal bed, here 40 to 50 inches thick, but separated into two benches by a parting of hard pyritiferous and sandy clay four to 20 inches thick. The longwall method of mining was pursued, as the roof is a brittle "slaty" shale that would be cut by coal pillars and ordinary timbers, and the "bench rock" parting could be used in building gob-walls. The pyrite and bituminous matter in the roof and parting material, however, caused the generation of so much heat when thrown into the gob that the mine was well known as the hottest in the State and one in which the men worked in considerable discomfort. Mr. George Jobson kindly furnished the following partial record of the shaft:

LOWER PART OF SHAFT AT LINGO.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Depth from surface	....	....	53	....
Limestone, impure (sump-rock of Lexington coal horizon)	4	....	57	....
Interval, about	16	....	73	....
Limestone, blue	2	....	75	....
Shale, black, "slaty"	2	6	77	6
COAL (Summit)	....	6	78	....
Clay	8	6	86	6
Limestone	1	6	88	....
Shale, brown, "slaty"	1	6	89	6
COAL (Mulky)	....	1	89	7
Clay	15	....	104	7
Sandstone	12	....	116	7
Shale, sandy at top	16	....	132	7
COAL, 30 inches Clay, hard, average, 8 " COAL, 14 " } (Bevier)	4	4	136	11
Clay	1	6	138	5
Limestone	4	....	142	5

Winslow cites the finding during shafting operations of the coal shown in the accompanying figure at a depth of 30 feet below the bed mined and, therefore, at the Tebo horizon. At Bucklin, in Linn county near Lingo, 32 inches is reported at the Eureka horizon, 70 feet below the Tebo.

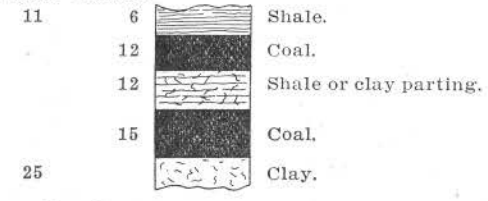

FIG. 60. The Tebo coal bed at Lingo.

Two miles south of Lingo, near a place known as Rocky ford (W. ½ Sec. 21, T. 57 N., R. 17 W.), the Bevier bed outcrops on Brush

creek and is essentially the same as at Lingo. Its altitude is, however, higher here, indicating a dip in the direction of Lingo. West of Lingo, along Mussel fork, coal from eight to 18 inches outcrops, but it is rarely mined. Norwood† describes a section 2½ miles northeast of Bucklin, near the county line, that includes 18 to 24 inches of coal at the Bevier horizon, near the level of Mussel fork.

MARION COUNTY.*

Marion county has produced very small quantities of coal from outliers of the Pennsylvanian series, although the outcropping stratified rocks of nearly the entire county belong to older formations. No coal was being mined when the region was visited by the writer in 1910, but Swallow notes several occurrences of the mineral. Coal Measures areas are confined to part of a rather large outlier in the southwest corner of the county composed chiefly of sandstone, to a small outlier on South Fabius river, and to a pocket on Houston branch. The areal extent of these outliers is shown on the geological map of the State contained in this report.

A small pocket of coal two feet thick is reported by Swallow from the N. W. ¼ Sec. 12, T. 58 N., R. 7 W., and two others with one foot of coal in each in the S. E. ¼ Sec. 21, T. 59 N., R. 7 W., and the S. E. ¼ Sec. 29, T. 57 N., R. 8 W., respectively. None of these deposits can be considered of much importance and it is doubtful if coal minable on any but a small scale will ever be found in the county.

MERCER COUNTY.

The surface of Mercer county is deeply covered with glacial drift, the loose clays and sands being more than 200 feet thick in some localities. The thick limestone beds at the base of the Missouri group may be seen along the valleys of the branches of Grand river, and they underlie approximately the areas indicated on the State geologic map. They form a useful guide to the depth at which the deeper coal beds lie. On the lower lands of the county and where the Missouri group has been replaced by drift, the Pleasanton, a formation distinguished from the overlying strata by the absence of any but very thin limestones, lies just below the drift. Near the top of the Pleasanton are one or two coal beds that are in general less than one foot in thickness and are of no importance, though a little fuel was obtained from them before the advent of the railroad. Aside from these no coal outcrops

†Mo. Geol. Survey, 1873-1874, p. 263.

*The topography of much of Marion county is shown on the map of the Palmyra quadrangle of the U. S. Geol. Survey. The geology was first discussed by G. C. Swallow (Geology of Marion County: First Report, Mo. Geol. Survey, 1855, pp. 171-185).

in the region. Drilling done within the last few years has revealed the presence of important coal reserves beneath the surface, however, and these bid fair to exercise a notable effect on the development of the county.

Two diamond drillings were made at Lineville by a company of citizens. One, bored in Iowa, three-fourths mile north of the State line, penetrated, in descending order, 337 feet of drift clay and sand, 83 feet of blue clay-shale with limestone nodules, 4 feet of black bituminous shale, 176 feet of blue sandy shale, and 18 feet of sandstone. No coal was found, but another drilling south of town in Missouri was more successful.

DRILLING THREE-FOURTHS MILE SOUTH OF LINEVILLE.*

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift, by drillers log	237	....	237	....
Shale, sandy to argillaceous, green to drab	230	....	467	....
Shale, red, purple and green	4	....	471	....
Shale, black, soft	....	4	471	4
Shale, olive-green	3	....	474	4
Limestone, gray to green, fine-grained	4	....	478	4
Shale, dark gray or brown, streaks of black shale near bottom	6	....	484	4
Shale, blue-gray, sandy	3	....	487	4
Sandstone, light bluish-gray, micaceous	24	....	511	4
Shale, black, bituminous	....	3	511	7
Shale, gray at top, dark drab at base, sandy to argillaceous	14	3	525	10
Limestone, gray	....	10	526	8
Shale, dark drab, no sand or mica	2	2	528	10
COAL, bony, poor quality	....	10	529	8
Shale, drab, fine-textured	12	6	542	2
Sandstone, gray, shaley, fine-grained	2	4	544	6
Shale, dark gray, micaceous	17	2	561	8
COAL, fair	....	11	562	7
Shale, gray, fine-textured, some pyrite	15	....	577	7
COAL, bony, poor	....	4	577	11
Shale, gray, fine-grained	3	4	581	3
Sandstone, gray, fine-grained	6	2	587	5
Shale, gray, dark at base, sandy streak in middle	2	6	589	11
Shale, black, bituminous	....	6	590	5
COAL, only fair	2	9	592	2
Shale, dark gray to blue, argillaceous	12	4	604	6
COAL	1	9	606	3
Shale, light gray	4	....	610	3
Shale, dark blue	9	....	619	3
COAL	....	10	620	1
Shale, light gray	4	4	624	5
Shale, mostly dark blue	30	6	654	11
Shale, sandy, blue and white, with much water	27	5	682	4

The surface at this drilling is about 200 feet higher than the nearest exposure 7 or 8 miles distant of the heavy limestones at the base of the Missouri group. If the strata lie horizontally, therefore, these limestone beds would be replaced by drift at Lineville; but the absence of the limestones of the Henrietta formation could not be accounted for in the same manner. The coal beds at 592 and 606

*Slightly modified from record kindly furnished by James H. Lees, Assistant State Geologist of Iowa, who examined the core.

feet resemble in their associations the upper and lower benches, respectively, of the Cainesville bed of the Princeton records, and it is possible that they are identical and that a strong southerly dip has brought the Cainesville to a higher level at Lineville than at Princeton. The fact that at Powersville the Lexington coal lies about 200 feet higher than it does at Princeton adds weight to this hypothesis, for an anticline (arch) may cross the Lineville district from Leon, Iowa, to Powersville. If the strata are horizontal, however, the Lineville drilling did not go sufficiently deep to reach the Cainesville horizon by 100 to 150 feet. The absence of outcrops in the vicinity makes it impossible to definitely decide this question except by additional drilling. Nine or ten prospect holes were drilled in the valley of Thomsons fork of Grand river from north of Princeton to about 5 miles south. Through the courtesy of Mr. T. W. Ballew of Princeton, the logs of 3 drillings were given to the Survey. The following record is typical:

KESTERSON FARM DRILLING THREE MILES SOUTH OF PRINCETON
(N. W. ¼ N. E. ¼ SEC. 8, T. 64 N., R. 24 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Surface material	10	....	10	....
Pleasanton shale—				
Limestone, shelly, sand and gravel	19	....	29	....
Shale, dark	21	....	50	....
Shale, light, sandy	10	....	60	....
Sandstone	9	....	69	....
Shale, sandy	2	....	71	....
Sandstone	22	....	93	....
Shale, light, red in middle	18	....	111	....
Shale, dark, soft	6	....	117	....
enrietta formation—				
Limestone, gray	2	....	119	....
Shale, dark	7	....	126	....
Shale, red at top, blue at bottom	3	....	129	....
Limestone, gray, crystalline	4	....	133	....
Shale, light blue	7	....	140	....
Shale, dark, "slaty" at bottom	9	....	149	....
Limestone, gray, hard	3	....	152	....
Cherokee shale—				
Shale, blocky, "slaty"	1	....	153	....
COAL	....	6	153	6
Clay, soft (Lexington)	....	4	153	10
COAL	1	2	155	....
Clay	....	6	155	6
Shale, dark	3	6	159	....
Limestone, gray	1	4	160	4
Shale, dark	1	8	162	....
Limestone, gray	3	....	165	....
Shale, brown, blue, and with thin streaks of COAL	2	....	167	....
Shale, gray, sandy in middle	13	....	180	....
Shale, black, "slaty"	5	....	185	....
Shale, light	6	....	191	....
Limestone, gray	4	....	195	....
Shale, gray	4	....	199	....
Limestone, crystalline	3	....	202	....
Shale, black, "slaty"	4	....	206	....
COAL (Mulky)	1	2	207	2
Clay, gray, hard	....	10	208	....
Shale, gray	16	....	224	....
Shale, sandy, dark at base	17	....	241	....

KESTERSON FARM DRILLNG THREE MILES SOUTH OF PRINCETON
(N. W. ¼ N. E. ¼ SEC. 8, T. 64 N., R 24 W.—Continued.

	Thickness.		Depth.	
Cherokee shale—Continued.	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Sandstone	11	....	252	....
Shale, dark	3	....	255	....
Sandstone	4	6	259	6
COAL (Bedford)	1	6	261	....
Clay, hard	1	....	262	....
Shale, sandy	8	....	270	....
Shale, dark, "slaty" at base	17	4	287	4
COAL (Bevier)	1	8	289	....
Clay, soft	1	....	290	....
Shale, gray, soft	4	....	294	....
Shale, dark	2	....	296	....
Limestone, gray, hard, impure	1	....	297	....
COAL (Tebo)	1	....	298	....
Clay	2	....	300	....
Shale, light, sandy at top	22	....	322	....
Shale, dark	1	....	323	....
Shale, gray	7	....	330	....
Shale, dark	4	....	334	....
COAL	1	....	335	....
Clay	3	....	338	....
Shale, blue	3	....	341	....
Shale, black, "slaty"	1	....	342	....
COAL	1	10	343	10
Shale, brown, with streaks of coal up to 1 inch	4	2	348	....
Shale, gray	10	....	358	....
Shale, dark	2	....	360	....
Shale, black, "slaty"	1	....	361	....
COAL	1	....	362	....
Shale, dark	18	....	380	....
COAL	....	10	380	10
Shale, dark	3	2	384	....
Shale, light	4	....	388	....
Shale, dark	7	....	395	....
Shale, sandy	15	....	410	....
Shale, dark, black in lower half	26	6	436	6
COAL	1	6	438	....
Shale, dark	1	....	439	....
Shale, light, sandy	12	....	451	....
Shale, black, "slaty"	1	....	452	....
Shale, sandy	5	6	457	6
Shale, dark to black	2	....	459	6
COAL	....	10	460	4
Shale, dark	2	8	463	....
Shale, light	5	....	468	....
Shale, dark	5	....	473	....
Shale, light	3	....	476	....
Shale, gray	3	2	479	2
COAL	2	3	481	5
Shale, dark (Cainesville)	1	....	482	5
COAL	2	6	484	11
Shale, sandy	1	1	486	....

Several lines of evidence show that the coal mined at Cainesville is the same as that at the bottom of the above drilling. At Princeton, as at Cainesville, the bed is 485 feet below the Hertha limestone at the base of the Missouri group. The Hertha and the limestone beds just above it outcrop prominently in the bluffs at and near Princeton. Only summaries of the coal in the other drillings obtained can be given here, beds less than 14 inches thick being omitted.

MULLINAX FARM, ON SOUTH SIDE OF PRINCETON (S. W. CORNER N. E. ¼ S. E. ¼ SEC. 34, T. 65 N., R. 24 W.).

Altitude of surface above sea level about 825 feet.

	Thickness. *Inches.*	Depth. *Feet.*
Horizon of coal—		
Lexington	16	174
Tebo	20	348
No name	18	366
No name	24	448
Cainesville, sandstone roof: COAL, 13 inches; bone, 4 "; COAL, 29 "	42	460
No name	16	472
Bottom of drilling	....	482
Total coal	136	

LIME KILNS, SOUTH OF PRINCETON.

Lexington	18	185
Mulky (?)	19	259
Bevier	24	306
Tebo	24	321
No name	17	337
No name	36	431
No name	19	445
Cainesville, sandy shale roof: COAL, 31 inches; shale, 18 "; COAL, 12 "	43	461
No name	19	471
No name	18	495
Bottom of drilling	....	508
Total coal	237	

AT IKE MASON'S SPRING, NEAR PRINCETON.

	Thickness. *Inches.*	Depth. *Feet.*
Horizon of coal—		
Bevier	14	244
No name	18	336
No name	28	357
No name	20	456
Cainesville, blue shale roof: COAL, 34 inches; blue shale, 15 "; COAL, 24 "	58	473
Bottom of drilling	....	476
Total coal	138	

ROCK QUARRY, HYDE'S SUGAR CAMP, ONE MILE SOUTH OF PRINCETON.

Summit	18	204
Bevier	16	291
No name	24	319
No name	17	363
No name	16	408
Cainesville, blue shale roof: COAL, 31 inches; blue shale, 29 "; COAL, 33 "	64	468
No name	20	479
No name	15	513
Bottom of drilling	....	603
Total coal	190	

COCKRELL FARM AT BUCKEYE BEND.

	Thickness. *Inches.*	Depth. *Feet.*
Horizon of coal—		
Lexington	24	116
Bevier	22	229
No name	15	274
No name	18	309
No name	24	322
Cainesville, blue shale roof: COAL, 30 inches; blue shale, 30 "; COAL, 34 "	64	434
No name	18	478
Bottom of drilling	....	490
Total coal	185	

If beds less than 14 inches were included, there would be from 19 to 65 inches (average 50 inches) more of coal in these borings. It will be noticed that in all drillings the Cainesville bed is of fair thickness, but that its value is somewhat impaired by an apparently persistent parting. Other persistent coals lie a short distance above and below the thicker bed; and in addition the Tebo, Bevier, Mulky, and Lexington, beds of known persistency in Missouri, are in many places of workable thickness. Owing to the uncertainty regarding the Lineville drilling, the northern limit of the Cainesville bed is not known. It is evidently more or less continuous between Princeton and Cainesville in the west-central part of the county. It extends at least 5 miles south of Princeton, but thins out somewhere north of Trenton. Near Mill Grove the limestones at the base of the Missouri group lie at about the same altitude above sea level as at Princeton, where the altitude of the Cainesville bed is 365 feet. South of Mill Grove it rises about 50 feet, and at the south county line it probably lies only 400 feet below the bottom lands. The Lexington bed, found at Spickards, probably underlies this part of the county. There are no deep drillings in eastern Mercer county. At Powersville, in western Putnam, the Lexington bed is 24 inches thick at a depth of 150 feet and an altitude of 820 feet above sea level, and a similar bed probably underlies parts of northeastern Mercer county. Near the county line, west of Harris (S. E. corner N. W. ¼ N. E. ¼ Sec. 33, T. 64 N., R. 22 W.), 215 feet of drift clay and sand were penetrated without reaching the Coal Measures.

By averaging the amount of coal in beds of 14 inches or more in the drillings at Lineville, Princeton, and Cainesville, and by giving each average equal weight, it may be estimated that there is a coal reserve for the county of 100 inches or 4,329,600,000 tons; but as there are no data concerning the deeper coals of the east half or the southeastern edge of the county, these figures may be in error.

MILLER COUNTY.

Many pockets of Pennsylvanian sandstone, shale, and coal occur in Miller county, most of them on the north side of the Osage river, in the western portion of the county. All these deposits are small, the largest being not over 700 feet in diameter, yet some of them carry considerable fuel, a few containing as much as 40 feet of cannel and bituminous coal. As the occurrence and characteristics of all the pockets has been very minutely described in a recent report† the facts will not be repeated here. When the county was visited in May, 1911, no coal mining had been recently undertaken.

MONITEAU COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....1,434 TONS.

Moniteau county, like the adjacent counties, contains a number of coal pockets, some of which have excited much interest. A report of this Survey published in 1905 describes so completely and so well the distribution and character of the Coal Measures pockets that note is made here only of those that have become better known through recent mining developments.

Monarch Coal and Mineral Company.—The Monarch Coal and Mineral Company is now operating the famous Simpson bank four miles west of Highpoint (N. E. ¼ S. W. ¼ Sec. 15, T. 43 N., R. 16 W.). Coal has been known to exist at this point for over half a century and considerable has been mined by a strip pit and, to a less degree, by shafts. The open pit exposes a nearly vertical wall of horizontally bedded Jefferson City limestone, against which the coal rests. As in most pockets, the coal dips steeply away from the wall of older rocks, and approaches horizontally in the center of the deposit. The entire mass appears to have slipped down into a sink hole or narrow valley, dragging along the walls retarding the outer portion. The thickness of coal is, therefore, greatest at the outer edges of the pocket, where a vertical measurement must be made diagonally across the bedding planes, and least in the center, where the strata are horizontal. The shale above the coal is, on the contrary, thickest in the center, 80 feet having been penetrated by a shaft, and practically absent on the borders. The cannel coal is reported to be at least 45 feet thick where

†Ball, S. H., and Smith, A. F., The Geology of Miller County: Missouri Bureau of Geology and Mines, Vol. I, 2nd series, 1903, pp. 90-118. The topography is shown on the Eldon, Versailles, and Tuscumbia quadrangles of the U. S. Geol. Survey.

*Van Horn, F. B., The Geology of Moniteau County: Missouri Bureau of Geol. and Mines, Vol. III, 2nd series, 1905, pp. 59-68. Topography is shown on the Boonville and Eldon quadrangles of the U. S. Geol. Survey.

dips are absent and is capped by four feet of low-grade bituminous coal that is separated from it by a very thin but persistent layer of iron pyrites. Under the cannel there is said to be at least 40 feet of dark clay containing many pebbles and boulders of flint and limestone.

It is the intention of the company to strip the entire deposit, as in only that way great waste of the mineral can be avoided. At present coal is pulled up an incline from the open pit and is also hoisted from a hundred-foot shaft. From the shaft, entries run in coal north 125 feet, and west and north 200 feet to open into the strip pit. Rooms 30 feet high open off the entries at irregular intervals. The product is run through a concentrator in order to separate the lead and zinc ores, which occur in sheets and veins in amount sufficient to pay the cost of mining the coal. The coal is hauled by wagon 10 miles to Versailles or 7 miles to Barnett for shipment or local sale.

Estimates of the amount of coal are largely conjectural. The pocket is reported to be about 150 feet wide and 400 feet long, an estimate that is probably under rather than over the true dimensions. On the basis of these figures, however, and of an average of 50 feet for the thickness of the coal, the pocket contains 3,000,000 cubic feet or about 75,000 tons of coal. Even though this amount be only half the actual content, it is evident that the construction of a long railroad spur to the mine would not pay, if the coal alone be considered.

California.—Northwest, north, and northeast of California a large number of small pockets have been worked and the greater number exhausted. In most of them both cannel and bituminous coal were present. A list of pockets visited by the writer in May, 1911, follows:

Locality.	Reported thickness of coal in feet.	Method of mining.	Remarks.
T. 45 N., R. 15 W.—			
N. E. ¼ S. E. ¼ Sec. 6	5 to 6	Shaft, 30 feet	Worked 1909.
N. W. ¼ S. W. ¼ Sec. 5			Exhausted.
S. W. ¼ Sec. 6		Shaft	Worked winters.
N. W. ¼ N. W. ¼ Sec. 15			Exhausted.
S. W. ¼ S. W. ¼ Sec. 23	6	Shaft, 30 feet	Nearly exhausted.

Tipton.—Several shallow pockets have been recently worked southeast of Tipton (S. E. ¼ S. E. ¼ and S. W. ¼ S. E. ¼ Sec. 26, and S. W. ¼ N. E. ¼ Sec. 27, T. 45 N., R. 17 W.). Deposits of this type are quickly mined out and abandoned. No work has been done at the more pretentious Newkirk mine, three miles northeast of Fortuna, for several years.

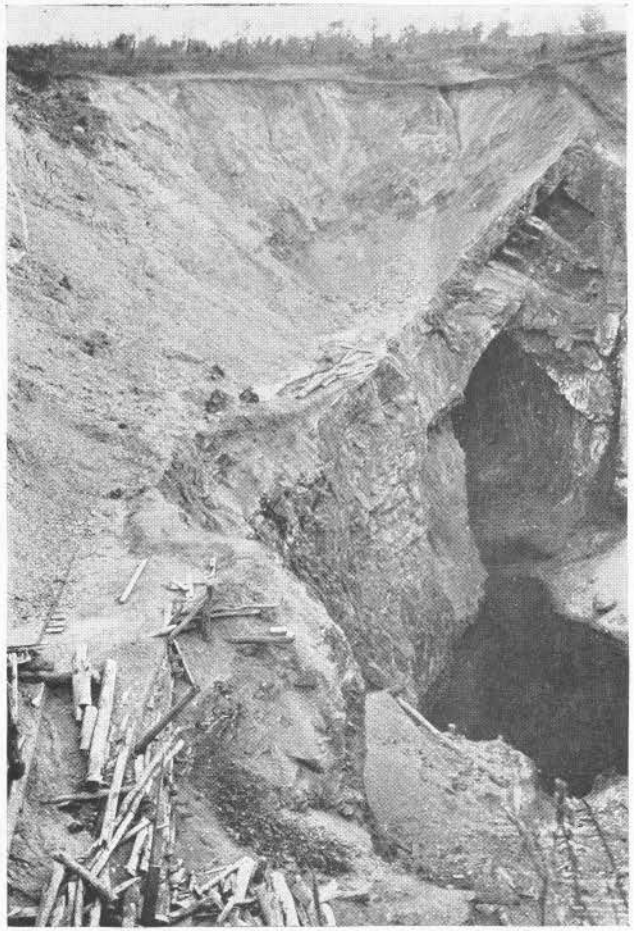

Fig. 1. Monarch strip pit, Moniteau county, showing the older rocks containing the coal pocket.

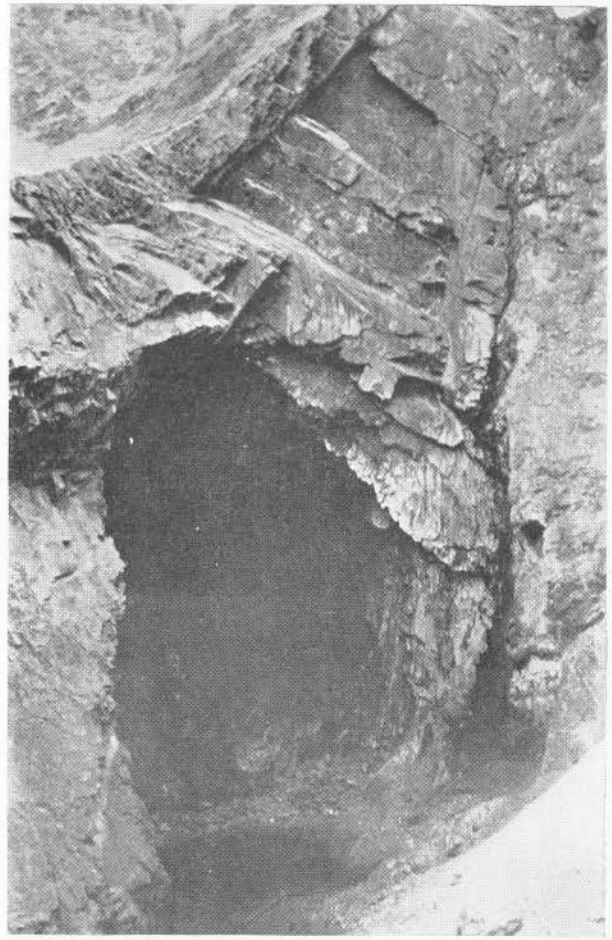

Fig. 2. Closer view of the Monarch strip pit.

MONROE COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....1,014 TONS.

Aside from unconsolidated deposits of drift and alluvium, the surface formations of the greater part of Monroe county are Mississippian in age and are consequently barren of coal. As shown on the State geological map, however, the main body of the Pennsylvanian Coal Measures occupies considerable areas in the higher lands in the western, southern, and southeastern portions of the region, and several large outliers appear in the northeast corner. The strata represented belong to the Cherokee shale and embrace the section from its base to the Summit cap-rock, though in much of the area the Mulky cap is the highest rock seen.

The overlap to the east of the Cherokee upon the Mississippian has its effect upon the stratigraphy of Monroe county. The Lower Coal Measures strata found in Randolph county on the west thin out toward the east, so that at Paris the Mulky coal lies near the Mississippian, instead of 100 feet above it, as at Yates. An important factor in this thinning is a decrease in the thickness of the Lagonda shale, which occupies the interval between the Bevier and Mulky coals; in Monroe county the Bevier bed is only 10 feet or less below the Mulky. The limestones between the Bevier and Tebo coals, so conspicuous in other areas, are represented only by very thin bands and by concretionary nodules in a clay matrix, except in the northeastern townships, where a sump-rock is better developed. The Tebo coal is persistent at about 20 feet below the Bevier. Below the Tebo a short, somewhat variable interval is filled chiefly with shale and fire clay with here and there a lenticular coal bed. The following section, measured along Pedee and Baker branches, near Madison, may be considered typical of the stratigraphic succession in the county:

		Feet.	*Inches*
1.	Shale, yellowish drab, containing many small limestone concretions..	10	....
2.	Limestone, dark blue to yellowish brown.....	5	....
3.	Shale, light drab and clayey above, grading downward to black, calcareous "slate".....	5	....
4.	COAL (Mulky).....	1	6
5.	Concealed.....	10	....
6.	COAL (Bevier).....	....	10
7.	Clay, packed with small limestone concretions.....	6	....
8.	Shale, light drab.....	3	....
9.	Shale, black, "slaty," with regular layer of limestone concretions at top.....	6	6
10.	Limestone, dark to grayish blue, calcite veins, compact, four inches to	1	....
11.	Shale, black, "slaty," in part blocky.....	4	....
12.	COAL (Tebo).....	....	10
13.	Clay.....	3	....
14.	Limestone, light brownish gray, very nodular.....	....	....

*The topography is shown on the Macon, Moberly, Palmyra, and Mexico atlas sheets, published by the U. S. Geol. Survey. Coal was briefly discussed by Winslow: Mo. Geol. Survey, 1891, pp. 84-86; and clays by Wheeler: Idem, Vol. XI, pp. 282-284 et al.

The region is not rich in coal deposits, only one thin bed, the Mulky, being of economic importance. This bed is very regularly 18 to 20 inches thick, except in the southeast corner of the county, where it is somewhat thicker. It has an excellent roof of firm "slate" that makes ideal longwall working. The coal is of good quality, containing a moderate amount of pyrite ("sulphur") in thin streaks and white gypsum scale in the joint planes. The Bevier bed, which is worked so extensively at Huntsville, Higbee, and Bevier, is less than one foot in thickness where seen in this county and is probably too thin to

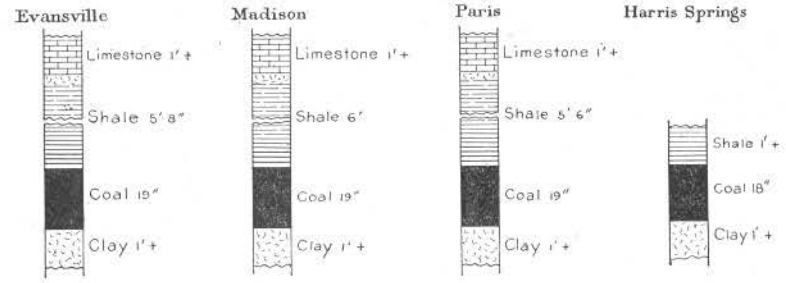

Fig. 61. The Mulky coal bed in Monroe County.

work in all parts of the region. The Tebo coal is likewise very thin in most places, though near Mud creek it is 18 inches thick and has been mined a little. Lenticular coals lower than the Tebo may exist, but, if they do, they are workable only in small areas. The Summit coal, 30 feet above the Mulky and with very similar capping materials, is found only in T. 55 N., R. 12 W., near the Randolph county line, where it is about 16 inches thick.

A study of the sections shows that the Mulky bed is easy to identify in all outcrops in which the Summit coal is absent. Aside from the Summit, the Mulky is the only bed having a thick limestone cap-rock separated from the coal by 4½ to 8 feet of shale that is "slaty" and contains limestone concretions in the lower part. The cap-rock thickens toward the east, increasing from 4 feet near Evansville to 15 feet northeast of Santa Fe, and as it thickens it loses its even-bedded and perpendicularly jointed character. The Summit cap-rock is much like that of the Mulky, but is more massive and breaks more readily into rhomboidal blocks. On weathering it assumes a gray color, whereas the Mulky becomes dark brownish drab. The shale between the Summit cap and coal is, moreover, thinner than that above the Mulky bed. The only coal mined for sale in Monroe county is taken from the Mulky bed by small local drifts near Evansville, Madison, Paris, and Middle Grove, each mine employing only a few men.

As shown on the geologic map the eastward continuation of the Moberly channel has cut out much of the regular Cherokee section

in southwestern Monroe county in an area equivalent to that of about one township. The nature of this channel has already been described

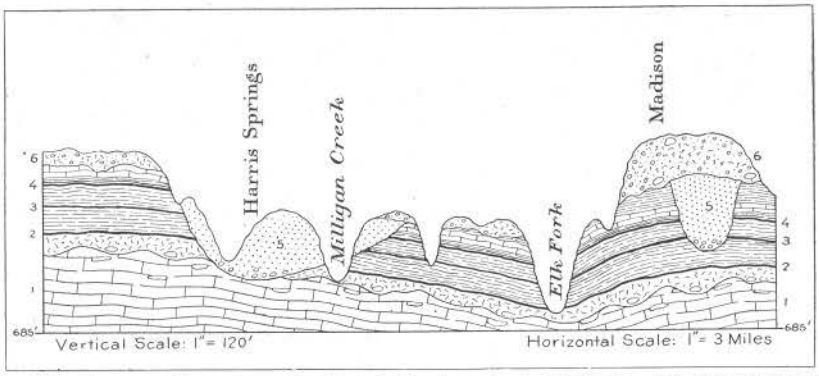

Fig. 62. Cross-section through Harris Springs and Madison. (1) Mississippian limestone. (2) Tebo coal. (3) Bevier coal. (4) Mulky coal. (5) Moberly channel. (6) Glacial drift.

in the general stratigrahic discussion; suffice it here to state that it is an ancient valley now filled with sandstone and shale, and that where it is present all but the lowest coal beds have been removed. In this area the filling consists almost entirely of massive red sandstone, in places resting directly on Mississippian limestone, and probably replacing all of the regular Cherokee beds in most of its area.

Aside from the territory occupied by the red Moberly sandstone, the Mulky coal bed underlies nearly all of the area marked as Pennsylvanian on the geologic map. As all the regular beds can be worked longwall, a large proportion of the county's coal can be recovered. If all beds or parts of beds less than 14 inches in thickness be neglected, the total original and reserve tonnage of the county may be roughly estimated as follows:

Bed.	Average thickness.	Area underlaid.	Tonnage.
Summit	17 inches	3,000 acres	7,650,000
Mulky	20 "	58,000 "	174,000,000
Tebo	16 "	15,000 "	36,000,000
Pockets and basins	24 "	3,000 "	10,800,000
			228,450,000

Evansville.—Small country mines are now operated on the Mulky bed northwest of Evansville in Randolph county, the coal outcropping in all the valleys of this district. In all other directions from the town, however, the only outcrops are those of the red sandstones of the Moberly channel. A prospect shaft was sunk years ago near the railroad at Evansville, but was abandoned soon after completion.

Middle Grove.—At Middle Grove and vicinity are outcrops of red Moberly sandstone, and of Mississippian limestone in the bottom of Milligan creek and its branches north and northeast of the village. The sandstone, with a conglomerate at its base in places, also appears at Harris Springs and for some distance up Milligan and Galbreath creeks. The south boundary of the Moberly channel lies one-half mile south of Harris Springs, however, and beyond it the Mulky cap-rock appears in the hillsides. Here (N. ½ N. W. ¼ Sec. 20, T. 53 N., R. 12 W. and vicinity) several small drifts are worked intermittently on the Mulky bed, which is 18 inches thick.

Madison.—A number of small drifts both north and south of Madison operate for local trade on the Mulky bed, which is very uniformly 18 to 20 inches thick, with the associations already described. It outcrops in Baker and Pedee branches, in the valleys of Flat creek and Elk fork, and on the western tributaries of Reeses fork. On the whole the bed lies nearly horizontal, though along Elk fork some surprising dips affect small areas. North and west of Madison a narrow channel of Moberly sandstone cuts out the coal and has perhaps removed them under Madison itself, as it is conspicuously developed at the cemetery on the west side of town. On Pedee branch, one mile northwest of Madison, a little coal has been taken from a cut bank by stripping the Tebo bed, here 10 inches thick and horizontally bedded. Only a short distance up the branch (S ½ Sec. 11, T. 54 N., R. 12 W.) no coal or other Cherokee strata are to be seen, Moberly sandstone outcropping as follows:

		Feet.
1.	Sandstone, light buff, thin-bedded	10 +
2.	Conglomerate, pebbles of Pennsylvanian limestone, both round and angular, in a firm calcareous matrix	4
3.	Sandstone, red	3

The westward continuation of this channel may be seen on Baker branch in the S. ½ Secs. 9 and 10 and N. ½ Secs. 15 and 16, T. 54 N., R. 12 W. A narrow tributary of the channel occurs on the south edge of Sec. 21, T. 54 N., R. 12 W. also.

FIG. 63. Mulky and Bevier coal beds at Atterbury drift, Madison.

Drifts working near Madison in 1911, all in T. 54 N., R. 12 W., were: (1) J. Farrel (N. E. ¼ S. W. ¼ Sec. 2), (2) J. Atterbury (N. W. ¼ N. E. ¼ Sec. 23), (3) Todd and Gooch (N. W. ¼ S. W. ¼ Sec. 24), (4) Dr. Todd (N. W. ¼ S. E. ¼ Sec. 23), (5) W. O. Maxey (S. W. ¼ N. E. ¼ Sec. 26) and (6) C. Schwartz (N. W. ¼ S. E. ¼ Sec. 27). The Mulky bed has been stripped a little in the N. ½ N. W. ¼ Sec. 2, S. E. ¼ N. W. ¼ Sec. 3, and in the N. W. ¼ N. E. ¼ and S. E. ¼ of Sec. 21. On the lower part of Baker branch a few tons have been stripped from the Tebo bed, here 16 inches thick.

All three coal beds are shown in the following section measured by Winslow just north of Elk fork bridge, due south of Madison; this section corresponds very closely with that measured on Pedee and Baker branches by the writer:

		Feet.	*Inches.*
1.	Limestone, brownish, compact, semi-crystalline, breaks in slabs	8	....
2.	Clay	1	....
3.	Shale, black, "slaty"	3	....
4.	COAL (Mulky)	1	6
5.	Clay and shale	12	....
6.	COAL (Bevier), exposed in creek bank	....	10
7.	Clay, with limestone nodules	3	....
8.	Shale, drab, clayey	6	....
9.	Shale, black, "slaty," concretionary band near center	7	....
10.	COAL (Tebo), reported found by drilling	1	6

Four miles southwest of Madison, on Elk fork above Bell bridge, the Mulky coal bed, here only a few feet above water level, is mined in a small way at the E. D. Sparks drift. At the bridge (N. W. ¼ Sec. 28, T. 54 N., R. 12 W.), the following section was measured just above water level:

		Feet.
1.	Limestone, bluish gray, thin-bedded	1
2.	Shale, yellowish drab, sandy	7
3.	Limestone, yellowish drab below, dove-color above, sub-crystalline	6
4.	Shale, light drab and clayey above, black and "slaty" below	8
5.	COAL	1
5.	Clay	5½

Four miles southeast of Madison the Mulky outcrops in the hills and has been mined by several small drifts. At the W. W. Enochs drift (S. W. ¼ S. W. ¼ Sec. 31, T. 54 N., R. 11 W.), its cap-rock is quite thick, as shown below:

		Feet.	*Inches.*
1.	Limestone, grayish drab, weathers in rather thin slabs	10	....
2.	Clay	1	....
3.	Shale, black, "slaty," blocky	5	6
4.	COAL, exceptionally free from "sulphur"	1	6
5.	Clay	1	2
6.	Limestone	....	....

Three miles north of Madison (N. W. ¼ N. W. ¼ Sec. 36, T. 55 N., R. 12 W.) is a split coal bed that does not correspond to any seen

elsewhere in the county and is evidently of limited areal extent. The section is:

		Feet.
1.	Shale, dark and light drab, with stringers of coal	9
2.	Sandstone, light buff, calcareous	1½
3.	Shale, light blue, sandy	11
4.	COAL	1
5.	Shale	2
6.	COAL	1
7.	Fire clay, white and yellowish white, about	10
8.	Mississippian limestone	....

Duncans Bridge.—In the northwestern portion of the county the Mulky coal bed, 18 to 20 inches thick, outcrops on the borders of the higher ridges at an elevation of 740 to 760 feet above sea level.* It is mined by farmers for their own use, chiefly by stripping, at many points in Marion township and the southern part of Woodlawn. Southwest of Ash the Summit coal bed also appears, as noted in the report on Randolph county (p. 347), but in most of Monroe county it has been removed by preglacial erosion and replaced by drift. Low down in the valley of Mud creek, notably north of Ash and at the county line,† and on the south side of Middle fork, the Tebo coal comes to the surface. A small drift is operated in this bed one mile southwest of Duncan's bridge (N. E. ¼ N. W. ¼ Sec. 17, T. 55 N., R. 12 W.), where the following section was measured:

		Feet.	Inches.
1.	Limestone, dark blue, light gray, very fine-grained	....	9
2.	Shale, black, "slaty", locally light drab and argillaceous	3	....
3.	COAL (Tebo)	1	5
4.	Clay	3	....

Near this drift red sandstone, probably the overlapping edge of a channel similar to the Moberly, appears at a higher level than the coal. This sandstone covers considerable territory west and north of the drift and outcrops along Middle fork to the Macon county line; at Duncans Bridge it rests on Mississippian limestone. North and west of Middle fork outcrops are few and no coal was found.

Lakenan.—Forming part of the Pennsylvanian outlier that extends northward into Shelby county, and lying only a few feet above the Mississippian, is a pocket of cannel coal one and one-half miles south of Lakenan. Several very short drifts are occasionally worked on the land of H. A. Greenwell (S. W. ¼ N. E. ¼ Sec. 18, T. 56 N., R. 9 W.), where there is 12 to 20 inches of coal overlain by three feet of light gray shale. Other pockets or basins containing thin coal beds are reported in this district.

Paris.—The Mulky coal has been mined a little on the divide between Middle and Elk forks, although in much of this territory west

*See Macon, Mo., topographic map published by U. S. Geol. Survey.
†See report on Randolph county.

to Madison it has been removed by preglacial erosion, the drift in many places extending down to the Mississippian. The only mining now prosecuted near Paris is on the north side of Middle fork at the Jesse Gilbert drifts (S. E. ¼ S. E. ¼ Sec. 32, T. 55 N., R. 10 W.), where the Mulky lies about 40 feet above the Mississippian limestones that outcrop in the valley sides. The product is hauled three miles to Paris for sale. A section near the two drifts in operation shows a second bed only a few feet below the Mulky:

		Feet.	Inches.
1.	Limestone, brownish gray, massive	3	....
2.	Shale, light gray and argillaceous above, grading into blue-black, "slaty," calcareous shale below	5	6
3.	COAL (Mulky)	1	7
4.	Clay	1+	....
5.	Limestone, nodular on top, not well exposed	1	....
6.	Shale	2	....
7.	COAL (Bevier)	1	1
8.	Clay, thickness variable, about	15	....
9.	Mississippian limestone	....	....

North of these drifts, farther west for several miles, and north of Paris occur strongly developed massive sandstones closely resembling those of the Moberly channel and probably corresponding to them in origin.

Small shafts and slopes have been operated 1½ miles northeast of Paris (N. E. ¼ Sec. 1) on the old Evans tract. The bed is very variable in thickness, attaining a maximum of nine feet, part bituminous and part cannel. That this coal forms part of one or more pockets and cannot be of great areal extent is shown both by the nature of the bed itself and by its relation to the Mississippi limestone outcropping at higher levels in the immediate vicinity. There may be sufficient coal here to yield important local supplies, but the installation of expensive equipments would be decidedly unwise. Other coal pockets are reported to exist southeast of Paris and near Florida.

Santa Fe.—The Mulky coal bed and associated strata outcrop on the divide north of Long Branch and in the southeastern corner of the county east and northeast of Santa Fe. The stratigraphy of the latter area is similar to that described at Perry in the Ralls county report and at the Hafner shaft in the Audrain county report.

MONTGOMERY COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....2,387 TONS.

The eastern border of the main body of the Pennsylvanian Coal Measures occupies the northwest corner of Montgomery county. A heavy cover of drift covers most of the district, so that it is only along

*The topography of the coal-bearing area is shown on the Mexico atlas sheet of the U. S. Geol. Survey. The first mention of coal is by Arthur Winslow (a preliminary report on coal: Mo. Geol. Survey, 1891, p. 79).

the creeks south of Wellsville that exposures of the chief coal-bearing rocks may be found.† A large outlier of Pennsylvanian occurs at Bellflower and a smaller one near High Hill, though these are barren of Coal.†† Small coal pockets, similar to those in Lincoln and Callaway counties, are scattered over the region in which older rocks outcrop, yet the amount of coal contained in these is small and their lateral dimensions are only a few rods.

The stratigraphy of the main measures is much like that of eastern Audrain county. The beds consist of thick limestones with intercalated shales, two coal beds, and a heavy deposit of fire clay at the base. The upper coal seam, the Summit, is very irregular in thickness, being absent in many places and workable in none so far located. The lower bed, the Mulky, had the same characteristics as at Martinsburg, being 30 inches thick and bearing in its lower portion a persistent though very thin streak of pyrite. The coal is of good quality in places, but in others the bed is much affected by small "slips," in the vicinity of which the roof is unreliable and the coal contains considerable "sulphur." White scale is found abundantly on the joint planes. The roof is a black "slaty" shale filled with limestone "niggerheads" that in places project downward into the coal and give some trouble. The longwall system of mining is universally employed and is well adapted to this seam. About 70,000 acres are underlain by the Mulky bed, giving the county a coal reserve of 315,500,000 tons. Not all of this reserve is available, as the faulty condition of the seam in part precludes its utilization.

At present only local mines, situated on Coal branch and Little Loutre creek, south of Wellsville, are operated in the county. The principal mine is that of Whitehead & Sons, one mile south of Wellsville, where coal is hoisted 40 feet by means of a horse-gin. A combination of outcrop and shaft measurements gives the following section for this vicinity:

		Feet.	*Inches.*
1.	Limestone, light blue and slightly nodular above, weathers yellowish brown in lower part, base not well exposed, in greater part irregularly bedded	15	....
2.	Clay, and shale	3	6
3.	COAL (Summit), thickness nothing to a maximum of	4	....
4.	Clay	3	....
5.	Limestone, light blue with dark blue spots, massive at base, and characteristically exposed in ledges forming small cascades in water courses	7	....
6.	Clay, with concretionary layers of limestone nodules	2	6
7.	Shale, dark blue, "slaty" but tough rather than brittle	7	6
8.	COAL, 1 foot, 9 inches Pyrite, ¼ inch (Mulky) COAL, 8 inches	2	5
9.	Clay, locally with limestone concretions in lower part	3	....
10.	Fire clay, white, 20 feet to	30	....
11.	Flint in loose blocks	10	....
12.	Mississippian limestone	....	....

†Broadhead, G. C., Warren County: Mo. Geol. Survey, 1855-1871, p. 64.
††Idem.

The Mulky coal bed has been mined from a number of drifts and shafts on Coal branch for half a mile both above and below the Whitehead mine. Just below the junction of the branch and Little Loutre creek Mississippian limestone is exposed along the stream bank. A short distance above the same place, on Coal branch, a cut bank exposes 30 feet of white fire clay resting on an irregular surface of broken and very flinty limestone. For nearly two miles along Little Loutre, above Coal branch, the Mulky bed has been drifted by country mines at many points. The only mine now open is the small drift of Levi Moore.

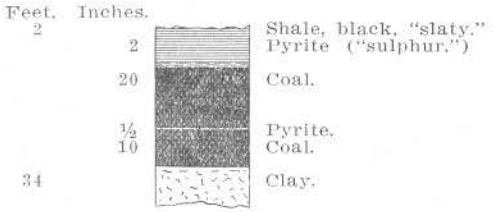

FIG. 64. Coal bed at Moore drift, near Wellsville.

In May, 1888, a shaft was sunk beside the railroad, one-half mile northwest of Wellsville, to a depth of 100 feet, and a shipping plant was installed and operated. A poor roof and faulty coal caused the abandonment of the mine. As reported by a miner who helped sink the shaft, the strata, which correspond closely with those in the outcrops on Coal branch, are as follows:

		Feet.	*Inches.*
1.	Soil and drift	64	....
2.	Limestone, thin-bedded	9	....
3.	Clay, with coal streak (Summit)	6	....
4.	Limestone, gray	6	6
5.	Shale, drab, clayey	10	....
6.	Shale, black, "slaty"	2	....
7.	COAL, 1 foot, 8 inches Pyrite, ½ inch COAL, 10 inches (Mulky)	2	6
8.	Clay, bluish near top, white below	30	....

MORGAN COUNTY.

The coal pockets of Morgan county, all of which are of trifling areal extent, were very fully described by this Survey* in 1908, and only the developments of late years are mentioned below. When the region was visited in May, 1911, no mining had been in progress for some time and all pits and shafts were filled with water.

*Marbut, C. F., The geology of Morgan County: Missouri Bureau Geol. and Mines, Vol. VII, 2nd series, 1908, pp. 51-57 and 79-83. The topography of most of the county is shown on the Eldon and Gravois Mills quadrangles of the U. S. Geol. Survey.

Stover Coal Mine.—The well-known Stover pocket, four miles southwest of Barnett and nine miles southeast of Versailles (S. E. ¼ N. E. ¼ Sec. 6, T. 41 N., R. 16 W.), was an important source of fuel for the neighboring towns and farms until the construction of the Chicago, Rock Island, and Pacific railway took away much of its local market. Very little mining has been done since the mine was visited and described by Marbut. About 15 feet of excellent bituminous coal, bearing a few intercalated streaks of clay are now to be seen at the entrance and in the rooms of the mine, neither the top nor bottom of the coal being exposed. Fuel tests and analyses of the coal will be found in last two chapters.

Ouachita Coal and Clay Products Co.—The Ouachita Coal and Clay Products Company owns a large brick plant four miles northwest of Versailles and obtains its coal from a pocket adjoining the old Hubbard and Moore mine, described by Marbut. Plastic clay shale at the top of the pocket now worked (S. W. ¼ S. W. ¼ Sec. 22, T. 43 N., R. 18 W.) is excavated and mixed with flint clay in the manufacture of brick products. The coal is reached from a hundred-foot shaft and several short slopes, about 15 feet in alternating layers of cannel and bituminous coal being exposed on one side of the pocket, where the strata dip 20° toward the center. Doctor Hubbard of Versailles reports that entries were run 150 feet southeast and 100 feet northeast from the bottom of the shaft without reaching the border of the pocket. Small prospect pits in Jefferson City limestone show, however, that the greatest diameter of the deposits is 500 feet at most.

Versailles.—Coal banks, now abandoned, worked small cannel pockets 1½ miles east of Versailles for many years. The best known of these were the Martin bank in the N. W. ¼ S. E. ¼ Sec. 5, T. 42 N., R. 17 W.; the McClure bank a quarter of a mile north of the Martin; and the Price bank one-half mile north of the McClure.

NODAWAY COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....650 TONS.

Nodaway county has the distinction of being the only county in the northwest corner of the State that has produced coal in commercial quantities. Most of the coal has come from the Nodaway seam and has been mined in the vicinity of Quitman, where operations were begun 60 or 70 years ago.

Most of the upland portion of the county is deeply buried beneath the drift, but the larger streams have cut through this and have exposed Pennsylvanian strata in a number of localities. A general section of the exposed strata is about as follows:

*The geology of Nodaway county is described by G. C. Broadhead (Iron ores and coal fields, 1872, Mo. Geol. Survey, 1873, pt. 2, pp. 388-402).

Fig. 1. Stover coal pocket, Morgan county.

Fig. 2. Strip pit, Dickey Clay Mfg. Co., near Deepwater, Mo.

Shawnee formation—	Feet.	Inches.
1. Shale, gray, sandy (top of Scranton)	2+	....
2. Limestone, gray, shaly at places	1–2	....
3. Shale, gray	0–1	....
4. COAL (Elmo), in places, black shale in others	....	6–14
5. Shale, drab	13	....
6. Limestone, weathering buff, nodular	2	....
7. Shale, sandy, with calcareous streaks and 2 septarian nodule layers in upper part	93	....
8. Limestone, gray, iron-stained (top of Howard)	2	....
9. Shale, gray or dark drab, apparently absent in places	3	....
10. Limestone, blue, weathering brown	2	....
11. Shale, blue at top, black and "slaty" below (top of Severy)	1–3	....
12. COAL (Nodaway), average	....	16
13. Shale, impure fire clay above, very sandy below, with clay shale at bottom	10–25	....
14. Limestone, blue, even layers 2 or 3 inches thick with blue shale partings (top of Topeka)	4	....
15. Limestone, buff, nodular, and shale	4–8	....
16. Shale, black, "slaty" at base, 6 inches to	3	....
17. Limestone, blue, weathering buff, shaley, in layers 1 inch to 4 feet thick with shale partings	10–15	....
18. Shale and sandstone, locally thin streaks of COAL (top of Calhoun), about	10	....
19. Limestone, blue, even layers, with 5-inch shale parting near base	2½	....
20. Shale, blue, with 1 or 2 thin layers of limestone	5–10	....
21. Limestone, gray, thin-bedded with flint and shale partings in upper part (top of Deer Creek)	12–15	....
22. Shale, light in upper part, black and "slaty" at bottom	5	....
23. Limestone, hard, gray	2	....
24. Shale	5–10	....
25. Limestone, buff	3	....
26. Shale, sandy (Tecumseh)	50+	....

The formations lying below the surface of the county are well shown in a diamond drilling carried to a depth of 1003 feet just east of Maryville, in the valley of 102 river (N. E. ¼ S. E. ¼ Sec. 17, T. 64 N., R. 35 W.).† The bottom of the drill-hole reached almost to the horizon of the Bevier bed in the Cherokee formation. The only coal penetrated was 3 inches at 306 feet, the horizon of the surface bed mined near Atchison, Kansas. Although the coal horizons a short distance above the Bevier are barren, workable beds may lie at greater depths than those explored in the drilling. Such deposits would lie more than 1000 feet beneath the surface in the greater part of the county and at slightly less depth in the valleys of the southeast.

The lowest outcropping formation in the county is exposed on the 102 and Platte rivers, near the south county line. The Deer creek limestone outcrops along Nodaway river in the southwestern part of the county, and along 102 river, where, north of Barnard, it forms a low escarpment. Along the Platte it is found in several places.

The Topeka limestone outcrops in most places where the Deer creek is seen. It contains a layer of black "slaty" shale, but no coal has ever been found in connection with this shale.

†Detailed record on file at offices of Mo. Geol. Survey at Rolla and will be published in full in a publication now in preparation.

The outcrop of the Nodaway coal appears along Nodaway river to north of Quitman, where it dips beneath the stream, only to appear again about 2 miles south of the state line. It probably underlies most of the county between the Nodaway and 102 rivers, being found on the latter near Arkoe and Hopkins, but in the vicinity of Maryville it is apparently cut out by preglacial erosion. In the northern part of the county it may underlie the divide between 102 and Platte rivers. The Elmo coal is found only in the northwestern portion of the county and is too thin to be important.

If, as seems probable, the Nodaway coal, where more than 14 inches thick, possesses an average thickness of 15 inches in one-third of the county (288 square miles), its total tonnage is about 414,720,000 tons. To this may be added about 500,000,000 tons for beds at the Bevier and lower horizons, bringing the total for the county to 914,720,000 tons.

DETAILED MENTION.

Quitman.—For many years coal has been mined near Quitman by drifting along the east side of the river and by shafts higher up on the hills. The mines are worked mostly in winter and for local trade. The coal is 12 to 20 inches thick and is overlain by black "slaty" shale and underlain by clay, furnishing ideal conditions for longwall mining. The coal is much the same wherever found in this vicinity; two sections will serve to show its associations.

SHAFT OF MR. REUBEN HARRIS (S. W. ¼ N. E. ¼ SEC. 9, T. 64 N., R. 37 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil	8	....	8	....
Clay and shale	31	....	39	....
Limestone, hard	3	2	42	2
Shale	2	....	44	2
Limestone, ash-gray	1	8	45	10
Shale	2	....	47	10
Shale, black, "slaty"	1	....	48	10
"Sulphur band"	....	0–1	48	11
COAL (Nodaway)	....	12–17	50	6
Clay, gray, sandy	7	....	57	6

EAST BANK OF NODAWAY RIVER AT QUITMAN.

	Feet.	*Inches.*
Limestone, blue	1	10
Shale, sandy	2	6
Limestone, blue, weathering brown	2	2
Shale, dark to drab	2	....
COAL (Nodaway)	1	2
Shale, impure, sandy clay at top, grading down through sandy shale to sandstone and to blue clay shale below	28	....
Limestone, blue, compact	2	....

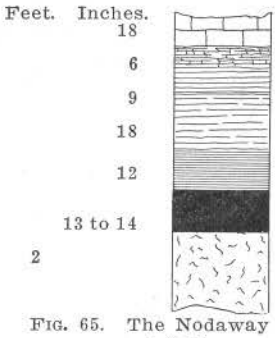

FIG. 65. The Nodaway coal bed at Quitman.

South of Quitman the Nodaway coal rises, the dip being to the north. It thins slightly, but has been mined locally as far as the vicinity of Graham, where it is reported to be 10 inches thick. East of Quitman the coal extends to at least the west side of T. 64 N., R. 36 W., and has been mined in Sec. 18 of that township. North of Quitman it soon dips under Nodaway river. On the land of W. C. Carpenter (S. E. ¼ Sec. 31, T. 65 N., R. 37 W.), it is reported to be 10 feet above low water. West of a stripping, it was reached by a shaft 71 feet deep, and was found to lie in a trough-shaped deposit whose axis is east of north. In the center of the trough the coal is reported to be 2½ to 3 feet thick for 25 feet on each side of the axis, thinning on the edge to about 1 foot. North of this place the coal is below the bottoms nearly to the Iowa line. West of Burlington Junction, it is about 30 feet below the level of the river and is reported 18 to 22 inches thick.

Two miles south of the Iowa line the coal again rises above the level of the river and the following section is exposed (Broadhead, modified):

	Feet.	*Inches.*
Shale, drab, with buff and brown tinge, contains concretions of ironstone..	12	....
Slope covered with debris from above	5	6
Limestone, dull, lead-colored, in 2 beds	4	6
Shale, blue and black, "slaty," with fossiliferous concretions	1	6
COAL, shaly near middle	....	5½
Shale, dark, lead-blue, clayey	....	4
COAL, good	....	2
Shale, blue	....	3
COAL, with an inch of clay near middle	....	6
Clay	....	....

Elmo.—The Elmo coal has been stripped in a few places near Elmo, but is probably confined to the part of the county west of Nodaway river, in townships 66 and 67 north. It is irregular in thickness, though rarely more than 14 inches. It outcrops in several places southeast of Elmo (near center Sec. 28, T. 66 N., R. 37 W., east side Sec. 30, and S. W. ¼ N. W. ¼ Sec. 33).

Arkoe.—The Nodaway coal was formerly mined about 2 miles south of Arkoe on a small branch flowing into 102 river from the west (N. W. ¼ S. E. ¼ Sec. 28, T. 63 N., R. 35 W.). Both the coal and the roof are rather variable; the former is reported to be 8 to 22 inches thick, with an average of 14 inches; the roof is of either light shale or black "slaty" shale. About 2½ acres have been mined out.

Hopkins.—The Nodaway coal has been mined for local use in shallow shafts about 4 miles southwest of Hopkins. A drilling near Hopkins reached a depth of 314 feet without finding coal, but a combination shaft and drilling 3½ miles northwest of Hopkins reached the Plattsburg limestone of the Lansing formation at 432 feet. The only coal beds penetrated were 2 to 6 inches thick, one at about 100 feet and another at the Atchison horizon at 248 feet.

PETTIS COUNTY.*

Coal has occasionally been mined in Pettis county for local use, but in the last few years little or none has been produced. The main coal-bearing area is confined to the western part of the county, as shown on the geological map of the State, and the Coal Measures have a maximum known thickness of only about 150 feet. The coal beds present in this area are, in general, irregular in thickness and distribution.

Outside of the region mapped as Pennsylvanian are pockets of Coal Measures sandstone and shale containing bituminous and cannel coal. As much as 20 feet of coal have been reported in these, though their lateral extent and the amount to be derived from any one of them is small and the quality of the fuel is poor. Pockets have been reported in T. 45 N., R. 22 W. and southeast of Sedalia, and they probably exist in other parts of the county.

The coal beds in the different parts of the county cannot be correlated with accuracy, but the estimate of a total original tonnage of 300,000,000 tons is believed to be conservative. This estimate does not include beds or parts of beds less than 14 inches in thickness and is made on a basis of 1800 tons per acre-foot of coal.

DETAILED MENTION.

Dresden.—About 2½ miles west of Dresden considerable mining was done at an early date. When Broadhead† visited the locality two mines were being operated by Messrs. Newport and Westlake near the

*G. C. Broadhead describes the geology along the line of the Missouri Pacific railroad west of Sedalia (Mo. Geol. Survey, 1873, pt. 2, pp. 155-166) and that of other areas along the western edge of the county (idem, pp. 33-38). The coal is mentioned by Arthur Winslow (Prelim. rept. on coal; Mo. Geol. Survey, 1891, pp. 126-127). The topography is shown on the Sedalia and Warrensburg sheets of the U. S. Geological Survey.

†Broadhead, G. C., Geology from Sedalia to Kansas City: Mo. Geol. Survey, Rept. 1872, pt. 2, 1873, p. 165.

line of the Missouri Pacific railroad. The mines were only 100 yards apart and operated the same bed at a depth of about 35 feet. The coal varied from 27 to 30 inches in thickness. Broadhead also reports about two feet of coal south of Dresden (S. E. ¼ N. E. ¼ Sec. 8, T. 46 N., R. 22 W.).

Lamonte.—Two or three shafts were formerly operated one to two miles east of Lamonte, near the Missouri Pacific railroad, but when the locality was visited in 1911 no mining was being done. R. E. Guthrie was engaged at that time in sinking a shaft on the land of H. Conway.

CONWAY SHAFT NEAR LAMONTE (S. W. ¼ S. E. ¼ SEC. 12, T. 46 N., R. 23 W.)

	Thickness. *Feet.*	Depth. *Feet.*
Soil	9	9
Limestone, gray, jointed	10	19
Shale, black, "slaty"	3½	22½
Limestone, black, hard, impure	1	23½
Shale, clayey	16	39½

The coal, which is said to be just below the 16 feet of shale in the above section, is reported to be 30 inches thick. At this shaft and at others in the vicinity much trouble has been caused by the great abundance of water entering from below the 12-inch limestone. The coals at the Guthrie shaft and the other mines in the vicinity, with one exception, perhaps, belong to the Tebo bed, though the rocks above them do not correspond very closely with those above the Tebo in eastern Johnson county.

DRILLING NEAR LAMONTE (SEC. 12, T. 46 N., R. 23 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil	8	....	8	....
Limestone	8	....	16	....
Shale, black, "slaty"	6	....	22	....
Limestone	1	....	23	....
Shale, gray	16	....	39	....
COAL	2	6	41	6
Sandstone	7	6	49	....
Clay	6	....	55	....
Shale, "slaty"	18	....	73	....
COAL	3	....	76	....
Clay	6	....	82	....
Shale, black	14	....	96	....
COAL	1	8	97	8
Clay	5	....	102	8
Shale, gray	6	....	108	8
Clay, white	8	....	116	8
Clay and sand	35	....	151	8
Limestone, reported as Mississippian	....	....	....	....

The coal at a depth of 76 feet was shafted but found to be dirty and was abandoned.

Houstonia.—Coal is reported to have once been mined near Houstonia, but nothing has been done recently. The coal found in

Saline and Johnson counties near the Pettis county line probably extends into the northwest corner of Pettis county.

Broadhead gives the following section in the eastern part of Sec. 21, T. 48 N., R. 23 W.:

SECTION FIVE MILES NORTHWEST OF HOUSTONIA.

	Feet.	*Inches.*
Clay	12	....
Sandstone	44	....
Flagstone, silico-calcareous, and shale similar to the rock over the coal at Jordan's, on Grand river, Henry county	7	....
Shale, ochery and bituminous, with some iron pyrites and fossil plants	3	....
COAL	1	4
Fire clay	....	....

PHELPS COUNTY.*

Phelps county, like adjacent areas, contains a few pockets of presumably Pennsylvanian shales, clays, and, in some places, coal. They are very small, their width and depth being measured in tens of feet. Occurrences are known at Rolla, a few miles north of Newburg, and northeast of St. James. Shumard states that coal of poor quality and very small extent had in early days been drifted and shafted in the St. James pocket (Sec. 9, T. 38 N., R. 6 W.).

PIKE COUNTY.†

The Pennsylvanian area of Pike county is very small, comprising, so far as known, only about three square miles along the Chicago and Alton railroad where it leaves the county on the west. According to Rowley, the only Coal Measures outcrop found is four miles northeast of Curryville, in the southern part of Sec. 1, T. 53 N., R. 40 W. According to the same authority, no regular seam has been found within the county, although pockets may possibly exist in the Indian creek country.

PLATTE COUNTY.‡

Aside from unconsolidated drift deposits, the surface formation of by far the greater part of Platte county is the Douglas, which is about 300 feet thick and consists chiefly of shale and sandstone. At its top, however, the Oread limestone is conspicuously developed

*Phelps County: Missouri Geol. Survey, 1855-1871, p. 240. The topography of most of the county is shown on the Rolla sheet of the U. S. Geol. Survey.

†The geology of this county is described by R. R. Rowley (The geology of Pike county: Missouri Bureau of Geol. and Mines, Vol. VIII, 2nd series, 1908). The topography of part of the region is shown on the Louisiana sheet of the U. S. Geol. Survey.

‡The general geology is described by G. C. Broadhead (Mo. Geol. Survey, Rept. for 1872, pt. 2, pp. 92-122, 325-343). Coal is mentioned by Arthur Winslow (Prelim. rept. on coal, Mo. Geol. Survey, 1891, pp. 114-116). The topography is shown on the Kansas City, Leavenworth, and Atchison sheets of the U. S. Geol. Survey.

on the highland near Iatan, in the northwest corner of the county. Along the Missouri as far up as Weston, on Platte river, and along the east side of the southeastern quarter of the county are outcrops of the thick limestones of the Lansing formation, which lies just below the Douglas. Near Parkville are outcrops of the Kansas City limestone, and it is near these that the chief coal horizons lie at the least depth.

No coal of importance outcrops at the surface in this region. Some is exposed in the Douglas formation along the Missouri bluffs. About 2 miles north of Waldron (S. W. corner Sec. 36, T. 52 N., R. 35 W.), 8 inches of coal may be seen, and a shallow shaft in the neighborhood is reported to have found the same bed to be 2 feet thick, but dipping at a high angle. Coal seams less than 1 foot in thickness outcrop in the bluffs from East Leavenworth to north of Weston, and also north of Iatan. Few of these surface beds are of workable thickness, but they are commonly impure and of lenticular character.

Although no local records showing the amount of coal in deeplying horizons are available, several in adjacent areas indicate that considerable coal underlies the region. The most important developments are at Leavenworth, where the three shafts of the Home-Riverside Coal Company, although situated in Kansas, derive much of their present considerable output from Missouri, work having been prosecuted beneath the river and beyond. All of the shafts are near the river, the North mine being in the north part of the city, the Home mine a mile south of the Terminal bridge and the Riverside mine 1 mile farther south. The coal mined lies at a depth of 707 to 720 feet and is the Bevier bed, which is so extensively mined in Macon and other counties in central Missouri. The product is sold locally to public institutions and the city trade and is shipped to points north and west. All of the mines have exceptionally powerful first-motion hoisting engines and improved machinery of other kinds. From 5000 to 6000 gallons of water are pumped daily from the Home and Riverside mines and 40,000 gallons from the North mine, the large quantity at the latter coming from an old shaft and drill hole sunk below the level of the Bevier bed. The longwall system of mining is employed, but the roof is not sufficiently strong to permit the use of a face track. Mining machines have not been successful; the coal is undercut by hand and need seldom be wedged. Props are placed 3 to 4 feet apart and at the same distance from the face. Slack and nut constitute about 20 per cent of the total product. Few timbers are required in the entries, as the roof arches itself and remains strong even after many years of exposure.

The coal mined varies only a few inches either way from an average of 22 inches. Bright and dull streaks alternate; the bed is hard and fracture irregular; there is no cleavage except that governed by

the position of the working face. Pyrite ("sulphur") appears in fine streaks and lenses, and there is a little white gypsum scale in thin

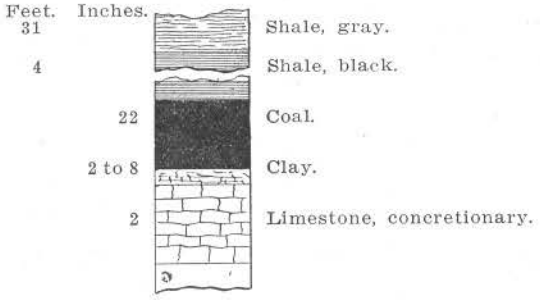

FIG. 66. The Bevier coal bed at Leavenworth.

plates. Regular partings of shale or pyrite are absent. The greater part of the roof is a firm dark drab shale ("slate") of excellent stability, but two other types of roof prevail over comparatively small areas. One, known as "sulphur top," is a pyritiferous shale full of shells, very hard when fresh but slacking quickly on exposure, which lies in thin lenses of considerable lateral extent. The other, "sandstone top," is a calcareous sandstone lying commonly about 17 feet above the coal and approaching it only along ancient channels; when it is only a short distance above the coal, the intervening "slate" will not stay up. Under the coal is 2 to 18 inches of clay, averaging 9 inches, beneath which is a limestone with a nodular upper surface that is an excellent foundation for props and gob walls. "Bells" occur in places and there is one large fault, accompanied by steep dips, in the North mine. As a whole, however, mining conditions are good.

In an attempt to locate the 36-inch coal bed found at Atchison, a shaft at the North mine was sunk to 999 feet and a boring continued to a total of 1,171 feet, at which depth terrific volumes of water were encountered. The Atchison bed is slightly thinner than at Atchison, but is still important. The Cherokee strata above the Tebo are remarkably similar to those in the same interval in central Missouri. A boring for oil and gas in North Leavenworth was carried to a still greater depth. The combined record is as follows:

LEAVENWORTH SHAFT AND BORINGS.*

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil	11	....	11	....
Douglas formation—				
Shale	13	....	24	....
Lansing formation—				
Shale and limestone	144	....	168	....

*Strata underlying Leavenworth are shown on Pl. XXVI of Vol. 3, and Pl. XCII of Vol. IX of the Univ. Geol. Survey of Kansas. Complete records will be given, with correlations, in publications now in preparation by the Missouri and U. S. Geol. Surveys.

LEAVENWORTH SHAFT AND BORINGS—Continued.

	Thickness. Feet.	Thickness. Inches.	Depth. Feet.	Depth. Inches.
Kansas City formation—				
Limestone and shale	200	....	368	....
Pleasanton shale—				
Shales, sandy near base	173	....	541	....
Henrietta formation—				
Limestone, hard	4	1	545	1
Shale	2	....	547	1
Limestone, soft	3	....	550	1
Shale, gray	9	....	559	1
Limestone, purple, hard	1	....	560	1
Shale, dark purple	2	....	562	1
Limestone, hard	2	....	564	1
Shale, "slaty"	2	....	566	1
COAL, good	....	8	566	9
Clay	....	1	566	10
Sandstone	5	....	571	10
Shale and sandstone, mixed with iron ore	5	....	576	10
Limestone	5	....	581	10
Shale, mixed with kidney iron ore	7	....	588	10
Limestone	2	....	590	10
Cherokee shale—				
Shale, black, "slaty," with kidney ore	6	....	596	10
COAL (Lexington)	1	....	597	10
Clay, hard	6	....	603	10
Limestone	5	....	608	10
Shale, "slaty"	1	....	609	10
Sandstone	5	....	614	10
Limestone	2	....	616	10
COAL	....	6	617	4
Sandstone	5	....	622	4
Clay	16	....	638	4
Shale, black, "slaty," with coal seams	1	....	639	4
COAL	....	6	639	10
Shale, black, "slaty"	2	....	641	10
Shale, sandy, "slaty"	7	....	648	10
Sandstone	2	....	650	10
Limestone	....	4	651	2
Shale, "slaty," with iron boulders	11	....	662	2
COAL (Mulky?), good	1	2	663	4
Clay, very hard	1	6	664	10
Sandstone, very hard, brown, full of water	3	....	667	10
Shale, "slaty", sandy	4	6	672	4
Shale, black, "slaty"	4	....	676	4
COAL (Bedford)	....	6	676	10
Sandstone, hard, full of water	5	....	681	10
Shale, sandy, "slaty"	5	....	687	10
Shale, black, "slaty"	19	....	706	10
COAL (Bevier), bed mined at Leavenworth	2	....	708	10
Clay	2	....	710	10
Limestone	2	6	713	4
Shale, dark, "slaty," with 2 inches of COAL	4	9	718	1
Limestone	4	9	722	10
Shale	4	4	727	2
COAL (Tebo)	1	4	728	6
Clay	....	8	729	2
Shale, "soapstone," dark	7	1	736	3
Sandstone	3	....	739	3
Limestone	1	6	740	9
Sandstone, light, micaceous	14	6	755	3
Shale	1	....	756	3
Limestone, very hard	2	....	758	3
Clay, with red streaks	5	6	763	9
"Shale," "sulphur" streaks	16	....	799	9
Shale, "slaty"	....	6	780	3

LEAVENWORTH SHAFT AND BORINGS—Continued.

	Thickness.		Depth.	
Cherokee shale—Continued.	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Sandstone, light	5	5	785	8
Limestone, white	4	10	790	6
Sandstone, varying in shade	8	2	798	8
Shale, "slaty," light at top, black at bottom	19	2	817	10
Sandstone, white, soft	7	5	825	3
Shale	4	....	829	3
Sandstone, gray	11	....	840	3
Sandstone, dark, with black shale, much water	3	7	843	10
Shale, black	7	9	851	7
Sandstone, very hard at top, dark at bottom	30	11	882	6
Shale, black, "slaty"	6	....	888	6
COAL	....	5	888	11
Sandstone, hard, seamed with "flint"	6	11	895	10
Shale, dark, with iron boulders, black and with a seam of coal near base	3	7	899	5
Shale, "slaty," black, with streaks of COAL near middle	16	4	915	9
COAL	....	4	916	1
Shale, dark	....	2	917	3
COAL	....	6	917	9
"Sulphur" parting	....	2	917	11
COAL	....	3	918	2
Sandstone, soft	11	....	929	2
Shale, "slaty," black	2	2	931	4
Sandstone, micaceous, white, great increase in water	48	4	979	8
Shale, "slaty," black	12	2	991	10
COAL	....	10	992	8
Sandstone	4	5	997	1
COAL	2	2	999	3
BORING.				
Clay	1	4	1,000	7
Sandstone, micaceous, hard at top	21	3	1,021	10
Shale, black, bituminous	6	7	1,028	5
COAL, impure	2	4	1,030	9
Clay	....	10	1,031	7
Shale, black, "slaty"	10	2	1,041	9
Sandstone, whitish, fine-grained, breaks easily	5	8	1,047	5
Shale, black, sandy	22	2	1,069	7
Sandstone, white, micaceous, peppered with black specks, water increases	16	3	1,085	10
COAL	1	....	1,086	10
Shale, dark, sandy	9	7	1,096	5
COAL, good	....	5	1,096	10
Sandstone, white, with seam of "flint"	4	1	1,100	11
Shale, some parts black, "slaty," with seams of "flint"	21	3	1,122	2
Sandstone, black at top	4	5	1,126	7
Shale, black, "slaty"	....	4	1,126	11
COAL	....	6	1,127	5
Shale, black, "slaty," burns readily	2	....	1,129	5
Shale, dark, sandy, seamed with "flint"	16	7	1,146	....
Sandstone, white, a few shale partings seamed with "flint," much water, (may be Mississippian)	404	....	1,550	....
Mississippian series—				
Limestone (certainly Mississippian and lower limit of coal)	20	....	1,570	....
Drilling continued to	....	....	2,116	....

The Leavenworth record probably holds good for much of northern Platte county. The Atchison drilling‡ represents conditions in the northwestern part, and the Randolph, Clay county, shaft and

‡See report on Buchanan county.

drillings, those in the southeastern part. The strata underlying the northeastern part of the region are probably like those in Clinton county, where, however, little is known about beds lower than the Bevier. The Smithville, Clay county, record shows a rather exceptional thickness of coal in one bed and may not apply to a large territory. All of these records, as well as observations made in other parts of the State, indicate that the Bevier coal is very persistent and that in this part of the State it is very uniformly 22 inches in thickness. The coal beds below it are more irregular, though possibly thicker in places. The depth of the Bevier horizon below the railroad levels is about 660 feet at Iatan and Weston, 640 at Beverly, 625 at Farley, 600 at Waldron, 490 at Parkville, 620 at Platte City and Tracy, 650 at Camden Point, 670 at Dearborn, and 625 at Edgerton.

The total coal penetrated by the North shaft and boring at Leavenworth is 197 inches, of which only 108 inches is in beds of 14 inches or over. At Randolph there are 50 inches and at Atchison 101 inches in beds of 14 inches or more. The average of the workable beds at these places, 86 inches, may safely be considered to underlie all of Platte county, making its total reserve tonnage 3,384,960 tons.

PUTNAM COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....78,274 TONS.

At least the eastern half of the Putnam county is underlain at moderate depths by the Lexington coal, the bed mined so extensively in Appanoose and Wayne counties, Iowa. Owing to the strong competition of fields with more direct transportation facilities, however, mining has never been prosecuted with great vigor and the production of the principal district is not increasing. Shipping mines are located at Mendota and at Blackbird near Unionville. Small mines supplying a local trade are operated in the threshing and winter seasons at many localities along Shoal creek and along both main branches of Blackbird creek nearly as far west as the Chicago, Burlington and Quincy railroad. Near Low Ground, in the southeast corner of the county, a little mining is done on a small scale on a lower bed, the Bedford.

The western half of the county is so deeply covered with unconsolidated drift clays that there are practically no exposures of the underlying rocks to furnish a key to the geology of the region. It is known, however, that the Lexington bed lies a short distance below Powersville, and it is probable that the shale and sandstone of the

*The geology was first described by C. J. Norwood (Rept. for 1873-1874: Mo. Geol. Survey, 1874, pp. 272-291). The coal is mentioned by Arthur Winslow (Prelim. rept. on coal: Mo. Geol. Survey, 1891, pp. 55-58). The topography of the southeastern quarter is shown on the Green City and Queen City sheets of the U. S. Geol. Survey.

Pleasanton underlie the drift of practically the entire region. The Pleasanton also caps the ridge tops in the eastern half of the county. Below the Pleasanton is the Henrietta, which contains several beds of limestone, and these, though they vary somewhat in detail, are remarkably persistent and outcrop conspicuously in the valleys of the main streams in the eastern half of the county. In the lower courses of these streams, especially near the Chariton river south of Livonia, are exposures of the shale and sandstone in the upper part of the Cherokee, the lowest formation of the Coal Measures. The constituent members of these formations and the relationships of the outcropping coal beds are shown in the following section, a modification of one published by Norwood:

GENERALIZED SECTION OF OUTCROPPING BEDS IN PUTNAM COUNTY.

		Thickness.		Total.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
Pleasanton shale—					
1.	Sandstone, gray, and shale	27	....	27	....
Henrietta formation—					
2.	Limestone, gray and drab	2	6	29	6
3.	Shale, green, clayey	1	....	30	6
4.	Limestone, bluish-gray, rough, irregularly bedded	2	....	32	6
5.	Shale, red and green at top and bottom, containing sandstone in places	24	....	56	6
6.	Limestone, gray to blue or greenish, with shaly partings	3	6	60	....
7.	Shale, red and blue, clayey	5	....	65	....
8.	Limestone, blue, even layer ("10-inch cap-rock")	....	10	65	10
9.	Shale, dark blue	1	....	66	10
10.	Shale, green, calcareous, or limestone	1	6	68	4
11.	Limestone, blue, hard when fresh but weathered soft and earthy	3	....	71	4
Cherokee shale—					
12.	Shale, drab ("clod")	1	2	72	6
13.	Shale, black, "slaty"	....	11	73	5
14.	COAL, with two or three clay partings (Lexington)	3	3	76	8
15.	Clay, 2 to 7 feet	3	4	80	....
16.	Limestone, blue to drab, uneven on top, 2 to 6 feet	3	....	83	....
17.	Shale and sandstone, whitish at top	20	....	103	....
18.	Limestone, dark, impure, 2 to 6 inches	....	3	103	3
19.	Shale, dark and soft at top, black and "slaty" below	5	6	108	9
20.	Shale, dark, calcareous, full of shells	....	6	109	3
21.	COAL (Summit)	....	2	109	5
22.	Clay, shaly at base	9	....	118	5
23.	Limestone, buff, nodular	1	6	119	11
24.	Shale, dark where Mulky coal is absent	2	....	121	11
25.	Limestone, gray, weathers buff; where present	1	5	123	4
26.	Shale, dark at top, black and "slaty" below, contains larger concretions; where present	6	....	129	4
27.	COAL (Mulky), absent in many places	1	9	131	1
28.	Clay at top, sandy shale and sandstone below, black shale at base, 50 to 60 feet	50	....	181	1
29.	COAL, with ¼-inch clay, hard, 4 inches from base (Bedford?)	2	4	183	5
30.	Clay	2	....	185	5
31.	Sandstone at top, shale below	17	6	202	11
32.	COAL (Bevier?)	1	6	204	5
33.	Clay	1	....	205	5

Strata between the Bevier and the Mississippian, the lower limit of coal, are shown in the drilling at Mendota. These beds, including the coals, are variable and lenticular and must be thoroughly explored by drilling before their resources can be definitely determined. In Putnam county there are 200 to 300 feet of Coal Measures between the Bevier horizon and the Mississippian. In this connection mention should be made of the diamond drilling at Sedan, Iowa, where coal 47 inches thick, in two benches separated by 8 inches of clay, was found at a depth of 321 feet.* Among the 377 feet of Cherokee beds found above the Mississippian there were 12 beds aggregating 21 feet 5 inches of coal. Of these 9 were more than 15 inches thick. The thickest coal bed in a deep drilling at Seymour, Iowa, however, was 29 inches and the total coal in all beds was only 7 feet 4 inches. It may be that the Cainesville horizon, which lies about 300 feet below the Lexington and is so productive in Mercer and Harrison counties, is of economic importance in parts of Putnam county.

The Lexington coal is a general favorite for domestic use. It is fairly free from objectionable forms of impurities and has a faintly developed rectangular cleavage that causes it to come from the mine in semi-block condition. The bed shows only a few thin streaks of iron pyrites, though white gypsum and calcite scale are abundant along the joint planes.

A limestone cap-rock about two feet above the coal bed makes an excellent mine roof. In many places, however, it is weakened by fractures and minute geological faults (''slips''), most of which also traverse the coal and are marked by highly inclined clay seams one inch to 2 feet in thickness (''clay slips''). The prevalence of these ''slips'' and of preglacial channels cause the room and pillar plan of mining to be more widely employed than the longwall system, though it is evident that longwall could easily be adapted to the field.

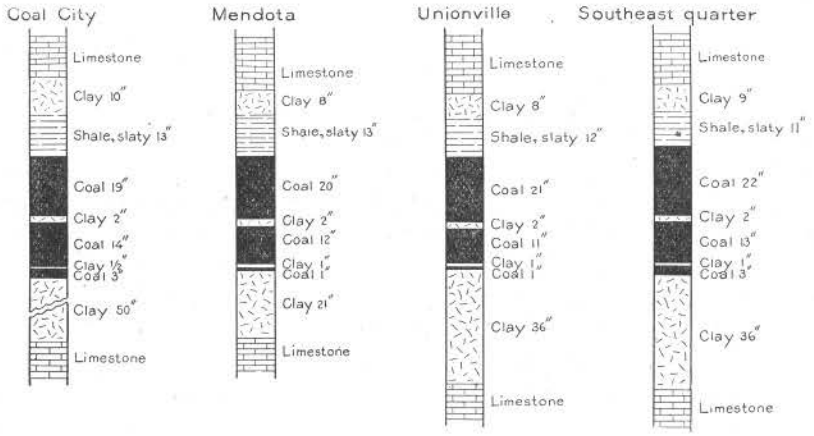

Fig. 67. The Lexington coal bed in Putnam County.

*Hinds, Henry, Coal deposits of Iowa, Ia. Geol. Survey, Vol. XIX, 1909, p. 266.

The coal and associated strata are remarkably uniform in character and thickness where exposed in mines and outcrops in the eastern part of the region. In the western half of the county the coal has been explored only near Powersville, where it appears to be somewhat variable and slightly thinner than farther east.

AVERAGE OF LEXINGTON BED IN EASTERN PUTNAM COUNTY.

	Feet.	*Inches.*
Limestone, "cap-rock"	3	....
Clay ("clod")	1	2
Shale, black ("slate")	....	11
COAL ("upper bench")	1	9
Clay ("mud band")	....	2
COAL ("lower bench")	1	....
Clay	....	1
COAL ("Dutchman")	....	3
Clay	2 to 7	....
Limestone ("bottom-rock")	2 to 6	....

In addition to "slips," the presence of numerous preglacial channels is a factor detrimental in mining operations. Before the deposition of the drift, a system of drainage resembling that of the present had been established. In places these old streams cut down to or below the level of the Lexington coal and were afterward filled with drift clay and sand. Such channels have removed the most coal where the Lexington bed lies at comparatively high altitudes. In these localities, which unfortunately include the mining districts of Mendota and Unionville, exploratory entries may suddenly leave coal of normal thickness and enter a mass of unconsolidated clay mixed with some sand and filled with boulders and pebbles.

At one place, near Glendale, a 21-inch coal bed, the Mulky, lies about 50 feet below the Lexington. Its distribution is probably very irregular, as in adjoining counties, and it probably underlies a very small area in Putnam county.

The two next lower coal beds are 80 to 120 feet below the Lexington and are separated by 15 to 20 feet of shale. These beds are probably the equivalents of the two benches of the Bevier in Adair county, but until this is proven, the higher will be designated the Bedford and the lower the Bevier. These beds outcrop only in the southeastern quarter of the county, but were found in the Mendota borings. The Bedford is 10 to 25 inches and the Bevier 16 to 21 inches thick. The two beds are probably persistent under a large part of the county and may be sufficiently close together in places to be mined as one bed.

Structurally, the county is quite simple. A low broad anticline, or arch, crosses the region in a northwest-southeast direction from northwest of Unionville to near the mouth of Wild Cat creek. From its

axis to the northeast corner of the county the dip amounts to about 100 feet, and south to Stahl, about 50 feet.

The Lexington underlies about two-thirds of the eastern half of the county as a bed averaging 38 inches of coal, and perhaps one-third of the western half as a bed averaging 28 inches. Beds below the Lexington appear to be irregular in distribution or thickness, or in both, and the lowest have been carefully explored only in the Mendota district. Their average total thickness can be estimated therefore only as the average of the total coal in the two Mendota drillings, beds less than 14 inches in thickness being excluded. Estimating 1800 tons as the content of the acre-foot of coal, there are then 864,960,000 tons in the Lexington bed and 3,431,232,000 tons in all lower beds 14 inches or more in thickness, or a total original coal reserve of 4,296,192,000 tons.

DETAILED MENTION.

Northeast Corner.—South of Coal City, Iowa, a few small mines have operated in the Lexington bed. Mines found open were the drifts of W. A. Blue (center Sec. 29, T. 67 N., R. 16 W.) and F. S. Berry (N. E. ¼ S. E. ¼ Sec. 5, T. 66 N., R. 16 W.). At the Blue mine the coal is only 12 feet above the Chariton, but it rises to the southwest and is about 20 feet higher for 1½ miles in that direction; farther south it is damaged by preglacial channels. In the vicinity of the Blue drift, mining conditions are better than in much of the county. The value of the bed is impaired by very few vertical clay seams ("slips") or thin cover.

STRATA EXPOSED IN NORTHEAST CORNER OF PUTNAM COUNTY.

	Feet.	*Inches.*
Clay	15	....
Sand	10	....
Clay	5	....
Shale, dark drab	5	....
Shale, red, blue at base	2	3
Limestone, containing shells	2+	....
Shale, dark blue and drab	12	....
Limestone, cap-rock	1	6
Clay, drab ("clod")	....	8 to 13
Shale, black, "slaty"	1	1
COAL ("upper bench")	1	6 to 8
Clay	....	2
COAL ("lower bench")	1	0 to 3
Clay	....	½
COAL ("Dutchman")	....	3½
Clay	2 to 7	....
Limestone, heavy-bedded	2	2

Livonia.—Very little mining is done near Livonia. The anticline, or arch, which traverses this part of the county, raised the Lexington bed to so high a level that it was removed by preglacial erosion for

a considerable distance back from the river. A lower bed, perhaps the Bedford, outcrops in the bank of Shoal creek, about three miles southwest of the town (S. W. ¼ N. E. ¼ Sec. 6, T. 65 N., R. 16 W.).

BEDFORD (?) BED ON SHOAL CREEK.

	Feet.	Inches.
Shale, dark drab	5	....
COAL, with lenses of pyrite	1	9
Clay	1	....
Sandstone, brown, with 6 inches of shale near middle	1	9
Shale, sandy, to creek level	2	6

Glendale.—Farther up Shoal creek and about 4 miles west of Livonia, the Lexington and Mulky beds, both higher than the Bedford, are exposed.

MULKY BED ON SHOAL CREEK (N. ½ N. W. ¼ SEC. 35, T. 66 N., R. 17 W.).

	Feet.	Inches.
Limestone, gray, hard, weathers deep buff	....	....
Shale, gray to black, banded, hard, sandy, contains large concretions	6	....
COAL, hard, with white scale which weathers red (Mulky)	1	9
Shale, banded, soft, coal streaks at base	1	8
Sandstone and sandy shale	8	....
Concealed to water in Shoal creek	17	....

On the north side of the creek are the drifts of Richard Humphreys (S. W. ¼ S. E. ¼ Sec. 26) and A. Stevens (S. E. ¼ S. E. ¼ Sec. 26), both in the Lexington bed. Both work only part of the year and supply a local trade. The average section here is:

LEXINGTON BED NEAR OLD GLENDALE.

	Feet.	Inches.
Limestone	....	....
Clay	1	6
Shale, black, "slaty"	....	10
COAL ("upper bench"), upper 10 inches parts in slabs because of very thin clay seams	1	10
Clay	....	2
COAL	....	8
Clay, pyritiferous ("lower bench")	....	½
COAL	....	4
Clay	....	½
COAL ("Dutchman")	....	1
Clay	....	....

The coal is of good quality, but the roof is slightly damaged by "slips." The same bed is intermittently worked in the vicinity of Omaha.

Mapleton.—The Lexington bed is mined by drifts and shallow shafts at a number of places 2 to 5 miles northwest of Mapleton, chiefly near the heads of small valleys between that place and Graysville.

SHAFT AND OUTCROP WEST OF MAPLETON (N. E. ¼ S. E. ¼ SEC. 11, T. 65 N., R. 17 W.).

	Feet.	Inches.
Limestone, gray, weathering buff	1	....
Slope, shaly	15	....
Limestone, gray, shaly	....	6
Shale, gray	2	....
Limestone, buff, 15 inches to	1	8
Concealed in top of shaft	6	....
Limestone	....	9
Shale, blue	3	9
Shale, black, "slaty"	2	5
COAL	....	9
Pyrite ("upper bench")	....	1/8 to 1/2
COAL	1	2
Clay	....	1 to 2
COAL ("lower bench")	1	1
Clay	....	1/2
COAL ("Dutchman")	....	6½
Clay	1+	....

The thickness of material between the coal and cap-rock is exceptionally great in the Mapleton shaft, a more common thickness being 18 to 32 inches. The coal averages 39 inches in the district. Mining is done on the room and pillar plan. "Clay slips" are small in most of the region. The underclay is at least 3 feet thick and rests on a limestone bottom-rock. Besides the shaft mentioned above, the following drifts are worked: (1) Lee Roland on land of Ada Roland (S. E. ¼ S. W. ¼ Sec. 7, T. 65 N., R. 16 W.); (2) M. Boston (S. E. ¼ N. W. ¼ Sec. 7); (3) D. Hurley (S. E. ¼ N. E. ¼ Sec. 12, T. 65 N., R. 17 W.); (4) James Vincent on land of J. A. Robbin, 1½ miles east of Graysville; (5) T. P. Collins on land of G. A. Bookout (S. W. ¼ S. E. ¼ Sec. 2, T. 65 N., R. 17 W.); (6) J. Stuff (N. W. ¼ N. E. ¼ Sec. 2, T. 65 N., R. 17 W.). At the last two, the upper 10 inches is "slab" coal of the same character as that near Glendale.

Worthington.—At "Slate Ford," one-half mile northeast of Worthington, 3 feet of black "slaty" shale outcrops just above low water in Chariton river. It is said to burn like a low-grade cannel coal. Some small drifts were formerly operated at the level of the railroad and near the Adair county line, south of Worthington. The coal is reported to be 24 to 26 inches thick and appears to be either the Bedford or Bevier bed. About one mile northwest on the west side of Wild Cat creek (S. W. corner Sec. 9, T. 64 N., R. 16 W.), the following section was measured at an abandoned drift:

	Feet.	Inches.
Shale, dark, "slaty" at base	6	....
COAL	2	....
Shale	....	½
COAL	....	4
Clay	....	6+

Low Ground.—What is, perhaps, the Bedford bed has been mined in drifts just east of the store at Low Ground, near Wild Cat creek

(S. E. ¼ S. E. ¼ Sec. 6, T. 64 N., R. 16 W.). The following section was measured at the entrance of an old drift:

	Inches.
Shale, light drab	36
Shale, black, "slaty"	10
COAL	9
Clay, hard	½
COAL	11
Clay	¼
COAL	4
Clay, bluish	6

Near this place Norwood found a still lower bed exposed, as shown in the following section:

	Feet.	*Inches.*
Shale, deep blue, argillaceous	10 +	....
COAL, with a thin clay parting 4 inches from bottom (Bedford?)	2	4
Shale, blue and drab, thinly laminated, sandy	15 to 20	....
COAL (Bevier?)	1	6
Clay, exposed in bed of creek	....	....

Sidney.—The Lexington bed is mined by drifts at the heads of hollows tributary to Blackbird creek. The following section, measured at the drift of F. W. Cook, one-half mile north of Sidney (N. E. ¼ S. E. ¼ Sec. 8, T. 64 N., R. 17 W.), is typical for the surrounding area:

LEXINGTON BED NEAR SIDNEY.

	Inches.
Shale, light	36
Limestone	21
Shale, light	9
Shale, black, "slaty"	11
COAL ("upper bench")	23
Clay	2½
COAL	10
Clay ("lower bench")	¼
COAL	4
Clay	1
COAL ("Dutchman")	1

The coal near Sidney is rather high above drainage levels and in places may be cut out by preglacial channels, though none such have been reported in the mines. Gypsum is present as usual, but there are comparatively few "slips." The room and pillar method is used in mining. The Sunshine strip-pit, 1½ miles northwest (S. W. ¼ Sec. 5, T. 64 N., R. 17 W.), and the drift of J. A. Hyatt, a little over one mile north (S. E. ¼ S. E. ¼ Sec. 5), utilize the same beds. Other mines are intermittently operated between Sidney and Rosewood.

Mendota.—The largest and one of the oldest mining camps in the county is located at Mendota on West Shoal creek. A spur one mile long connects some of the Mendota mines with the Chicago, Burlington and Quincy railroad at Mendota Junction, and other mines are on shorter spurs. Most of the product is shipped. The coal mined, the Lexington, lies near the level of the creek and is mined both by shafts and drifts.

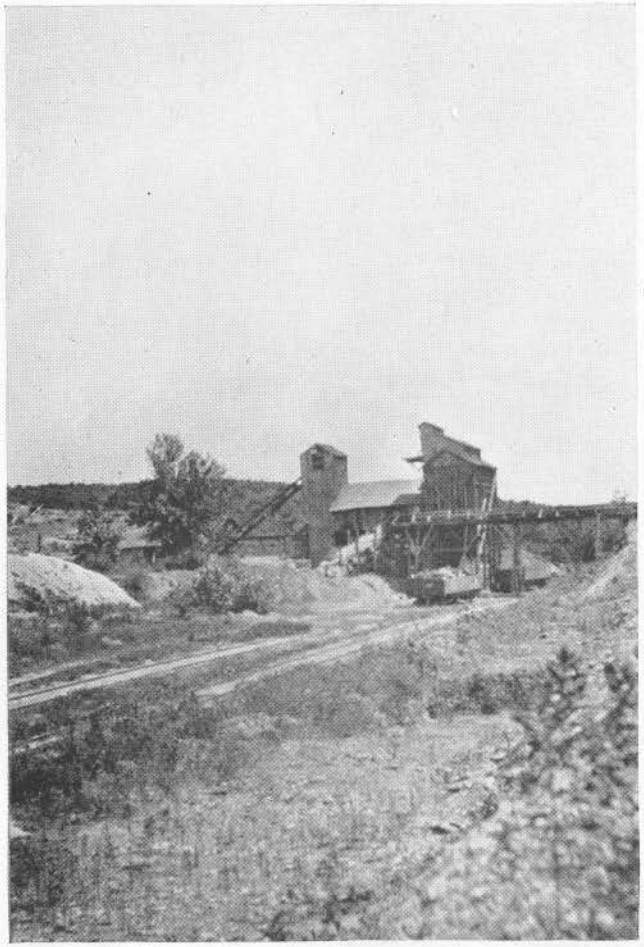

Fig. 1. No. 2 shaft, Mendota Coal and Mining Co., Mendota, Mo.

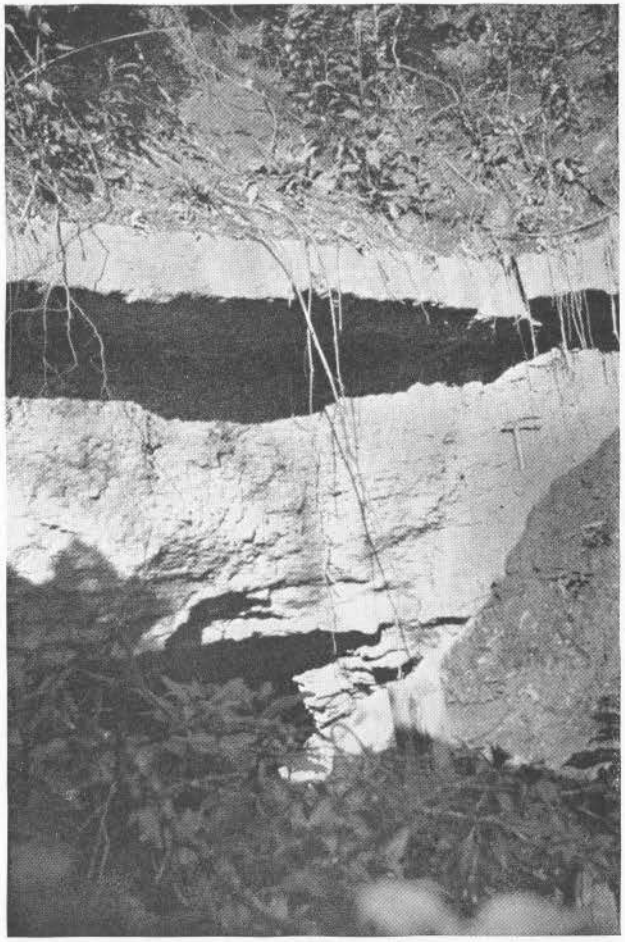

Fig. 2. Rocks overlying the Lexington coal bed; old drift east of Unionville, Mo.

LEXINGTON BED IN MENDOTA DISTRICT.

		Feet.	Inches.
1.	Limestone, cap-rock	2 to 3	....
2.	Shale, drab, clayey ("clod"), 5 to 24 inches	....	8
3.	Shale, black, "slaty" 11 to 18 inches	1	1
4.	Shale, black, not "slaty," carbonaceous, rarely present ("black bat"), 0 to 18 inches	....	....
5.	COAL ("upper bench"), 18 inches to	1	8
6.	Clay, ½ to 4 inches	....	2
7.	COAL ("lower bench"), 9 inches to	1	....
8.	Clay	....	1
9.	COAL ("Dutchman")	....	1
10.	Clay, very variable in thickness	2	....
11.	Limestone	....	....

In appearance the Lexington coal is the same as in other parts of the county. In places lenses of "black bat" lie on the coal and reduce the thickness of the upper bench. It was formerly mined room and pillar, undercut, and wedged. The longwall system is being introduced, and is successful in the better mines, though opposed by the miners. About 13 per cent of slack is produced. One of the chief troubles of the district is preglacial channels filled with soft boulder clay. In some of the mines the cap-rock has been removed in places, causing bad falls and softening of the coal. Even the coal itself is gone in smaller areas. The main channel is said to traverse the north part of old No. 1 workings, near the Mendota store, and to follow the line of the railroad to Cincinnati, Iowa. Tributary channels are plentiful in mine No. 9 and in nearly all the abandoned Mendota mines. Where these channels are absent, the cap-rock forms an excellent roof. Few timbers are required, even in entries that have been used for 20 years. Along the roads both the "slate" and "clod" are brushed down. In longwall working, the "slate" is used in the gob walls and in many places the "clod" is left up.

Most of the larger mines are operated by the Mendota Coal Co. and are: (1) mine No. 2, shaft 64 feet, in N. W. ¼ N. W. ¼ Sec. 1, T. 66 N., R. 18 W., now the largest and best producer; (2) mine No. 7, drift, in S. E. ¼ S. W. ¼ Sec. 35, T. 67 N., R. 18 W., idle since Dec. 1, 1909; (3) mine No. 9, drift, in S. E. ¼ S. W. ¼ Sec. 27, near Mendota station. The Rogers Coal Co. also operates a shipping drift not far from the station (S. E. ¼ N. W. ¼ Sec. 27).

In addition to the shipping mines, a large number of small mines, most of them drifts which work only in the fall and winter, are situated along the bluffs of Shoal creek and its larger tributaries. These extend north to the Iowa line, southwest to Sec. 5, T. 66 N., R. 18 W. and down Shoal creek.

Two diamond drillings, bored for the Mendota Coal Co. by York Bros., furnish the only reliable information in regard to the Lower Coal Measures strata of the county.

DRILLING NEAR RAILROAD ONE-FOURTH MILE SOUTH OF THE MENDOTA STATION. TOP ABOUT FIFTEEN FEET BELOW LEVEL OF LEXINGTON COAL BED.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift and soil	16	....	16	....
Shale, blue at top, light below	6	....	22	....
Limestone	4	....	26	....
Shale, light	2	....	28	....
Limestone	2	....	30	....
Shale, black at top, sandy and light below	7	....	37	....
Sandstone	2	....	39	....
Shale, sandy at top	27	....	66	....
Limestone	1	....	67	....
Shale, light at top, blue below	15	....	82	....
COAL (Bedford)	....	10	82	10
Clay, sandy	2	2	85	....
Sandstone	5	....	90	....
Shale, sandy	7	....	97	....
Shale, blue	5	....	102	....
COAL (Bevier)	1	9	103	9
Clay	2	3	106	....
Shale, light	4	....	110	....
Limestone	3	....	113	....
Shale, sandy	2	....	115	....
Shale, black	8	....	123	....
Shale, light	3	....	126	....
COAL (Tebo)	1	6	127	6
Clay	3	6	131	....
Sandstone	4	....	135	....
Shale, brown to light, sandy near top	9	....	144	....
Sandstone	1	....	145	....
Shale, red at top, blue in middle, sandy at base	10	....	155	....
Sandstone, hard	4	....	159	....
Shale, variegated, sandy at top	9	....	168	....
Sandstone, with shale partings	12	....	180	....
Shale and sandstone	19	....	199	....
Shale, blue	6	....	205	....
COAL	....	2	205	2
Shale, sandy at top, variegated	14	10	220	....
Shale, blue	11	....	231	....
COAL	....	7	231	7
Clay	1	5	233	....
Sandstone	12	....	245	....
Shale, blue, sandy in middle	17	....	262	....
COAL	....	7	262	7
Sandstone	3	5	266	....
Shale, light at top, blue below	9	7	275	7
"Rock," black	3	....	278	7
Shale, sandy	2	5	281	....
COAL	....	2	281	2
Clay	....	10	282	....
Shale, sandy	4	....	286	....
Shale, blue	2	....	288	....
COAL	....	5	288	5
Clay	1	7	290	....
Shale, light, sandy at base	6	....	296	....
Sandstone, hard	2	....	298	....
Shale, sandy	2	....	300	....
Sandstone, hard	2	....	302	....
Shale, calcareous	4	....	306	....
Shale, sandy	6	....	312	....
Shale, green	2	....	314	....
Shale, variegated	4	....	318	....
Shale, calcareous	3	....	321	....
Shale, light	1	....	322	....
Shale, calcareous	5	....	327	....
Sandstone, hard	3	....	330	....
Shale, calcareous	2	....	332	....
Limestone	4	6	336	6

The lowest member of this drilling is certainly Mississippian and the lower limit of coal, though it is possible that the line should be drawn at 302 feet. Another drilling, one mile south of the railroad station and at about the same level as the last, penetrated the following coal beds:

	Thickness. *Inches.*	Depth. *Feet.*
COAL (Bedford)	21	109
COAL (Bevier)	16	118
COAL (Tebo)	14	144
COAL	19	163
COAL, soft	15	217
COAL	2	268
COAL	8	274
COAL	15	301

In other respects the record is similar to that of the first drilling. The Mississippian was reached at either 305 or 337 feet.

On the divide at Howland, 4 miles southwest of Mendota and 97 feet higher, a hole was drilled in drift to a depth of 164 feet, showing the Lexington coal to have been removed by preglacial erosion.

Unionville.—The central part of Putnam county is underlain at moderate depths with the Lexington coal bed, except where the latter has been removed by preglacial erosion and its place taken by unconsolidated deposits of drift clay. The coal outcrops along North and South Blackbird creeks northeast and southeast of Unionville, and is extracted by a number of small local mines on or near the outcrop and by the shipping mines at Blackbird. The bed mined is much the same as in other parts of the county. "Clay slips" are rather numerous but are troublesome only in certain localities. In many places the roof is weak because of the thickness of the drift and the lack of sufficient hard rock cover. Where the drift lies farther from the coal, however, the roof is excellent. Room and pillar is the common method of mining, though longwall is being tried. The tendency of the thick underclay to "squeeze" and "heave" is one of the difficulties encountered under the latter system.

LEXINGTON BED IN UNIONVILLE DISTRICT.

	Inches.
Limestone	24
Clay, shaly, 4 to 20 inches	8
Shale, black, "slaty," 4 to 18 inches	12
COAL, 18 to 24 inches	21
Clay, 0 to 6 inches	2
COAL, 10 to 14 inches	11
Clay, 0 to 2 inches	1
COAL, 0 to 2 inches	1
Clay, 30 to 84 inches	50
Limestone	18

The largest and only shipping mines in the district are those of the Missouri Mining, Manufacturing, and Mercantile Co. (formerly Blackbird Block Coal Co.), about 2 miles northeast of Unionville, on

the Chicago, Burlington and Quincy railroad. This company owns or controls about 3,500 acres and two mines in T. 66 N., Rs. 18 W. and 19 W. Only one of the mines, a slope (S. W. ¼ S. E. ¼ Sec. 24, T. 66 N., R. 18 W.) in which the coal lies 80 feet below the entrance, was in operation when visited. Cars are pulled up the incline by a gasoline engine. In the same locality is the small coal mine of A. P. Anderson (N. E. ¼ N. W. ¼ Sec. 30), where coal is hoisted 73 feet by horse-power. According to Mr. Anderson, the rocks above the coal in this neighborhood average as follows:

STRATA ABOVE LEXINGTON BED NEAR BLACKBIRD.

	Feet.	*Inches.*
Drift	....	....
Limestone, heavy-bedded	1	8
Shale, white	11	....
Sandstone, yellowish-brown, micaceous	3	....
Shale, white	2	....
Limestone, massive	2	....
Shale, blue	11	....
Limestone, blue, hard ("10-inch cap-rock")	....	10
Shale, gray	5	....
Limestone, weathers to clay ("cap-rock")	2	....
Shale, drab ("clod")	....	7
Shale, black, "slaty"	....	8
COAL (Lexington), mined	2	8

East and southeast of Unionville, along both forks of Blackbird creek, are many country mines, most of which are worked in fall and winter for farm use, though some of the product is hauled into town. The coal averages 34 inches, exclusive of the clay partings. The mines found in operation were those of: (1) J. Mosby, shaft 29 feet, S. E. ¼ S. W. ¼ Sec. 34, T. 66 N., R. 18 W.; (2) D. Shehan, slope, S. E. ¼ N. W. ¼ Sec. 34, T. 66 N., R. 18 W.; (3) W. E. Shelton, shaft 20 feet, N. W. ¼ S. E. ¼ Sec. 34, T. 66 N., R. 18 W.; (4) Moore Brothers, drift, S. E. ¼ S. E. ¼ Sec. 34, T. 66 N., R. 18 W.; (5) E. E. Payton, drift, S. W. ¼ N. W. ¼ Sec. 20, T. 66 N., R. 17 W.; (6) A. M. Shelton, drift, S. E. ¼ N. E. ¼ Sec. 30, T. 66 N., R. 17 W.; (7) G. Affot, drift, N. W. ¼ S. E. ¼ Sec. 32, T. 66 N., R. 17 W.; (8) V. R. Blubaugh, drift, S. E. ¼ N. E. ¼ Sec. 12, T. 65 N., R. 18 W.; (9) J. P. Hymes, drift, S. W. ¼ S. E. ¼ Sec. 20, T. 65 N., R. 18 W.; (10) J. D. Stratton, drift, N. W. ¼ S. E. ¼ Sec. 20, T. 65 N., R. 18 W.; (11) Wycoff drift, N. W. ¼ S. E. ¼ Sec. 28, T. 65 N., R. 18 W.; (12) E. Nordan, drift, S. W. ¼ N. E. ¼ Sec. 28, T. 65 N., R. 18 W.

A shipping mine was formerly operated within a mile northeast of the town, but was abandoned because the coal was found to be badly cut up by preglacial channels. Several unsuccessful attempts have been made to find the Lexington bed under Unionville itself. Apparently, however, it had been completely removed, for a trial shaft near the railroad station and a number of drillings were barren. Below is the rather imperfect record of a bore that reached the base of the Coal Measures.

WELL AT POWER HOUSE, UNIONVILLE.

	Thickness. *Feet.*	Depth. *Feet.*
Clay and soil, Lexington coal apparently replaced by drift	220	220
Shale, black, "slaty"	5	225
"Rock"	4	229
Clay	4	233
Shale, black, "slaty"	12	245
Clay	32	277
Sandstone	30	307
Shale, black, "slaty"	3	310
Shale	42	352
Shale, clay and "slate"	57	409
Black cuttings	21	430
Shale, etc	90	520
Sandstone	25	545
White cuttings, hard, water bearing, probably Mississippian limestone	....	....

One to 2 miles south of town in Secs. 3 and 10, T. 65 N., R. 19 W., five churn drillings beginning at a lower level were bored on the land of Z. T. Brawford. Only one of these failed to find the Lexington bed of workable thickness, the others showing 24 to 31 inches of coal at depths of 90 to 157 feet. The record of the deepest drilling is as follows:

DRILLING SOUTH OF UNIONVILLE (N. W. ¼ S. E. ¼ SEC. 3, T. 65 N., R. 19 W.).

	Thickness. Feet.	Inches.	Depth. Feet.	Inches.
Drift	116	....	116	....
Shale, green	10	8	126	8
Shale, mixed	8	9	135	5
Limestone	3	2	138	7
Shale, light to gray	10	5	149	....
Limestone	1	7	150	7
Shale, gray	3	10	154	5
"Clod"	2	3	156	8
Shale, dark	....	6	157	2
COAL	1	7	158	9
Clay (Lexington)	....	2	158	11
COAL	1	....	159	11
Clay	1	3	161	2

Powersville.—The only mine in the western part of the county is about 2 miles north of Powersville, near and east of the Chicago, Milwaukee and St. Paul railroad. The shaft, which is 150 feet deep, is operated by J. W. Doman. The mine was full of water when visited and no very exact information about it could be obtained. Reports by miners leave little doubt, however, that the Lexington bed is the one operated. It is said to vary from 24 to 33 inches in thickness in addition to a 2-inch clay band near its middle. Above the coal is 6 to 12 inches of black shale on which rests a limestone cap-rock about 2 feet thick. The same coal bed is reported from shallow borings at Powersville.

RALLS COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....17,649 TONS.

Aside from small pockets, the coal-bearing rocks of Ralls are confined to the southern part of the county, being well exposed in the vicinity of Perry. These measures are thin and are composed of the same strata as at Vandalia, including one workable coal bed, tentatively correlated with the Mulky. The section also exhibits a striking similarity to that at Paris and Madison, a thin coal seam lying locally a few feet below the Mulky as in Monroe county. The drift covering the prairie region northeast of Perry is about 30 feet thick, and the highest indurated rock beneath it is an impure irregularly bedded limestone 15 feet thick, with partings of clay especially numerous at its base. Below this is a compact limestone cap-rock 15 inches in thickness. Between the cap-rock and the Mulky coal bed are 7 to 11 feet of shale, light blue at the top, but black, "slaty", and bearing numerous lenses and oval concretions of impure limestone in its lower part; this makes a very satisfactory roof for longwall mining. Under the coal are a few feet of clay resting in places on a thin band of limestone, which, however, is absent in much of the area. From 8 to 12 feet below the Mulky bed is a second coal seam (Bevier), the interval between the two being occupied chiefly by dark shale. This seam is 12 to 18 inches in thickness, though rarely over 14 inches; it cannot be considered commercially important and is not everywhere present. It is underlain by 7 to 18 feet of white or light-colored fire clay that lies on a thin layer of white sandstone or directly on Mississippian limestone. The Mississippian is well exposed in the bluffs at and north of Perry and is low in Lick creek valley to within a few miles of the Audrain county line.

All coal mined in the county is taken from the Mulky bed on the longwall system by undercutting two feet or more and wedging down. The coal, which is about two feet thick, bears a very thin seam of pyritiferous clay 2 to 5 inches from the base and contains some pyrite and white scale, but on the whole is clean. A few "slips," one of them having a throw of 18 inches, are accompanied by clay seams in the adjacent coal. In places rolls in the roof cut out the upper coal for short distances along the mine faces. It may be roughly estimated that 40,000 acres are underlain with an average of two feet of coal in this bed, giving the county an original coal reserve of 144,000,000 tons, of which only a negligible quantity has been mined.

*The topography of the coal-bearing district is depicted on the Mexico atlas sheet, published by the U. S. Geol. Survey. Coal is mentioned by Arthur Winslow (a preliminary report on coal: Mo. Geol. Survey, 1891, pp. 82-84) and clay deposits by H. A. Wheeler (Mo. Geol. Survey, Vol. XI, pp. 407-408).

North and East of Perry.—The most eastern occurrence of coal is in Sec. 27, T. 54 N., R. 6 W., where the Mulky bed, here 30 inches thick, is found near the summit of a hill. The Pennsylvanian aggregates only 40 feet in thickness, and is horizontal in position. Mississippian rocks dipping 10′ are exposed along the creek.†

The only shipping mines in Ralls county are located on the St. Louis and Hannibal railway, two miles northeast of Perry. Hoisting is done by horse-power. In this district are the shafts of the Ralls County Coal Co. No. 2, 50 feet deep (S. W. ¼ S. W. ¼ Sec. 24, T. 54 N., R. 7 W.), and the Clark Coal Co., 60 feet deep (N. E. ¼ N. E. ¼ Sec. 26, T. 54 N., R. 7 W.). The seam worked is 28 inches thick, with a half-inch clay parting 6 to 10 inches from the bottom. It dips gently southwest.

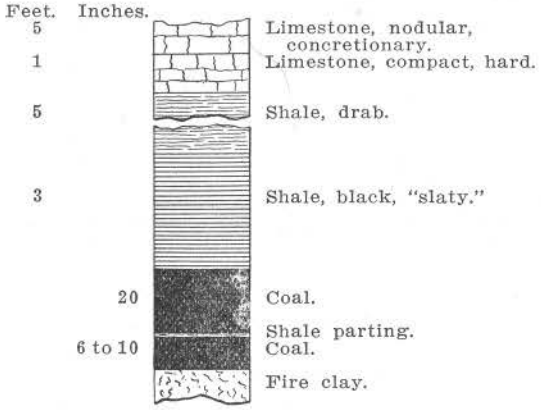

FIG. 68. Coal bed at shipping mines, northeast of Perry.

One to two miles north of Perry, on the east side of Lick creek, several small mines are operating for the wagon trade: Jacob Phillips and Henry Peer drifts (S. E. ¼ N. E. ¼ Sec. 22, T. 54 N., R. 7 W.), Henry Smith drift (S. E. ¼ S. W. ¼ Sec. 22), and John Berry slope (S. E. ¼ N. W. ¼ Sec. 22). The Coal Measures from 22 to 26 inches, exclusive of a clay parting from one-half to one inch thick, which lies about four inches from the bottom of the bed. Workable coal north and northeast of Perry appears to be confined to a basin less than two miles in width with the longer axis extending from the Berry slope through the Ralls county shaft and thence east of southeast. On either side of the basin erosion has removed most of the Mulky bed, leaving only patches here and there. At Perry itself and for one mile north and east and two miles south no coal exists, and the drift lies on Mississippian limestone or on the basal clays of the Pennsylvanian.

South of Perry.—Two miles south of Perry, the Mulky coal outcrops in an eastern tributary of Lick creek and is mined intermittently

†Winslow, Arthur, Preliminary report on coal, Mo. Geol. Survey, 1891, p. 83.

in small local drifts, among the more important of which are those of G. F. Lonsberry and C. M. Jackson (S. W. ¼ N. E. ¼ Sec. 10, T. 53 N., R. 7 W.). The coal bed is practically the same as in the drifts north of Perry. South to the county line and west to the hills bordering Spencer creek, the Mulky bed underlies all lands except those low down in Lick creek valley.

West and Northwest of Perry.—On the west side of Lick creek the Mulky coal bed outcrops well up in the hills as far north as Greenlawn and in the small tributaries from the west. Small drifts operated for the wagon trade are: Lath Giles on land of James Boulware (S. W. ¼ S. E. ¼ Sec. 28, T. 54 N., R. 7 W.), Frank Westfall on land of Samuel Gill (N. W. ¼ S. E. ¼ Sec. 28), James Keenan on land of R. B. Fry (N. W. ¼ S. E. ¼ Sec. 28), and N. B. Kindred (S. W. ¼ N. E. ¼ Sec. 16). In this part of the field the coal is 21 to 24 inches thick, exclusive of a three-fourths-inch clay seam three inches from the bottom.

RANDOLPH COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....349,600 TONS.

For more than thirty years coal mining has been vigorously prosecuted in Randolph county, and it may safely be said that very few counties in Missouri possess such important deposits of coal. Three

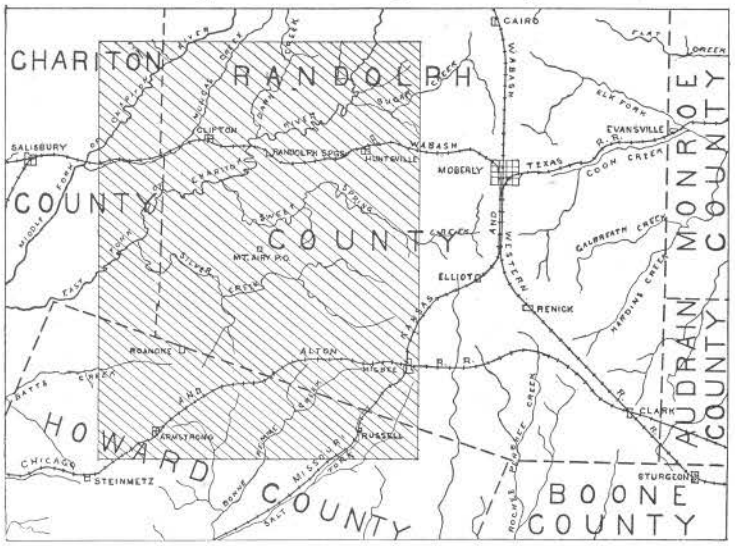

FIG. 69. Index map of the Huntsville quadrangle.

*The topography of the eastern half of the county is shown on the Moberly and Macon sheets of the U. S. Geological Survey, and the topography and geology of the western half on the Huntsville and Bevier sheets of the Missouri Geological Survey, republished in revised form in this volume. The writer is much indebted for information to earlier reports: (1) Geology of Randolph County, by G. C. Broadhead: Mo. Geol. Survey, 1855-1871, pp. 93-110; (2) Geology of the Huntsville Quadrangle, by C. F. Marbut, Mo. Geol. Survey, vol. 12, pt. 2, 1898, pp. 311-371; and (3) A report on the Bevier sheet, by C. H. Gordon: Mo. Geol. Survey, 1893 (also Vol. IX, 1896), pp. 1-75. The coal was briefly described by Arthur Winslow (Preliminary rept. on coal, Mo. Geol. Survey, 1891, pp. 67-73).

main lines of railroad tap the fields, and mines at Huntsville, Kimberly, Elliott, Renick, Higbee, and Yates ship over them to points west and southwest. In addition a large number of small local drifts and shallow shafts are scattered along the stream courses. During recent years production has been much curtailed by the financial difficulties of a company that owned a very large acreage of coal land and had bought up many valuable properties; now, however, a new company has taken over these holdings and the outlook for the future is brighter.

The stratigraphic section for the county was first worked out by Broadhead, and this, considerably modified, is as follows:

GENERAL SECTION.

Pennsylanian series in Randolph County.	Thickness. *Feet.*	Total. *Feet.*
Pleasanton shale—		
1. Shale, in part sandy, more than	15	15
Henrietta formation—		
2. Limestone, gray, rough-bedded, impure, with specks of calcite	2	17
3. Shale, light buff to drab, calcareous at top	14	31
4. Limestone, blue to dove, irregularly bedded in greater part	9	40
Cherokee shale—		
5. Shale, coal streaks at top (horizon of Lexington coal)	3	43
6. Limestone, blue to dove, irregularly bedded, breaks into nodules with clayey partings (the "Chætetes Limestone")	10	53
7. Sandstone and sandy shale, the former chiefly in the middle, 16 to 32 feet	18	71
8. Limestone, dark blue to grayish drab, rings under hammer, compact, massive except for poor parting in center, good vertical fracture causes it to break into blocks (the "Rhomboidal Limestone"), 2 to 5 feet	3	74
9. Shale, black, "slaty," one to 3 feet	2	76
10. COAL (Summit), 0 to 20 inches	1	77
11. Clay	2	79
12. Limestone, clay, and shale, varies greatly at different points, the "conglomerate rock" of drillers	11	90
13. Shale, light drab, 2 to 5 feet	4	94
14. Limestone, much like the "Rhomboidal," one to 6 feet	3	97
15. Shale, light colored and soft at top, black and "slaty" below, one to 6 feet	3½	100½
16. COAL (Mulky), 0 to 24 inches	1½	102
17. Clay, in places with a thin limestone layer at base	2	104
18. Shale, in part clayey and in part sandy, in many places with lenses of sandstone, 5 to 40 feet, in general thins to the east	20	124
19. COAL (Bevier), 6 to 72 inches	4	128
20. Clay, 4 to 60 inches	1	129
21. Limestone, bluish-drab, very hard, very rough on upper surface, impure, one to 6 feet	3	132
22. Shale, calcareous, one foot to	3	135
23. Limestone, bluish-gray to drab, silicious, mostly in even beds, absent in many places	2	137
24. Shale, contains a few thin calcareous beds, very variable in thickness	20	157
25. COAL (Tebo), 0 to 48 inches, absent in many places	1	158
26. Shale, with lenses of sandstone and a few thin coal beds, grades into clay at base, very variable in thickness and character, 20 to 90 feet	60	218
Mississippian series—		
27. Flint and limestone (lower limit of coal)	....	....

The distribution of the formations is indicated on the State geologic map. Nos. 1-21 are very persistent and regular within the

limits of the section, but lower strata are very irregular, changing rapidly from point to point. The upper surface of the Mississippian is decidedly uneven, so much so that it projects up nearly to the horizon of the Bevier coal in a few places, though in general it is from 70 to 120 feet below that bed. It is exposed at the surface in two very small areas in the western half of the county (center south line Sec. 12, T. 54 N., R. 15 W. and S. E. ¼ N. E. ¼ Sec. 17, T. 53 N., R. 15 W.).

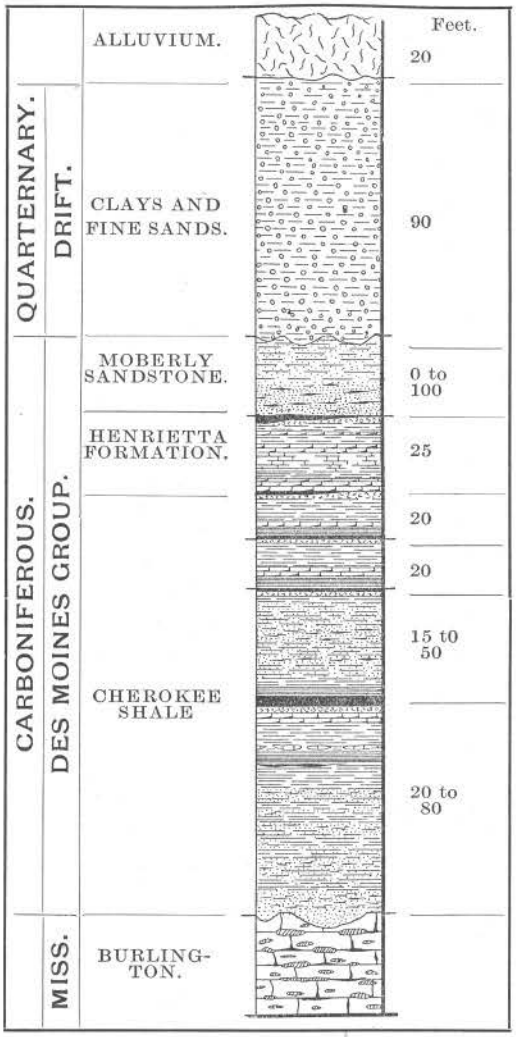

FIG. 70. General section of the rocks of the Huntsville quadrangle (after Marbut).

Structurally the Coal Measures, when broadly considered, dip very gently west and northwest. Certain small areas, however, are affected by folds whose axes apparently trend northwest and southeast. Thus both north and south of Yates the coal beds are higher

than in neighboring districts and at Thomas Hill they are lower than they are at short distances north or east. These irregularities are most plentiful in the eastern half of the county and can be detected by a careful examination of the maps of the Huntsville and Bevier quadrangles.

Crossing the county from east to west, as shown on the State and Huntsville geologic maps, is an old channel filled with shale and sandstone that is later in age than any members of the general section. The waters which excavated the channel removed all or most of the Coal Measures from its central portion and less from its sides. The chief coal beds are, therefore, absent in the main part of this old valley in a strip two to three miles wide lying a short distance south of the Wabash railroad from Clifton to Moberly and along and south of the Missouri, Kansas and Texas railroad from Moberly to Evansville.

Of the coal beds listed in the general section, three are persistent and one is fairly so. They are rather easily distinguished one from another both by their own characteristics and by the strata associated with them. The uppermost bed, the Summit, is characterized by a limestone cap-rock separated from the coal by one to three feet of black "slaty" shale, and is less than 14 inches in thickness in most places, though at Thomas Hill and north of Milton it is a few inches thicker and is of some economic importance. The Summit coal bed is present everywhere except where removed by erosion.

The next lower coal bed is the Mulky (Macon City),† which has an overlying "slaty" shale and a cap-rock much like that of the Summit bed. The shale is commonly slightly thicker, however, averaging nearly four feet, and there are some slight differences in the nature of the cap-rock. The Mulky coal is of exceptionally good quality and is mined at a few country banks and just at present also at Renick in one of the larger mines. It commonly has a thickness of 18 inches, though it thins or even disappears abruptly in certain areas, and is thin over a larger territory along the eastern edge of the county. In the northeast quarter of the county, where the Bevier bed is thin, the Mulky is even now of considerable value for local use, and its good quality, excellent roof, and nearness to the surface will make it more so when the Bevier approaches exhaustion.

The third and most important bed is the Bevier, the coal worked by all but one of the shaft mines and by most of the country banks. It outcrops in nearly all of the deeper valleys and lies less than 200 feet below the higher divides. Except where removed by preglacial erosion and its place taken by drift or where it is cut out by recent erosion in the valleys of East fork and a few other streams, the Bevier

†The bed called in this area the Macon City by Marbut and Gordon has been correlated with the Mulky of Lafayette county and is given the latter designation in this report.

underlies the greater part of the western half of the county with an average thickness of nearly four feet. The eastern boundary of the thicker coal appears to correspond very closely with the line of the Wabash railroad from Jacksonville through Moberly to Clark; east of this line the bed is in general too thin for working under present market conditions though there are a few tracts of land near the railroad under which there is thick coal. The bed also thins slightly near the western border of the county, though even there it remains thick for a Missouri coal. In that region it lies for the greater part below drainage levels, where it can be found only by drilling; and the lack of railroad facilities has discouraged prospectors.

The Bevier bed contains a moderate amount of "sulphur" in streaks and thin lenses of iron pyrites and a very little in white vertical films of gypsum. Its quality is shown in the chapter on analyses. It is a good shooting coal, but it is to be hoped that the near future will see a cessation of the wasteful practice of shooting off the solid and a more general use of the longwall method of mining. The roof is in most places a "soapstone" or a sandy shale that gives fair satisfaction if carefully watched. In places, however, sandstone comes down next to the coal, making a strong roof, but one with an uneven under surface that causes irregularity in the thickness of the coal.

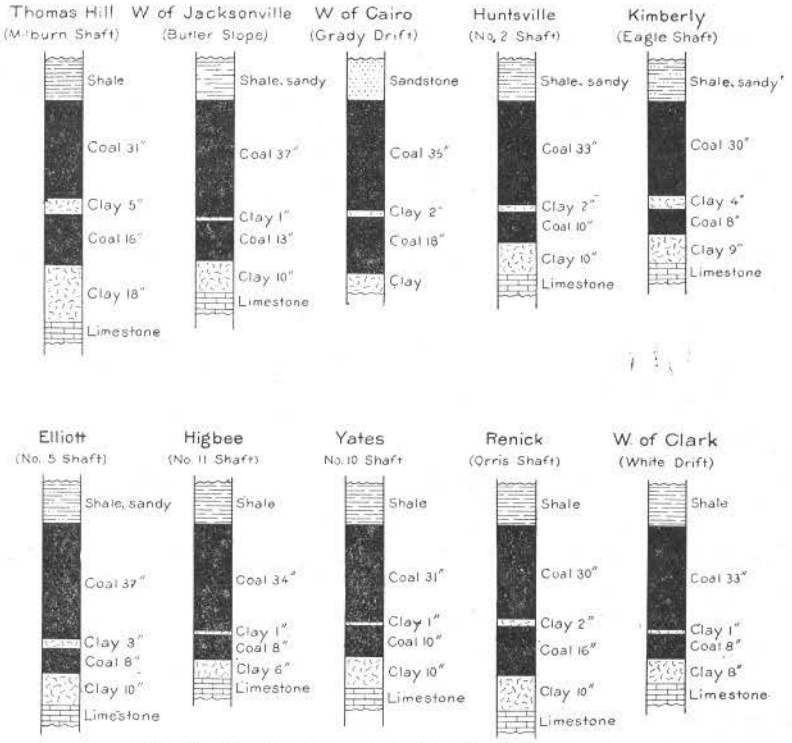

Fig. 71. The Bevier coal bed in Randolph County.

In a few places the base of the coal is slightly irregular, and in others the value of the bed is lessened by "clays," or small masses of foreign material let in from the floor or roof. The problems connected with "squeezing" of the underclay and with the firm setting of props are greatly simplified in this field because of the limestone sump-rock that lies only a short distance below the coal. One striking feature of the bed, well shown in the illustrated coal sections, is the presence of a remarkably persistent clay band in the lower part. This band is commonly pure clay and only two inches thick, but locally it is very sandy or even pyritiferous and is then very hard and not easy to handle. Locally, also, the band thickens, being so thick in some places in the western part of the county as to be detrimental in mining.

The Tebo (Lower Ardmore)‡ coal bed, which lies a short distance below the Bevier, is reported to be four feet thick at one exposure north of Yates and is known to be 18 inches at several other points. Where search has been made for it by drilling, however, it has been found to be thin or absent and cannot be considered to be a "blanket" or persistent bed. No important coal beds are known to lie below the Bevier, though it is very probable that basins of fairly thick coal of rather small areal extent lie at various horizons.

In the following estimate of the total original tonnage, necessarily a rough one, only beds or parts of beds more than 14 inches thick are included, and there is considered to be 1800 tons per acre for every foot of coal.

Range.	Township.	Thickness of beds in inches.	Area in square miles.	Tons of coal.
13 W.	55 N.	Mulky 18, Bevier 14	34	104,448,000
14 W.	55 N.	Mulky 16, Bevier 30	32	141,312,000
15 W.	55 N.	Mulky 16 in half of area, Bevier 48	32	172,032,000
16 W.	55 N.	Bevier 47	18	81,216,000
13 W.	54 N.	Summit 14 in one-third of area, Mulky 18, Bevier 14	30	105,600,000
14 W.	54 N.	Mulky 18, Bevier 30	32	147,456,000
15 W.	54 N.	Mulky 14 in one-fourth of area, Bevier 40	26	108,576,000
16 W.	54 N.	Bevier 36	15	51,840,000
13 W.	53 N.	Mulky 18, Bevier 30	27	124,416,000
14 W.	53 N.	Mulky 16, Bevier 45	24	140,544,000
15 W.	53 N.	Mulky 14 in half of area, Bevier 40	18	81,216,000
16 W	53 N.	Bevier 30	6	17,280,000
13 W.	52 N.	Mulky 17, Bevier 33	34	163,200,000
14 W.	52 N.	Mulky 14, Bevier 43	31	168,632,000
15 W.	52 N.	Mulky 14, Bevier 40	19	98,496,000
16 W.	52 N.	Bevier 30	5	14,400,000
		Coal in basins at horizons, especially the Tebo, not included above. In all parts of the county	.....	300,000,000
			383	2,020,664,000

‡The bed called in this area the Lower Ardmore by Marbut and Gordon has been correlated with the Tebo of Henry county and is given the latter designation in this report.

DETAILED MENTION.

Area north of Moberly Channel.

Levick Mill.—On the west bank of Mud creek, in T. 55 N., R. 13 W., at Levick Mill (N. E. ¼ S. W. ¼ Sec. 10), S. M. Halterman has several drifts in the Mulky coal, which is about 20 feet above creek level, is 18 inches thick, and is separated from a four-foot limestone cap-rock by 5½ feet of shale that is black and "slaty" in the lower part. The Bevier coal lies only seven feet below the Mulky, and is only seven feet thick. Henry Taylor also has drifts in the Mulky 1½ miles southeast (N. W. ¼ N. E. ¼ Sec. 14), where it is 18 inches thick and lies six feet below the Bevier, which is said to measure 20 inches. At both localities the output is small, only local trade being supplied, and the coal is undercut on the longwall plan and wedged down. The coal is of excellent quality and the bed is easily mined because of its splendid roof; many farmers have small pits near their homes and take out sufficient fuel for their own use. The seam outcrops in T. 55 N., R. 13 W., in nearly all the valleys of the eastern half and in that of Hoover creek in the northwest corner, and underlies all the higher lands of the township except a few in the extreme northeast portion where a sandstone channel cuts out the regular beds. The Summit coal lies under the western and southern portions of the township and varies from 12 to 17 inches in thickness. Where the Bevier outcrops near Mud creek it is very thin, but farther west it thickens and lies at a slightly greater distance below the Mulky. Thus on Hoover creek, near the county line south of Cox, the Bevier is said to measure 22 inches and to be 15 feet below the Mulky. The relation of the Mulky coal to the beds just above the top of the strata indicated in the section below is well shown in the bluff on Mud creek at the Monroe county line, where the Tebo bed appears at water level and probably lies only a short distance above the base of the Coal Measures:

		Feet.	*Inches.*
1.	Limestone, dark blue to drab, weathers to slabs, compact	5	....
2.	Clay	1	6
3.	Shale, black, "slaty"	3	6
4.	COAL (Mulky)	1	8
5.	Clay	3	....
6.	Interval, probably containing a thin coal seam (Bevier)	5	....
7.	Clay	3	....
8.	Limestone, blue to light gray, semi-crystalline, irregularly bedded	2	6
9.	Clay	1	4
10.	Limestone, light gray	....	4
11.	Shale, drab, poorly exposed	12	....
12.	Limestone, layer of concretions in shale	....	8
13.	Shale, black, "slaty"	7	....
14.	Limestone, dark blue to drab, compact	....	7
15.	Shale, black, "slaty"	5	....
16.	COAL (Tebo), reported thickness	1	6

Milton.—At Milton, south of Milton near the railroad, and between Milton and Evansville the Mulky coal bed outcrops in the

valleys and is 15 to 24 inches thick. It is intermittently mined for local use at a number of small drifts of which that of T. F. Fowler (S. W. ¼ Sec. 24, T. 54 N., R. 13 W.) was found in operation. At this bank the coal is 19 inches thick and is separated from its cap-rock by 68 inches of shale that is black and lithified at the base and grades upward into softer gray material. The mine is worked longwall and the coal is wedged down after undercutting.

In the Milton district the Bevier is thin and lies only a short distance below the Mulky. South of the Missouri, Kansas, and Texas railroad all coal beds have been removed by the Moberly channel and their places taken by sandstone. Northwest of Milton, however, the Mulky outcrops at several places, and in Sec. 16, what is probably the Summit bed, outcrops with a thickness of 12 to 16 inches, separated from a 40-inch cap-rock of blue limestone by 28 inches of black "slaty" shale. North of Milton, on Flat creek, these two beds may again be seen. In a side tributary from the north (N. E. ¼ S. E. ¼ Sec. 1, T. 54 N., R. 13 W.) two small strip-pits yield the following:

		Feet.	*Inches.*
1.	Shale, drab, sandy	12	....
2.	Limestone, dark blue to drab, compact, vertically jointed	2	6
3.	Clay in upper half and black "slaty" shale in lower	2	6
4.	COAL (Summit)	1	5
5.	Clay and concealed	6	....
6.	Shale, light blue	15	....
7.	Limestone, dark blue to drab, compact, bedded	6	....
8.	Clay in upper part and black "slaty" shale in lower, reported	4	....
9.	COAL (Mulky), reported	1	8

The above section combined with that taken at the county line on Mud creek includes all of the Coal Measures of this vicinity except the basal clays.

Jacksonville.—Exactly how much coal underlies the prairie country around Jacksonville could not be ascertained. The Summit and Mulky coal beds are 13 and 20 inches thick, respectively, at their nearest outcrops on Hoover creek, and are about the same in the breaks of East fork on the opposite side of the divide. The two upper beds, therefore, probably possess these thicknesses under Jacksonville itself. The Bevier bed, only 22 inches thick where it appears in Hoover creek, is much thicker near East fork. This thinning toward the east is probably gradual.

West of Jacksonville, in the eastern tributaries of East fork, the Mulky coal bed is 18 inches thick and lies 14 feet above the Bevier. The Tebo bed lies near water level and is 18 inches thick where the road west from Jacksonville crosses East fork.

In Sec. 5, T. 55 N., R. 14 W. a group of small drifts,* that supply wagon trade during the greater part of the year, work the Bevier on the room and pillar plan and shoot off the solid. Those operated in

*See map of Bevier quadrangle in the report on Macon county, p. 270.

1910 were owned by John Sparkman (Lot 2 of N. W. ¼), David Washington (Lot 1 of N. W. ¼), C. W. Butler (N. E. ¼ S. W. ¼), Henry Dean (N. W. ¼ S. E. ¼), and Daniel Durham (S. E. ¼ S. W. ¼). The roof is a "soapstone" or sandy shale, replaced by sandstone in small areas; the underclay between the coal and the limestone sump-rock is 6 to 24 inches thick. At the Durham and Dean drifts the coal is one to four feet in thickness, being made irregular by a sandstone roof with wavy under surface; at the other mines it averages 50 inches, of which 1 to 13 inches lie below a clay band about one inch thick. The following section was measured by H. A. Wheeler at the Penny bridge over East fork, three miles southwest of Jacksonville:

		Feet.	*Inches.*
1.	Shale, yellow	8	....
2.	Limestone, brown	3 to 5	....
3.	Shale, black, "slaty"	2	....
4.	COAL (Mulky)	1	3
5.	Fire clay	1	....
6.	Limestone	2 to 3	....
7.	Shale, yellow and gray	2 to 3	....
8.	Sandstone	2 to 3	....
9.	COAL (Bevier)	3	....
10.	Fire clay	1	....
11.	Limestone, yellow, thin-bedded	4	....
12.	Interval (shaly sandstone?)	10 to 12	....
13.	Limestone, yellow	6	....
14.	Interval (shale?)	5	....
15.	Shale, soft and gray	15	....
16.	Shale, black, "slaty"	6+	....
17.	COAL (Tebo), as measured by writer near water level	....	8

Cairo.—As at Jacksonville, the exact thickness of the coal beds under the divide near Cairo could not be ascertained. A somewhat unsatisfactory record of a well at the town states that there is one foot of coal at a depth of 97 feet, two feet at 126 feet, six inches at 139 feet, and two feet at 172 feet. Not quite two miles southwest of Cairo (S. E. ¼ Sec. 3) 18 inches of coal, probably the Mulky bed, underlies black "slaty" shale and limestone; the Bevier coal is well developed. Three miles northwest of Cairo (Sec. 27) the Mulky is 16 inches thick and the Bevier is as shown in the following section:

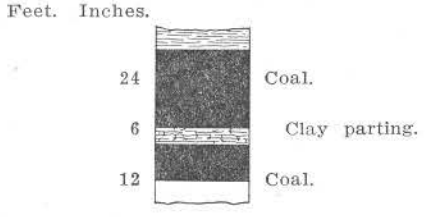

FIG. 72. Section of the Bevier coal bed northwest of Cairo.

About three miles farther west, near East fork, the Bevier coal is occasionally mined at the small G. W. Grady drift (N. W. ¼ S. W. ¼

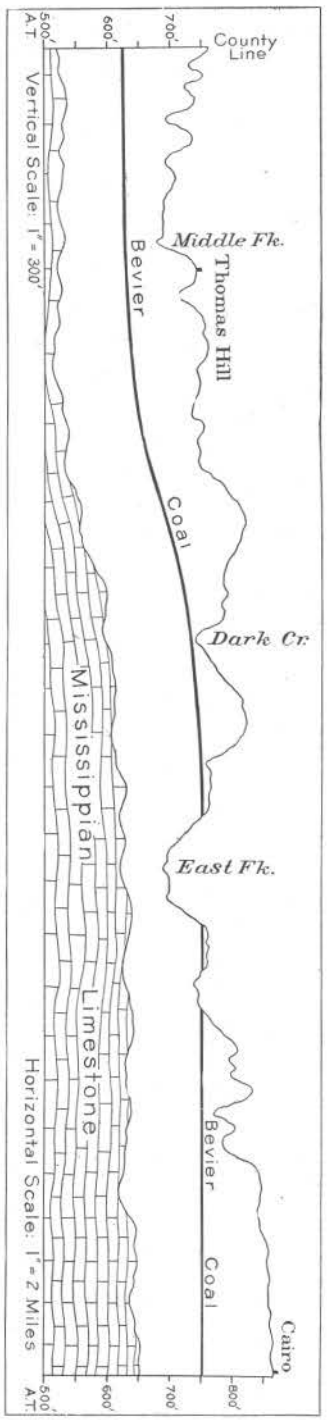

Fig. 73. Diagrammatic cross-section from west to east in northwestern Randolph county.

Sec. 30, T. 55 N., R. 14 W.). The roof is a sandstone that has a slightly uneven lower surface that causes the thickness of the coal to vary from 4 to 6 feet, the average being 54 inches exclusive of two inches of clay 18 inches from the base. The Bevier bed is also mined at the somewhat larger drift of Ernest Foster on a small branch southeast of the Grady (S. W. ¼ N. E. ¼ Sec. 32), where the coal has a shale roof and averages 55 inches exclusive of a three-inch clay parting. One mile south (N. E. ¼ Sec. 5, T. 54 N., R. 14 W.) are some abandoned drifts in which the Bevier coal was four feet thick.

Darkville.—On the divide proper between Middle and East forks (except in the Thomas Hill district)† no outcrops are visible, all coal beds and other rocks being covered by drift except along the main valleys of the forks or comparatively close to them in tributaries. Nevertheless there is reason to believe that much of the divide is underlain with strata similar to those at Huntsville (p 358), though the value of some of the coal (Bevier) may be considerably decreased by the fact that in places it lies very close to the under surface of the drift. In the N. E. ¼ Sec. 2, T. 55 N., R. 15 W., the Bevier bed outcrops 4½ feet thick, but numerous drill records made in the same land section show that it does not everywhere maintain such a thickness. The following section (N. W. corner Sec. 2, T. 55 N., R. 15 W.) illustrates the proximity of the coal and the drift and shows some of the strata below the coal:

†See map of Bevier quadrangle in report on Macon county, p. 270.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift clay	81	3	81	3
2.	COAL (Bevier)	2	3	83	6
3.	Limestone	7	3	90	9
4.	Shale	....	10	91	7
5.	Limestone	1	1	92	8
6.	Shale	6	2	98	10
7.	Limestone	1	4	100	2
8.	Shale	3	3	103	5

In the following record (N. edge W. ½ Lot 4, N. E. ¼ Sec. 2, T. 55 N., R. 15 W.) the Bevier is completely gone because of preglacial erosion; No. 2 of this record is probably one of the limestones lying only a few feet below the Bevier bed:

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift	44	6	44	6
2.	Limestone	3	4	47	10
3.	Sandstone	4	3	52	1
4.	Shale	9	4	61	5
5.	Limestone	....	6	61	11
6.	Shale, dark, "slaty" at base	8	10	70	9
7.	COAL (Tebo?)	1	6	72	3
8.	Shale, red in lower part	19	10	92	1
9.	Sandstone	9	3	101	4
10.	Shale, gray, dark at base	19	1	120	5
11.	COAL	....	2	120	7
12.	"Bed Rock" (Mississippian?)	....	....	....	....

From the county line down the west side of East fork valley the rocks are concealed in most places. Three miles southeast of Darkville are several old drifts and one (S. E. ¼ S. E. ¼ Sec. 26, T. 55 N., R. 15 W.) still intermittently worked by the Webster brothers, in which the Bevier coal is said to be over four feet thick and to bear a clay band two to five inches thick. The roof is a smooth "soapstone" shale and the underclay is about one foot thick and rests, of course, on limestone. Broadhead states that the same coal bed is four feet thick and has a sandstone roof one mile north of Webster's (N. E. ¼ S. E. ¼ Sec. 23). Two miles south of the Webster drift (S. E. ¼ S. W. ¼ Sec. 2, T. 54 N., R. 15 W.) is the small drift of J. S. Adams, in which 41 inches of coal is divided 10 inches from the bottom by about one inch of clay. The roof is a strong clayey sandstone that has a very uneven under surface, so that the thickness of the coal varies somewhat. There are 18 inches of clay between the coal and the limestone sump-rock.

Three miles northwest of Darkville several small mines have been operated on the Bevier bed; and the J. P. Collins slope (N. E. ¼ S. W. ¼ Sec. 8, T. 55 N., R. 15 W.) is now mining 52 inches of coal exclusive of an average of four inches of clay 17 inches from the bottom. The roof is a clay shale of only fair stability. In small ravines near Middle fork, about 1½ miles southwest of the Collins slope, a group of small abandoned mines (N. ½ Secs. 18 and 19) showed coal 4½ to six feet thick with a clay parting of two to 13

inches. In places in the district as much as five feet of clay occupies the interval between the coal and the limestone sump-rock. The Mulky bed was not seen, but is said to be 18 inches thick in parts of the district.

Thomas Hill. ‡—At Thomas Hill a fold in the rocks causes the strata to lie at lower levels than on the north and east, so that the Bevier coal is about 35 feet below the level of Middle fork. This insures sufficient solid cover over the coal in the region near Thomas Hill, and the thickness and purity of the bed will make the district important when railroad facilities are secured. From shaft and outcrop observations Winslow compounded the following section:§

		Feet.
1.	Limestone, compact	3
2.	Shale, black, fissile	2
3.	COAL (Summit)	1½
4.	Concealed, probably shales	13
5.	Limestone, yellowish gray	3
6.	Clay (in bed of river)	3½
7.	Shale, black, fissile (horizon of Mulky coal)	1½
8.	Sandstone, micaceous, friable	8
9.	Shale, sandy	23½
10.	Shale, black	½
11.	COAL, 6-inch clay seam 1½ feet from bottom (Bevier)	4½
12.	Clay	1½
13.	Limestone	(?)

Wheeler gives a section* that differs in minor respects and includes slightly higher limestones. The Summit bed is uncommonly thick here and coal is lacking at the Mulky horizon; west of the bridge, however, there is at least six inches of coal in the Mulky bed. Two shafts are now working in the Bevier seam, both using horse-whim hoists and supplying a large country trade. The Milburn shaft is on the east bank of Middle fork a few rods above the bridge and is 57 feet deep. The Jackson and Harris shaft is three-fourths of a mile west of the bridge and is 50 feet deep. The bed worked is essentially the same at the two mines. It is 47 to 50 inches thick, exclusive of a band of hard dark clay, two to eight inches thick (average, four inches) that lies about 18 inches from the bottom. The coal appears to be of excellent quality, though "sulphur" is moderately abundant. The roof is a clay shale with a thin layer of "slaty" shale at the base; it is fairly satisfactory and will be found to improve as it is explored farther away from the bottom lands. It falls in the entries as far up as the tough hard shale about three feet above the coal. Owing to the deadening effect of the clay parting, shots placed above it do not affect the lower bench, which may then be cut and wedged up so as to produce a large proportion of lump.

Between Middle fork and the Chariton county line the rocks are

‡See map of Bevier quadrangle in report on Macon county.
§A report on the Bevier sheet, Mo. Geol. Survey, 1893, p. 17.
*Clay deposits, Mo. Geol. Survey, vol. XI, 1896, p. 409.

concealed by heavy deposits of drift, and little is known about the coal of the district. From the known occurrences of coal at Thomas Hill and northeast, and at Prairie Hill and Fish Trap Ferry in Chariton county, there is every reason, however, to believe that very similar deposits underlie this divide in greater part and that they will be much less cut up by drift channels than in Darkville district. The Bevier bed lies too low to outcrop anywhere except along Middle fork north of Thomas Hill, and this fact is sufficient to account for the lack of information concerning it.

Moberly.—The Moberly channel, filled with sandstone and shale, passes through the city of Moberly, cutting out all of the important coal beds in a strip two or three miles wide from north to south and of great length from east to west. In the large clay pit, about one mile southwest of Moberly in this channel, more than 50 feet of clay shale is exposed and much more is reported to have been penetrated by the drill. Several holes bored in and near the city have failed to reveal more than very thin coal seams, but Wheeler† gives the following section as found in a shaft one mile north of the Union railroad station, evidently where the north side of the channel is not sufficiently deep to have cut through all of the coal previously deposited:

		Feet.
1.	Clay, glacial	85½
2.	Sandstone	115
3.	COAL	
4.	Clay, potter's	10
5.	Shale, black	30
6.	COAL	3

East of the city for several miles along Coon creek, along the north branch that flows near the railroad and also along the south branch for one mile above the confluence of the two branches in Sec. 33, the massive red sandstones and intercalated shales of the Moberly channel may be seen, at least 75 feet being exposed. Farther up the south branch (N. E. ¼ Sec. 9, T. 53 N., R. 13 W.), however, regular beds of the Coal Measures appear and 16 inches of coal is exposed in the creek bed. Still farther up (N. E. ¼ Sec. 18) a little fuel has been obtained from a thin bed that may be the Summit.

Kimberly.—Kimberly is a small camp halfway between Moberly and Huntsville, north of which the Bevier coal bed outcrops in deep, narrow ravines. One shaft with railroad connections and several mines that haul a large amount of coal to Moberly are working in this district, the demands of the city enabling them to continue operations during the entire year. All the mines work room and pillar and shoot off the solid. The shipping mine is operated by the Eagle Coal Co. on a short spur from the Wabash railroad (N. W. ¼ N. E. ¼ Sec. 34,

†Mo. Geol. Survey, vol. XI, p. 343.

T. 54 N., R. 14 W.). The product is hoisted 95 feet by a small steam plant. The roof is a sandy shale that "shells off" on exposure and requires careful timbering; its under surface is uneven, causing the coal to range in thickness from 30 to 48 inches. The clay band is 2 to 8 inches thick and the underclay 9 inches to the sump-rock.

The Mulky bed is 18 inches thick and lies 15 feet above the Bevier. The Summit is about 12 inches thick.

South of the old Eagle mine, one-half mile south of the new Eagle shaft, the Bevier is replaced with Moberly sandstone. This and other evidence shows that the northern limit of the Moberly channel near Kimberly corresponds roughly with the line of the Wabash railroad. The Collins shaft, sunk years ago on the Moberly channel, penetrated the following strata, of which the upper 203 feet are channel members and the remainder regular beds at low horizons:

		Feet.
1.	Clay and shale	85
2.	Sandstone	116
3.	Conglomerate (limestone, sandstone and shale)	2
4.	Clay	8
5.	Shale	2
6.	COAL	¾
7.	Clay	14
8.	Shale, in part "slaty"	4
9.	COAL, 10 inches to	2

In addition to the Eagle shaft, there may also be mentioned the Williams and Rupp slope (N. E. ¼ N. E. ¼ Sec. 32, T. 54 N., R. 14 W.); Henry Ward shaft, 58 feet deep (N. W. ¼ N. W. ¼ Sec. 34); T. Marriott & Son slope (S. E. ¼ S. W. ¼ Sec. 27; and J. M. Cronan drift (N. E. ¼ S. E. ¼ Sec. 28). The normal thickness of coal at these mines is 40 to 48 inches, but in places the roof of sandy shale cuts down into the bed and reduces its thickness. The clay parting lies about nine inches from the bottom of the coal and averages four inches in thickness, though in many places it is as much as eight inches and at one point between the Marriott and Cronan mines it has the unusual thickness of 18 inches. Along the upper courses of Sugar creek, north of the district just mentioned, the Bevier outcrops with the same characters as at Kimberly. The nature of the strata above the Bevier coal in both districts is shown in the following section measured near the Marriott slope:

		Feet.
1.	Limestone, light blue to gray, semi-crystalline, irregular fracture ("Chætetes")	2+
2.	Shale, light drab	2
3.	Sandstone, dark red, thin-bedded	6
4.	Shale, bluish drab, sandy	10
5.	Limestone, brownish blue to drab, in two beds, compact, vertical fracture ("Rhomboidal")	4
6.	Shale, black, "slaty"	2
7.	COAL (Summit)	1
8.	Clay	2
9.	Limestone, light blue with dark blue spots, in part thin-bedded, sandy	8 to 12

		Feet.
10.	Shale, light-colored	2 to 5
11.	Limestone, blue to drab, massive, compact, much like the "Rhomboidal"	4½
12.	Clay at top, and black, "slaty" shale below	5
13.	COAL (Mulky)	1½
14.	Clay	½
15.	Limestone, dark blue to gray, weathers to nodules	1
16.	Shale, in part sandy, and some sandstone	20
17.	COAL (Bevier)	4
18.	Clay	1
19.	Limestone, very rough upper surface, impure	2

Huntsville.—Huntsville has long been known as a mining center for the Bevier bed, which is nearly four feet thick there.

Huntsville was one of the first districts in which mining was energetically pursued. At first drifts were driven into the seam from the valleys near the city and between it and East fork and Sugar creek; later many shafts were sunk along the railroad from one mile west of Huntsville as far east as Kimberly, were worked out and abandoned. According to shaft records published by Marbut,‡ the upper coal beds are absent near the railroad, though north of it, on the west side of the city and elsewhere, the Mulky bed is 18 inches thick and is separated from the Bevier by about 25 feet of shale and sandstone. Several drillings have been made near Huntsville, and all agree in placing the top of the Mississippian 75 to 90 feet below the Bevier and in reporting nothing workable in the interval.

The only mines having direct railroad connections are shafts 2 and 12 of the Northern Central Coal Co. No. 12 has been recently sunk beside the main line east of Huntsville (S. W. ¼ S. W. ¼ Sec. 31, T. 54 N., R. 14 W.) to take out coal left near old workings on the west. It is 81 feet deep and obtains electric power for hoisting from the plant at No. 2. No. 2 lies one-fourth mile southeast of the Huntsville depot (N. W. ¼ S. E. ¼ Sec. 36) on a short switch from the Wabash. The shaft is 78 feet deep and the equipment includes a geared hoisting engine, four boilers, self-dumping cages, high-speed engine and a generator, six Sullivan mining machines, and two six-ton haulage motors. Additional electric equipment is being installed. The plan of working is room and pillar with bottle-necked rooms, half with machines and half with pick work. The roof is a strong sandy shale with fairly smooth under surface. There are a few "clay slips" in the coal and rolls in the roof. The underclay rests on limestone and is 6 to 15 inches thick. The coal bed is slightly undulatory and averages 43 inches in thickness, exclusive of two inches of hard clay 10 inches from the bottom.

About one mile south of Huntsville the northern edge of the Moberly channel cuts off the coal, but between the city and East fork on the northwest, and Sugar creek on the north a number of drifts and short slopes are situated in the numerous small valleys. Those

‡Mo. Geol. Survey, vol. XII, pt. 2, 1898, pp. 333-334.

near the railroad are the largest producers and ship some coal; the others are small affairs and supply local trade. The coal bed and associated strata are much like those at No. 2 shaft.

Mine.	Location.	Thickness of coal.	Thickness of clay band.
		Inches.	*Inches.*
Diamond Coal Co..	S. W. ¼ N. W. ¼ Sec. 36, T. 54 N., R. 15 W...	42	2 to 6
Wm. Mitchell.....	S. E. ¼ S. E. ¼ Sec. 26, T. 54 N., R. 15 W...	42	3
G. W. Morris.....	S. W. ¼ N. W. ¼ Sec. 25, T. 54 N., R. 15 W...	44	(?)
J. R. May.....	S. W. ¼ N. E. ¼ Sec. 30, T. 54 N., R. 14 W...	45	2½

North of Sugar creek, near Huntsville, the Bevier has its full thickness, but in many places lacks sufficient solid cover. In Sec. 19, T. 54 N., R. 14 W., in the small mines of W. C. Hunt, Zeltner and Patrick, and A. Staple, the roof is a sandy shale of fair stability, the underclay is about one foot thick and the coal measures 42 to 47 inches, with 1 to 10 inches of clay less than one foot from the bottom.

Northwest of Huntsville, on the west side of East fork, the Bevier bed has been found four feet thick in places, but in many areas the cover over it is thin, and careful prospecting should precede any attempt at exploitation. Several drillings have been made to find workable coal beds below the horizon of the Bevier, but so far as known all have been unsuccessful. The Mississippian limestone outcrops in the bed of East fork three miles north of Huntsville (south line Sec. 12, T. 54 N., R. 15 W.). A well two miles northwest of the city (S. W. ¼ N. E. ¼ Sec. 23, T. 54 N., R. 15 W.) struck Mississipian flint at 57 feet, which is about 75 feet below the Bevier. A drilling on the F. M. Hammett farm (near southwest corner Sec. 15, T. 54 N., R. 15 W.) reached the Mississippian at 123 feet and found very little coal below the Bevier, as shown in the following record:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	16	....	16	....
Shale	11	7	27	7
COAL (Bevier)	3	6	31	1
Clay	1	9	32	10
Limestone	3	5	36	3
Shale	3	4	39	7
Limestone	....	9	40	4
Shale	3	8	44	....
Limestone	1	4	45	4
Shale, "slaty"	8	8	54	....
Limestone	....	7	54	7
Shale, "slaty"	5	2	59	9
COAL (Tebo)	1	3	61	....
Shale	15	8	76	8
Limestone	....	7	77	3
Shale	22	1	99	4
Shale, "slaty"	3	6	102	10
COAL (Eureka?)	....	7	103	5
Shale, "slaty" and sandy	20	....	123	5
Limestone (Mississippian?)	4	2	127	7

Randolph Springs.—Between the mines at Huntsville and Randolph Springs outcrops are very scarce and little is known concerning the nature of the coal beds. South and southwest of the village, however, a few occurrences indicate that much of the higher territory is valuable coal land.

North of Randolph Springs the drift conceals the rocks in large areas. Gordon records an outcrop (Sec. 20, T. 54 N., R. 15 W.), apparently at the Bevier horizon, consisting of three feet of coal in thin layers interlaminated with clay and shale. It is probable, however, that the Bevier is of better quality in many places and much of the territory on both sides of Dark creek contains good coal.

Clifton.—Along Muncas creek the Bevier coal lies too low to outcrop and little is known about it. It is reasonable to suppose that it is of nearly the same quality and thickness under at least parts of the divides between Middle fork and lower Muncas and Dark creeks as it is at Thomas Hill on the north and near Salisbury on the west. Years ago a hole about one mile east of Clifton was bored 100 feet without striking coal, but was probably started at too low a level to penetrate the Bevier bed.

AREA SOUTH OF MOBERLY CHANNEL.

Elliott.—In a shaft formerly operated beside the railroad station at Elliott the Bevier bed was four feet thick and lay 146 feet below the surface; the Mulky was 15 inches thick and 17 feet higher, and the Summit 8 to 15 inches thick and 20 feet above the Mulky.* This shaft is now abandoned, but the Northern Central Coal Co. operates a mine (No. 5) two miles west of Elliott (S. W. ¼ N. E. ¼ Sec. 28, T. 53 N., R. 14 W.) on a spur from the Missouri, Kansas and Texas railroad. The equipment is modern and includes a double-hoisting engine, three boilers, a high-speed engine and 100 kw. generator, a six-ton haulage motor, and self-dumping cages. The shaft is 135 feet in depth. There is as much as 5½ feet of coal in places, but the average thickness is 45 inches in addition to a three-inch clay band about 8 inches from the bottom. The underclay rests on limestone and is about 10 inches thick. The roof is excellent for the Bevier bed, consisting of hard sandy shale except locally where black "slaty" shale lies on the coal in small areas. This mine could be worked longwall to advantage, thereby saving a larger proportion of the coal than under the room and pillar plan employed under former managements.

Two miles northeast of No. 5 shaft is the D. T. Bradley mine (N. W. ¼ S. E. ¼ Sec. 15, T. 53 N., R. 14 W.), where the product is hoisted 55 feet by a horse-whim and hauled away in wagons. The

*See Marbut, C. F.: Mo. Geol. Survey, vol. XII, pt. 2, 1898, p. 339, for complete shaft record.

Bevier bed, the one utilized, is nearly four feet thick. This mine lies only a short distance north of the southern edge of the Moberly channel, north of which the principal coal beds are absent for about two miles.

Renick.—J. S. Orris leases from the Northern Central Coal Co. a shaft on the western edge of Renick with a steam-hoisting outfit and shipping connections with the Wabash railroad. The Mulky bed is the one now mined and is 17 to 19 inches thick. It is excellent coal, being comparatively hard and free from "sulphur" and highly valued for domestic use. It has a splendid roof of 52 inches of black "slaty" shale overlain with over four feet of compact gray limestone. The longwall system is employed, the coal coming down over night after being undercut 30 inches. Formerly the Bevier bed, 44 inches thick, was worked from this same shaft; it had an unsatisfactory roof of clay shale, only the lower foot being at all firm.

The Bevier was also once mined at shafts beside the railroad at Renick. The following record of one of the old air-shafts shows the relations of the various beds in this district:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay	50	....	50	....
Limestone, blue	2	....	52	....
Shale, black, "slaty"	....	6	52	6
COAL (Summit)	....	10	53	4
Clay and shale (with limestone?)	22	....	75	4
Limestone, yellow	3	6	78	10
Shale, black, "slaty"	2	....	80	10
COAL (Mulky)	1	6	82	4
Shale, gray	15	....	97	4
COAL, 30 inches Clay, 3 " COAL, 18 " } (Bevier)	4	3	101	7
Clay, six inches to	1	8	103	3

South of Renick, on the upper branches of Roche Perche creek, the members of the above section outcrop and the Bevier is mined at small country banks as far south as the Boone county line and beyond. Two miles southeast of town the thirty-foot shaft of J. Brown (N. W. ¼ S. E. ¼ Sec. 8, T. 52 N., R. 13 W.) and only a few rods distant that of H. A. Slaughter both hoist with horse-whims and both mine the Bevier coal, which is 38 inches thick, exclusive of one inch of clay six inches from the bottom. The Mulky bed is 17 inches thick and is separated from the Bevier by 15 feet of clay shale and from its own limestone cap-rock by five feet of black "slaty" shale.

Farther downstream, south of the railroad (N. E. ¼ Sec. 19, T. 52 N., R. 13 W.), a group of small drifts in the Bevier bed is operated by W. T. White, J. W. Chisholm, and J. Stockton. The bed, which contains only a moderate amount of "sulphur" and few "clay slips," is 41 inches thick and has one inch of clay eight inches from the bottom. The roof is a "soapstone" shale with smooth under-

surface. Broadhead states that a short distance south, in section 30, the Bevier bed is 45 inches thick.

Near the Missouri, Kansas and Texas railroad, on the headwaters of the western branch of Roche Perche creek, is the shallow shaft of W. M. Naylor (N. E. ¼ N. E. ¼ Sec. 14, T. 52 N., R. 14 W.), where hoisting is done by horse-whim and the product hauled away in wagons. The Bevier is 40 inches thick and has the usual one-inch clay parting near the base. The roof is a smooth clay shale of fair stability. Four miles down this branch (S. E. ¼ N. W. ¼ Sec. 31), in a newly opened slope of J. F. Bogie, the Bevier bed is as at the Naylor shaft. The Mulky is said to be 18 inches thick and to lie 30 feet above the Bevier. Another 18-inch bed (Tebo) is reported to lie 25 feet below the Bevier and the Mississippian limestone 75 feet lower.

The divide between Moniteau and Roche Perche creeks, south of the railroad, has recently been drilled and a large acreage of coal land sold to a syndicate. The strata found are shown in the following record of a hole near the county line (N. W. ¼ N. E. ¼ Sec. 35, T. 52 N., R. 14 W.):

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	65	3	65	3
Limestone	2	....	67	3
Shale	21	1	88	4
Limestone	7	....	95	4
Shale	19	8	115	....
Limestone	4	4	119	4
Shale, "slaty"	2	9	122	1
COAL (Summit)	1	3	123	4
Clay	....	6	123	10
Sandstone	13	....	136	10
Limestone	2	....	138	10
Shale, "slaty"	1	....	139	10
COAL (Mulky)	1	....	140	10
Shale, sandy	27	8	168	6
COAL (Bevier)	3	10	172	4
Clay	1	7	173	11

Clark.—So far as known no thick coal has been found at Clark or east and north of the town. It is reported, however, that the Bevier was found to be more than four feet thick at a depth of 180 feet one mile to the west, and that a 26-inch coal seam was found 50 feet above it. It is said that six other holes drilled along a line running west from this for three miles and thence south along the ridge to Rucker disclosed similar thicknesses of coal. These statements are in part corroborated by outcrop observations.

Higbee.—Higbee has been an important coal-producing center for many years and has had near it some large and well-equipped mines that worked the Bevier bed at a depth of about 170 feet below the surface of the prairie lands, as indicated on the map of the Huntsville quadrangle. Shaft sections and descriptions of large mines once operated one mile west and two miles southwest of Higbee and a

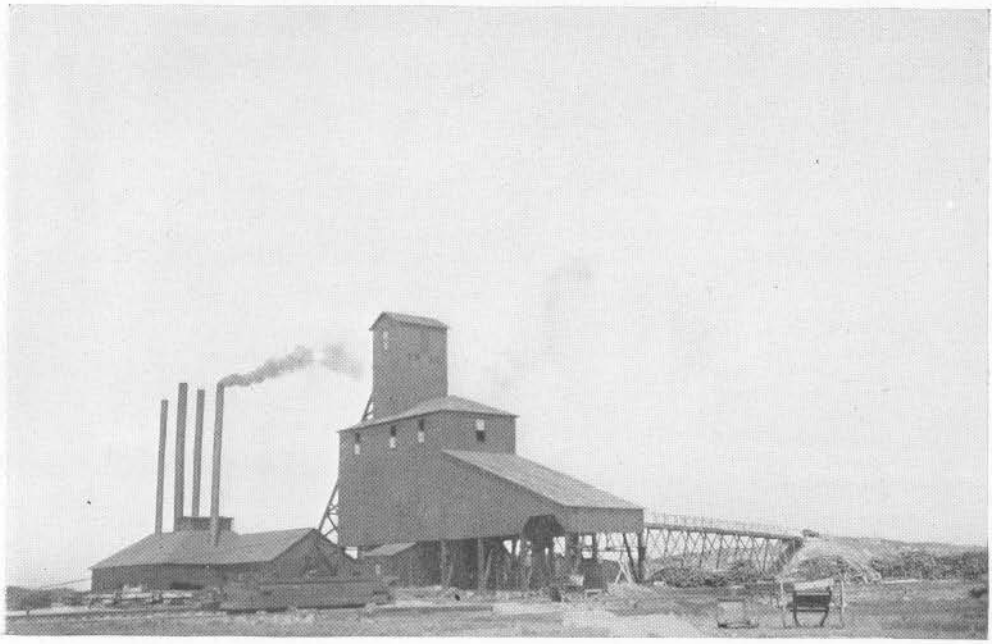

Fig. 1. No. 11 shaft, Northern Central Coal Co., Higbee, Mo.

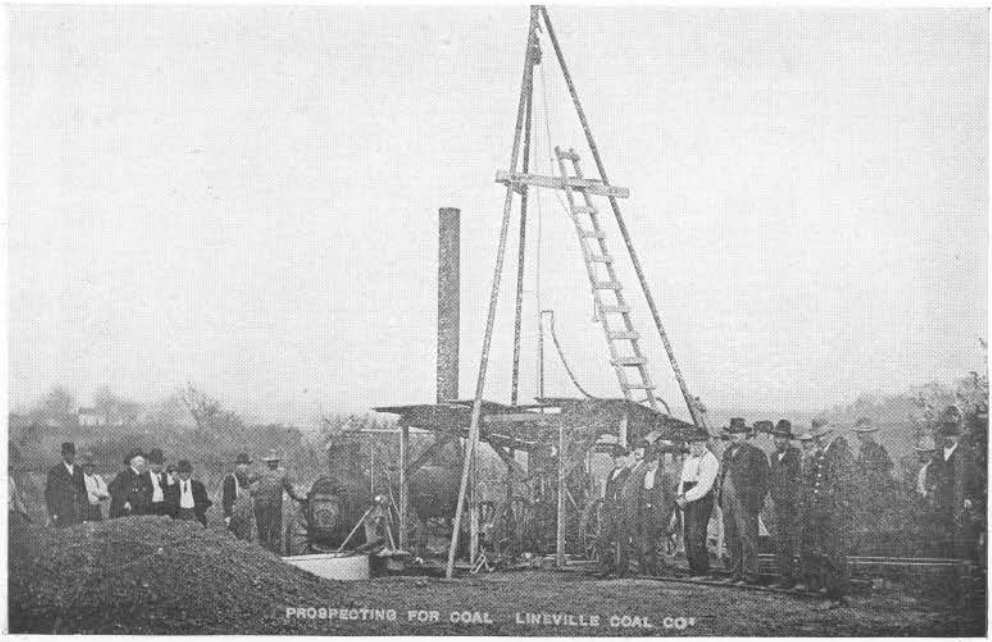

Fig. 2. Diamond drill rig, used in prospecting near Lineville, Mo.

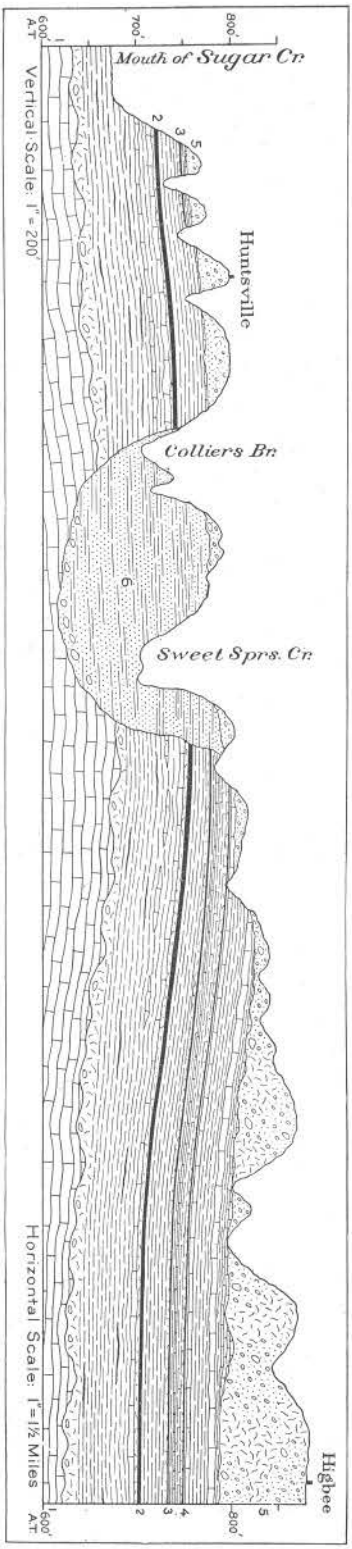

Fig. 74. Cross-section from Huntsville to Higbee. (1) Mississippian limestone. (2) Bevier coal bed. (3) Mulky coal. (4) Summit coal. (5) Glacial drift. (6) Moberly channel.

record of a drill hole north of town have been given elsewhere† and will not be repeated here. A new drilling near the Walton shaft, one-half mile southeast of town (S. W. ¼ S. W. ¼ Sec. 16, T. 52 N., R. 14 W.) shows very well the relationships and thicknesses of the coal beds:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	84	10	84	10
Shale	3	6	88	4
Limestone ("Chætetes".)	7	....	95	4
Shale	19	8	115	....
Limeston .e	4	4	119	4
Shale, "slaty"	2	9	122	1
COAL (Summit)	1	3	123	4
Clay	....	6	123	10
"Conglomerated" (limestone and shale)	13	....	136	10
Limestone	2	....	138	10
Shale, "slaty"	1	....	139	10
COAL (Mulky)	1	....	140	10
Clay	1	....	141	10
Shale, sandy	26	8	168	6
COAL (Bevier)	3	10	172	4
Clay	1	7	173	11

The Walton shaft had just reached the Bevier coal at 184 feet when the region was visited in 1910 and substantial top works and a spur from the Alton were being constructed. It is probable that this mine will produce much coal. The only mine in actual operation near Higbee at that time was the Northern Central No. 11, 1½ miles north of town, near the Missouri, Kansas and Texas railroad (S. W. ¼ S. E. ¼ Sec. 5). This mine is one of the most modern in the State, the equipment including a large first-motion hoist, four boilers, generator and high-speed engine for electric plant, shaker screens, self-dumping cages, aerial tramway on dump, and 10 Sullivan and 3 Goodman mining machines. The double "bottle-necked" plan of the room and

†Mo. Geol. Survey, vol. XII, pt. 2, 1898, pp. 342-343,361.

pillar system is employed. Shipping is done over both the Alton and the Missouri, Kansas and Texas railroads. The shaft is 176 feet deep to the Bevier bed, which has a roof of soft, drab, clay shale that requires much timbering in the roadways. The coal averages in thickness:

	Inches.
COAL, upper six inches dirty	34
Pyrite	1
COAL	8
Clay, nothing to	12
Limestone, upper surface uneven	....

East of Higbee, on Moniteau creek and its tributaries, the strata penetrated in the upper part of the drilling at the Walton shaft and described in more detail in the general section of the county, outcrop in many places. Owing to a slight dip down stream the Bevier coal remains below the level of Moniteau creek as far as the Howard county line and beyond, but the Summit bed outcrops conspicuously beneath its resistent cap-rock. The latter coal seam is 19 inches thick one mile north of the county line, 13 inches, 1½ miles north, and eight inches, two miles farther upstream, thus showing a gradual thinning to the north. The Mulky, on the other hand, thickens and thins with no apparent regularity in this part of the county, averaging perhaps 16 inches. North of Higbee (N. W. ¼ Sec. 6, T. 52 N., R. 14 W., and N. W. ¼ S. W. ¼ sec. 30, T. 53 N., R. 14 W.) outcrops of the Summit show only 10 inches to one foot of coal.

Yates.—One mile east of Yates, beside the tracks of the Alton railroad, is shaft No. 6 of the Northern Central Coal Co., which is 130 feet deep to the Bevier bed, 40 inches in thickness. This mine has not been operated for some time and may not be reopened. One-half mile northeast of Yates (N. E. ¼ S. W. ¼ Sec. 10, T. 52 N., R. 15 W.), however, the same company now works its mine No. 10, which has a shaft 65 feet deep, and is connected with the Alton by a short spur. The equipment includes a geared hoisting engine, one boiler, self-dumping cages, and shaker screens. The bed utilized, the Bevier, is a good shooting coal and is worked room and pillar. The coal is of good quality and is about 41 inches thick, exclusive of 1½ inches of sandy, pyritiferous clay 10 inches from the bottom. The roof is a "soapstone" shale that is weak in places and fairly satisfactory in others. The underclay averages 10 inches in thickness and rests on the usual limestone sump-rock. On the west side of the shaft the coal dips rather steeply to the west, but farther on becomes again nearly horizontal.

In 1910 a drilling was made from the bottom of No. 10 air shaft to a depth of 509½ feet, of which only the upper 75 feet was in Coal Measures. No coal was found below the Bevier bed. A combination surface near mine No. 10 furnishes the following complete record of the Pennsylvanian stratigraphy in the vicinity:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	30	7	30	7
Shale, soft	18	....	48	7
Limestone	....	7	49	2
Shale	25	2	74	4
COAL (Bevier)	3	8	78	....
Clay	4	....	82	....
Limestone	5	....	87	....
Shale, gray, sandy	10	....	97	....
Shale, black and gray, "slaty"	11	....	108	....
Shale, clayey	38	....	146	....
Shale, black, "slaty"	6	....	152	....
Shale, streaked "slaty" and clayey	5	....	157	....
Flint and limestone (Mississippian)	....	....	....	....

One mile southwest of Yates, beside the railroad (N. W. ¼ S. W. ¼ Sec. 16, T. 52 N., R. 15 W.), a shaft was sunk through 77 feet of drift and seven of sandstone without encountering coal; a hole was then drilled 92 feet deeper, but the only coal found was 18 inches at 134 feet from the surface.* The absence of the Bevier and other coal beds here does not necessarily mean that they are not present under neighboring lands.

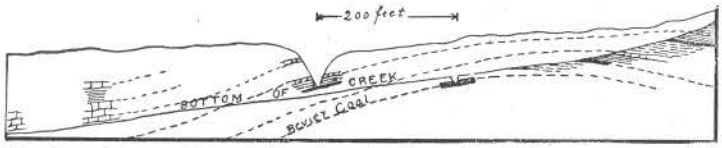

FIG. 75. Showing southward dip of rocks from the Hudson outcrop. (Marbut.)

About a mile and a half southeast of Yates (N. E. ¼ Sec. 22), at the old Hudson outcrop, an arch brings the Summit coal, one foot thick, and the Mulky, 16 inches thick, above creek level, and the Bevier, which is four feet thick, almost up to the bed of the stream, where it has been stripped. Both above and below this point these beds lie below drainage level.

About a mile and a half north of Yates the Bevier bed is reached at 22 feet by the country shaft of A. Stallman, leased by Clem and Demort (S. E. ¼ S. W. ¼ Sec. 3). The coal is 43 inches thick, exclusive of one inch of clay 11 inches from the bottom. The roof is a clay shale of fair stability, and the underclay is four feet thick. The Mulky bed is reported to be 18 inches thick and to lie 30 feet above the Bevier. From this point down Coal creek, on the next creek west, on Turner's fork, and on Silver creek nearly to the Chariton county line, the Bevier bed lies only a few feet above or below drainage level.

One mile north of the Stallman shaft the Bevier is finely exposed at the base of a bluff and is worked at the two small country drifts of M. O'Brien (W. ½ S. E. ¼ Sec. 34, T. 53 N., R. 15 W.), where the coal is of very good quality. Mr. O'Brien reports that in dry seasons

*For complete record see Marbut, Mo. Geol. Survey, vol. XII, pt. 2, p. 345.

he has taken coal from a bed four feet thick that lies just below the Bevier. Such a thickness must be only local in occurrence, as it has not been observed in outcrops or drillings in other parts of the county or in the drilling in the Yates shaft only two miles south. The writer was able to see only the top of this lower bed and measured the following section above it:

		Feet.	*Inches.*
1.	Shale, drab, a fair roof	17	....
2.	COAL, 34 inches Clay, 1 inch COAL, 14 inches (Bevier)	4	1
3.	Clay	1	6
4.	Limestone, weathers unevenly	2	6
5.	Shale	9	....
6.	Limestone, compact, homogeneous	....	8
7.	Shale	1	....
8.	COAL, reported	4	....

Broadhead states that below O'Brien's (Sec. 33, T. 53 N., R. 15 W.) the Bevier outcrops in the bed of Silver creek and is variable in thickness, though commonly measuring only 20 inches (?); and that northeast of O'Brien's (N. E. ¼ N. W. ¼ Sec. 26, T. 53 N., R. 15 W.) it consists of four feet of good coal and a five-inch parting of hard clay. Neither the Summit nor the Macon City beds appear to be of workable thickness in this district.

Roanoke.—The rocks exposed near Roanoke are described in the report on Howard county, and remarks there made in regard to the Armstrong district (p. 210) apply here. North of Roanoke in Silver creek, however, rocks as low as the Bevier bed are exposed in a few places. In Sec. 36, T. 53 N., R. 16 W. the Bevier lies at water level, and one-half mile east it is nine feet above the water and is only 16 inches thick. Apparently it is somewhat variable in thickness in this area, but is probably as much as three feet or more at many places not yet located. Higher beds are not of importance, though in one place the Summit is 18 inches thick; and the status of lower beds is unknown, with the probability that they are also negligible. Marbut mentions the old Cross drift (N. E. ¼ N. E. ¼ Sec. 34, T. 53 N., R. 16 W.), where there is a coal bed that lies near the base of the "Chætetes Limestone" and about 15 feet above the Summit coal bed. This bed is said to be two to five feet in thickness and must be of small lateral extent, for a trace of coal smut is the only carbonaceous material that appears at this horizon in other parts of the county.

RAY COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....349,601 TONS.

Since very early times coal has been mined at Camden, Richmond and other places in Ray county. During the last decade or two the growth of the industry has been steady and consistent, until today the region is recognized as one of the most important in the State. Shipping mines are now located near Richmond, Camden, Fleming and Swanwick, and local ones near Vibbard, Knoxville, Morton, Lakeview and Orrick, and the product is shipped to St. Joseph, Kansas City and other points in northern Kansas and to northwestern Missouri.

All the coal mined is from the Lexington bed, which outcrops in the Missouri bluffs in the southeastern part of the county and lies within easy shafting distance in a large area. Although the bed averages slightly less than two feet in thickness, the exceptional quality of the coal and the ideal conditions under which it may be mined on the longwall system enable operators to compete with the thicker coals of other fields. The propinquity of large centers of consumption is also an important factor.

Longwall with face track is the only system of mining practiced. Where the overlying shale is very thin, as at Richmond, timber props are used, though the great strength of the cap-rock renders close timbering unnecessary. Rock shot down to make room in the entries is used for building "gob" walls. At Camden the "block slate" can be used to prop behind the faces. A limestone bottom-rock a short distance below the coal prevents serious trouble with the underclay. The use of motor haulage and mining machines is exceptional.

As in Lafayette county, the Lexington bed of Ray may be regarded as being of two closely related types. In most of the districts the coal lies in two benches divided by a clay parting about 2 inches thick, and is separated from a limestone cap-rock by 8 inches or less of black "slaty" shale. In the Knoxville and Richmond districts the cap-rock commonly lies directly on the coal. At Camden and Fleming, however, there is everywhere about 10 inches of "slaty" shale between the coal and the cap-rock, and the clay parting cannot be found. Here and elsewhere another persistent parting commonly lies 2 to 4 inches from the bottom of the coal, but it is less than one-half inch thick and is composed of pyrite or very pyritiferous clay. In all districts the amount of visible pyrite and other impurities is small. White gypsum

*Some measurements of the coal were made by G. C. Broadhead (Mo. Geol. Survey, Report for 1872, pt. 2, pp. 63-71, 83-86). Detailed reports with maps showing the topography and geology were published by C. F. Marbut (Richmond and Lexington sheets, Vol. XII, pt. 2, of the Missouri Geol. Survey, 1898); the maps are republished in revised form in this volume. The topography of the western half of the county is shown on the Independence quadrangle of the U. S. Geol. Survey.

scale is present in thin vertical films. Streaks and lenses of mother coal are rather common in places, but do not impair the quality of the bed.

One of the chief difficulties encountered, especially west of Richmond, at Lakeview, and in a few country districts, is what is termed "faulty coal." Along some working faces the upper bench of coal is nearly or completely gone, its place being taken by the roofing material, and in some places the roof may even cut far down into the lower bench. In the principal producing mines, areas of "faulty" coal are of very small extent.

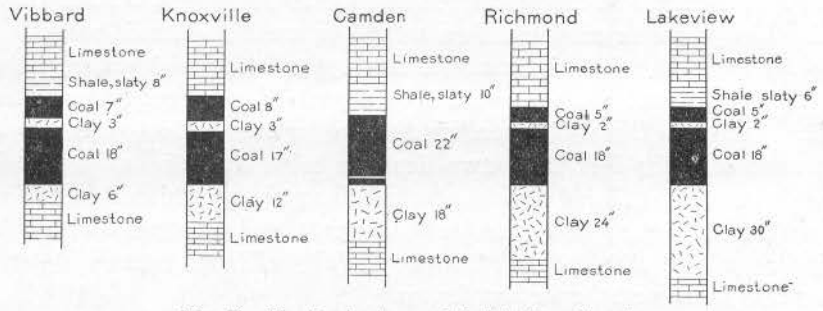

Fig. 76. The Lexington coal bed in Ray County.

Aside from deposits of loose drift material, the surface rocks in the western part of Ray county and on the ridges in the northeast include thick beds of limestone, which belong to the Lansing formation and the Kansas City limestone, and which constitute the basal portion of the Missouri group. According to F. C. Greene these formations include:

THE MISSOURI GROUP IN RAY COUNTY.

		Feet.
Lansing formation—		
1.	Limestone, blue, weathering buff, cherty, not known to outcrop, but probably caps the divide at Lawson	10
2.	Shale and sandstone, with thin limestone in middle	60 to 70
Kansas City limestone—		
3.	Limestone, light gray, crystalline, thin-bedded	7 to 10
4.	Shale, sandy, with 0 to 6 inches of COAL near middle	25
5.	Limestone, dark gray, weathering buff, thin-bedded, locally enclosing one foot of black, "slaty" shale	6
6.	Shale enclosing micaceous sandstone	14 to 20
7.	Limestone, gray	2 to 10
8.	Shale, drab to red, argillaceous	15 to 20
9.	Limestone, gray, sub-oolitic	3
10.	Shale, with thin beds of limestone, especially near base	20 to 30
11.	Limestone, blue, weathering buff, cherty at top	14 to 20
12.	Shale, black and "slaty" in middle	10 to 15
13.	Limestone, gray, oolitic, nodular at top (Bethany Falls)	20
14.	Shale, blue at top, black and "slaty" below	3
15.	Limestone, in two thin layers	1
16.	Shale	5 to 15
17.	Limestone, gray (Hertha)	4 to 6

The Lexington coal bed lies about 200 feet below the Hertha limestone, which forms the base of the Missouri group.

The Des Moines group, which lies below the Missouri group, includes the Pleasanton shale, Henrietta formation, and Cherokee shale.

The Pleasanton consists chiefly of shale and sandstone and outcrops along the Missouri bluffs and on the slopes below the escarpment formed by the basal beds of the Missouri group in the eastern half of the county.

The Henrietta formation includes several conspicuous limestones with interbedded shales, and appears in a narrow strip of country just above the outcrop of the Lexington coal. The typical succession of strata in these two formations is shown in the records of the Knoxville and the Mercantile Coal Company's shafts given in this report.

Only a few feet of the top of the Cherokee formation is exposed in Ray county, but the underlying shale, clay, and sandstone of which it is chiefly composed, are well shown in the record of a drilling made near old mine No. 3 of the Richmond and Camden Coal Co., south of Richmond. In other parts of the State the Cherokee is the formation which contains the thicker coal beds. In Ray county only the Bevier appears to be workable, and so far as known it is only 18 inches thick, though it may be thicker in basins in the large unexplored parts of the county. As shown by the record just mentioned, the Cherokee is 354 feet thick. In a hole drilled 4 miles north of Orrick (N. E. ¼ N. E. ¼ Sec. 34, T. 52 N., R. 29 W.) it was 403 feet thick† and in one 3 miles south of Ovid (N. E. ¼ S. E. ¼ Sec. 2, T. 53 N., R. 27 W.) 349 feet. No coal can lie below the Cherokee formation, for it rests upon thick beds of flinty limestone belonging to the Mississippian series.

The Lexington coal horizon underlies all of the county except the flood plain of Missouri river. After excluding probable "faulty" areas, where the coal is less than 14 inches thick, there remains about 320 square miles in which this bed averages 20 inches. The Bevier, the only other workable bed known, lies 113 feet below the Lexington and probably maintains an average of 18 inches under at least half the county. The following table is based on an estimate of 1800 tons of coal per acre-foot:

TOTAL ORIGINAL TONNAGE OF RAY COUNTY.

Lexington bed	614,400,000 tons
Bevier bed	483,840,000 "
Total	1,098,240,000 tons

Of this total, as well as can be estimated from imperfect records, about 7,809,000 tons has been mined and utilized. In a recent law suit

†Record published by Broadhead (Mo. Geol. Survey, Rept. for 1872, pt. 2, p. 84). The identification of coal beds in both this deep well and the one near Ovid was too imperfect to be used in estimating the coal resources of the region.

it was held that 3,485 tons of coal could be recovered from an acre of the Lexington coal in the Richmond district. Mining men claim, however, that 3,000 tons would be a high estimate. In the Camden field, operators estimate a yield of 2,600 tons per acre in actual practice.

DETAILED MENTION.

Vibbard.—Schooler and Bates have recently sunk a one-compartment shaft to the Lexington bed near the railroad, one-half mile south of Vibbard. The "spotted rock" (Bethany Falls limestone) was reached at 154 feet and was found to be 18 feet thick. The Lexington coal was reached at a depth of 400 feet. Hoisting is done with a small upright engine. Connections had not been made with the railroad, but it was the intention to sink a larger shaft and install a shipping plant. In appearance the Lexington coal is of exceptionally good quality here and the thickness of the bed is not affected by irregularities. Very little pyrite is visible, though white gypsum and calcite scale may be seen in the joints.

LEXINGTON BED AT VIBBARD.

	Feet.	*Inches.*
Shale, blue	30	....
Limestone	12	....
Shale, blue	5	....
Limestone, thin-bedded at base, with shale partings	7	....
Shale, black, "slaty" ("block slate")	....	8
Shale, gray, not "slaty," full of shells ("gray bat")	....	0 to 6
COAL	....	7
Clay, with many coal streaks	....	3
COAL	1	6
Clay	....	2 to 8
Limestone, with uneven top	....	....

Knoxville.—The Lexington coal is mined by Hugh Blair from a deep shaft at Knoxville (N. E. ¼ S. E. ¼ Sec. 34, T. 54 N., R. 28 W.), the product being hoisted 188 feet by horse-power and sold to the local trade. Entries are well brushed and working places are high and comfortable. The succession of strata in this part of the county is shown by the following record furnished by James and Robert Blair, combined with detailed measurements made in the mine:

RECORD OF KNOXVILLE SHAFT.

Top of shaft at level of base of Kansas City limestone.

	Thickness. *Feet.*	*Inches.*	Depth. *Feet.*	*Inches.*
Pleasanton shale—				
Shale, blue	11	....	11	....
Shale, red	9	....	20	....
Sandstone	50	....	70	....
Shale	15	....	85	....
Limestone	8	....	93	....
Sandstone	7	....	100	....
"Black seam"	....	8	100	8
Clay	2	4	103	....

RECORD OF KNOXVILLE SHAFT—Continued.

	Thickness.		Depth.	
Pleasanton shale—Continued.	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Shale, red	11	....	114	....
Shale, sandy	11	....	125	....
Shale, red	13	....	138	....
Limestone	....	6	138	6
Clay	2	6	141	....
Henrietta formation—				
Limestone	2	6	143	6
Clay, shaly	3	6	147	....
Limestone	4	6	151	6
Shale, sandy	3	....	154	6
Sandstone	10	....	164	6
Shale	9	....	173	6
"Slaty" shale and clay	1	6	175	....
Limestone	4	6	179	6
Shale, sandy	2	6	182	....
Limestone, cap-rock	4	6	186	6
Cherokee shale—				
COAL	....	8	187	2
Clay, with coal streaks	....	3	187	5
COAL	1	5	188	10
Clay	1	....	189	10

The Lexington coal is regular at the thicknesses shown, though in a few places the upper bench may be absent or as much as 14 inches thick, and the lower varies from 15 to 20 inches. In places one foot or less of black "slaty" shale intervenes between the coal and the cap-rock. Lenses of tough gray shale, three feet or less thick, rest here and there on the coal. The latter is of fine appearance, much like that at Vibbard, and has less visible pyrite than that at Richmond. It is noticeably blocky and lacks horizontal parting planes.

Three and one-half miles southwest of Knoxville, a recent drilling for oil on the land of Steven Mullin found apparently the full thickness of the Lexington coal at a depth of 172 feet, or 204 feet below the base of the Missouri group exposed in the hillside above the drill hole.

Three miles east of Knoxville and 12 miles north of Richmond (S. W. ¼ N. E. ¼ Sec. 32, T. 54 N., R. 27 W.) is the shaft of Wm. Bisbee. Coal from the Lexington bed is hoisted 147 feet with a small steam plant. The coal and associated rocks are much like those at Knoxville, except that the former is much more irregular in thickness. The uneven lower surface of the cap-rock causes the coal above the clay band to be cut out in most of the mine and that below the clay has also been partly removed in places. This part of the Lexington appears to be much like that at Swanwick.

Ovid.—The old Sater shaft was formerly worked north of Ovid, on Mud creek (S. W. ¼ S. E. ¼ Sec. 13, T. 54 N., R. 27 W.), where the Lexington bed was at its full thickness. (See Fig. 77.) Further down Mud creek, one mile north of Tinneys grove (Sec. 2, T. 54 N., R. 26 W.), a bed that Marbut somewhat doubtfully refers to the Lexington horizon, was only two inches thick where penetrated by a shaft.

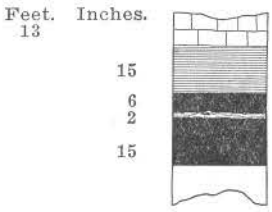

FIG. 77. The Lexington coal bed north of Ovid.

In a drilling for oil made by the Western Oil and Development Co. 3 miles south of Ovid (N. E. ¼ S. E. ¼ Sec. 2, T. 53 N., R. 27 W.), starting at or near the base of the Kansas City formation, three feet of coal was recorded at the Lexington horizon at a depth of 205 feet, but this thickness probably includes the overlying black shale and all or part of the underclay. The thick Mississippian limestone, the lower limit of coal, was reached at 554 feet. Between the Lexington and the Mississippian no coal was found, the strata recorded being chiefly shales, with some sandstone. The imperfections inherent in a churn drill record make it possible that thin coal beds like those in the diamond drill record at Richmond were penetrated and not detected.

Orrick.—At the old town of Albany, one-half mile north of Orrick, the Albany Coal Co. operates a small mine, hoisting by horse-power. The bed mined is the Lexington and is quite regular in thickness except at one portion of the face where it measures as much as 36 inches. The mine is wet, as it is at the edge of the river flood plain. Between the hoisting and air shafts there is a northwesterly dip of one foot in 60.

LEXINGTON BED AT ALBANY MINE, ORRICK.

	Feet.	*Inches.*
Gravel and sandstone	48	....
Limestone	4	....
Shale	4	....
Limestone	8	....
Shale, black, "slaty" ("block slate")	....	7
Clay, carbonaceous ("black jack")	....	0 to 3
COAL	1	10
Clay, with streaks of coal	....	0 to 6
Clay, light drab	....	0 to 18
Limestone	....	....

Fleming.—On the west side of Fleming (N. W. ¼ S. E. ¼ Sec. 29) a large shipping mine, No. 50 of the Central Coal and Coke Co., has a shaft 81 feet deep and a working face extending 5,000 feet northeast and 4,000 feet north from its bottom. The mine is equipped with a steam plant for hoisting and an electric plant to furnish power for electric lights, two haulage motors, and a number of chain mining machines.

Between the railroads, on the east side of Fleming, the shipping mine of the Martin-Hubbell-Osborne Coal Co., No. 7, has a shaft 100

feet deep and a working face extending 1,100 feet north and east and 800 feet west from the shaft. The coal beds at this mine and at Central No. 50 are practically identical in detail and are very regular.

LEXINGTON BED AT FLEMING.

	Feet.	*Inches.*
Limestone	11	....
Shale, white	4	....
Limestone, cap-rock	9	....
Shale, black, "slaty" ("block slate")	....	8
Clay, pyritiferous, full of shells	....	1
COAL (Lexington)	1	9
Clay, light gray except dark streak at top	....	6 to 36
Limestone	....	....

Camden.—One mile southwest of Camden, beside the railroads (S. W. ¼ S. W. ¼ Sec. 27), two mines, Nos. 1 and 2, of the Richmond and Camden Coal Co., have shafts 50 feet deep to the Lexington bed, showing that this bed lies nearly 50 feet higher than at No. 7 mine on the east side of Fleming, only one mile farther west. Both mines have steam hoists and ship considerable coal. The details of the coal bed and associated strata are the same as at the Fleming mines, though the cap-rock is said to be only 6 feet thick.

Mr. Pickering reports that he found in drilling in lower Camden 7 inches of coal (Mulky) with 14 inches of "slaty" shale and a limestone cap-rock above it. Forty feet lower was one foot of coal (Bevier) overlain with 9 inches of limestone and considerable sandstone and shale. The Mulky was 45 feet and the Bevier 95 feet below the Lexington coal.

Two mines, located about one mile northeast of Camden, near the edge of the bluffs (N. W. ¼ N. W. ¼ Sec. 24), ship over a short spur from the Santa Fe. The shaft of the Pickering Coal Co., mine No. 4, is 53 feet deep, and that of the Martin-Osborne Coal Co., mine No. 3, 43 feet. Both mines have small steam hoists and work west. The faces are connected. The coal bed and its associations are the same as at the Fleming mines, except that the cap-rock measures 11 feet, the "block slate" 10 inches, and the "black jack" resting on the coal three inches.

Two miles northeast of these mines (S. E. ¼ N. E. ¼ Sec. 12) is the 73-foot shaft of the Fowler Coal and Mining Co., mine No. 2, on a spur from the Santa Fe. This is a comparatively new mine, hoisting by steam power, with a circular face 500 feet from the shaft. In this locality the transition between the typical Lexington bed of the Camden district and the same bed at Richmond may be seen. The upper bench of coal found at Richmond and absent at Camden is present in the greater part of the mine, and there is a corresponding thinning of the Camden "block slate."

LEXINGTON BED AT FOWLER MINE, BETWEEN CAMDEN AND RICHMOND.

	Feet.	*Inches.*
Limestone	7	....
Shale, black	5	....
Limestone	1	....
Shale, white	5	....
Limestone, dark gray above, light gray below, cap-rock	5	....
Shale, gray, with shells ("bat")	....	2
Shale, black, "slaty" ("block slate")	....	2 to 6
COAL	....	5
Clay	....	2
COAL	1	6
Clay	....	6 to 36
Limestone	....	....

Richmond.—The city of Richmond has been well known for many years for the large amount of coal it produces and sells in many parts of northern Missouri. As in the rest of Ray county, the Lexington is the only bed mined. Shipping mines are located on the Santa Fe and on a long spur known as the Belt Line, or the Richmond and Henrietta railroad, which encircles the western and northern sides of the city. In addition there are a few small mines in the surrounding country. From southwest to northeast the shipping mines on the Belt Line are: (1) Martin and Hubbell, mine No. 22, shaft 80 feet, steam hoist, electric power plant for three drag mining machines; (2) Wm. Pence, mine No. 15, shaft 80 feet, steam hoist; (3) Krispin and Ward, mine No. 21, shaft 84 feet, horse-whim hoist, and (4) Ray County Coal Co., mine No. 23, shaft 55 feet, steam hoist. In the mines farthest west the cap-rock cuts down into the coal for short distances along the faces, the coal being quite regular and the roof smooth elsewhere. At the Ray County mine the cap-rock is abnormally thin in one part of the workings and the solid cover slight, causing falls and letting in considerable water.

Beside the Santa Fe railroad, within a mile and a half west of Richmond, are the following from east to west: (1) Crawford and Wilson, mine No. 8, shaft 95 feet; (2) Pickering, mine No. 9, shaft 92 feet; (3) Pickering, mine No. 11, shaft 95 feet, connected with No. 9 for escape and ventilation; (4) Martin and Hubbell, mine No. 10, shaft 95 feet; (5) Calnen and Blair, mine No. 18 (N. E. ¼ N. E. ¼ Sec. 35), shaft 120 feet, and (6) Richmond and Camden, mine No. 12 (N. W. ¼ N. E. ¼ Sec. 35), shaft 120 feet. All these mines hoist by steam power, ship most of their product, and have inexpensive though adequate equipments. They have worked out considerable territory in the twenty years or more that most of them have been in operation. The Mercantile Coal Co., mine No. 17, is north of the others, on a spur track (N. W. ¼ S. E. ¼ Sec. 25). It hoists 188 feet by steam power and uses part of its product in a clay plant operated at the mine.

The coal in the district west of Richmond is, in general, quite regular, though cut by a few real faults, along which its level is

changed a few feet; the largest noted is one with a downthrow of 6 feet to the west in mine No. 11. "Faulty" places, where the cap-rock partly or completely cuts out the top bench of coal and more rarely part of the lower bench, affect small portions of the working faces. In the west workings of mine No. 11 and in most of Nos. 12 and 18 these "faulty" areas are particularly abundant. The area of low coal evidently embraces the western end of the Richmond district and extends to and beyond Swanwick.

Along the railroad south of Richmond the Richmond and Camden Coal Co. formerly operated a number of large mines that have exhausted their territories. In addition to the Fowler mine, mentioned previously, two shipping plants, the Richmond and Camden, mine No. 14 (N. E. ¼ N. W. ¼ Sec. 31), shaft 100 feet, and the Pence and Calnen, mine No. 6 (N. E. ¼ N. E. ¼ Sec. 12), shaft 100 feet, hoist by steam power. The coal here is of normal thickness except in a very few places. Locally a few inches of shale intervene between it and the cap-rock.

In addition to the large mines, a few without railroad facilities, north, east, and southeast of Richmond, hoist by horse-power and sell their product locally or haul it to the city. Those found in operation were: (1) S. L. Washington (S. E. ¼ N. W. ¼ Sec. 30, T. 52 N., R. 27 W.), shaft 81 feet; (2) Thomas Shea (N. E. ¼ N. E. ¼ Sec. 20), shaft 32 feet; (3) Perry Rice (S. E. ¼ S. W. ¼ Sec. 29), shaft 60 feet; (4) P. J. Keyes, operated by Ottman and Dickson (N. E. ¼ N. W. ¼ Sec. 32), shaft 59 feet; (5) James Watson, operated by Rosewaren and Hawkins (S. E. ¼ N. W. ¼ Sec. 32), shaft 85 feet; (6) Jacobs, operated by Wilkinson and Winigan (S. E. ¼ N. W. ¼ Sec. 4, T. 51 N., R. 27 W.), shaft 65 feet; and (7) H. R. Buchanan (S. W. ¼ S. W. ¼ Sec 5), shaft 26 feet. At all these mines areas of low coal or thin cover appear to be very small. The district southeast of Richmond is probably the one to which operations on a large scale will be transferred when the territory now having railroad communication is exhausted.

The Lexington bed of Richmond is very uniform at all the mines tributary to the city, except in the "faulty" areas mentioned. The general nature of the bed is described on page 233. The details of the bed, as determined from measurements taken in every mine, are as follows:

LEXINGTON BED IN RICHMOND DISTRICT.

	Feet.	*Inches.*
Limestone, dark, gray, somewhat soft, about	3	....
Limestone, light gray, hard, parts from next above when shot	2½ to 3½	....
Shale, "slaty", 0 to 4 inches, commonly absent	....	....
COAL, 0 to 7 inches	....	5
Clay, with coal streaks	....	2
COAL, 17 to 20 inches	1	6
Clay, upper 2 inches dark, remainder light gray	0 to 5	....
Limestone	....	....

The strata above the coal are fairly well shown in the record of the Mercantile Coal Company's shaft, the deepest in the district. The thickness of the limestones above the cap-rock varies considerably, even in adjacent mines.

SHAFT OF MERCANTILE COAL COMPANY, ONE-HALF MILE NORTHWEST OF RICHMOND. TOP ABOUT EIGHTEEN FEET BELOW BASE OF KANSAS CITY LIMESTONE.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil	4	6	4	6
Pleasanton shale—				
Sandstone, very hard	3	....	7	6
Blue rock, very hard (limestone?)	2	8	10	2
Shale, red, soft	4	....	14	2
Shale, white, sandy, hard	52	....	66	2
Shale, blue, sandy	11	....	77	2
Sandstone, light, brown, very hard	5	....	82	2
Shale, white, calcareous, soft	10	....	92	2
Limestone, soft	4	3	96	5
Sandstone, hard and soft	7	....	103	5
Rock, very hard (limestone?)	....	10	104	3
Shale, red, soft	4	6	108	9
Blue rock, soft	6	....	114	9
Henrietta formation—				
Limestone, hard	8	6	123	3
Shale	15	....	138	3
Limestone (?)	5	....	143	3
Clay, soft	5	....	148	3
Shale, blue, calcareous, soft	4	....	152	3
Shale, hard and soft	17	....	159	3
Clay	3	....	172	3
Limestone, very hard	5	8	177	11
Sandstone, hard	1	6	179	5
Limestone, hard	1	....	180	5
Clay top, shale below	2	3	182	8
Limestone, hard	5	6	188	2
Cherokee shale—				
COAL (Lexington)	2	2	190	4
Clay	2	8	193	....
Limestone, very hard	4	....	197	....

Accurate knowledge of the coal and other beds below the Lexington horizon is confined to the following excellent diamond-drill record, furnished by John Gibson, Sr. It contains no coal beds that could compete with the Lexington, though the Bevier bed is of workable thickness:

DEEP DRILLING NEAR OLD RICHMOND AND CAMDEN NO. 3 MINE, TWO MILES SOUTH OF RICHMOND (CENTER WEST LINE S. E. ¼ SEC. 6, T. 51 N., R. 27 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil and clay	40	....	40	....
Henrietta formation—				
Limestone	2	6	42	6
Shale, blue and black	3	....	45	6
Limestone, gray	5	....	50	6
Cherokee shale—				
COAL (Lexington), mined	2	....	52	6
Clay, dark	1	10	54	4
Limestone, with clay balls	5	9	60	1

DEEP DRILLING NEAR OLD RICHMOND AND CAMDEN NO. 3 MINE, TWO MILES SOUTH OF RICHMOND (CENTER WEST LINE S. E. ¼ SEC. 6, T. 51 N., R 27 W.)—Continued.

	Thickness.		Depth.	
Cherokee shale—Continued.	*Feet.*	*Inches.*	*Feet.*	*Inches.*
Shale, light	16	....	76	1
Limestone, gray, hard	1	3	77	4
Shale, black (horizon of Summit coal)	2	....	79	4
Shale, calcareous	2	....	81	4
Shale, light	5	6	86	10
Limestone	2	....	88	10
Shale, greenish, sandy	22	8	111	6
Limestone, hard	....	10	112	4
COAL (Mulky)	....	4	112	8
Shale, light	15	....	127	8
Sandstone, containing hard balls	4	2	131	10
Shale, sandy	34	....	165	10
COAL (Bevier)	1	6	167	4
Clay	1	6	168	10
Limestone, mixed with clay	4	....	172	10
COAL (Tebo?)	....	4	173	2
Clay, upper half soft, lower hard	7	2	180	4
Shale, sandy	4	....	184	4
Shale, variegated, with clay in lower part	32	....	216	4
Shale, black, "slaty"	....	6	216	10
Shale, and clay, brown and blue	30	....	246	10
Shale, black	1	3	248	1
Clay	5	9	253	10
Sandstone, containing hard balls	5	....	258	10
Shale, black	1	6	260	4
Sandstone	10	....	270	4
Sandstone and shale	9	6	279	10
Shale, black	9	....	288	10
Shale and sandstone, alternating	10	6	299	4
COAL, poor	....	4	299	8
Shale, in part sandy	8	....	307	8
Shale and sandstone	6	....	313	8
Shale, dark	12	....	325	8
Sandstone and shale, dark in upper half	22	....	347	8
Sandstone	2	....	349	8
Shale, dark, "slaty" at base	8	6	358	2
COAL	....	6	358	8
Clay	1	....	359	8
Sandstone and shale	15	....	374	8
"Boulder"	....	5	375	1
Sandstone and shale	8	....	383	1
Sandstone	7	6	390	7
Clay and "boulders"	7	....	397	7
Shale, black	7	....	404	7
Mississippian series (lower limit of coal)—				
Limestone, identified by J. A. Gallaher	5	....	409	7

Swanwick.—Because of the "faulty" nature of the Lexington coal, the only bed known to underlie the district, mining at Swanwick has not been entirely successful. The Maple Hill Coal Co. operates a steam-power shaft beside the railroad one-half mile south of Swanwick. The Lexington bed lies at a depth of 90 feet, 206 feet below the limestone at the base of the Missouri group, which is exposed in the neighboring hills. The upper bench, in most of the workings, is cut down by sags in the cap-rock to a thickness of only 2 or 3 inches, and in places half or more of the lower bench is also lacking. About one-fourth of the working face, however, shows the full thickness of the bed, as follows:

FULL THICKNESS OF LEXINGTON BED AT SWANWICK.

	Feet.	Inches.
Limestone	3 to 5	....
COAL	....	6
Clay	....	2
COAL	....	7
Clay	....	6 to 12
Limestone	6 to 8	....

Morton.—Two miles northwest of Morton, the Lexington coal lies at about the level of Crooked river and has been mined at a number of places for local trade. The only mines in operation in the autumn of 1910 were: (1) A. Hughes, operated by Frank Killion (N. E. ¼ S. W. ¼ Sec. 11, T. 52 N., R. 27 W.), shaft 31 feet, horse-whim hoist, and (2) J. McMillian, operated by Jesse McDaniel (N. W. ¼ S. E. ¼ Sec. 11), drift. Here, too, the coal bed is "faulty," the upper bench being cut out in places by rolls in the roof. Where the bed is of full thickness the section is as follows:

LEXINGTON BED AT HUGHES MINE, FIVE MILES NORTHEAST OF RICHMOND.

	Feet.	Inches.
Limestone, light gray	4	....
Shale, light drab	4	2
Limestone, light gray	4	6
Shale, black, "slaty," 2 to 24 inches, average	....	6
Shale, gray, with shells ("gray bat")	....	0 to 5
COAL	....	6
Clay, 0 to 3 inches, average	....	2
COAL	1	4
Clay	2	....
Limestone	....	....

Lakeview.—Two miles of the bluffs at Lakeview are fairly pitted with drift openings a few feet above the level of the flood plain. Coal is hauled to Hardin and Norborne and supplied to farmers from all of the eastern border of Ray county and the western border of Carroll county. Although many working places are hundreds of feet from the bluffs, cars are commonly pushed out by hand. The cap-rock is seldom shot down and the entries are, therefore, very low. Drifts in the bluffs from east to west are: (1) J. Bryant, John Woodruff operator (N. W. ¼ S. W. ¼ Sec. 13, T. 52 N., R. 26 W.); (2) J. Bryant, Carl King operator; (3) John Sprowl, James Edgar operator; (4) John Sprowl, F. Bucklinger operator; (5) W. L. Clark; (6) F. Huston; (7) J. J. Kallenberger; (8) R. A. King, James Doran operator; and (9) M. J. Loeven (S. E. ¼ S. W. ¼ Sec. 15). J. C. Clark has a slope a short distance back from the bluffs in a small valley (N. W. ¼ S. W. ¼ Sec. 14), and J. J. McCorkendale a 60-foot shaft with horse-whim hoist a short distance northeast (S. E. ¼ N. W. ¼ Sec. 14).

The Lexington, the bed mined, is much like that at Richmond where the entire bed is present, but the district is very "faulty." Although the cap-rock makes an exceedingly strong roof, its lower

surface is uneven and cuts down into the coal. The upper bench of coal is absent in much of the territory, and part or even all of the lower bench is lacking in some of it. Where the full bed is found its average is:

FULL THICKNESS OF LEXINGTON BED NEAR LAKEVIEW.

	Feet.	*Inches.*
Limestone, gray, compact	4	....
Limestone, thin-bedded, with thick partings of shale	10	6
Limestone, light gray above, bluish-gray below, heavy-bedded	3	6
Shale, black, "slaty," 0 to 12 inches	....	6
COAL	....	5
Clay	....	2
COAL	1	6
Clay, 24 to 40 inches	2	6
Limestone	....	....

ST. CHARLES COUNTY.*

Aside from deposits of alluvium and drift the surface strata of nearly the whole of St. Charles county belong to the Mississippian series and are, therefore, barren of coal. West and southwest of St. Charles, however, an outlier of Pennsylvanian coal covers about 10 square miles. Coal has been worked for local use at several points near the city, the thickness of the bed varying from 13 to 30 inches. No mining has been in progress here for many years.

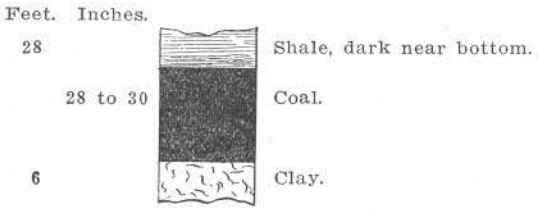

FIG. 78. Coal bed at St. Charles.

ST. CLAIR COUNTY.†

AVERAGE ANNUAL PRODUCTION, 1901-1910.....3,470 TONS.

St. Clair, although situated on the border of the Ozark region, at one time enjoyed a reputation as a coal shipping county. At present its entire output, with possibly a few exceptions, is taken from small country mines and is consumed within its own borders. The eastern outcrop of the Pennsylvanian stretches across the county from the northeast to the southwest corner, but some large outliers are found

*Winslow, Arthur, Preliminary report on coal: Geol. Survey of Missouri, 1891, p. 166. The topography is shown on the St. Charles quadrangle of the U. S. Geol. Survey.

†The coal is briefly described by Arthur Winslow (Prelim. rept. on coal: Mo. Geol. Survey, 1891, pp. 156-159). The topography is shown on the Butler, Clinton, Stockton, and Nevada sheets of the U. S. Geol. Survey.

south of Osage river. A northwesterly dip causes the easternmost Pennsylvanian to outcrop only on the tops of the hills and ridges. In the vicinity of Appleton City Coal Measures extend to a depth of nearly 300 feet. Except in the latter region, the Pennsylvanian consists almost entirely of sandstone, or locally of sandy shale, and is probably in greater part underlain by coal. At Monegaw Springs and other places the sandstone forms prominent cliffs.

The coal mined apparently comes from but two seams, the Tebo, found only near Appleton City, and a bed which lies 100 feet or more lower stratigraphically and which has many of the characters of the Jordan coal of Henry county and may be the equivalent of that bed. It is rather surprising that the strata should exhibit any regularity so near the old shore line, but certain horizons can be easily recognized at widely separated localities. The lower coal bed is generally overlain by a few feet of shale, which in turn is overlain with sandstone, but the latter is locally replaced by sandy, argillaceous, or sandy calcareous shale resembling limestone. As would be expected with a roof of this sort, the thickness of the coal is variable, ranging from less than two to nearly four feet. In some places a good thickness of clay underlies the coal, but in others sandy shale or hard sandstone comes to within a few inches of the coal, and in a few places the coal rests directly upon sandstone.

On a basis of 1,800 tons of coal per acre-foot, the total original tonnage of deposits 14 inches or more in thickness is estimated to be as follows:

	Tons.
Tebo coal, average 20 inches under 14 square miles	26,880,000
Lower coal, average 30 inches under 200 square miles	576,000,000
For the county	602,880,000

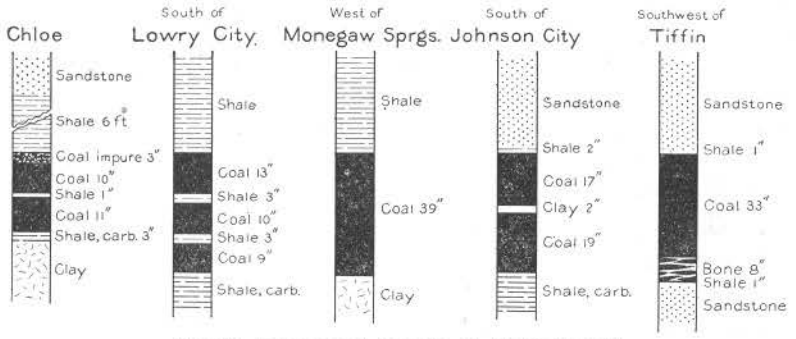

Fig. 79. Lower coal beds in St. Clair County.

DETAILED MENTION.

Chloe.—Surface coal has been found at several places near Chloe. A short distance to the north coal was once stripped, but the locality has apparently been abandoned. Opposite the store at Chloe (lot 4

of the N. W. ¼ Sec. 6, T. 39 N., R. 25 W.) is the local drift of R. S. Phillips. At about the level of the railroad are 21 to 36 inches of coal, overlain by massive red sandstone which is 25 feet thick in the vicinity, and underlain by a hard sandy clay. The coal is of good quality but contains thin scales of gypsum and pyrite. The sandstone roof cuts into the coal in places. The coal does not shoot down easily, nor can the underclay be readily taken up. About two miles northwest of Chloe (lot 7 of the N. W. ¼ Sec. 2, T. 39 N., R. 26 W.), at the old strip-pit of the Dickey Clay Manufacturing Company, the following section was measured:

		Thickness.	
		Feet.	*Inches.*
1.	Sandstone, reddish-brown	10+	....
2.	Shale, light gray	6	....
3.	COAL, dirty	....	3
4.	COAL, hard, with fine streaks of pyrite	....	10
5.	Shale	....	1
6.	COAL	....	11
7.	Clay, very carbonaceous, hard	....	3

In places near the county line the Mississippian limestone projects upward through the coal horizon and outcrops high in the hills.

Lowry City.—The Pennsylvanian near Lowry City consists chiefly of red sandstone, most of which lies above the horizon of the coal mined and is confined to the ridges. It is hardly to be expected that coal will be found under the sandstone over the whole region, as it is certain to be cut out locally by the sandstone. Again, the Mississippian limestone lies but 25 feet below the coal, and projects up through it in places where the original coal swamp once surrounded an ancient island of that material. In many places, where the sandstone rests directly on the coal, it forms a good roof. Where shale intervenes between the coal and sandstone, mining conditions are not so good. The coal contains shale in fine streaks or thin partings. About one mile southeast, on the land of L. L. Griggs (S. W. ¼ S. E. ¼ Sec. 30, T. 39 N., R. 25 W.), J. C. Collins operates a shaft 25 feet deep to 18 inches of coal free from partings. Red massive sandstone forms a good roof with smooth undersurface. A number of old workings, now abandoned, are situated in this vicinity; others lie a little over two miles south of town near the drift of G. W. DeLozier (S. W. ¼ N. E. ¼ Sec. 2, T. 38 N., R. 26 W.). The following section shows the nature of roof and coal at the latter place:

		Thickness.	
		Feet.	*Inches.*
1.	Shale, light, sandy, with impressions of ferns	9+	....
2.	Shale, with coal streaks	....	6
3.	COAL, hard, good	....	13
4.	Shale, dark	....	3
5.	COAL	....	10
6.	Shale, carbonaceous	....	3
7.	COAL, somewhat dirty	....	9
8.	Shale, carbonaceous	1	....
9.	Interval	25	....
10.	Limestone (Mississippian)	....	....

Osceola.—All outcrops in the immediate vicinity of Osceola are of Mississippian rocks, but a few miles west the Pennsylvanian appears in the southern extension of the Lowry City coal field. Mining conditions are much the same as near Lowry. About three miles northwest is the drift of G. W. Humphreys (S. E. ¼ S. E. ¼ Sec. 11, T. 38 N., R. 26 W.) in which the coal is rather full of shale, but is otherwise much the same as that in the DeLozier mine. The Samuel Lewis drift is about four miles north of west of Osceola (N. W. ¼, N. W. ¼ Sec. 14), and the T. L. Greathouse (old Hoover) drifts are a little farther west on the land of T. M. Johnson (N. W. ¼, S. E. ¼ Sec. 15). At the latter place the following section was measured:

		Thickness.	
		Feet.	*Inches.*
1.	Shale, light, very sandy	4	10
2.	Shale, carbonaceous	....	1
3.	COAL, rather dirty	....	9
4.	Shale	....	1
5.	COAL	....	15
6.	Clay, dark, hard	....	....

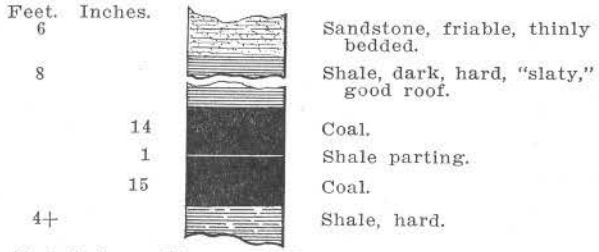

FIG. 80. Coal bed on Johnson land northwest of Osceola.

The upper bench of the coal thickens in places to 14 inches. The coal is undermined and wedged down and sold to the local trade or is hauled into Osceola and Lowry City. Two miles east of Osceola coal has been mined in a small outlier of Pennsylvanian from a shaft about 15 feet deep. This deposit is shown in figure 81.

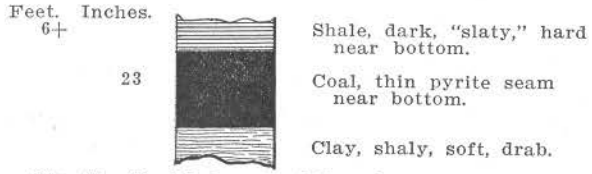

FIG. 81. Coal bed east of Osceola.

Monegaw Springs.—The coal supply of Monegaw Springs is derived from a locality about four miles due west. The bed averages about three feet and the coal is of fairly good quality, though with some pyrite. At the shaft of Robert Moore on land of J. R. Morris (N. W. ¼ S. E. ¼ Sec. 28, T. 38 N., R. 27 W.) the following section is reported:

SHAFT OF ROBERT MOORE, WEST OF MONEGAW SPRINGS.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil, weathered shale and sandstone	19	....	19	....
Shale, hard, calcareous and arenaceous	17	....	36	....
Shale, "slaty"	4	....	40	....
Shale, white or gray, soft at base	....	7	40	7
COAL	2	8	43	3

The bed is worked on the room and pillar plan, and the coal is hoisted by a horse-whim. Two hundred yards northwest is the A. J. Foster shaft (S. E. ¼ N. W. ¼ Sec. 28), in which a similar bed is reported. In the southwest quarter of the same section Robert Allison from time to time operates a stripping and drift. At the entrance of the drift the following section was measured:

	Thickness.	
	Feet.	*Inches.*
Shale, dark, clayey, with thin streaks of coal	2	4
COAL, some pyrite, but fairly good	3	3
Clay	2+	....

The bed in the above section is known as a "40-inch coal," but is said to average about three feet. A track leads to a small tipple at the roadside from which the product is hauled to nearby farms and villages. Two to three miles northwest of this group of mines are those of U. G. Barnett (N. E. ¼ Sec. 19, T. 38 N., R. 27 W.), where the coal is reported three feet thick, and Wm. Allison (middle N. ½ Sec. 20), where it is said to be two feet thick and of excellent quality.

Johnson City.—For many years an area extending from about two miles east and south from Johnson City has been intermittently mined. The coal is apparently the same as that near Lowry City and west of Monegaw Springs, having the same characteristic roof and partings. One-half mile south of the village the mine of I. D. and J. E. Riggs on the land of Simon Shoop (S. W. ¼ N. W. ¼ Sec. 32, T. 39 N., R. 27 W.), reports the following record for the shaft, combined with a detailed measurement of the coal:

SECTION OF SHOOP SHAFT, ONE-HALF MILE SOUTH OF JOHNSON CITY.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Soil	7	....	7	....
2.	Sandstone	5	....	12	....
3.	Shale, drab	25	....	37	....
4.	Shale, soft, taken down in entries to hard top above, 10 to 70 inches, average	1	3	38	3
5.	Shale, blue clay "draw slate," many fern impressions and pyrite concretions	....	5	38	8
6.	COAL, thin scales of pyrite on cleavage faces	1	7	40	3
7.	Shale, black, with streaks of coal	....	2	40	5
8.	COAL	....	4	40	9
9.	Clay, softer than parting No. 7	....	2	40	11
10.	Limestone, concretionary, pyritiferous, 0 to 10 inches, but generally absent	....	....	....	....
11.	COAL	1	3	42	2
12.	Shale, "rash," black, with thin layers of shiny coal	....	6	42	8
13.	Sandstone, in sump	3	....	45	8

In some places beds Nos. 6-11 measured four feet, owing to the thickness of the partings. The coal is mined on the room and pillar plan, being shot one bench at a time. The mine is equipped with two cages, hoisted by a horse-whim, and the product is sold locally or hauled to Appleton City. In the vicinity of the mine are several old strippings.

The mines of Ed. Short are located about 2½ miles south of Johnson City (N. E. ¼ N. W. ¼ Sec. 8, T. 38 N., R. 27 W.). At the new shaft the following was measured:

SHORT SHAFT, TWO AND ONE-HALF MILES SOUTH OF JOHNSON CITY.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Sandstone, red and orange at top, grading below into white, with black streaks parallel to bedding planes, micaceous	34	....	34	....
2.	Shale, drab, full of plants, 2 to 6 inches, where measured	....	2	34	2
3.	COAL, has a little pyrite in thin scales on cleavage faces	1	5	35	9
4.	Clay, soft, 1 to 2 inches	....	2	35	11
5.	COAL	1	7	37	6
6.	Shale, "rash," black, thin layers of coal	....	6	38	....
7.	Interval to Mississippian, reported about	50	....	....	....

In a nearby drift the bed measured 41 inches and it is said to be uniform as to thickness and partings in all the workings in the vicinity. The coal, which is of good quality except for a few pyrite concretions, is mined on the longwall plan. The mine is equipped with two cages, hoisted by horse-power. The coal is sold locally or is hauled to Appleton City and Rockville. In a ravine north of the mine a prospect drift shows the following section:

		Thickness.
		Inches.
1.	Sandstone, not in place	....
2.	Clay, dark	9
3.	Sandstone, shaly	4
4.	COAL	2
5.	Shale, hard, red "paint rock"	30
6.	COAL, 8 feet above that mined in shaft	14

About two miles northeast of Johnson City, in an abandoned stripping known as the "Sunny Slope bank" (S. E. ¼ N. W. ¼ Sec. 28, T. 39 N., R. 27 W.), the overlying shale is washed down over the coal, which, however, is reported to be as follows:

	Feet.	*Inches*
Shale, "blue slate"	17–20	....
COAL	1	6
Clay, black	....	1 to 2
COAL	1	6
Shale, black, "rash"	....	....

It is apparently the same coal as that found south of Johnson City.

Appleton City.—The Tebo coal lies near the surface and has been stripped in many places both east and west of Appleton City, where it presents the same characters as in Henry county to the north and

Bates county to the west. The product is sold in Appleton City. In places a layer of concretionary black limestone wedges in between the coal and the overlying "slate" and somewhat reduces the thickness of the bed. In one place this layer was found 27 inches thick. The coal contains some "sulphur" in concretions that may be removed. At the stripping on the land of John Benson, one mile southwest of town

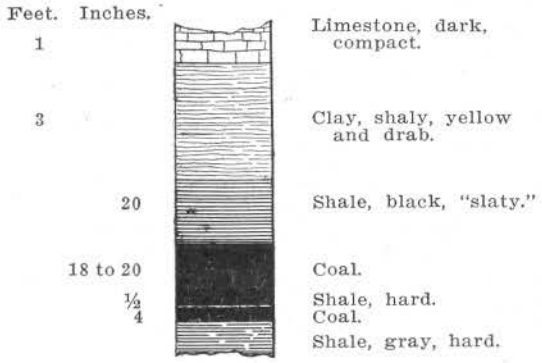

FIG. 82. The Tebo coal bed at Appleton City.

(N. W. ¼ S. W. ¼ Sec. 4, T. 39 N., R. 28 W.), the following section was measured:

	Feet.
Clay and soil	....
Limestone	1½ to 2
Shale, light at top, black at base	2½
Shale, black, "slaty"	2 to 3
COAL (Tebo)	2

At the stripping of James Cook, two miles due east, the coal is 22½ inches thick. Two miles southeast, in the stripping of M. Anderson (S. E. ¼ N. E. ¼ Sec. 8, T. 39 N., R. 28 W.), it is 24 inches thick, and a short distance south of this on the same branch (N. E. ¼ S. E. ¼ Sec. 8), in the stripping of Lee Talbott, it is 21 inches thick.

A drilling 2½ miles southeast of town (½ mile southeast of the Cook stripping) is reported to have found three feet of coal at a depth of 70 feet. Within the city limits a diamond drilling furnished the following record of the Pennsylvanian strata penetrated:

DIAMOND DRILLING AT APPLETON CITY.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Clay, light gray, yellow, and blue	12	....	12	....
Clay, blue, compact, and hard blue shale with pyrites	5	....	17	....
Shale, blue, hard	3	....	20	....
COAL (reported as lignite)	1	....	21	....
Clay	2	....	23	....
Shale	2	....	25	....
Limestone and gray shale	3	10	28	10
Shale, gray	7	2	36	....
Limestone and blue and black shale	22	....	58	....
Shale, blue and gray, sandy at base	17	....	75	....

DIAMOND DRILLING AT APPLETON CITY—Continued.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Shale, light-buff, and shaly sandstone	9	....	84	....
Shale, light gray, sandy	16	....	100	....
Sandstone, gray and red	14	....	114	....
Shale, blue-gray, hard	34	6	148	6
COAL	1	4	149	10
Clay, sandstone, and gray shale	10	2	160	....
Sandstone, gray, and black marly shale	5	....	165	....
Shale, sandy, blue-black	9	6	174	6
COAL	....	6	175	....
Shale, black, and sandstone	22	....	197	....
Shale, blue	30	....	227	....
COAL	....	10	227	10
Clay, blue sandy shale, soft white sandstone, and coarse, gray, calcareous sandstone	15	2	243	....
Sandstone, white, soft	21	....	264	....
Shale, blue limestone, and hard, white sandstone	21	....	285	....
Sandstone, and black shale	10	....	295	....
Limestone (Mississippian, lower limit of coal)	....	....	....	....

Winslow suggests that the coal at 149 feet is probably the same as that mined south of Johnson City.

Vista.—Formerly some shipping mines were located on the north edge of Vista, but they appear to have exhausted the coal and have been abandoned. The depth to the coal is reported to have been 8 to 60 feet, the greater depths being due to rather steep dips and not to differences in surface levels. At the deepest places the water was so abundant as to prohibit mining. The coal ranged from three to four feet in thickness, and drilling showed it to extend south of town, but no development work has been done. Winslow measured the section shown in figure 83.

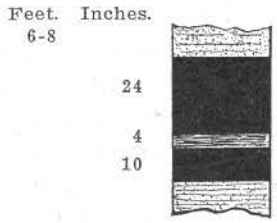

FIG. 83. Coal bed at Vista.

Oyer.—The coal mined at Lebeck and Balm in Cedar county extends at least a short distance into St. Clair county. It has been found four to five miles southwest of Oyer (Secs. 3, 9, 10, T. 36 N., R. 27 W.), where it was formerly stripped. Its thickness varies from 18 to 20 inches, and it has the same characters as in Cedar county. In the same vicinity (S. E. ¼ Sec. 3) four feet of coal is reported to have been found at a depth of 45 feet, but this has not been verified by shafting.

Tiffin.—At Zenor's mill, near Tiffin, coal three or four feet thick is reported to have been found. Matthew Bros. operate a drift on the land of David Zenor, about 2½ miles southwest (N. W. ¼ S. W. ¼

Sec. 23, T. 37 N., R. 28 W.), in which the coal is 41 inches thick, with a roof of thin-bedded sandstone and a floor of hard sandstone separated from the coal by only one inch of clay. The coal is rather impure, being full of shale and pyrite, especially at the bottom. It is mined on the longwall plan and sold locally.

Southwest Corner of County.—The coal found at Eldorado Springs extends over the county line into St. Clair, and was formerly mined by David Eberhardt on Hudson Bros.' land (N. E. ¼ N. W. ¼ Sec. 10, T. 36 N., R. 28 W.). The coal, which covers a small area on top of a mound measured 23 inches in some strippings. It is overlain with about 10 feet of firm shale, above which is massive sandstone; it lies only about 30 feet above the base of the Coal Measures.

ST. LOUIS COUNTY.*

In early days the coal of St. Louis county exerted a marked effect on the development of St. Louis city and the surrounding country. Mining was actively pursued until most of the more cheaply mined supply was exhausted. At present practically the only output is as a side product of the large clay mines of the Cheltenham and other districts. Early mines were most abundant a few miles southwest of St. Louis, where a bed two to six feet in thickness was utilized. Coal has also been mined about 10 miles north of the city and at Charbonniere.

The Coal Measures area of St. Louis county is a large outlier surrounded on all sides by older formations. It is to be considered part of the Illinois rather than of the Missouri coal field, being surrounded on the north, west, and south by older formations and separated from the coal-bearing rocks of Illinois only by the valley of the Mississippi. The thickness of the Pennsylvanian is small and the distribution and arrangement of its material is very irregular.

The following much generalized section by Fenneman† is fairly typical for the region:

PENNSYLVANIAN SERIES IN THE CHELTENHAM DISTRICT.

		Feet.
1.	Weathered limestone ("tumble rock")	0–4
2.	Pipe clay, etc., maximum	15
3.	COAL (local)	0–4
4.	Limestone or "very hard blue rock"	3–15
5.	Red and blue clays, "keel," pipe clay, etc	13–36

*The geology of the county was first described by B. F. Shumard (Mo. Geol. Survey, 1855, pt. 2, pp. 169-184) and in more detail by N. M. Fenneman (Geology and Mineral resources of the St. Louis quadrangle: Bull. 438, U. S. Geol. Survey, 1911, 73 pp., map). The coal is mentioned by Arthur Winslow (prelim. rept. on coal, Mo. Geol. Survey, 1891, pp. 165-166); the clays and shales of the Pennsylvanian by H. A. Wheeler (Mo. Geol. Survey, vol. XI, 1896), and the lime and cement materials by H. A. Buehler (Bureau of Geology and Mines, vol. VI, 2nd ser., 1907, pp. 198-206). The topography of the coal-bearing area is shown on the St. Louis special map of the U. S. Geological Survey.

†Op. Cit. p. 25.

PENNSYLVANIAN SERIES IN THE CHELTENHAM DISTRICT—Continued.

		Feet.
6.	COAL (very local)	0–1½
7.	"Roof" of fire clay, dark shaly sandstone, or arenaceous shale with some plant remains	1–7
8.	"Clod," an impure clay liable to fall in mining (local)	0– ⅔
9.	Coal streak (very local)	0– ½
10.	Fire clay, Cheltenham bed	2½–12
11.	Light-colored sandstone with pyritic crystals	....
12.	Limestone containing red chert (Mississippian)	....

The following detailed local record is furnished by the shaft at the Krümmel & Büchner mine, Columbia Avenue and Woods Street, St. Louis:

		Thickness.		Depth.	
		Feet.	Inches.	Feet.	Inches.
1.	Soil, loess, etc	38	....	38	....
2.	Limestone	4	....	42	....
3.	COAL	2	6	44	6
4.	Very hard blue rock	8	....	52	6
5.	Clay, not refractory	10	....	62	6
6.	Blue shale and "keel"	15	....	77	6
7.	Dark shaly sandstone forming roof of mine	2	6	80	....
8.	Fire clay, Cheltenham bed	7	....	87	....

Shumard noted five feet of coal on River des Peres, west of St. Louis. It lay about 80 feet above the base of the Coal Measures and two feet below the base of a six-foot bed of limestone. Fenneman describes a general section for the territory northwest of St. Louis, near Pattonville, in which there is 18 inches of coal about 16 feet above the base of the Coal Measures and 60 feet below a limestone 10 to 18 feet thick, the rest of the section being sandstone and shale. The coal-bearing area extends two or three miles north of Charbonniere, on the Missouri river, where the following section was taken by Shumard:

SECTION AT CHARBONNIERE.

		Feet.
1.	Slope, covered by soil and trees	60
2.	Rough, light-gray, compact limestone, in masses embedded in clay	6
3.	Light-colored, impure fire clay	6
4.	Hard, compact, light bluish-gray, hydraulic limestone, in uneven masses	2
5.	Yellow argillaceous shale, with ochreous stains	8
6.	Purple, sandy shale, with fine micaceous particles disseminated	13
7.	Bluish argillaceous shale	46
8.	Dark greenish and reddish fossiliferous shale	6
9.	Dark sandy shale	8
10.	Seams of coal, reported to be	1½

The coal at the bottom of the section is near the water level of the Missouri. Limestones older than the Pennsylvanian outcrop across the north side of the county, but coal has been found in the Mississippi nearly east of Charbonniere. On Watkins creek (southeast corner of T. 47 N., R. 7 E.) Shumard measured 18 inches of coal lying only a few feet above the base of the Coal Measures, with clay both above and below it.

The irregularity in the character of deposition makes it very difficult to estimate the amount of coal concealed beneath the surface.

Outcrops are scarce and information must be derived largely from well and drill records. It is not probable, however, that many important deposits remain undiscovered in so well settled an area. On the assumption that there is an average thickness of 18 inches of coal in three-fourths of the 165 sq. miles occupied by Coal Measures, the total original tonnage of the county was 212,544,000 tons.

SALINE COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....554 TONS.

Coal mining in Saline county has been largely confined to small neighborhood mines, operated at intervals during the colder months. The greater part of the county is covered with a thin veneer of Pennsylvanian, which is obscured in the northern part by a thin mantle of drift and loess that makes the delineation of geologic boundaries uncertain.

GENERAL SECTION, PENNSYLVANIAN OF SALINE COUNTY.

	Feet.
Henrietta formation—	
Limestone, gray, thick to thin-bedded	10
Cherokee shale—	
Shale, gray to black, horizon of Lexington coal	6
Limestone, gray to dark, heavy-bedded	3 to 4
Shale, gray to drab	20 to 30
Limestone, gray to dark drab, breaks in rhomboidal blocks	1 to 2
Shale, black, "slaty"	2
Limestone, black, pyritiferous, lenticular	0 to 1½
COAL (Summit)	0 to ½
Clay, white, shaly	6
Limestone, buff, nodular	1 to 2
Shale	1 to 6
Limestone, bluish, weathering to yellow or brown	1 to 4
Shale, yellow at top, black and "slaty" below and with large spherical or oval concretions	2 to 6
COAL (Mulky)	1 to 2
Clay, grading to shale below	5 to 15
Sandstone, micaceous	30 to 40
Shale, drab to black	3 to 6
Limestone, black, bituminous, pyritiferous	0 to 1
COAL (Bevier)	1 to 1½
Clay	½ to 1
Limestone, nodular at top	1 to 2
Shale, black and "slaty" above with, in places, blue clay below	5 to 10
COAL (Tebo)	1 to 2

The thickness of Pennsylvanian below the Tebo is variable. About 3 miles south of Blackburn (N. W. ¼ N. W. ¼ Sec. 8, T. 49 N., R. 23 W.), the Mississippian, the lower limit of coal, was reached at a depth of 212 feet, at Mount Leonard at 165 feet, 3 miles southwest of Marshall at 112 feet, in Marshall at 75 to 100 feet.

*The geology is described by B. F. Meek (Mo. Geol. Survey, Rept. for 1855-71, pp. 157-188). The coal is mentioned by Arthur Winslow (Prelim. rept. on coal: Mo. Geol. Survey, 1891, pp. 124-126). The topography is shown on the Marshall, Glasgow, and Sedalia sheets of the U. S. Geol. Survey.

Aside from the more or less persistent coal beds which appear in the general section and are found chiefly in the western half of the county, numerous basins and pockets of coal, of small areal extent, lie near and beyond the main body of the Coal Measures. Coal of exceptional thickness has been found in some of them.

The total original tonnage estimated on a basis of 1,800 tons per acre-foot and including only beds and parts of beds over 14 inches thick, is as follows:

TOTAL ORIGINAL TONNAGE OF SALINE COUNTY.

				Tons.
Mulky, average	16 inches	56	square miles	85,016,000
Bevier, "	14 "	72	" "	96,768,000
Tebo, "	18 "	72	" "	124,416,000
Slater and vicinity, average	18 "	9	" "	15,552,000
Miami " " "	18 "	6	" "	10,368,000
Basins and pockets, about				5,000,000
				337,120,000

DETAILED MENTION.

Arrow Rock and Napton.—Coal in this part of the county is contained in basins and pockets of small extent and is of both the bituminous and cannel types. The principal pockets are those on Flat creek and near Napton, but at the present time no mining is being done at either of these places. In a pocket formerly mined at Napton the coal was 22 feet thick. In spite of the great thickness of many of these pockets, they are rarely of sufficient size to be of more than local importance.

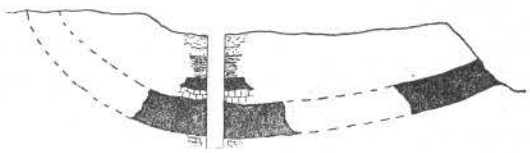

FIG. 84. Sketch of coal deposit formerly mined at Napton. (Winslow.)

Sweet Springs.—Several small shafts and drifts have been opened 1 to 1½ miles southwest of Sweet Springs, but the only mine now in operation is the drift of W. D. McFarland on the land of J. L. Eckhoff, near the Pettis county line. At this mine the coal lies 50 feet or less above the base of the Coal Measures. It is mined by the longwall method and is sold principally in Sweet Springs. The following section was measured at the face:

	Feet.
Shale, black, with much iron, a fairly firm roof	1+
Shale, black, semi-block, comes down with coal	⅔
COAL, hard, clean except bottom 2 inches, which contain streaks of pyrite	2

Elsewhere in the district the coal varies from 20 to 36 inches and contains considerable pyrite ("sulphur"). At the old Marmaduke shaft, near the Eckhoff drift, fires in the gob gave much trouble.

Four miles west of Sweet Springs coal 28 inches thick has been mined, the upper 12 inches being of very poor quality.

Blackburn.—Three to six miles southeast of Blackburn a number of small local mines operate on the Mulky bed. Those operating at present are (1) R. P. Tuck on the land of Mrs. Larue (S. E. ¼ N. W. ¼ Sec. 8, T. 49 N., R. 23 W.), shaft, 10 feet deep to 14 inches of coal; (2) O. Maupin on the land of Henry Tegtmeyer (N. W. ¼ N. W. ¼ Sec. 8, T. 49 N., R. 23 W.), shaft, 16 feet deep to 12 inches of coal; and (3) J. Loftus on the land of Peter Durnil (N. E. ¼ N. E. ¼ Sec. 16, T. 49 N., R. 23 W.), slope to 18 inches of coal. The bed varies from 12 to 20 inches in thickness and the coal is fairly clean and free from "sulphur". It is overlain by 2½ to 6 feet of black "slaty" shale and has a limestone cap-rock. In places "niggerheads" in the roof shale give trouble.

Between Elmwood and Herndon one or two small mines are occasionally worked in the winter for local trade.

About 3 miles northeast of Blackburn (S. E. ¼ S. E. ¼ Sec. 5, T. 50 N., R. 23 W.), 12 inches of coal, probably the Mulky, was found in a well at a depth of 30 feet. It is reputed to be overlain by black "slaty" shale and to have a limestone cap-rock. The ridge on the east side of Blackburn is capped by the limestone over the Lexington coal, the coal itself being very thin or absent.

Mount Leonard.—Coal was formerly shafted and stripped about a mile southwest of Mount Leonard (S. E. ¼ Sec. 15, T. 50 N., R. 23 W.), but nothing could be learned of its thickness. From one-half to 1 mile east, coal has also been mined. One mile east (S. E. ¼ N. W. ¼ Sec. 18, T. 50 N., R. 22 W.) is the shaft of Otto Lindstrom on the land of Dolph Ransburger, where the following section was measured:

	Thickness.	
	Feet.	*Inches.*
Clay, soil, and weathered shale (timbered)	14	....
Limestone, thin-bedded	1	....
Shale, soft, black	4	....
Shale, soft, gray, rather poor roof	5	....
COAL (Tebo)	1	10
Clay, in sump	4	....

The coal is mined on the room and pillar method, hoisted by steam, and sold locally. On the hill to the west are two abandoned shafts, in one of which this coal lay at a depth of 55 feet, 14 feet below 1 foot of coal at the Bevier horizon.

Shackleford.—A short distance south of Shackleford (N. E. ¼ N. W. ¼ Sec. 23, T. 50 N., R. 22 W.) G. Hutchinson has a stripping in the Bevier coal, which is here 18 inches thick and is overlain by more than 5 feet of shale.

About 1 mile west (S. E. ¼ S. E. ¼ Sec. 15, T. 50 N., R. 22 W.) is the drift of J. T. Jones on land of W. F. Vawter. The following section was measured here:

	Thickness.	
	Feet.	*Inches.*
Sandstone (quarried)	....	....
Shale, gray	3+	....
Shale, black, soft	3	....
Limestone, black, impure, hard when fresh	....	6 to 12
COAL (Bevier)	1	2
Clay, black	....	6
Limestone, nodular	....	....

At other places on the same land this coal is reported to reach a thickness of 16 inches. It is claimed that another bed, slightly thicker and probably the Tebo, lies 12 feet below it. In the vicinity the Mulky coal was formerly mined but the workings are now abandoned. The Mulky has been mined at a number of places 3 to 6 miles southwest of Shackleford, viz., (1) I. L. Thornton on the land of John Mitchell (N. E. ¼ S. W. ¼ Sec. 27, T. 50 N., R. 22 W.), stripping, coal 20-24 inches; (2) W. R. Combes on the Hunter place (S. W. ¼ S. E. ¼ Sec. 27, T. 50 N., R. 22 W.), stripping, 18 inches; (3) B. Weston (N. W. corner Sec. 34, T. 50 N., R. 22 W.), stripping, 18 inches; and (4) R. M. Tuck (N. W. ¼ N. E. ¼ Sec. 8, T. 49 N., R. 22 W.), shaft about 20 feet deep, 18 inches. In many other places in this vicinity and on Ferris creek the same bed is stripped for local use.

Marshall.—No coal is known to occur at Marshall, but about 3 miles southwest (N. W. corner Sec. 33, T. 50 N., R. 21 W.) 15 inches is reported in a drilling at a depth of 100 feet, 12 feet above the base of the Coal Measures.

Slater.—In a drill hole at Slater only a thin and pyritiferous bed of coal was struck, at a depth of about 120 feet. Three to five miles southeast of Slater, however, in the valley of Fish creek and its tributaries, is the most productive district in the county. The coal mined is 18 to 21 inches thick and of rather inferior quality, producing considerable clinker because of numerous lenticles of pyrite ("sulphur"). Thirty feet or more of reddish-brown sandstone overlies it and makes a good roof. All the mines are small and most of them are short-lived. The room and pillar method is used and the coal is under-cut and wedged down. The following list of drifts and short slopes found in operation will give some idea of the known distribution of this bed:

(1) Richard Richardson on land of Mrs. P. M. Thompson (S. W. ¼ S. E. ¼ Sec. 18, T. 51 N., R. 19 W.); (2) Arthur Colt, one-fourth mile northeast of last; (3) J. W. Fizer (S. W. ¼ N. W. ¼ Sec. 20, T. 51 N., R. 19 W.); (4) Phelan Fizer (N. W. ¼ S. E. ¼ Sec. 20, T. 51 N., R. 19 W.); and (5) J. W. Murphy (S. W. ¼ S. E. ¼ Sec. 17, T. 51 N., R. 19 W.).

FIG. 85. Coal bed near Slater.

About 4 miles west of this locality, near the middle of T. 51 N., R. 20 W., on Thrailkill branch, coal 14 to 18 inches thick was formerly mined. At this place it was overlain by shale, but sandstone was found in a well one-half mile north. Meek was inclined to correlate this sandstone with that below the Mulky coal in the western part of the county, and if he is right the bed mined is the Bevier. This belief is strengthened by the following section about 2½ miles west of Slater (Sec. 4, T. 51 N., R. 20 W.):

	Thickness. Feet.
Slope	50–60
Sandstone, thickness unknown but showing	4
COAL (Bevier), said to be	1½
Clay	2
Limestone, hard, compact, gray	1 (?)
Clay, yellow and bluish	12
COAL (Tebo)	1½

Gilliam.—Meek reports what appeared to him to be an isolated basin of coal, 26 inches thick, about 1 mile northeast of Gilliam (Sec. 28, T. 52 N., R. 19 W.). Only the upper part of the bed could be seen and it was overlain by 13 inches of dark sandy shale.

Miami.—South of Miami several small mines have been worked intermittently. One mile southeast the 60-foot shaft of J. M. Hisle (S. W. ¼ S. E. ¼ Sec. 4, T. 52 N., R. 21 W.) shows coal about 3 feet thick in what appears to have been a basin deposit that dipped toward the center and thinned on the edges. A mile east of this, on the land of Mark Whitaker (N. E. ¼ N. E. ¼ Sec. 10, T. 52 N., R. 21 W.), is an abandoned drift in 16 to 21 inches of coal, overlain by black impure pyritiferous limestone of variable thickness. Another bed four or five feet below the one mined is reported to be 30 inches thick but of poor quality. Coal is also reported in Secs. 9 and 13 of this township and on Edmonson creek, about 6 miles southeast of Miami.

Grand Pass.—The following is the record of a churn drill hole sunk on the hillside, about 23 feet above the Missouri flood plain:

DRILLING ONE MILE WEST OF GRAND PASS.

	Thickness. Feet.	Inches.	Depth. Feet.	Inches.
Surface clay	17	....	17	....
Shale, blue	9	....	26	....
Shale, black, "slaty," rotten	1	....	27	....
Shale	9	2	36	2
Shale, and rotten "slate"	1	9	37	11

DRILLING ONE MILE WEST OF GRAND PASS—Continued.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
COAL (Bevier)	....	6	38	5
Limestone	2	6	40	11
Shale	1	....	41	11
Limestone, hard, white	3	9	45	8
Shale	3	3	48	11
Shale, black, "slaty"	....	7	49	6
COAL (Tebo)	1	5	50	11
Limestone	....	9	51	8
Shale, white, blue, red and yellow	82	5	134	1
Shale, white, sandy	6	....	140	1
Sandstone	2	6	142	7
Shale, dark	9	....	151	7

SCHUYLER COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....5,700 TONS.

Coal is mined in two districts in Schuyler county, one, by far the largest, in the northwest corner, and the other west of Queen City, near Jimtown. Most of the mines are small, there being only one from which the product is shipped.

The eastern half of the county is deeply buried beneath glacial drift which conceals or replaces all or most of the coal beds originally deposited there. No outcrops have ever been found east of the "Grand Divide," which is marked approximately by the line of the Wabash railroad. At Greentop a drilling 300 feet deep is reported to have penetrated only drift, but another one-fourth mile southwest found six inches of coal at 206 feet. Drilling at Queen City was carried to 295 feet, at which depth a very hard rock was encountered, above which was 25 feet of white sand, either Cherokee or drift. These drillings, if accurate, indicate the absence of coal to depths below the level of the nearest outcropping beds near the Chariton. Several drillings have been made at Lancaster. One at the courthouse is reported to have penetrated 210 feet of clay, boulders, and a few feet of sandstone, below which was 30 feet of white sand. Another just north of the depot struck coal of undetermined thickness at a depth of 325 feet.

In spite of the heavy drift cover there are places in eastern Schuyler where workable coal has been spared by preglacial erosion. One such locality has been discovered in the northeastern portion of the region, for coal has been mined in Davis county, Iowa, only one-fourth mile north of the state line and 7½ miles northeast of Lancaster (S. E. ¼ Sec. 14, T. 67 N., R. 14 W.). The shaft, which is in the valley of Fabius creek, penetrated the following:

*The geology is described by C. J. Norwood (Rept. for 1873-1874: Mo. Geol. Survey, pp. 292-302). The topography, except a strip about six miles wide on the north edge of the county, is shown on the Edina and Queen City sheets of the U. S. Geol. Survey.

RECORD OF LUNSFORD COAL SHAFT.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	199	....	199	....
Sandstone, hard	1	5	200	5
Shale, black and "slaty" at base	17	....	217	5
"Rock"	....	8	218	1
Shale, black, "slaty," hard	4	....	222	1
COAL	1	6	223	7
Clay	1	....	224	7
Sandstone, hard at top, soft below	7	....	231	7
Shale, black and "slaty" at base	17	....	248	7
"Rock," hard	....	9	249	4
Shale, black, "slaty," hard, not a good roof	2	6	251	10
COAL, with 4 to 6 inches clay	3	2	255	....

The same coal is reported to have been found ½ mile south of the Missouri line. At other places east of the "Grand Divide" much excitement has been caused at times by the finding of large detached pieces of coal in the drift. Such occurrences have occasionally led to the useless expenditure of money for development purposes.

The general section of the rocks exposed near the Chariton river is the same as Nos. 5 to 25, inclusive, of the Putnam county section (p. 330). Three coal beds are known, and undiscovered deposits may lie below them in places.

The highest coal, the Lexington bed, is 44 inches thick. The roof is composed of black, "slaty" shale, clay, and limestone, except where the drift comes down to the coal, and clay or sand forms the roof. "Slips" are present, but do not seriously interfere with mining. The Lexington coal is clean and free from "sulphur" and is a general favorite with the people of the county. It is apparently confined to an area of five square miles in the northwest corner of the county. Farther down the Chariton it rises and is replaced by drift.

About 100 feet below the Lexington are two closely associated beds, thought to be the two benches of the Bevier coal separated by a parting varying from two inches to more than four feet. They are known to outcrop at only one locality in the county, near Jimtown, west of Queen City, where the upper bench is reported 28 to 32 inches thick, and the lower 12 inches. In most places the Bevier lies too low to outcrop, and no drilling has been done to determine its presence. As it is a persistent bed in Adair county, it is probable that it underlies considerable territory in this region.

No evidence regarding the presence or absence of coal beds lower than the Bevier is in existence. At Memphis, in Scotland county, the lower beds contain very little coal. In Adair county at least one persistent bed, the Tebo, lies below the Bevier. Near Sedan, in Appanoose county, Iowa, drilling has shown considerable coal in the Cherokee.† Between the Lexington coal and the top of the Mississippian limestone,

†Hinds, Henry, Coal deposits of Iowa, Iowa Geol. Survey, Vol. XIX, 1909, p. 266. For a summary see report on Putnam county in this volume.

the lower limit of coal, there are probably 350 to 400 feet of Coal Measures.

Any estimate of the total coal reserve of the county in beds of 14 inches or more must necessarily be extremely conjectural. The following is based on the best available evidence:

TOTAL ORIGINAL TONNAGE OF SCHUYLER COUNTY.

							Tons.
Lexington bed,	44 inches	under	5	square	miles	.....	21,120,000
Bevier bed,	20 "	"	60	"	"	.....	115,200,000
Other beds,	30 "	"	70	"	"	.....	201,600,000
							337,920,000

DETAILED MENTION.

Queen City.—At a locality about seven miles west of Queen City, near the mouth of Elm creek, mining has been carried on intermittently for a number of years for local trade. The principal mine at present is that of Ira Golston (N. E. ¼ N. W. ¼ Sec. 23, T. 65 N., R. 16 W.). The following record is reported by Mr. Golston from memory:

GOLSTON SHAFT, WEST OF QUEEN CITY.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift clay, gravel, etc.	20	....	20	....
Sandstone and sandy shale, steel-blue, hard, containing films of coal	40	....	60	....
Shale, black, "slaty," 8 inches to	....	10	60	10
COAL, maximum 2½ feet	2	4	63	2
Sandstone, blue, hard	4	....	67	2

The coal mined corresponds in thickness, as well as in other characteristics, to the upper bench of the Bevier coal as exposed on Shoal creek in Putnam county, and is probably identical with it. It is mined on the room and pillar plan, hoisted by horse-power, and sold locally or hauled to near-by towns.

In an abandoned shaft a few rods distant the same coal is said to have been found separated from a 12-inch bed below by 30 inches of sandstone, which in a short entry driven southwest changed to only two inches of clay. Where the parting is thin, the bed closely resembles the Bevier of the Novinger field. Several attempts to find coal on neighboring lands are said to have failed, though what is probably the same bed has been mined at other places in the vicinity. It may be that the coal was locally removed by the erosion that took place in Pennsylvanian time, and that its position is indicated by a conglomerate of rounded pebbles in a firm calcareous matrix outcropping near the top of the Golston shaft.

Glenwood.—In and near the bluffs of the Chariton river, northwest of Glenwood and southwest of Coatesville, a group of drifts in the Lexington coal bed supply a large local trade. One of these,

known as the Snake Den, has been in operation intermittently for nearly 50 years. Mines found open in 1910 were: (1) Snake Den, S. W. ¼ S. E. ¼ Sec. 34, T. 67 N., R. 16 W.; (2) Black Diamond, and (3) J. Watson, S. E. ¼ S. W. ¼ Sec. 34; (4) W. Horton, N. E. ¼ S. W. ¼ Sec. 34; (5) P. E. Gordy, S. W. ¼ N. E. ¼ Sec. 34. The coal is excellent for domestic purposes, "sulphur" and other impurities being comparatively rare, though white gypsum and calcite scale appear on the joint planes. The cap-rock and "slaty" shale make a firm roof, except where they are weakened by fractures. Vertical clay seams, two feet and less in thickness, traverse the coal in places and more rarely extend up into the cap-rock. The drift lies close to the cap-rock. The average thickness of the entire coal bed is 44 inches, the variations in the district being as follows:

LEXINGTON BED SOUTHWEST OF COATESVILLE.

	Inches.
Shale, with nodules of limestone	50
Limestone, heavy-bedded, cap-rock	30
Clay	6–36
Shale, black, "slaty"	7–14
Clay, containing powdered coal	0– 3
COAL	19–26
Clay	½– 4
COAL	12–16
Clay	1
COAL	0– 3
Clay	14–18
Limestone, impure, bottom-rock, more than	24

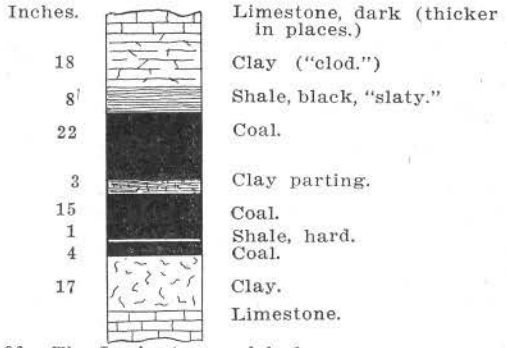

FIG. 86. The Lexington coal bed northwest of Glenwood.

At the mines the Lexington lies only a few feet above the bottom lands, but it rises to the southwest, and near the center of Sec. 3, T. 66 N., R. 16 W. rocks 50 feet or more below it lie at the level of the flood plain. This rise accounts for the absence of the Lexington coal along the river south of the district described, for where it lies much above the river it has been removed by preglacial erosion and its place taken by drift.

Coal City.—The only shipping mine in the county is near the point where the Chariton river enters Missouri. This is Manufac-

turers Coal and Coke Co. No. 10, recently sold to the Coal City Coal Co. It is served by a short spur from the Iowa and St. Louis railroad. The mine has a slope entrance situated in Missouri, but the working faces are in Iowa. When the region was visited the mine had been idle for several months and could not be entered. The Lexington, the bed mined, lies at the level of the river and is the same as that in northeastern Putnam county.‡ It averages only a few inches less than in the drifts farther south and mining conditions are much better, there being fewer and smaller vertical clay seams and fractures in the coal and roof. The Lexington is said to have been traced by drilling as far east as Guinn Station (Zola P. O.). Farther east it is reported to be absent, having been cut out by erosion, probably, and replaced with drift.

SCOTLAND COUNTY.*

Scotland county, the second from the east in the north tier of Missouri counties, is so heavily drift-covered that it offers little attraction to geologists and has been the scene of very little field work. The drift varies from 50 to 400 feet in thickness, the maximum being reported from a well in the northeast corner of the county. Although outcrops are very few, it is known that beneath the drift in all but the southern townships lie Coal Measures of Cherokee age, chiefly shale and sandstones, which aggregate 150 feet or less in thickness and are easily distinguished from the thick limestones of the underlying Mississippian series.

It is highly probable that coal beds of importance will in time be found in the Coal Measures of this region. So far no thick coal has been discovered, for little drilling has been done except near Memphis. It would not be financially safe to sink a shaft without previously drilling at least one hole on every forty-acre tract it was purposed to work, as the variable thickness of the drift, the uneven upper surface of the Mississippian, and the absence of known "blanket veins" of coal all make it impossible to judge any large amount of territory by one or two drillings. The most encouraging feature of the situation is that the rocks of Scotland county are stratigraphically the same as those which carry the thick coals so extensively mined in Monroe, Mahaska, Polk, and other counties in Iowa.†

Chunks and masses of coal, some yielding as much as two wagon-loads of fuel, are common in the drift in the western part of the county, and their discovery has often led to great excitement among people not familiar with their significance. These masses were evi-

‡See report on Putnam county, p. 333.

*The topography of the southern part of the county is shown on the Edina quadrangle of the U. S. Geol. Survey.

†Hinds, Henry, Coal deposits of Iowa: Iowa Geol. Survey, vol. XIX, 1909.

dently torn from their native ledges some distance either north or west of their present location. Coal 24 inches thick is reported found by drilling in Sec. 15, T. 65 N., R. 11 W., three miles southeast of Memphis, and some coal is reported from several borings in Sec. 18, T. 66 N., R. 11 W. A number of cores have been drilled in the neighborhood of Memphis, but have failed to show coal beds more than a few inches thick:

NORTH EDGE OF MEMPHIS.

Altitude of surface about 780 feet above sea.

	Thickness.	Depth.
	Feet.	*Feet.*
Drift	158	158
Shale, gray, sandy	8	166
Sandstone	1½	167½
Rock, hard, ferruginous	2	169½
Shale, gray	9	178½
Shale, dark blue	7	185½
Shale, black, carbonaceous, with coal streaks (alt. 595 ft.)	3	188½
Shale, gray	6	194½
Shale, blue, sandy	7½	202
Shale, gray	7	209
Shale, dark	3½	212½
Rock (limestone?)	1	213½
Shale, blue	8½	222
Shale, gray, sandy below	14	236
Shale, green and blue, sandy	18	254
Shale, with calcareous concretions, sandy	7	261
Sandstone	8	269
[Record blurred]	5	274
Sandstone, dark, blue shale partings	11	285
Shale, gray, sandy	2	287
Limestone, gray (alt. 493 ft.) } Mississippian	4	291
Sandstone, hard } Mississippian	11	302
Limestone } Mississippian	7	309

ON WITTY FARM (N. W. ¼ N. W. ¼ SEC. 1, T. 65 N., R. 12 W.).

Altitude of surface about 700 ft. above sea.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Drift	76	....	76	....
Shale, blue	4	....	80	....
Shale, white	5	....	85	....
Shale, sandy	6	....	91	....
Shale, black, carbonaceous (alt. 609 ft.)	3	....	94	....
Shale, white	2	....	96	....
Shale, blue	7	....	103	....
COAL (alt. 597 ft.)	....	4	103	4
Shale, sandy	2	....	105	4
Shale, white	8	....	113	4
Shale, gray	5	....	118	4
Shale, blue, fossiliferous	6	....	124	4
Limestone, fossiliferous	1	....	125	4
Shale, blue	2	....	127	4
COAL (alt. 573 ft.)	....	8	128	....
Shale, white	3	....	131	....
Shale, gray, sandy	4	....	135	....
Shale, blue	5	....	140	....
COAL (alt. 560 ft.)	....	9	140	9
Shale, white	3	....	143	9
Shale, blue	12	....	155	9
COAL (alt. 544 ft.)	....	11	156	8

ON WITTY FARM (N. W. ¼ N. W. ¼ SEC. 1, T. 65 N., R. 12 W.)—Continued.

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Shale, white	2	....	158	8
Shale, blue	2	....	160	8
Limestone, fossiliferous	1	....	161	8
Shale, black	....	3	161	11
COAL (alt. 538 ft.)	....	4	162	3
Shale, white	4	....	166	3
Sandstone, gray	4	....	170	3
Limestone (Mississippian, alt. 530 ft.)	3	....	173	3

Only mere summaries can be given of other holes drilled near Memphis:

ON SHENK FARM (N. W. ¼ S. W. ¼ SEC. 3, T. 65 N., R. 12 W.).

Altitude of surface about 720 ft. above sea.

	Feet.
Drift	90
Shale, yellow and blue	35
Sandstone	4
Limestone (Mississippian, alt. 591 ft.)	6
Total depth	135

ON WITTY FARM (N. E. ¼ N. E. ¼ SEC. 2, T. 65 N., R. 12 W.).

Altitude of surface about 720 ft. above sea.

	Feet.	*Inches.*
Drift	67	....
Sandstone and shale	22	9
COAL (alt. 630 ft.)	....	4
Shale, white and blue	11	....
Limestone, fossiliferous	....	5
Shale, black	8	....
COAL (alt. 610 ft.)	....	4
Shale and sandstone	40	4
Limestone (Mississippian, alt. 570 ft.)	3	....
Total depth	153	2

ON LEACH FARM (S. E. ¼ S. E. ¼ SEC. 36, T. 66 N., R. 12 W.).

Altitude of surface about 740 ft. above sea.

	Feet.	*Inches*
Drift	164	....
Shale, white and blue	13	....
Limestone	1	2
Shale, and sandstone	23	6
COAL (alt. 538 ft.)	1	....
Shale and sandstone	28	....
Limestone (Mississippian, alt. 510 ft.)	4	....
Total depth	234	8

ON CITY LOT (S. E. ¼ N. E. ¼ SEC. 12, T. 65 N., R. 12 W.).

Altitude of surface about 700 ft. above sea.

	Feet.
Drift	120
Shale, blue and brown	6
COAL (alt. 574 ft.)	1
Shale, white, blue and gray	26
Rock	1½
Shale, blue	12
Total depth	166½

ON STRUBBLE FARM (N. W. ¼ S. W. ¼ SEC. 5, T. 65 N., R. 11 W.).

Altitude of surface about 800 ft. above sea.

	Feet.	*Inches.*
Drift	234	....
Shale and sandstone	9	....
COAL (alt. 557 ft.)	....	5
Shale, white, black, and blue	32	2
Limestone (Mississippian, alt. 525 ft.)	17	....
Total depth	292	7

The above drillings show well: (1) the great and variable thickness of the drift, the "solid" varying in altitude from 522 feet to 653 feet above sea level; (2) the variation from 493 to 591 feet in the altitude of the surface of the Mississippian limestone; and (3) the presence of numerous very thin beds of coal that are moderately persistent at some horizons.

SHELBY COUNTY.*

As determined by Broadhead and shown on the State geological map embodied in this report, the Coal Measures rocks in Shelby county are confined to a strip along the west boundary, an elongated area extending from north of Shelbina southeast to the county line near Lakenan, and to a narrow tongue reaching north from the county line near Hunnewell to North river. The western half of the county, however, is so deeply covered with glacial drift that the stratified formations are completely concealed, making it very possible that Pennsylvanian strata of the main body of the Coal Measures exist farther east than is indicated on the map.

Little coal has been discovered in this region nor are the prospects for future developments very bright. In a well at Hunnewell and another one-fourth mile from the town, six feet of coal is somewhat doubtfully reported. Some coal is mined south of Lakenan, as described in the chapter on Monroe county. A bed only one foot thick was noted by Broadhead in the E. ½ S. E. ¼ Sec. 33, T. 57 N., R. 9 W.

At present the only mining done in Shelby county is confined to a small slope and strip pit operated by Jacob Raby three miles north of Shelbina (S. E. ¼ S. W. ¼ Sec. 16, T. 57 N., R. 10 W.), the product from which is hauled to town in wagons. Following is a measurement made at the face in the slope:

		Inches.
1.	Shale, drab, rather soft	....
2.	COAL	32
3.	Clay, drab, hard	12
4.	COAL	11
5.	Shale, "slaty" (at mouth of slope)	42

*The geology was first described by G. C. Broadhead (Shelby County: Mo. Geol. Survey, 1855-1871, pp. 65-73). The topography of the western edge of the county is shown on the Macon and Atlanta sheets and of the eastern edge on the Palmyra sheet of the U. S. Geol. Survey.

The coal is very variable in thickness and dips rather steeply without regularity as to direction. In the strip-pit at the entrance to the slope the clay parting thickens to 22 inches and is very bituminous. The upper half of the top bench is a good bituminous coal; the remainder of the seam is a cannel and burns readily with a clear flame when lighted with a match. Coal of very variable thickness is reported at several points within a radius of a mile west, south, southwest, and southeast of the Raby slope, but is cut off a short distance to the north, at the Shelby county railroad bridge over Salt river, by Mississippian limestone which outcrops above the level of the coal. It is probable that no extensive regular coal seam exists here. Valuable brick clays associated with the coal are utilized at the Shelbina Brick and Tile Works.

BORING NEAR RABY SLOPE.

		Feet.	*Inches.*
1.	Clay, white, pure	16	....
2.	Shale, black	4	....
3.	COAL, with clay parting	3	8
4.	Clay, white, pure	12	....

SULLIVAN COUNTY.†

AVERAGE ANNUAL PRODUCTION, 1901-1910.....2,010 TONS.

In Sullivan county only thin coal beds outcrop near the railroads, the thicker beds being more deeply buried than in the surrounding counties, and consequently little mining or prospecting has been done. The only shipping mine is at Milan and even small local drifts are confined to Spring creek and to the vicinity of Milan, Reger, and Cora.

A syncline, or area in which the strata lie lower than in adjacent territory, causes the appearance in the central part of the county of relatively high rocks. These comprise the lower portion of the Missouri group and contain at the base limestones which are excellent markers and which outcrop conspicuously in a railroad cut near the Milan coal shaft, as shown in the section below. The Bethany Falls is the thickest limestone to appear in the county.

		Feet.	*Inches.*
1.	Limestone, in nodules	3	....
2.	Limestone, gray, heavy-bedded above, thin-bedded below (Bethany Falls)	12	4
3.	Shale, blue	1	10
4.	Shale, black, "slaty"	1	6
5.	Limestone, gray	....	4
6.	Shale, drab	5	....
7.	Sandstone, yellow, even and thick-bedded	4	9
8.	Shale, light drab, sandy	10	4
9.	Limestone, gray (base of Missouri group)	4	....

†The geology was first described in a county report (Mo. Geol. Survey, 1873-1874, pp. 222-241) by Broadhead, who, however, in his general section assigns the lower coal (Lexington) on Spring creek to a position to which the present writer is unable to agree.

Below the Missouri group are 80 to 150 feet of shales and sandstones constituting the Pleasanton shale. The Pleasanton is very changeable in character, in some places consisting largely of sandstone, in others of shale. It contains a few very thin limestones and a number of coal beds which in most places are either too thin or too impure to be workable. The presence of red shale is characteristic. The Pleasanton is the highest formation underlying the drift in the greater part of Sullivan county.

Below the Pleasanton is the Henrietta formation, composed of shales and limestones, as shown in the Milan shaft record. It is about 30 feet thick and outcrops only along the main branches of Locust and Yellow creeks in the southern part of the county, and on Spring creek.

Below the Henrietta are the shales, thin limestones, and sandstones of the Cherokee, which outcrops only low down in the valley of main Locust creek and on East and West Locust and Yellow creeks in T. 61. Only the upper portion shows even in those localities, and knowledge of the formation is practically wholly derived from the Milan shaft record (p. 407), which was sunk through about 110 feet of it to the Bevier horizon.

Within a few feet of the top of the Cherokee is the Lexington coal horizon, at which a thick bed of excellent coal is found in the northeastern part of the county. The coal outcrops on Spring creek, where it constitutes a neglected resource. It thins to the south and west, but probably is workable in much of the northern half of the county.

As in other counties, the Summit bed is nowhere workable and the Mulky is absent or very thin except in a few small areas.

The Bevier bed, the one mined so extensively at Novinger in Adair county, is mined at Milan at a depth of 220 feet. It probably underlies all of the county with a thickness of 18 inches or more, but where it is thicker its value is greatly impaired by a clay parting that separates it into two benches. The only information in regard to this bed was obtained from developments in adjacent counties and at Milan, and from a drilling south of Cora. The only drilling which reached strata lower than the Bevier is one of doubtful value four miles east of Galt, where there is said to be 107 feet of drift and 43 feet of Pennsylvanian "rock" and shale resting on at least 276 feet of Mississippian limestone. This record places the Mississippian much nearer the surface than would be expected from other evidence. Judging by drillings in neighboring counties, 200 to 300 feet of Coal Measures lie below the Bevier horizon, and include at least two horizons at which workable coal is found in many places, the most persistent (the Tebo) being only about 50 feet below the Bevier. A drilling to the Mississippian, a formation known to all experienced

coal drillers, might yield important results in some part or parts of the county. The horizon of the thick coal recently found at Princeton and Cainesville lies about 200 feet below that of the Bevier, though the extension of this bed into Grundy county is extremely problematical.

When the depth to any horizon is known, that of the others can be estimated from the Milan shaft record and other information contained in this report. Thus, the depth to the Bevier coal at Green Castle is about 260 feet, and at Green City 300 feet. At Milan its position has been determined by shafting. Along Locust creek, north and south of Reger, it lies at a depth of 100 to 150 feet; in the valley of East Locust from Cora to Browning at the same depth or slightly less; and near the south county line on Yellow creek at 75 to 100 feet. Little is known about the north-central part of the county, and it can only be said that the Bevier horizon lies probably 200 to 300 feet below the towns north of Milan. The Lexington horizon, 100 feet higher, is more important in this district. The western quarter of the county is also little known as the drift is very thick. Near Harris (S. E. corner N. W. ¼ N. E. ¼ Sec. 33, T. 64 N., R. 22 W.) the drill went 215 feet through soil, clay, and sand without reaching the Coal Measures. It is probable that the coal once mined at Galt underlies neighboring parts of this county.

Any estimate of the total tonnage of Sullivan county must necessarily be very rough. The following table is based on 1,800 tons per acre-foot, and is very conservatively considered for beds or parts of beds more than 14 inches in thickness:

Coal in Pleasanton shale	55,000,000	tons
Lexington bed	736,128,000	"
Bevier bed	1,680,000,000	"
Other beds, especially the Tebo	500,000,000	"
Total	2,971,128,000	tons

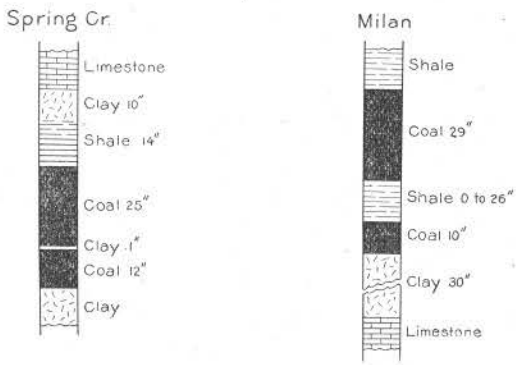

Fig. 87. The Lexington and Bevier coal beds in Sullivan County.

DETAILED MENTION.

Green Castle and Green City.—The coal beds described as occurring at Stahl, in Adair county (p. 45), probably underlie the northeastern portion of Sullivan county. Provided the strata lie level west of Stahl, the Lexington coal would lie 160 feet below Green Castle and 200 feet below Green City. A drill operated one mile east of Green City depot (N. W. ¼ N. E. ¼ Sec. 17), in a hollow lower than the town, struck at 161 feet 32 inches of coal, which, judging from the description furnished of the overlying strata, probably is the Lexington bed. North of Green Castle the Lexington outcrops near water level from the county line up Spring creek as far as section 21 and up North creek to section 15. Small drifts and slopes have been recently worked on the following lands: (1) Myers (N. E. ¼ S. E. ¼ Sec. 27, T. 64 N., R. 18 W.); (2) Kent (N. E. ¼ S. W. ¼ Sec. 27); (3) Phillips (N. E. ¼ S. W. ¼ Sec. 27); (4) Rhodes (N. E. ¼ N. E. ¼ Sec. 28); (5) Beeler (S. W. ¼ N. E. ¼ Sec. 26); and (6) Henley (S. W. ¼ N. E. ¼ Sec. 25). On Myers land 42 inches of coal was seen, separated into two benches by one inch of clay 14 inches from the bottom. At the mine on the Henley ranch, one-half mile west of the Adair county line, the coal is a few feet above the flood plain and is as follows:

		Feet.	*Inches.*
1.	Limestone	1	6
2.	Shale	1	4
3.	Limestone	1	....
4.	Clay	....	10
5.	Shale, black, "slaty"	1	2
6.	COAL, 22 to 27 inches Clay, ½ to 2 " COAL, 10 " Clay, pyritiferous, 0 to 2 " COAL, 2 " (Lexington)	3	3
7.	Clay, more than	1	6

According to a measurement by C. J. Norwood (N. E. ¼ Sec. 27, T. 64 N., R. 18 W.), 31 feet of shales and sandstone extend from the top of the above section up to a four-foot limestone bed (top of the Henrietta formation ?), above which is a great thickness of shale and sandstone. The Lexington coal of Spring creek valley is important though as yet little appreciated. The coal is of excellent quality, especially for domestic use, and the bed has a strong roof that makes longwall working easy. "Sulphur" is moderate in amount, occurring in small lenses of iron pyrites and vertical films of white gypsum. "Clay slips" (vertical or highly inclined veins of clay) are troublesome in places and locally the value of the upper bench is greatly impaired by them and by rolls in the roof. Nevertheless, large areas of good coal could be easily reached from drifts or short slopes, and Spring creek valley affords an easy gradient for the construction of a railroad spur.

North of Green City, on Spring creek, a little coal has been taken from a bed in the upper part of the Pleasanton formation, about 85 feet higher stratigraphically than the Lexington bed. At George Bradshaw's new drift (N. W. ¼ N. E. ¼ Sec. 19, T. 64 N., R. 18 W.) and vicinity 18 to 30 inches of coal is overlain with four feet of dark shale that is "slaty" at base and contains a very thin limestone layer. Large quantities of sandstone may be seen a short distance above and below the level of the coal. Coal at this horizon is evidently lenticular and not of great commercial importance. It fails to appear in good outcrops in several localities.

Boynton.—At Boynton 40 feet or more of thick-bedded sandstone, with a thin conglomerate at the base, probably forms part of the Pleasanton formation. Several miles northwest of the town, and one-fourth mile east of main Locust creek (100 yards north of southwest corner Sec. 27, T. 64 N., R. 20 W.) a shaft reached the Lexington bed. The following record, by the man who sunk the shaft, was furnished from memory, and the details are, therefore, open to question:

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil and sand	12	....	12	....
Shale	....	6	12	6
Limestone	3	....	15	6
Shale, red in lower part	10	4	25	10
Limestone, shaly and impure	8	....	33	10
Shale, red	3	....	36	10
Limestone, in 3 layers with 2-inch partings	2	8	39	6
Shale	5	....	44	6
Limestone, hard	2	6	47	....
Shale, black	8	....	55	....
COAL, with 0 to 3 inches clay parting (Lexington)	2	4	57	4
Clay	4	....	61	4
Limestone	....	5	61	9
Shale	1	....	62	9
Limestone, hard	....	....	....	....

Sorrel.—A drilling made about 200 yards northwest of the station at Sorrel (Elgin) is said to have gone 234 feet and to have penetrated 46 inches of coal at the bottom. No record could be obtained and no comments on the apparent accuracy of the report can, therefore, be made.

Milan.—In 1890 a shaft was sunk 190 feet to the Bevier coal bed, which was found to be 40 inches thick. This shaft and another were abandoned after a time, because of the presence of "bench rock" and other troubles. In 1905, however, a third shaft started between the railroad tracks one-half mile south of the depot reached the coal at 225 feet. This shaft was still being operated in 1910 by the Milan Coal Co., though under unusual difficulties. The coal is 36 to 42 inches thick, but about 10 inches from the bottom the bed is separated into two benches by an irregular parting of impure clay shale one to 26 inches in thickness. The strata in the mine dip strongly to the north.

Below the coal is 30 inches of clay resting on limestone, and above it is a considerable thickness of gray shale. Both the longwall and room and pillar systems of mining have been tried; the former is preferred, as with it the "bench rock" can be more easily disposed of and all but the lower two feet of the roof shale stands well.

The strata are much disturbed at Milan, rocks stratigraphically higher than those found elsewhere in this part of the State outcropping in its vicinity. Limestones lying near the base of the Missouri group form the hill upon which the city stands and also outcrop close to the coal shaft. The coal mined, the Bevier, lies 255 feet below the base of the Missouri group. The record furnished by W. R. Morgan and printed below shows, therefore, all the principal coal horizons above the Bevier; none of them possess workable coal at this point, although the Lexington coal is 16 inches thick where penetrated by the shaft sunk in 1890.

DRILLING ONE-HALF MILE SOUTHEAST OF MILAN.

		Thickness.		Depth.	
		Feet.	*Inches.*	*Feet.*	*Inches.*
1.	Drift clay and sand	45	....	45	....
Pleasanton shale—					
2.	Shale, variegated	37	1	82	1
Henrietta formation—					
3.	Limestone	2	9	84	10
4.	Shale	3	3	88	1
5.	Limestone	4	5	92	6
6.	Shale	1	2	93	8
7.	Limestone	....	10	94	6
8.	Shale	1	8	96	2
9.	Limestone	1	9	97	11
10.	Shale	9	5	107	4
11.	Limestone	2	....	109	4
12.	Shale	....	6	109	10
13.	Limestone	1	....	110	10
Cherokee shale—					
14.	Shale, light	2	....	112	10
15.	Shale, black, "siaty" (horizon of Lexington coal)	2	....	114	10
16.	Shale, lower half mixed with rock	6	....	120	10
17.	Limestone, very hard	1	9	122	7
18.	Shale, blue, dark at base	19	1	141	8
19.	Limestone	....	5	142	1
20.	Shale, black	3	2	145	3
21.	Limestone	....	5	145	8
22.	Shale, dark (horizon of Summit coal)	2	....	147	8
23.	Shale, light	5	....	152	8
24.	Limestone	1	....	153	8
25.	Shale, light blue	1	4	155	....
26.	Limestone	1	9	156	9
27.	Shale, blue in greater part	13	11	170	8
28.	Limestone	....	8	171	4
29.	Shale	7	....	178	4
30.	Coal and "slate" (Mulky coal)	....	8	179	....
31.	Shale	36	6	215	6
32.	COAL, 39 inches Shale, 12 " COAL, 7 " (Bevier)	4	10	220	4
33.	Clay	....	7	220	11

On the west side of Milan (N. E. ¼ S. W. ¼ Sec. 3, T. 62 N., R. 20 W.) and about two miles northwest (N. E. ¼ S. E. ¼ Sec. 33, T. 63 N., R. 20 W. and vicinity), small drifts have been operated, but are now temporarily abandoned. The coal mined is 14 to 22 inches thick and lies in the upper part of the Pleasanton formation, 30 feet below the limestone forming the base of the Missouri group and about 220 feet above the coal in the Milan shaft. A one-inch dirt seam lies about six inches from the base of the coal. The roof is a light shale; the floor 18 inches of soft clay resting on harder clay. In Sec. 27, T. 63 N., R. 20 W. the coal is interlaminated with clay seams which destroy its value. This bed cannot be considered of more than very local importance.

Reger.—On Locust creek for several miles north of Reger, strata as low as those constituting the Henrietta formation outcrop, showing that the Bevier horizon is slightly nearer the surface here than at the Milan shaft. Coal 16 inches thick lies a short distance above the railroad track 1½ miles southwest of Reger (N. E. ¼ N. W. ¼ Sec. 36, T. 62 N., R. 21 W.). This bed, which was once drifted, lies well up in the Pleasanton formation. Another thin bed, somewhat lower stratigraphically, was mined years ago near creek level one mile south of Reger (S. W. ¼ Sec. 31), and 18 inches of coal is reported to lie about 15 feet above Locust creek three miles farther south (S. W. ¼ N. E. ¼ Sec. 18, T. 61 N., R. 20 W.). Over the coal is six feet of black shales containing limestone concretions like those of the Mulky horizon in neighboring counties. A short distance north the limestone just below the Lexington coal horizon outcrops at creek level. These beds are all higher than the Bevier, though their exact position was not determined.

Cora.—Attempts, long been abandoned, were once made to mine in a very small way a thin coal on the west side of East Locust creek at Cora. More coal has been taken from a drift 2½ miles southwest of town, where the bed is 18 to 20 inches thick (S. W. ¼ N. W. ¼ Sec. 21, T. 61 N., R. 20 W.). Broadhead correlates this bed with the one in Sec. 18 and states that it was also found southeast of Cora on Pawpaw creek (Sec. 14, T. 61 N., R. 20 W.). It is reported that a drilling made on low land halfway between Cora and Browning penetrated four feet of coal at 81 feet. If this is the Bevier bed, as seems probable, it may be that part of the reported thickness consists of the clay parting so characteristic of the seam in this part of the State.

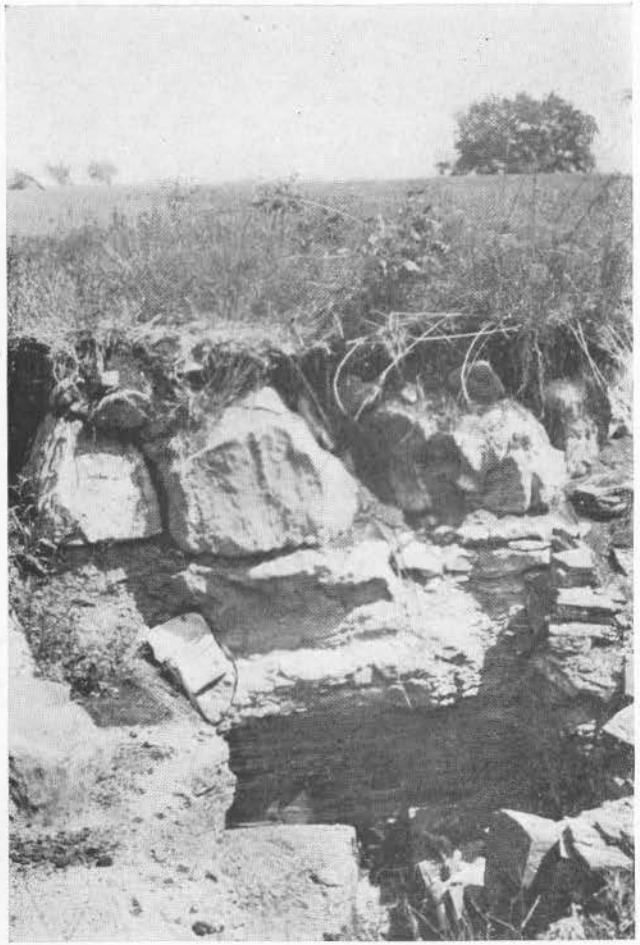

Fig. 1. Lexington coal bed, 1½ miles south of Eve, Vernon county.

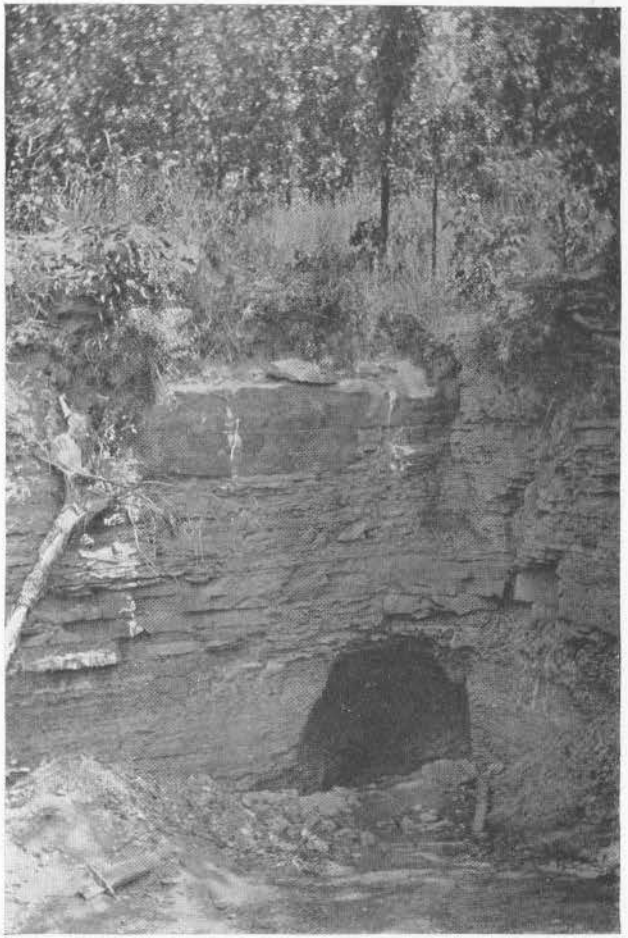

Fig. 2. Shepard drift, 6 miles northeast of Sheldon, Vernon county.

VERNON COUNTY.*

AVERAGE ANNUAL PRODUCTION, 1901-1910.....133,360 TONS.

Until very recent years Vernon county produced considerable coal, chiefly from the thick deposits of the Panama district, but in 1910 the output was only 24,032 tons. Some coal is still shipped from Panama, and small quantities are sold locally at numerous strip-pits and at a few drifts and shafts.

The Coal Measures of Vernon county include only two formations, the Henrietta and the Cherokee. The Henrietta appears only on the higher lands in the northwestern quarter, on the tops of mounds and ridges near the western edge of the county, and near Walker and Arthur. It outcrops conspicuously because of its resistant limestone beds. The Cherokee, which is at the surface in by far the greater part of the region, consists mainly of shale and sandstone, and contains only one important limestone. In the western part of the county this limestone is a thin bed that weathers out in characteristic slabs from which it derives its name of "diamond rock" in adjoining portions of Kansas. In the northern part of the county it is thicker and lies 50 feet or more above the important coal horizons of the Panama and neighboring districts. The succession of strata above the Rich Hill coal horizon is shown in the outcrop measurements and drill records given in the descriptions of the Eve, Moundville, Panama, and Walker districts.

Because of the slight dip to the northwest, the oldest rocks outcrop in the southeastern part of the county. Mississippian limestone, in and below which there is no coal, appears in small areas in the valley bottoms along the eastern edge and on the Osage 1 mile west of Belvoir. Southeast of the Missouri, Kansas and Texas railroad and east of Drywood creek, exposures consist very largely of sandstone that forms the lower half of the Cherokee.

The higher coal beds are thin but persistent. The highest, a bed lying near the base of the Henrietta formation, is sufficiently thick to be important only on the mound northwest of Bronaugh. The next lower bed is the Lexington, known in Kansas as the lower Fort Scott or the Fort Scott red coal. This bed, which lies 3 or 4 feet below the top of the Cherokee shale, is rarely more than a foot in thickness, except near Eve, where it is locally as much as 20 inches. Even where very thin it is used by farmers when other supplies of fuel are scarce. The next lower coal bed of importance lies 80 to 140 feet below the Lexington and only a short distance below the "diamond

*The geology is described by G. C. Broadhead and C. J. Norwood (Rept. for 1873-1874: Mo. Geol. Survey, 1874, pp. 119-154). The coal is mentioned by Arthur Winslow (Prelim. rept. on coal: Mo. Geol, Survey, 1891, pp. 150-156). The topography is shown on the Nevada, Fort Scott, Butler and Mound City sheets of the U. S. Geol. Survey.

rock." It is stripped at a number of places in the western part of the county, though everywhere less than 2 feet thick. If the correlations tentatively proposed for Bates county are correct, this bed is the Mulky.

The most important coal horizon is the Rich Hill, which is 150 to 200 feet below the Lexington. Its characteristics are described in the Bates county report. The lower Rich Hill bed in places attains a thickness of 6 feet, but was deposited only in basins and is absent or very thin in many areas. Basins of thick coal are known at and north of the mouth of Marmaton river near Walker, and at Moundville; thorough prospecting in the northern and western parts of the county might reveal other important deposits at the same horizon. No very important coals have been found below the Rich Hill, though lenticular beds, commonly less than 30 inches thick, may be seen in the southeast quarter of the county and near Schell City.

Modified so that 1,800 tons are assigned to each acre-foot of coal and all deposits less than 14 inches thick are omitted, Broadhead's calculations give Vernon a total original coal reserve of 1,257,408,000 tons. Of this amount only a negligible quantity has been mined and utilized.

Metz.—About 2 miles west of Metz a number of strippings in the coal below the "diamond rock" are worked only in fall and winter. At one of these (S. W. ¼ S. W. ¼ Sec. 8, T. 37 N., R. 32 W.) the following was measured:

	Feet.	*Inches.*
Limestone, blue, hard, more than	1	....
Shale, light at top, black, "slaty" below	7	....
COAL (Mulky?), reported	1	3

Four drillings were made 2 miles and less northeast of Metz, in attempts to find the Rich Hill bed. In the S. W. ¼ S. W. ¼ Sec. 2 there were 30 inches of coal at a depth of 84½ feet. At another place the following section was recorded:

DRILLING TWO MILES NORTHEAST OF METZ (N. W. ¼ N. E. ¼ SEC. 11, T. 37 N., R. 32 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil	10	....	10	....
Shale, sandy	20	....	30	....
Shale	9	4	39	4
COAL	....	8	40	....
Clay	2	....	42	....
Shale	3	....	45	....
Shale, black, "slaty"	2	....	47	....
COAL	1	6	48	6
Clay	10	....	58	6
Shale	9	6	68	....
Limestone, full of shells	2	....	70	....
Shale	4	....	74	....
COAL	....	3	74	3
Clay	12	9	87	....
Shale, black, "slaty"	2	....	89	....
COAL (Rich Hill?)	2	8	91	8
Clay	....	5	92	1

Three miles north of Metz (S. W. ¼ N. E. ¼ Sec. 34, T. 38 N., R. 32 W.), on Reeds creek, Norwood noted an outcrop of 18 to 20 inches of coal overlain by 4 feet of clay and 3 feet of "slaty" shale.

Stotesbury.—East and southeast of Stotesbury (Secs. 22, 25, 27, and elsewhere) a number of small strippings have been made of the coal beneath the "diamond rock." Although it is only 12 to 14 inches thick, this bed is so situated in many places that considerable quantities of fuel can be obtained by stripping 6 feet or less of overburden. Lying on the coal are 2 to 4 feet of light drab shale on which rests a few feet of black "slaty" shale containing "niggerheads" of impure limestone and having a thin limestone cap-rock.

Broadhead describes the following section of lower beds outcropping on the Little Osage (Sec. 22, T. 37 N., R. 33 W.) and correlates them with the beds at the base of Timbered Hill, east of Horton:

		Feet.	*Inches.*
1.	Shale, light blue, in thin laminæ	5	6
2.	COAL	....	10
3.	Fire clay	2	6
4.	Shale, brown, gypsiferous	3	6
5.	COAL	....	6
6.	Shale, blue, in thin laminæ, inclosing brown limestone nodules	3	6
7.	Fossiliferous calcareous stratum	....	....
8.	Shale, black, bituminous	2	....
9.	COAL	1	3
10.	Clay, containing limestone nodules in lower part	3	....

The following record of the oil and gas well drilled just east of Stotesbury, on the south bank of the Osage, is interesting, though the thicknesses given for the coal beds are hardly reliable:

	Thickness. *Feet.*	Depth. *Feet.*
Soil	9	9
Cherokee shale—		
Shale	20	29
COAL	3	32
Shale, in part blue	58	90
"Black sand" and blue shale	30	120
Limestone	5	125
Shale, in part blue	12	137
COAL	3	140
Sandstone and shale	30	170
Shale, in part "slaty"	35	205
Shale, black and blue, and sandstone	20	225
Shale	18	243
Limestone	2	245
Shale, sandy	15	260
Sandstone, fine-grained, micaceous	5	265
Shale, gray and black, with some sand	5	270
Shale, carbonaceous, sandy at base	8	278
Mississippian formation (lower limit of coal)—		
Limestone, gray, in part cherty	67	345

Richards.—In depressions in the prairie near Richards, the coal below the "diamond rock" is stripped on a small scale (S. E. ¼ N. E. ¼ Sec. 10, S. E. ¼ S. E. ¼ Sec. 2, and elsewhere). It is the same here as near Stotesbury. One mile southeast of town (S. E. ¼ S. E. ¼ Sec.

15) small pits reach a 14-inch bed, which is overlain with 10 inches of dark and 7 feet of light shale, and which may be 15 to 20 feet lower, stratigraphically, than the coal just mentioned. On the high ridge between Richards and Stotesbury the Lexington bed and the conspicuous limestones above it outcrop. The coal, however, rarely exceeds one foot in thickness.

Eve (Clayton).—The coal just below the "diamond rock" outcrops on the prairie north and east of Eve and is stripped in places. Just north of town a high mound shows the Lexington coal near the top and the "diamond rock" around the base.

OUTCROP ON MOUND NORTH OF EVE.

		Feet.	*Inches.*
1.	Limestone, light gray to buff, more than	6	....
2.	Interval including black, "slaty" shale and 6 inches of COAL	6	....
3.	Limestone, buff, massive	5	....
4.	Shale, black, "slaty"	4	....
5.	COAL (Lexington)	1	2
6.	Concealed	61	....
7.	Limestone, dark blue, breaks in diamond-shaped flags	1	....
8.	Shale, black, "slaty"	3	6
9.	Limestone, dark blue	....	6
10.	Shale	3	....
11.	Limestone, dark	....	6
12.	Shale, black, "slaty," with large and small limestone concretions	5	....
13.	Shale, light drab, sandy	5	....
14.	Shale, bluish-black	2	....
15.	COAL (Mulky?), average	1	4

Norwood measured the following section a short distance northwest of Eve (S. W. ¼ Sec. 5), and placed the top of it 23 feet below the "diamond rock:"

		Feet.	*Inches.*
1.	Shale, ochreous	5	....
2.	COAL	....	10–12
3.	Clay, ochreous	10	....
4.	COAL, good	1	....
5.	Shale, pyritiferous, thins out at west	....	9–36
6.	COAL (Rich Hill?), very good	....	9–17
7.	Clay, blue	....	....

On the upland south and southwest of Eve, the Lexington bed, known as the Fort Scott red coal, outcrops in many places. It was formerly stripped extensively 1½ miles southwest of town and is now utilized at a number of small pits. The coal is 12 to 20 inches thick and is in demand for domestic use. The roof is 40 inches of black, "slaty" shale that grades upward to one foot of drab clay. On the clay is a massive limestone that weathers buff and is about 5 feet thick. Owing to difficulty in handling the limestone, stripping is not carried far back from the outcrop.

A drilling at Eve is said to have penetrated 4 feet of coal at a depth of 100 feet, or at about the horizon of the Rich Hill bed. This report needs confirmation and is important if true.

Swart.—On small mounds about 1½ miles northwest and southwest of Swart, the Lexington is occasionally stripped and exhibits about the same variations in thickness as near Eve. On the flat prairie between Eve and Swart, the Mulky (?) coal outcrops in very few places and is commonly less than 14 inches thick.

Bronaugh.—In an area of about 2 square miles in Secs. 17 and 20, at and near Bronaugh, the "diamond rock" outcrops on the upland and the Mulky (?) probably lies a short distance below it. This coal bed is stripped a little in a small outlier 2 miles southeast of town (S. W. ¼ S. W. ¼ Sec. 28, T. 34 N., R. 32 W.), where the following was measured:

		Feet.	*Inches.*
1.	Limestone, drab, clinks, jointed, weathers in slabs	....	6
2.	Interval, including black, "slaty" shale	8	....
3.	Shale, light drab, with small, ferruginous concretions	6	....
4.	Shale, light bluish-gray	2	....
5.	COAL (Mulky?), 12 to 18 inches	1	6
6.	Clay	....	....

Between Bronaugh and Moundville, about a mile west of the railroad (Secs. 6 and 7, T. 34 N., R. 32 W.), is a high mound or ridge about 2 square miles in extent. On the top of the mound a bed corresponding to the upper coal at Fort Scott is stripped occasionally. This bed lies in the Henrietta formation, a few feet above the Lexington horizon, and is not known to be of workable thickness elsewhere. Because of the thick overlying limestone, it is not stripped far back from the outcrop and most of the available deposit has been utilized. In recent years a 13-inch bed that outcrops around the base of the mound has been a larger producer. The relations between the two beds are as follows:

		Feet.	*Inches.*
1.	Limestone, light gray, thinly and irregularly bedded, forms top of mound	3	....
2.	Clay	1	....
3.	Shale, black, "slaty," with small concretions in upper half, black in lower half	2	10
4.	COAL, stripped	1	2
5.	Interval, by barometer about	70	....
6.	Limestone, dark blue, jointed	1	....
7.	Interval, probably including COAL, by barometer about	30	....
8.	Sandstone, light brown, calcareous	....	8
9.	Shale, light and sandy at top, black and "slaty" at base	7	8
10.	COAL, stripped	1	1
11.	Concealed	13	....
12.	Limestone, dark blue, laminated, more than	....	4
13.	Shale	2	....
14.	COAL, streak	....	....

Moundville.—At Moundville three small mines are supplying local trade and shipping small quantities of coal from a thick bed which apparently lies at the Rich Hill horizon and is about 150 feet lower, stratigraphically, than the coal capping the mound near Bronaugh. The 25-foot shafts of A. S. Brown and D. K. Perkins are in the northwest corner of town, and the 30-foot shaft of W. J. Smith is a short

distance beyond (N. W. ¼ S. W. ¼ Sec. 34). The coal is hard and contains pyrite in lenses. The roof is good, except near the rather common "horsebacks" and "rolls" in the roof. The latter are 2 to 12 feet wide and cut out part of the coal in places.

BROWN SHAFT AT MOUNDVILLE.

	Feet.	*Inches.*
Limestone, light blue, compact	1	6
Shale, drab, sandy	14	....
Shale, dark blue, hard	8	....
COAL	2	4
Clay	1	....
COAL	....	8–12
Clay	2	....
COAL, in part cannel, not mined, 12 to 28 inches, average	1	4

At the Perkins mine only the top bench, 16 inches thick, was being mined, though the two lower benches are said to be the same as at the Brown shaft. At the Smith shaft the bottom bench is reported to be 3 feet thick. This basin of thick coal, which is little more than a mile wide from east to west, has been removed by erosion a short distance north of Moundville and is not known to extend more than 1½ miles south of town.

Two miles west of Moundville is the stripping of A. H. Franks (Lot 9 N. W. ¼ Sec. 6) in a bed that is, perhaps, the same as the one stripped around the base of the mound farther south.

FRANKS STRIPPING, WEST OF MOUNDVILLE.

	Feet.	*Inches.*
Sandstone, thin-bedded	1	....
Shale, very sandy at top, some dark layers in lower half	5	6
Shale, black, "slaty"	1	6
COAL	1	2

Nevada.—Little except thick massive and thin-bedded sandstone beds are exposed at and near Nevada. The city waterworks well penetrated 52 feet of sandstone, 110 feet of shale with only a trace of coal, and reached Mississippian limestone at 170 feet. A gas well 3½ miles southeast of the city penetrated similar beds and reached the base of the Coal Measures at 185 feet. No coal worthy of mention has been found near Nevada, though beds 18 inches and less in thickness have been prospected several miles east and north on Drywood creek and Marmaton river.

FIG. 88. The lower Rich Hill coal bed at Timbered Hill.

Horton.—Five miles southwest of Horton, near Ketterman (N. E. ¼ S. W. ¼ Sec. 30, T. 37 N., R. 30 W., and elsewhere), a 2-foot bed of coal is occasionally stripped for local use. Above it at least 3 feet of black "slaty" shale and black limestone in thin flat lenses lies in places directly on the coal. Miners say this bed has much the same characteristics as the upper Rich Hill of the Panama district. It is possible that basins of thicker coal lie below it at the lower Rich Hill horizon.

Northeast of Horton, near the mouth of Marmaton river on a high mound called Timbered Hill, stripping was formerly done and several shafts sunk, in one of which (N. W. ¼ N. W. ¼ Sec. 14, T. 37 N., R. 31 W.) 12 inches of coal was found at a depth of 22 feet, 18 inches at 38 feet, and 42 inches at 60 feet. The last named appears to be the lower Rich Hill, the bed so extensively mined a few miles farther north. Because of lack of transportation facilities, no mining has been done here in recent years.

Arthur, Panama, and Carbon Center.—Between the bottom lands of the Little Osage and the Bates county line, for 2 or 3 miles on both sides of the railroad from Rich Hill to Nevada, is the southern continuation of the Rich Hill field. From this area some of the best producers in the State formerly shipped coal and the country is pitted with large abandoned strippings. Most of the readily available de-

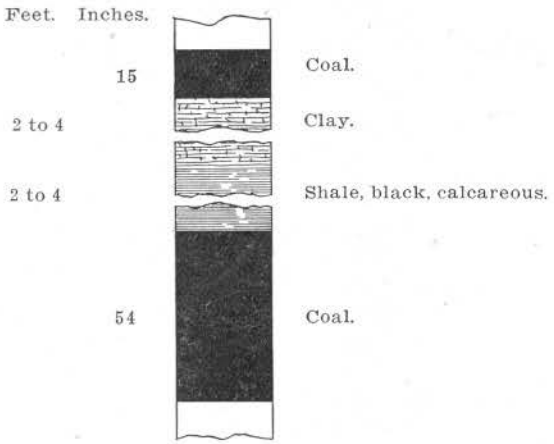

Fig. 89. The Rich Hill coal beds at Carbon Center.

posits have been exhausted and the present production is comparatively small. Coal is now shipped only from the strip-pit and shaft of the Jones Coal Company, 2 miles northeast of Arthur (N. W. ¼ N. W. ¼ Sec. 4, T. 37 N., R. 31 W.). Here the lower Rich Hill bed is 4 to 6 feet thick and the roof a firm black shale except in local areas of "white top." In places thin limestone lenses rest on the coal or lie

3 feet above it. The upper Rich Hill coal is 6 to 12 feet above the lower and is regularly 18 inches thick. This basin of thick coal is said to have included 400 acres, all but 60 of which have been mined out. From the Jones strip-pit to an old shaft one-fourth mile south, the dip is at least 150 feet.

The character of the coal and other deposits in this area is the same as in the Rich Hill district, described in the Bates county report. The following records show the similarity of the two districts:

DRILLING ONE-HALF MILE SOUTH OF PANAMA (N. W. ¼ N. W. ¼ SEC. 32, T. 38 N., R. 31 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Soil	4	....	4	....
Henrietta formation—				
Limestone	5	....	9	....
Shale, black, "slaty"	3	....	12	....
Clay	3	....	15	....
Limestone	3	....	18	....
Cherokee shale—				
Shale, sandy	7	....	25	....
Sandstone	8	....	33	....
Shale, sandy in upper half, blue in lower	72	6	105	6
COAL (Summit?)	....	9	106	3
Clay	....	9	107	....
Limestone	4	....	111	....
Shale, sandy	40	10	151	10
COAL (Mulky?)	....	10	152	8
Clay	15	4	168	....
Shale, black, hard	9	10	177	10
COAL (upper Rich Hill)	1	5	179	3
Clay	1	9	181	....
Shale, black, hard	10	....	191	....
COAL (lower Rich Hill)	3	7	194	7
Clay	....	5	195	....

DRILLING TWO MILES SOUTHWEST OF PANAMA (S. W. ¼ N. E. ¼ SEC. 36, T. 38 N., R. 32 W.).

	Thickness.		Depth.	
	Feet.	*Inches.*	*Feet.*	*Inches.*
Surface material	12	....	12	....
Cherokee shale—				
Shale, sandy	8	....	20	....
Sandstone	10	....	30	....
Shale, sandy	12	9	42	9
Sandstone	3	3	46	....
Shale, sandy in upper half	20	....	66	....
"Rock," blue, hard	1	6	67	6
Shale, blue	19	8	87	2
COAL (Summit?)	....	6	87	8
Clay	....	8	88	4
Limestone	8	....	96	4
Shale, black in upper half	15	....	111	4
COAL (Mulky?)	....	10	112	2
Clay	6	2	118	4
Shale, blue at base	13	....	131	4
COAL (upper Rich Hill)	1	....	132	4
Clay	4	11	137	3
Shale, black, hard	1	1	138	4
COAL (lower Rich Hill)	3	1	141	5
Clay	....	4	141	9

Schell City.—Coal is mined for local trade at a number of places north and west of Schell City. The Maus stripping, a short distance north of town (N. E. ½ N. E. ¼ Sec. 33), works a thick coal, which has the following section in the DeTallante stripping 1 mile to the northwest (middle E. ½ S. W. ¼ Sec. 28):

	Feet.	*Inches.*
Sandstone, more than	3	....
Shale, light and sandy at top, dark and "slaty" at base	11	8
COAL, reported	....	36 to 44

A group of strippings 1 mile southwest of Schell City (E. ½ Sec. 5, and S. W. ¼ Sec. 4), show coal 15 to 18 inches thick overlain with sandstone and conglomerate. The sandstone cuts down into the coal locally.

Four miles west of town several drifts and shallow shafts belong to A. Myers (N. ½ S. W. ½ Sec. 36, T. 38 N., R. 30 W.) and other drifts belonging to F. M. Cox and Wm. Duncan (S. W. ¼ S. W. ¼ Sec. 36). The following was measured in one of the shafts:

	Feet.	*Inches.*
Sandstone	5	....
Conglomerate, ferruginous	1	....
Shale, dark, soft	....	5
COAL, hard	1	6
Sandstone	....	....

That this deposit is not far above the base of the Coal Measures is shown by outcrops of Mississippian limestone 40 feet above the Osage west of Belvoir and only 1½ miles north of the mines. Farther up the Osage, at Halley's Bluff, 20 inches of coal has been stripped on the river bank. The roof is a sandy shale and about 30 feet above it are 30 to 40 feet of gray to buff sandstone. The Mississippian probably lies only a short distance below the river at this point.

Harwood.—Stripping and some underground work are done 2 to 3 miles southwest of Harwood at the Rich Hill or lower horizons. The following mines were visited: (1) W. M. Smith on land of C. E. Moore (N. W. ¼ N. W. ¼ Sec. 31, T. 37 N., R. 29 W.), slope and stripping, coal 26 to 30 inches, roof sandstone; (2) F. Y. Ewing (N. E. ¼ N. E. ¼ Sec. 36), stripping, same as Moore; (3) F. Y. Ewing (S. W. ¼ N. W. ¼ Sec. 36), shaft and stripping, coal 20 to 42 inches, roof 20 inches black shale overlain with sandstone; (4) John Hardy on land of I. M. Hart (S. E. ¼ S. E. ¼ Sec. 25), slope, coal 27 inches; (5) F. M. Mayberry (S. E. ¼ S. E. ¼ Sec. 26), stripping. On the south side of the road, near the Mayberry pit, the following section was recorded:

	Feet.	*Inches.*
Sandstone	2	....
Shale, light and sandy at top, black and "slaty" at base	5	....
Limestone, black, shaly	2	....
COAL, reported thickness	3	6

Walker.—In the mound northwest of Walker are the two beds of coal shown in the following section:

SECTION TWO MILES NORTHWEST OF WALKER (N. W. ¼ SEC. 8, T. 36 N., R. 30 W.).

	Feet.	Inches.
Sandstone, coarse, massive, and conglomerate	15	....
Concealed	26	....
Limestone, lower 2 feet blue, weathering buff, upper part mottled gray, thin-bedded	10	8
Shale, drab, clayey	1	9
Limestone, blue, weathers to buff-colored rhomboids	....	9
Shale, drab, calcareous at top	1	3
Shale, black, "slaty"	1	9
Shale, light drab	15	2
COAL (Mulky?), weathered	1	....
Shale, upper 30 feet light drab, bottom 5 feet black and "slaty," grading into black bituminous limestone at base	35	....
COAL (Rich Hill)	2	....
Clay	....	....

The upper coal, 12 to 15 inches thick and very clean, is stripped on every farm on the mound. The lower bed underlies the surrounding prairie also, and has been stripped at many places in the northern part of T. 36 N., R. 30 W. Its thickness varies from 18 to 30 inches. Attempts have been made to mine it from drifts in the mound but the black limestone forming the roof has a tendency to fall. North of High Tower creek the Mulky (?) is stripped in many places in Secs. 22, 26, 32, 33, and 34, T. 37 N., R. 30 W., where it has the same characteristics.

Sheldon.—A basin of coal 3 to 3½ feet thick was formerly stripped between Milo and Sheldon (N. E. ¼ S. E. ¼ Sec. 2) on the Ferry farm, but nothing has been done there for several years. Ten feet or more of sandstone lies on the coal in places. On J. L. Maxwell's place (N. E. ¼ N. E. ¼ Sec. 16, T. 34 N., R. 31 W.) 30 inches of coal with sandstone cover have been reported found in a well.

Five miles northeast of Sheldon, on Clear creek and near Bellamy, several mines supply a large territory, though their output is small. The coal beds, which are less than 100 feet from the base of the Coal Measures, appear to thicken only locally and to be absent in many places. At the bottom of the Clear creek bluffs (N. E. ¼ S. W. ¼ Sec. 16), in the drift of J. A. Lowe, the roof is excellent and the beds dip 10° S. W.

COAL AT LOWE DRIFT.

	Feet.	Inches.
Sandstone, yellowish-white, massive	40	....
Sandstone, with shale partings	10	....
COAL, fair	1	....
Shale, carbonaceous, thickness variable	....	2
COAL, good	1	6
Shale, carbonaceous	....	4
Clay, light blue, sandy, hard	1	....

What is probably the same bed, though lying at a higher level, has been mined in many small drifts and slopes on the land of F.

Baker (S. E. ¼ S. E. ¼ Sec. 16). The coal contains non-persistent shale partings and one that is fairly regular. In one place there are only 13 inches of coal, but the following is the typical section:

COAL AT BAKER DRIFTS.

	Feet.	Inches.
Sandstone	6	....
Shale, sandy, fair roof if not brushed	5	....
COAL, with 1 inch of shale in middle	1	10
Shale, carbonaceous	....	1
Clay, sandy, hard	2	6

At the R. W. Shepard slope, a short distance east (S. W. ¼ S. W. ¼ Sec. 15), the coal bed and roof are the same as at Baker's.

One-half mile west of Bellamy (N. W. ¼ Sec. 23, T. 34 N., R. 29 W.), there are 18 inches of coal with a sandstone roof and a 3-inch parting of shale. Two miles northeast of the village (S. W. ¼ S. W. ¼ Sec. 7 and vicinity), recent strippings have been made in 12 to 18 inches of excellent coal, on which lies 12 feet of yellowish-white, massive, cross-bedded sandstone. Other exposures of thin coal beds appear farther down McCarty creek.

WARREN COUNTY.*

Warren county contains only a few square miles of Pennsylvanian strata in an outlier halfway between Pendleton and Jonesburg, where drab limestone and fragments of coal have been found. No coal of importance has been located in this area. A number of pockets in different parts of the county contain coal, but they are of very small extent and their coal is of uncertain quality.

WORTH COUNTY.

So far as known there are no outcropping coal beds in Worth county. Aside from glacial drift, the surface formation of most of the county is the Douglas shale. In the Lawrence shale, a thick member of the upper part of the Douglas, some comparatively unimportant coal beds were found in Gentry county, and it may be that similar deposits exist beneath the drift in Worth. At Denver the upper part of the Lansing formation is brought to the surface by an anticline (arch), so that at that place the Bevier horizon, at which there is some coal in Gentry county, lies only about 625 feet below the surface.

The only definite information concerning the coal horizons of the Cherokee shale is derived from the record of a core recently bored three-fourths of a mile east of Allendale, in the northeastern part of the county. This record is very important, for it proves the existence

*Broadhead, G. C., Warren County: Mo. Geol. Survey, 1855-1871, pp. 37-64. The topography is shown on the Hermann sheet of the U. S. Geol. Survey.

of workable Cherokee coal beds much farther west than they had hitherto been found on the northern edge of the State. A thick limestone series, probably the basal members of the Kansas City limestone (base of Missouri group), was penetrated at a depth of 375 to 420 feet and 3 coal beds at more than 900 feet, the highest and thickest apparently occupying the horizon of the Cainesville bed of Harrison and Mercer counties. Drilling was stopped in massive, micaceous sandstone, evidently of lower Cherokee age, at a depth of 1,135 feet. Following is the record of the strata which bear the coal beds mentioned:

	Thickness.		Depth.	
	Feet.	*Inches*	*Feet.*	*Inches.*
Shale, black, "slaty," with "sulphur" bands	7	6	933	5
COAL (Cainesville?)	2	3	935	8
Shale, gray, sandy	7	....	942	8
Clay	2	5	945	1
Shale, dark	....	6	945	7
Shale, with "sulphur" bands	2	....	947	7
COAL	1	6	949	1
Shale, dark	5	....	954	1
COAL	1	4	955	5
Clay	....	9	956	2
Shale, sandy	5	....	961	2
Shale, black	1	6	962	8

The two lower coal beds are so close together that it is doubtful if both could be mined from the same shaft. There is a total of 45 inches in the two higher beds, however, and it is fair to consider that thickness an average for the entire county, making the total original tonnage 1,140,480,000 tons.

OTHER COUNTIES.

Small outliers and pockets of Pennsylvanian, scattered over the surface of many counties in southwest and south Missouri, are not described in detail in this report. Camden, Hickory, Polk, Greene, Christian, Lawrence, and Newton counties contain a large number of these outliers, the position of many of which is shown on the State geological map accompanying this report. Some of the deposits in nearly every county contain coal, but not of sufficient quality or in sufficient quantity to be of more than very local interest. With the exception of a report on Greene county,† very little has been published on this region, and the economic importance of the coal pockets was not considered sufficient to justify their examination by the writer.

†Shepard, F. M., Report on Greene County: Geol. Survey of Missouri, Vol. XII, pt. 1, 1898, pp. 123-141 and 211-212.

CHAPTER V.

CHEMICAL ANALYSES OF MISSOURI COALS.

Method of Sampling.—Analyses of Missouri coals have been published in a number of the earlier reports of this Bureau, but on account of the lack of uniformity or standardization of method, both in taking the coal sample and in making the analysis, these analyses lack reliability as well as a parity basis for examination and comparison. Many of them were doubtless correctly made, but it is generally impossible to distinguish the valid analyses from those that are subject to question. The U. S. Geological Survey experienced the same difficulty, which resulted in the appointment of a committee to determine the best method of sampling the beds. The method selected by this committee for the Federal Survey has been adopted as the standard for the Missouri work.

The number of samples taken for analyses and the points selected for sampling depend largely on the size of the mine, the daily production and the variability in the quality or thickness of the coal. At most of the mines in the State three samples were taken. When a point for sampling was selected—invariably a fresh face in the active workings of the mine—the face of the bed was cleared of burned powder, dirt, and loose coal from roof to floor, for a width of about 5 feet, in order to prevent any loose fragments or foreign matter from falling from the face of the coal to the sampling cloth. For the same reason insecure pieces of the roof were also taken down in advance. In the middle of the area thus cleared, the coal was cut away with the pick from roof to floor for a width of one foot and to a depth of at least one inch, with a view to removing any discolored, altered, or otherwise deteriorated coal that might be near the surface, and also to square up that portion of the face in preparation for the sample cutting. The floor was then smoothed and cleaned and the sampling cloth spread on it close to the face of the coal. Then a uniform cut perpendicular to the bed was made 2 inches deep and 6 inches wide (or 3 inches deep and 4 inches wide in the softer coals) from the roof down the middle of the foot-wide cut previously made in the coal face. Enough coal was cut to make a sample weighing at least 6 pounds for each foot of the thickness of the bed. In cutting the sample care was taken to exclude such impurities—bony layers,

shale partings, "sulphur" lenses, streaks—as are commonly rejected in mining and preparing the coal at the mine. Usually partings over three-eighths of an inch in thickness were rejected. As soon as the sample was cut, it was crushed in the mine so that all of the particles would pass a half-inch mesh. The sample was then thoroughly mixed by two men grasping the opposite corners of the blanket and rolling it diagonally by raising one corner at a time. The pile was then flattened and quartered, and two opposite quarters brushed off. The remainder was again repeatedly mixed and quartered until reduced nearly to the amount required to fill a 9 by 3-inch cylindrical can (standard size). After labeling, the top of the can was screwed on tight and sealed with adhesive tape to prevent the admission of air as well as the escape of gases. The samples were then sent to the U. S. Geological Survey or, later, to the Bureau of Mines, where they were analyzed.

The analytical and other tests of the coals of Missouri were carried out under a co-operative agreement with the U. S. Geological Survey, which agreement was continued after the reorganization of the Technologic Branch of that Survey as the Bureau of Mines. It is believed that the samples taken in the manner described above* represent fairly the coal as produced at the points where the samples are taken in the mines. To obtain a more accurate showing of the quality of the coal, as a whole, in any mine it is, however, desirable to collect a considerable number of samples distributed among as many points as may be practicable (the more the better) in the mine, since the coal often varies somewhat as to ash, moisture, or sulphur, and, so, as to calorific value, in different parts of a single mine. For this reason the analyses quoted below may not, on account of the small number of samples taken from each mine, always represent the average of the coal as mined not only in all parts of the mine but also as produced through a term of years during which mining operations may have extended to other points in the same property. While, perhaps, not always accurately representative of the average quality of the coal in the particular mine the combined analyses are probably adequate and satisfactory in showing the quality of the coal and bed in the district from which they were obtained. The samples were collected by V. H. Hughes, J. M. Webb, R. D. Killian, M. Albertson and Henry Hinds.

THE CONSTITUENTS OF COAL.

Primarily coal is composed in varying proportions (1) of impurities, mainly of inorganic origin, which are detrimental to its value, and (2) of matter of organic origin, that is, derived from the vegetal

*For full description of the methods of sampling see Bureau of Mines, Technical Paper No. 1, 1911, 18 pp.

debris from which the coal was formed. The organic matter includes the essential fuel or heat-producing portion. In the table under "proximate analysis" four constituents of the coal are given, and under "ultimate analysis" five, with the ash percentage common to both.

The proximate analysis is not an elementary analysis, that is, it does not attempt to show the percentages of the chemical elements, hydrogen, oxygen, carbon, etc., in the coal. It is merely a conventional method of treatment for the purpose of ascertaining: (1) The relative amounts of certain important impurities, such as the moisture and the ash; and (2) the general nature of the combustible matter as indicated by the amount of "volatile matter" contained in it. In this process the coal is subjected to a carefully prescribed treatment by heat, supposed to be comparable to that endured by coal in the ordinary process of coke making. In general terms, the proportion of the coal that is driven off as gas—that is, the part which is volatilized under the roasting—is classed as "volatile matter." The remaining part, which is supposed to correspond very nearly to the organic matter left in coke, is termed "fixed carbon." By deducting the moisture from the volatile matter the so-called "volatile combustible matter" is determined. In modern practice the proximate analysis is much refined and carefully standardized, and has lost much of its original significance, but it is still a purely conventional and arbitrary process.

The moisture and ash, which are the principal impurities—not parts of the combustible matter, of the fuel—are determined as in the ultimate analysis, as also is the sulphur, one of the chemical elements sometimes measured for inclusion in the proximate as well as in the ultimate analysis.

The moisture consists of that which is inherent in the coal—that is, residual water from the original peat or that subsequently generated by chemical action,—together with the extraneous water taken up by the coal in various ways and stored between the grains and in the joints. The moisture is approximately, though never exactly, determined in the samples by drying (usually at a temperature of 105° C.) and weighing again. By subtracting from the hydrogen and oxygen reported in the ultimate analysis of the "air-dried" coal the amounts of these two elements corresponding to the previously determined moisture in the "air-dried" sample and recalculating the remaining percentages to total one hundred per cent, the analysis of the fuel is reduced to the "dry coal" basis. Dividing the remaining percentages by one minus the percentage of ash similarly recalculates the analysis to the ash-free basis; and so on.

In the average bituminous coal of moderately low rank, as mined, ash is nearly equal to moisture in importance as a harmful ingredient.

In the lower grades of coal the moisture predominates; in the higher grades the ash generally exceeds the moisture. Ash is the more objectionable for it not only absorbs heat but also produces refuse, which must subsequently be handled and disposed of.

There are three sources of ash in coal, two primary and one secondary. All vegetable matter contains some mineral matter which remains as ash when the compound is burned. The plants which formed the coal were no exception. A second primary source of ash was the fine particles of dust, sand or mud that were blown or washed into the swamp in which the coal was formed. A third portion of the ash was formed much later. Many Missouri coals are associated with limestone cap-or bottom-rocks; and circulating waters, after dissolving portions of these have later deposited in joints and crevices of the coals certain carbonates and sulphates, all contributions to ash, appearing as crystals and white incrustations or "scale". Transparent flakes of gypsum (selenite) are common. Some oxide of silica, as well as clay, may also be deposited by circulating waters.

The chemical composition of ash is extremely variable, but it consists chiefly of the oxides of iron (Fe_2O_3), calcium (CaO), aluminum (Al_2O_3), magnesium (MgO), silicon (SiO_2) and sodium and potassium (Na_2O, K_2O) combined with certain acids, to form calcite, selenite, aluminum silicate, and other minerals.

The volatile matter in the coal includes small quantities of nitrogen and carbon dioxide, but, predominantly, it is composed of organic compounds of carbon, hydrogen and oxygen. Sulphur is also included in some of the compounds.

In the ultimate analysis, the elements composing the moisture in the coal as analyzed, the volatile matter, and the fixed carbon are included under the columns of the table headed Hydrogen, Carbon, Nitrogen, Oxygen, and Sulphur. The purpose of this form of analysis is to reveal the proportions of each of these elements in the coal, particularly those that produce heat, but the analysis does not express the chemical combinations of these elements; neither the number nor the nature of all the organic compounds existing in any type of coal are fully known. The gases driven off by heat may be analyzed, but they are only the products of the decomposition of the organic compounds existing in the coal.

The important elements in any coal are the carbon, which forms the greater part of the fuel if the coal is not too high in ash to burn, and the hydrogen, which, though relatively small in amount, has a heating power per unit about four times that of unit carbon. The sulphur lends a slight heat increment to the coal under certain conditions, particularly if it exists in a free state. The nitrogen of the coal, always very small in amount, is presumably passive and inert and is chiefly notable as a diluent, displacing other matter of positive

value. The oxygen, on the other hand, is not only inert and diluent, but it appears to have the effect of neutralizing so much of the hydrogen as would be necessary to form water with the oxygen in the process of burning.

In the original vegetal debris contributed to the mother peat the oxygen nearly equaled the carbon in weight, thus constituting the most serious of the harmful elements in the lower ranks of coals, its anticalorific effect being nearly equal to that of the same weight of ash.† The progressive advancement of the fuels from peats to coals of successively higher ranks through the action of dynamo-chemical agencies is marked chiefly by the progressive elimination of the oxygen, which up to the point of anthracitization of the coals accomplishes a corresponding improvement in the quality and heat value or efficiency of the fuel. Simultaneously there is a progressive reduction of moisture also. Accompanying the elminiation of oxygen there are less important losses of the volatile carbon and of the hydrogen. The net result is a relative increase or concentration of the carbon in the coal and, up to a certain variable point, a relative increase in the percentage of the hydrogen not neutralized in effect by the oxygen.

In this connection it should be noted that the oxygen reported in the ultimate analysis, which appears in general to range between 9 and 12 per cent in Missouri coals, includes the oxygen of the moisture of the coals as reported on the "air-dried" basis, as well as the oxygen in the organic compounds of the coal. The latent or organically combined oxygen in the coal may roughly be determined by subtracting one-ninth of the reported moisture percentage from the oxygen percentage given in the ultimate analysis.

The calorific values of the carbon, hydrogen and free sulphur are rated at 8,080, 34,460, and 2,250 heat units respectively. These values are used in calculating the efficiency of the coal from the ultimate analysis, the percentage of hydrogen being discounted by so much as might be necessary to form water with the oxygen present. This is graphically expressed in Dulong's formula for calculating the calorific value of the coal as follows, in which S = sulphur, C = carbon, H = hydrogen, and O = oxygen:

$$2250\ S + 8080\ C + 34460\ (H - O_8)$$

As already noted, carbon is the principal combustible matter in coal. Other things being equal, the greater the amount of "fixed carbon" (that part of the carbon which is not driven off with the volatile combustible matter) the greater the heating value of the coal up to a certain limit—that is, until the coal approaches the grade or quality of anthracite. Fixed carbon has not, however, so high a heating value as the hydrocarbons (compounds of C and H); there-

†See Bull. U. S. Geol. Survey, 382, 1909: Bull. Bureau of Mines, No. 29, 1911.

fore some coals, like cannels, which contain relatively large amounts of volatile hydrocarbons, have higher efficiencies than those which contain a large amount of "fixed carbon," provided the amounts of oxygen and ash are the same. Most coals, not cannels, that contain small percentages of "fixed carbon," have relatively low heating values, owing mainly to the larger quantities of oxygen they contain either combined in the organic compounds or in the moisture of the coal.

In the coals of Missouri sulphur usually occurs as pyrite or marcasite, but it also appears frequently as sulphates in the "white scale" that fills some of the joints. It is also present as free sulphur. The total amount revealed by the ultimate analyses ranges from 1.74 per cent to 7.90 per cent in the coal as received. When free, sulphur has a heating value much less than that of carbon, as has already been stated, and therefore tends to lower the efficiency of the coal. In the sulphides its heat value is still less, and in the sulphates it may be rated as a harmful impurity. The sulphides deserve further consideration as harmful because of their tendency to form iron oxide and clinker, and especially because of their bad effects on iron, whether in the grate or in the product of the blast furnace.

From the foregoing it will be seen that the analysis of any coal at once furnishes an index to both its character or type and its heating value.

METHOD OF STATEMENT OF ANALYSES.

In the accompanying table the analyses are stated in four forms—(a) air dried; (b) as received; (c) moisture-free, and (d) moisture- and ash-free. Coal is "air dried" by exposing it in pulverized form to a current of dry warm air in conformity with certain explicitly prescribed rules. The loss of moisture in this process is presumed to correspond in a general way to that which the coal ordinarily undergoes in transportation from the mine to the point where it is used. The moisture loss of Missouri coals while they are thus dried ranges from 3.50 per cent to 13.70 per cent. After "air drying," the percentages of moisture, volatile combustible matter, fixed carbon, and other constituents are determined as shown in the table under *a* (= air dried). The figures under *b* (= as received) represent the coal as it existed when the sample can was opened. It approximates the state of the fuel at the face in the mine. In the proximate analysis the "as received" form is calculated by multiplying the percentages in the air-dried coal by 1 minus the air-drying moisture loss (1.00 — air-drying loss) and adding the air-drying loss, as shown in the following example, in which the air-drying loss was 8.60 per cent.

	Coal (air dried).				*Coal (as received).*
Moisture	3.25	x	91.40	2.97 (+8.60)	11.57
Volatile combustible matter	34.58	x	91.40		31.61
Ash	18.50	x	91.40		16.91
Fixed carbon	43.67	x	91.40		39.91
Total	100.00				100.00

Air-drying loss 8.60%.

The "as received" form of statement of the ultimate analysis is obtained similarly by recalculating and adding the H and O represented by the air-drying loss in the moisture ($^1/_9$ and $^8/_9$ respectively).

The reduction of the analyses to the dry coal or moisture-free basis (*c* of the table), and to the ash- and moisture-free basis (*d* in table) has already been explained.

Moisture- and ash-free coal is sometimes termed "pure coal," though the latter term is more properly applied to coal that is ash-, moisture- and sulphur-free.

CALORIFIC VALUE.

The relative efficiencies of various coals are approximately determined in the laboratories by burning them in an apparatus called a calorimeter,* in which the amount of heat developed by the total combustion of a given weight of the coal is accurately measured, and the results of such determinations are stated in calories or in British thermal units or both. A calorie is the amount of heat required to raise one kilogram of water, at maximum density, one degree centigrade. The British thermal unit is the heat needed to raise one pound of water, maximum density, one degree Fahrenheit. Calorific values may be converted to B. t. u.'s by multiplying by 1.8.

*The Mahler bomb calorimeter was used in all tests given in this report.

COAL ANALYSES.

Moist. =moisture, V. =volatile matter, F. C. =fixed carbon; H. =hydrogen, C. =carbon, N. =nitrogen, O. =oxygen; Cal. V. Det'd. =calorific value determined, B. T. U. =British thermal units; a. =air dried, b. =as received, c. =moisture free, d. =moisture and ash free.

ADAIR COUNTY.

Location.	Lab. No.	Sample.	Loss air dry.	Proximate.				Ultimate.					Cal. V. Det'd.		Name of bed.
				Moist.	Vol.	F. C.	Ash.	H.	C.	N.	O.	S.	Calories.	B. T. U.	
Connelsville—1½ miles south.	10,888	a.	11.40	5.27	36.26	44.19	14.28	5.00	62.93	1.13	12.92	3.74	6,418	11,552	Bevier.
		b.	.....	16.07	32.13	39.15	12.65	5.70	55.76	1.00	21.58	3.31	5,685	10,235	
		c.	.....	.....	38.28	46.65	15.07	4.66	66.44	1.19	8.70	3.94	6,775	12,195	
		d.	.....	.....	45.07	54.93	.....	5.49	78.23	1.40	10.24	4.64	7,977	14,359	
Kirksville—½ mile west.	10,106	a.	11.10	3.93	36.05	44.37	15.65	4.87	63.13	1.05	11.15	4.15	6,412	11,542	Bevier.
		b.	.....	14.59	32.05	39.45	13.91	5.56	56.12	.93	19.79	3.69	5,700	10,260	
		c.	.....	.....	37.52	46.19	16.29	4.61	65.71	1.09	7.98	4.32	6,674	12,013	
		d.	.....	.....	44.82	55.18	.....	5.51	78.50	1.30	9.53	5.16	7,973	14,351	
Kirksville—½ mile west.	10,442	a.	9.80	5.10	35.80	44.53	14.57	4.95	62.56	1.11	10.95	5.86	6,343	11,417	Bevier.
		b.	.....	14.40	32.29	40.17	13.14	5.56	56.43	1.00	18.58	5.29	5,721	10,298	
		c.	.....	.....	37.72	46.93	15.35	4.63	65.93	1.17	6.74	6.18	6,683	12,029	
		d.	.....	.....	44.56	55.44	.....	5.47	77.88	1.38	7.97	7.30	7,895	14,211	
Novinger—2½ miles southwest.	10,090	a.	9.50	6.22	36.11	46.33	11.34	5.11	64.54	1.08	14.04	3.89	6,576	11,837	Bevier.
		b.	.....	15.13	32.68	41.93	10.26	5.68	58.41	.98	21.15	3.52	5,951	10,712	
		c.	.....	.....	38.51	49.40	12.09	4.71	68.82	1.15	9.08	4.15	7,012	12,622	
		d.	.....	.....	43.81	56.19	.....	5.36	78.28	1.31	10.33	4.72	7,976	14,357	
Novinger—2½ miles north.	10,089	a.	10.40	5.95	37.34	43.44	13.27	5.06	64.43	1.10	12.77	3.37	6,454	11,617	Bevier.
		b.	.....	15.73	33.46	38.92	11.89	5.69	57.72	.99	20.69	3.02	5,783	10,409	
		c.	.....	.....	39.71	46.18	14.11	4.68	68.50	1.17	7.96	3.58	6,863	12,353	
		d.	.....	.....	46.23	53.77	.....	5.45	79.77	1.36	9.25	4.17	7,991	14,384	
Stahl—1 mile northwest.	10,081	a.	9.50	6.48	38.46	42.92	12.14	5.33	63.08	1.05	14.45	3.95	6,421	11,558	Lexington.
		b.	.....	15.36	34.81	38.84	10.99	5.88	57.09	.95	21.52	3.57	5,811	10,460	
		c.	.....	.....	41.13	45.89	12.98	4.93	67.45	1.12	9.30	4.22	6,866	12,359	
		d.	.....	.....	47.27	52.73	.....	5.67	77.51	1.29	10.68	4.85	7,890	14,202	

AUDRAIN COUNTY.

Location.	Lab. No.	Sample.	Loss air dry.	Proximate.				Ultimate.					Cal. V. Det'd.		Name of bed.
				Moist.	Vol.	F. C.	Ash.	H.	C.	N.	O.	S.	Calories.	B. T. U.	
Martinsburg—¼ mile west.	11,478	a.	8.80	1.38	42.38	43.50	12.74	4.88	66.71	.91	9.10	5.66	6,790	12,222	Mulky.
		b.	.....	10.06	38.65	39.67	11.62	5.43	60.84	.83	16.12	5.16	6,192	11,146	
		c.	.....	.....	42.97	44.11	12.92	4.79	67.65	.92	7.98	5.74	6,885	12,393	
		d.	.....	.....	49.35	50.65	.....	5.50	77.69	1.06	9.16	6.59	7,907	14,233	

Vandalia— ¼ mile north.	9,993	a.	7.40	3.20	42.42	41.07	13.31	5.04	66.01	1.05	9.31	5.28	6,808	12,254	Mulky.
		b.	.....	10.36	39.28	38.03	12.33	5.49	61.13	.97	15.19	4.89	6,304	11,347	
		c.	.....	.....	43.82	42.42	13.76	4.84	68.20	1.08	6.66	5.46	7,033	12,659	
		d.	.....	.....	50.81	49.19	.....	5.61	79.08	1.25	7.73	6.33	8,155	14,679	
BARTON COUNTY.															
Mindenmines— 1 mile northeast.	11,180F	a.	4.20	1.28	33.47	55.91	9.34	5.13	74.72	1.43	5.60	3.78	7,534	13,561	Weir-Pittsburg.
		b.	.....	5.43	32.06	53.56	8.95	5.38	71.58	1.37	9.10	3.62	7,218	12,992	
		c.	.....	.....	33.90	56.64	9.46	5.05	75.69	1.45	4.52	3.83	7,632	13,738	
		d.	.....	.....	37.44	62.56	.....	5.58	83.60	1.60	4.99	4.23	8,430	15,174	
Mindenmines— 2 miles northwest.	11,188F	a.	4.30	1.64	32.37	53.99	12.00	4.80	70.68	1.14	6.16	5.22	7,163	12,893	Weir-Pittsburg.
		b.	.....	5.87	30.98	51.67	11.48	5.07	67.64	1.09	9.72	5.00	6,855	12,339	
		c.	.....	.....	32.91	54.89	12.20	4.70	71.85	1.16	4.78	5.31	7,282	13,108	
		d.	.....	.....	37.48	62.52	.....	5.35	81.84	1.32	5.44	6.05	8,294	14,929	
BATES COUNTY.															
Amsterdam—	11,309	a.	7.60	1.72	34.75	47.80	15.73	4.62	66.54	1.09	7.73	4.29	6,738	12,128	Mulberry.
		b.	.....	9.19	32.11	44.17	14.53	5.11	61.48	1.01	13.91	3.96	6,226	11,207	
		c.	.....	.....	35.36	48.64	16.00	4.50	67.70	1.11	6.33	4.36	6,856	12,341	
		d.	.....	.....	42.10	57.90	.....	5.36	80.60	1.32	7.53	5.19	8,162	14,692	
Hume— 4 miles east.	11,229	a.	9.90	2.63	33.70	51.80	11.87	4.88	70.21	1.33	9.40	2.31	6,965	12,537	Mulberry.
		b.	.....	12.27	30.36	46.68	10.69	5.50	63.26	1.20	17.27	2.08	6,275	11,295	
		c.	.....	.....	34.61	53.20	12.19	4.72	72.11	1.37	7.24	2.37	7,153	12,875	
		d.	.....	.....	39.41	60.59	.....	5.38	82.12	1.56	8.24	2.70	8,146	14,663	
New Home— Sec. 30, T. 39 N., R. 32 W.	11,225	a.	8.30	1.86	36.08	46.30	15.76	4.74	65.75	1.10	7.14	5.51	6,752	12,154	Lower Rich Hill.
		b.	.....	10.01	33.09	42.45	14.45	5.27	60.29	1.01	13.93	5.05	6,192	11,146	
		c.	.....	.....	36.77	47.17	16.06	4.62	66.99	1.12	5.60	5.61	6,881	12,386	
		d.	.....	.....	43.80	56.20	.....	5.50	79.81	1.33	6.68	6.68	8,197	14,756	
Rich Hill— 2 miles northwest.	11,200	a.	6.20	1.70	37.86	46.90	13.54	5.02	67.35	1.07	7.52	5.50	6,955	12,519	Lower Rich Hill.
		b.	.....	7.79	35.51	44.00	12.70	5.40	63.17	1.00	12.57	5.16	6,524	11,742	
		c.	.....	.....	38.51	47.72	13.77	4.91	68.51	1.08	6.13	5.60	7,075	12,735	
		d.	.....	.....	44.66	55.34	.....	5.69	79.45	1.25	7.12	6.49	8,205	14,769	
Rich Hill— 2 miles south.	11,195	a.	7.90	1.41	37.29	44.82	16.48	4.83	65.39	1.20	6.80	5.30	6,726	12,107	Lower Rich Hill.
		b.	.....	9.20	34.34	41.28	15.18	5.53	60.22	1.11	13.28	4.88	6,195	11,151	
		c.	.....	.....	37.82	45.46	16.72	4.75	66.32	1.22	5.62	5.37	6,823	12,281	
		d.	.....	.....	45.41	54.59	.....	5.70	79.64	1.46	6.75	6.45	8,193	14,747	

Location.	Lab. No.	Sample.	Loss air dry.	Proximate. Moist.	Vol.	F. C.	Ash.	Ultimate. H.	C.	N.	O.	S.	Cal. V. Det'd. Calories.	B. T. U.	Name of bed.
BOONE COUNTY.															
Columbia— 4½ miles north.	11,482	a.	9.30	1.61	37.08	46.74	14.57	4.68	66.32	1.01	7.84	5.58	6,641	11,954	Bevier.
		b.	.....	10.76	33.63	42.40	13.21	5.27	60.15	.92	15.39	5.06	6,023	10,841	
		c.	.....	.....	37.69	47.51	14.80	4.56	67.40	1.03	6.54	5.67	6,749	12,148	
		d.	.....	.....	44.24	55.76	.....	5.35	79.11	1.21	7.68	6.65	7,921	14,258	
CALDWELL COUNTY.															
Hamilton— 1½ miles north.	10,172	a.	4.70	6.60	36.73	43.41	13.26	5.15	63.38	1.22	11.94	5.05	6,467	11,641	Bevier.
		b.	.....	10.99	35.00	41.37	12.64	5.43	60.40	1.16	15.56	4.81	6,163	11,093	
		c.	.....	.....	39.32	46.48	14.20	4.73	67.86	1.30	6.51	5.40	6,924	12,463	
		d.	.....	.....	45.83	54.17	.....	5.51	79.09	1.52	7.59	6.29	8,070	14,526	
CALLAWAY COUNTY.															
Fulton— 2 miles southwest.	11,504	a.	9.30	1.62	36.19	50.76	11.43	4.79	70.25	.99	8.13	4.41	7,044	12,679	Bevier.
		b.	.....	10.77	32.82	46.04	10.37	5.37	63.72	.90	15.64	4.00	6,389	11,500	
		c.	.....	.....	36.78	51.60	11.62	4.67	71.41	1.01	6.81	4.48	7,160	12,888	
		d.	.....	.....	41.62	58.38	.....	5.28	80.80	1.14	7.71	5.07	8,102	14,584	
CLAY COUNTY.															
Missouri City— 1 mile west.	10,231	a.	11.10	3.56	37.45	44.92	14.07	4.99	65.35	1.11	11.17	3.31	6,534	11,761	Lexington.
		b.	.....	14.26	33.29	39.94	12.51	5.67	58.10	.99	19.79	2.94	5,809	10,456	
		c.	.....	.....	38.83	46.58	14.59	4.77	67.76	1.15	8.30	3.43	6,775	12,195	
		d.	.....	.....	45.46	54.54	.....	5.58	79.33	1.35	9.72	4.02	7,932	14,278	
GRUNDY COUNTY.															
Trenton— ¾ mile north.	10,161	a.	4.90	7.40	40.13	40.25	12.22	5.36	64.60	1.09	13.46	3.27	6,472	11,650	Tebo (?).
		b.	.....	11.94	38.16	38.28	11.62	5.64	61.43	1.04	17.16	3.11	6,155	11,079	
		c.	.....	.....	43.33	43.47	13.20	4.89	69.76	1.18	7.44	3.53	6,990	12,582	
		d.	.....	.....	49.92	50.08	.....	5.63	80.37	1.36	8.57	4.07	8,053	14,495	

HARRISON COUNTY.

Melbourn— ¼ mile east.	11,377	a.	12.00	3.80	42.20	46.29	7.71	5.18	69.52	1.25	12.90	3.44	7,007	12,613	Lexington.
		b.	.....	15.34	37.14	40.74	6.78	5.89	61.18	1.10	22.02	3.03	6,166	11,099	
		c.	.....	.....	43.87	48.12	8.01	4.95	72.27	1.30	9.89	3.58	7,283	13,109	
		d.	.....	.....	47.69	52.31	.....	5.38	78.56	1.41	10.76	3.89	7,917	14,251	

HENRY COUNTY.

Calhoun— 2½ miles west.	11,317	a.	8.70	2.08	40.79	44.52	12.61	4.86	67.69	.99	9.93	3.92	6,844	12,319	Tebo.
		b.	.....	10.60	37.24	40.65	11.51	5.41	61.80	.90	16.80	3.58	6,249	11,248	
		c.	.....	.....	41.66	45.46	12.88	4.73	69.13	1.01	8.25	4.00	6,990	12,582	
		d.	.....	.....	47.82	52.18	.....	5.43	79.35	1.16	9.47	4.59	8,023	14,441	
Clinton— 3½ miles northwest.	11,251	a.	6.40	2.92	39.99	43.19	13.90	4.98	66.77	.96	9.32	4.07	6,800	12,240	Tebo.
		b.	.....	9.13	37.43	40.43	13.01	5.37	62.50	.90	14.41	3.81	6,365	11,457	
		c.	.....	.....	41.19	44.49	14.32	4.80	68.78	.99	6.92	4.19	7,005	12,609	
		d.	.....	.....	48.07	51.93	.....	5.60	80.27	1.16	8.08	4.89	8,176	14,717	
Clinton— 1 mile north.	11,305	a.	10.70	2.09	38.84	43.41	15.66	4.82	65.38	1.08	8.97	4.09	6,664	11,995	
		b.	.....	12.57	34.68	38.77	13.98	5.49	58.38	.96	17.54	3.65	5,951	10,712	
		c.	.....	.....	39.67	44.34	15.99	4.68	66.78	1.10	7.28	4.17	6,807	12,253	
		d.	.....	.....	47.22	52.78	.....	5.57	79.49	1.31	8.67	4.96	8,102	14,584	
Clinton— 2 miles east.	11,373	a.	10.30	2.74	36.85	48.65	11.76	4.89	68.97	1.25	10.26	2.87	6,917	12,451	Jordan.
		b.	.....	12.76	33.05	43.64	10.55	5.53	61.87	1.12	18.36	2.57	6,205	11,169	
		c.	.....	.....	37.89	50.02	12.09	4.71	70.92	1.28	8.05	2.95	7,113	12,803	
		d.	.....	.....	43.10	56.90	.....	5.36	80.67	1.46	9.15	3.36	8,091	14,564	
Clinton— 3 miles southeast.	11,265	a.	8.30	1.74	38.20	47.24	12.82	4.87	67.60	1.16	7.68	5.87	6,931	12,476	Jordan.
		b.	.....	9.90	35.03	43.31	11.76	5.39	61.99	1.06	14.42	5.38	6,356	11,441	
		c.	.....	.....	38.88	48.07	13.05	4.76	68.80	1.18	6.24	5.97	7,055	12,699	
		d.	.....	.....	44.72	55.28	.....	5.47	79.13	1.36	7.17	6.87	8,114	14,605	
Deepwater— ¾ mile east.	11,255	a.	8.40	1.86	38.02	45.59	14.53	4.64	66.53	1.08	8.50	4.72	6,768	12,182	Jordan.
		b.	.....	10.10	34.83	41.76	13.31	5.18	60.94	.99	15.26	4.32	6,199	11,158	
		c.	.....	.....	38.74	46.46	14.80	4.52	67.78	1.10	6.99	4.81	6,895	12,411	
		d.	.....	.....	45.47	54.53	.....	5.31	79.55	1.29	8.20	5.65	8,093	14,567	
Deepwater—	11,313	a.	8.10	1.74	36.76	50.34	11.16	4.88	70.94	1.12	7.95	3.95	7,145	12,861	Jordan.
		b.	.....	9.70	33.78	46.26	10.26	5.38	65.19	1.03	14.51	3.63	6,566	11,819	
		c.	.....	.....	37.41	51.23	11.36	4.76	72.19	1.14	6.53	4.02	7,271	13,088	
		d.	.....	.....	42.21	57.79	.....	5.37	81.44	1.29	7.36	4.54	8,203	14,765	
Lewis— ¾ mile north.	11,270	a.	9.60	2.04	38.35	45.50	14.11	4.93	66.24	1.05	8.97	4.70	6,767	12,181	Tebo.
		b.	.....	11.44	34.67	41.13	12.76	5.53	59.88	.95	16.63	4.25	6,117	11,011	
		c.	.....	.....	39.15	46.44	14.41	4.81	67.62	1.07	7.29	4.80	6,907	12,433	
		d.	.....	.....	45.74	54.26	.....	5.62	79.01	1.25	8.51	5.61	8,070	14,526	
Windsor— 2 miles west.	10,355	a.	7.50	6.50	35.93	45.28	12.29	5.47	63.96	.92	12.95	4.41	6,474	11,653	Bowen.
		b.	.....	13.51	33.24	41.88	11.37	5.89	59.16	.85	18.65	4.08	5,988	10,779	
		c.	.....	.....	38.43	48.42	13.15	5.08	68.40	.98	7.67	4.72	6,923	12,461	
		d.	.....	.....	44.25	55.75	.....	5.85	78.76	1.13	8.83	5.43	7,971	14,348	

JOHNSON COUNTY.

Location.	Lab. No.	Sample.	Loss air dry.	Proximate.				Ultimate.					Cal. V. Det'd.		Name of bed.
				Moist.	Vol.	F. C.	Ash.	H.	C.	N.	O.	S.	Calories.	B. T. U.	
Sutherland— ½ mile west.	10,354	a.	6.50	6.45	40.37	44.86	8.32	5.57	67.45	1.14	13.37	4.15	6,819	12,274	Bevier.
		b.	.....	12.53	37.75	41.94	7.78	5.93	63.07	1.06	18.28	3.88	6,375	11,475	
		c.	.....	.....	43.16	47.95	8.89	5.19	72.10	1.21	8.17	4.44	7,288	13,118	
		d.	.....	.....	47.37	52.63	.....	5.69	79.14	1.33	8.97	4.87	7,999	14,398	
LAFAYETTE COUNTY.															
Corder— ½ mile south.	10,246	a.	7.00	7.90	35.84	44.20	12.06	5.27	63.61	1.14	14.14	3.78	6,389	11,500	Lexington.
		b.	.....	14.35	33.33	41.10	11.22	5.68	59.16	1.06	19.36	3.52	5,942	10,696	
		c.	.....	.....	38.91	47.99	13.10	4.78	69.07	1.24	7.70	4.11	6,937	12,487	
		d.	.....	.....	44.77	55.23	.....	5.50	79.48	1.43	8.86	4.73	7,982	14,368	
Corder— 1 mile north.	10,353	a.	7.70	5.03	37.23	45.46	12.28	5.38	64.28	1.17	11.96	4.93	6,620	11,916	Lexington.
		b.	.....	12.34	34.36	41.97	11.33	5.83	59.33	1.08	17.88	4.55	6,110	10,998	
		c.	.....	.....	39.20	47.87	12.93	5.09	67.68	1.23	7.88	5.19	6,970	12,546	
		d.	.....	.....	45.02	54.98	.....	5.85	77.73	1.41	9.05	5.96	8,005	14,409	
Higginsville— ½ mile south.	10,245	a.	6.60	6.22	36.55	39.37	17.86	5.16	60.63	.99	12.23	3.13	6,145	11,061	Lexington.
		b.	.....	12.41	34.14	36.77	16.68	5.55	56.63	.92	17.30	2.92	5,739	10,330	
		c.	.....	.....	38.98	41.98	19.04	4.76	64.65	1.06	7.16	3.33	6,552	11,794	
		d.	.....	.....	48.15	51.85	.....	5.88	79.86	1.30	8.85	4.11	8,093	14,568	
Lexington— 2½ miles west.	10,233	a.	10.70	4.73	35.01	45.90	14.36	4.98	63.47	1.13	12.43	3.63	6,454	11,617	Lexington.
		b.	.....	14.92	31.26	41.00	12.82	5.64	56.68	1.01	20.61	3.24	5,763	10,373	
		c.	.....	.....	36.74	48.19	15.07	4.68	66.62	1.19	8.63	3.81	6,774	12,193	
		d.	.....	.....	43.26	56.74	.....	5.51	78.44	1.40	10.16	4.49	7,976	14,357	
Napoleon— 2 miles east.	10,232	a.	10.10	3.72	35.60	44.79	15.89	5.00	62.10	1.09	12.49	3.43	6,323	11,381	Lexington.
		b.	.....	13.44	32.00	40.27	14.29	5.62	55.83	.98	20.20	3.08	5,684	10,232	
		c.	.....	.....	36.97	46.52	16.51	4.77	64.50	1.13	9.53	3.56	6,566	11,819	
		d.	.....	.....	44.28	55.72	.....	5.71	77.25	1.35	11.43	4.26	7,864	14,156	
Waverly— 1½ miles south.	10,352	a.	8.50	3.17	36.02	43.56	17.25	4.74	61.68	1.00	7.80	7.53	6,400	11,520	Waverly.
		b.	.....	11.40	32.96	39.86	15.78	5.28	56.43	.92	14.70	6.89	5,856	10,541	
		c.	.....	.....	37.20	44.99	17.81	4.53	63.69	1.04	5.16	7.77	6,610	11,898	
		d.	.....	.....	45.26	54.74	.....	5.51	77.49	1.27	6.28	9.45	8,042	14,476	
Wellington— 2½ miles west.	10,234	a.	10.00	5.90	36.07	47.13	10.90	5.21	65.77	1.16	13.49	3.47	6,640	11,952	Lexington.
		b.	.....	15.31	32.46	42.42	9.81	5.80	59.19	1.04	21.04	3.12	5,976	10,757	
		c.	.....	.....	38.33	50.09	11.58	4.84	69.89	1.23	8.78	3.68	7,056	12,700	
		d.	.....	.....	43.35	56.65	.....	5.47	79.05	1.39	9.93	4.16	7,980	14,364	

LINN COUNTY.

Brookfield— 1¼ miles east.	11,424	a.	12.90	2.51	41.39	46.74	9.36	5.03	69.66	1.14	9.98	4.83	7,004	12,607	Tebo.
		b.	.....	15.09	36.05	40.71	8.15	5.81	60.67	.99	20.17	4.21	6,100	10,980	
		c.	.....	.....	42.46	47.94	9.60	4.86	71.45	1.17	7.96	4.96	7,184	12,931	
		d.	.....	.....	46.97	53.03	.....	5.38	79.04	1.29	8.80	5.49	7,947	14,305	
Brookfield— 3 miles southeast.	11,416	a.	12.60	2.66	41.64	47.25	8.45	5.20	69.81	1.20	10.60	4.74	7,070	12,726	Tebo.
		b.	.....	14.92	36.39	41.30	7.39	5.94	61.01	1.05	20.47	4.14	6,179	11,122	
		c.	.....	.....	42.77	48.54	8.69	5.03	71.71	1.23	8.47	4.87	7,263	13,073	
		d.	.....	.....	46.84	53.16	.....	5.51	78.54	1.35	9.27	5.33	7,954	14,317	
Marceline— ¾ mile west.	11,420	a.	10.40	2.35	43.85	45.50	8.30	5.23	70.34	1.20	10.16	4.77	7,120	12,816	Tebo.
		b.	.....	12.51	39.29	40.76	7.44	5.85	63.02	1.08	18.34	4.27	6,380	11,484	
		c.	.....	.....	44.91	46.59	8.50	5.10	72.03	1.23	8.26	4.88	7,292	13,126	
		d.	.....	.....	49.08	50.92	.....	5.57	78.72	1.34	9.04	5.33	7,969	14,344	

MACON COUNTY.

Bevier— 2 miles west.	10,201	a.	8.70	5.60	38.00	45.76	10.64	5.19	65.54	1.16	13.83	3.64	6,671	12,008	Bevier.
		b.	.....	13.81	34.69	41.79	9.71	5.71	59.84	1.06	20.36	3.32	6,091	10,964	
		c.	.....	.....	40.25	48.48	11.27	4.85	69.43	1.23	9.37	3.85	7,067	12,721	
		d.	.....	.....	45.36	54.64	.....	5.47	78.25	1.39	10.55	4.34	7,967	14,341	
Bevier— 1¼ miles southeast.	9,991	a.	11.20	5.69	37.59	46.13	10.59	5.08	65.60	1.18	13.71	3.84	6,647	11,965	Bevier.
		b.	.....	16.25	33.38	40.97	9.40	5.75	58.25	1.05	22.14	3.41	5,903	10,625	
		c.	.....	.....	39.86	48.92	11.22	4.70	69.55	1.25	9.21	4.07	7,048	12,686	
		d.	.....	.....	44.90	55.10	.....	5.29	78.34	1.41	10.38	4.58	7,939	14,290	
Bevier— ¼ mile east.	9,992	a.	8.80	4.61	43.93	41.46	10.00	5.24	67.53	1.13	11.69	4.41	6,843	12,317	Mulky.
		b.	.....	13.00	40.06	37.82	9.12	5.76	61.59	1.03	18.48	4.02	6,241	11,234	
		c.	.....	.....	46.04	43.48	10.48	4.97	70.79	1.18	7.96	4.62	7,173	12,911	
		d.	.....	.....	51.43	48.57	.....	5.55	79.08	1.32	8.89	5.16	8,013	14,422	

PLATTE COUNTY.

Leavenworth, Kan.— (Coal mined in Missouri.)	12,848	a.	9.00	3.36	38.92	40.06	17.66	4.57	62.13	1.18	9.22	5.24	6,236	11,225	Bevier.
		b.	.....	12.06	35.42	36.45	16.07	5.16	56.54	1.07	16.39	4.77	5,675	10,215	
		c.	.....	.....	40.28	41.45	18.27	4.34	64.29	1.22	6.46	5.42	6,453	11,615	
		d.	.....	.....	49.28	50.72	.....	5.31	78.66	1.49	7.91	6.63	7,895	14,211	
Leavenworth, Kan.— (Coal mined in Missouri.)	12,852	a.	9.10	3.15	38.74	43.04	15.07	4.73	64.84	1.20	9.31	4.85	6,552	11,794	Bevier.
		b.	.....	11.96	35.21	39.13	13.70	5.31	58.94	1.09	16.55	4.41	5,956	10.721	
		c.	.....	.....	39.99	44.45	15.56	4.52	66.94	1.24	6.73	5.01	6,765	12,177	
		d.	.....	.....	47.36	52.64	.....	5.35	79.28	1.47	7.97	5.93	8,012	14,421	

PUTNAM COUNTY.

Location.	Lab. No.	Sample.	Loss air dry.	Proximate. Moist.	Vol.	F. C.	Ash.	Ultimate. H.	C.	N.	O.	S.	Cal. V. Det'd. Calories.	B. T. U.	Name of bed.
Mendota— 1 mile southeast.	11,401	a.	15.20	3.83	38.47	46.03	11.67	4.80	65.69	1.07	11.95	4.82	6,578	11,840	Lexington.
		b.	.....	18.45	32.62	39.03	9.90	5.76	55.71	.91	23.63	4.09	5,578	10,040	
		c.	.....	.....	40.00	47.86	12.14	4.55	68.31	1.12	8.86	5.02	6,840	12,312	
		d.	.....	.....	45.53	54.47	.....	5.18	77.75	1.27	10.09	5.71	7,785	14,013	

RANDOLPH COUNTY.

Location.	Lab. No.	Sample.	Loss air dry.	Proximate. Moist.	Vol.	F. C.	Ash.	Ultimate. H.	C.	N.	O.	S.	Cal. V. Det'd. Calories.	B. T. U.	Name of bed.
Higbee— 5 miles southeast.	10,183	a.	6.60	5.33	34.90	44.68	15.09	5.02	62.63	1.03	11.22	5.01	6,432	11,641	Bevier.
		b.	.....	11.58	32.60	41.73	14.09	5.42	58.50	.96	16.35	4.68	6,041	10,874	
		c.	.....	.....	36.87	47.19	15.94	4.67	66.16	1.09	6.85	5.29	6,831	12,296	
		d.	.....	.....	43.86	56.14	.....	5.56	78.70	1.30	8.15	6.29	8,126	14,627	
Huntsville. South end.	11,455	a.	11.50	1.96	39.54	46.92	11.58	4.86	68.08	1.04	8.58	5.86	6,894	12,409	Bevier.
		b.	.....	13.23	34.99	41.53	10.25	5.58	60.25	.92	17.81	5.19	6,101	10,982	
		c.	.....	.....	40.33	47.86	11.81	4.74	69.44	1.06	6.97	5.98	7,031	12,656	
		d.	.....	.....	45.73	54.27	.....	5.37	78.74	1.20	7.91	6.78	8,289	14,920	
Huntsville— ¾ mile south.	11,451	a.	10.10	2.25	40.40	47.70	9.65	4.96	70.43	1.13	9.47	4.36	7,078	12,740	Bevier.
		b.	.....	12.12	36.32	42.88	8.68	5.58	63.32	1.02	17.48	3.92	6,363	11,453	
		c.	.....	.....	41.33	48.79	9.88	4.81	72.05	1.16	7.64	4.46	7,240	13,032	
		d.	.....	.....	45.86	54.14	.....	5.34	79.95	1.29	8.47	4.95	8,034	14,461	
Renick— ¼ mile west.	11,500	a.	6.60	2.26	42.69	45.91	9.14	5.23	70.75	1.01	8.90	4.97	7,180	12,924	Mulky.
		b.	.....	8.71	39.87	42.88	8.54	5.61	66.08	.94	14.19	4.64	6,706	12,071	
		c.	.....	.....	43.67	46.98	9.35	5.08	72.38	1.03	7.08	5.08	7,346	12,233	
		d.	.....	.....	48.17	51.83	.....	5.60	79.84	1.14	7.82	5.60	8,103	14,585	

RAY COUNTY.

Location.	Lab. No.	Sample.	Loss air dry.	Proximate. Moist.	Vol.	F. C.	Ash.	Ultimate. H.	C.	N.	O.	S.	Cal. V. Det'd. Calories.	B. T. U.	Name of bed.
Camden— 2 miles west.	10,217	a.	10.80	5.64	36.78	46.47	11.11	5.17	65.72	1.21	13.46	2.33	6,615	11,907	Lexington.
		b.	.....	15.83	32.80	41.46	9.91	5.81	58.62	1.08	21.61	2.97	5,901	10,622	
		c.	.....	.....	38.97	49.26	11.77	4.81	69.65	1.28	8.96	3.53	7,011	12,620	
		d.	.....	.....	44.17	55.83	.....	5.45	78.94	1.45	10.16	4.00	7,946	14,303	
Richmond— 2 miles south.	10,235	a.	10.40	4.67	34.93	45.18	15.22	4.98	62.53	1.11	11.96	4.20	6,343	11,417	Lexington.
		b.	.....	14.58	31.30	40.48	13.64	5.62	56.03	.99	19.96	3.76	5,683	10,229	
		c.	.....	.....	36.64	47.39	15.97	4.68	65.59	1.16	8.20	4.40	6,653	11,975	
		d.	.....	.....	43.61	56.39	.....	5.57	78.06	1.38	9.75	5.24	7,918	14,252	

Richmond— ½ mile north.	10,200	a. b. c. d.	9.20	4.80 13.56	37.76 34.29 39.67 45.75	44.79 40.66 47.04 54.25	12.65 11.49 13.29	5.10 5.65 4.79 5.52	64.06 58.16 67.29 77.60	1.15 1.04 1.20 1.38	12.89 19.89 9.07 10.47	4.15 3.77 4.36 5.03	6,590 5,984 6,923 7,984	11,862 10,771 12,461 14,371	Lexington.
Vibbard— ¼ mile south.	11,368	a. b. c. d.	8.30	5.21 13.08	40.28 36.94 42.50 46.13	47.06 43.15 49.64 53.87	7.45 6.83 7.86	5.25 5.73 4.92 5.34	70.03 64.22 73.89 80.19	1.08 .99 1.14 1.24	13.15 19.44 8.98 9.75	3.04 2.79 3.21 3.48	6,998 6,417 7,383 8,013	12,596 11,551 13,289 14,423	Lexington.

SULLIVAN COUNTY.

Milan— ½ mile south.	10,143	a. b. c. d.	8.40	5.14 13.11	35.20 32.24 37.11 46.21	40.97 37.53 43.19 53.79	18.69 17.12 19.70	4.88 5.40 4.53 5.64	58.28 53.38 61.44 76.51	1.00 .92 1.06 1.32	10.68 17.25 6.45 8.04	6.47 5.93 6.82 8.49	6,002 5,498 6,328 7,880	10,804 9,896 11,389 14,182	Bevier.

VERNON COUNTY.

Moundville— Northwest corner.	11,204	a. b. c. d.	5.10	1.48 6.50	34.36 32.61 34.88 39.09	53.56 50.83 54.36 60.91	10.60 10.06 10.76	4.89 5.21 4.80 5.38	71.62 67.97 72.69 81.46	1.15 1.09 1.17 1.31	6.52 10.72 5.29 5.92	5.22 4.95 5.29 5.93	7,293 6,921 7,302 8,295	13,127 12,458 13,324 14,931	
Panama— 2 miles south.	11,208	a. b. c. d.	4.40	1.69 6.02	37.59 35.94 38.24 45.31	45.37 43.37 46.15 54.69	15.35 14.67 15.61	5.00 5.27 4.89 5.79	66.47 63.55 67.62 80.13	1.08 1.03 1.10 1.30	5.99 9.64 4.57 5.42	6.11 5.84 6.21 7.36	6,882 6,579 7,001 8,296	12,388 11,842 12,602 14,933	Rich Hill.

DISCUSSION OF THE ANALYSES.

The analytical data relating to the coals of Missouri comprise a large volume, a great part of which either has been, or will, in due time, be printed in the publications of the U. S. Geological Survey or of the Bureau of Mines. These analyses include not only the report for each individual sample collected from any given mine, with its location in the mine, but also analyses, usually both proximate and ultimate, and supplemented by calorific determinations, made from a "composite" sample, which is obtained by mixing equal parts of the several individual samples from that mine. Such "composite" samples, based on the combined samples, are believed to be more correctly representative of the coal from the mine than is the analysis of the individual sample. Under the circumstances, it has seemed best to the State Survey to condense the very bulky material by omitting the individual sample analyses and their detailed locations and to simplify the statement by citing, as more representative as well as more comprehensive than any selected individual sample analyses, the "composite" analysis for each mine. In the table there are given, therefore, only the "composite" analyses, each of which is based on a mixture of the individual samples collected from each mine.

The following comparisons and conclusions are based on the composite analyses. For two mines no composite analysis was available and the analyses of the three individual mine samples for each were therefore averaged. The samples collected represent more completely the mines of the State than any heretofore collected, but since they do not cover the whole area of each bed any conclusions or comparisons based on them must necessarily be incomplete.

The following table shows the number of mines sampled in each county and the name of the bed from which the sample was collected:

TABLE SHOWING NUMBER OF MINES SAMPLED IN EACH COUNTY AND NAME OF BED REPRESENTED.

Name of county.	Name of bed.						
	Mulberry.	Lexington.	Mulky.	Bevier.	Tebo.	Lower beds.	Total.
Adair		1		5			6
Audrain			2				2
Barton				4			4
Bates	2			3			5
Boone				2			2
Caldwell				1			1
Callaway				1			1
Clay		1					1
Grundy					1		1

TABLE SHOWING NUMBER OF MINES SAMPLED IN EACH COUNTY AND NAME OF BED REPRESENTED—Continued.

Name of county.	Name of bed.						
	Mulberry.	Lexington.	Mulky.	Bevies.	Tebo.	Lower beds.	Total.
Harrison		1				1	2
Henry					3	6	9
Johnson				1			1
Lafayette		6				1	7
Linn					3		3
Macon			1	2			3
Platte				2			2
Putnam		1					1
Randolph			1	3			4
Ray		4					4
Vernon				2			2
Sullivan				1			1
Totals	2	14	4	27	7	8	62

AVERAGE COMPOSITION OF MISSOURI COALS.

The averages of the more important constituents reported in the analyses of the coals of the entire State are shown in the next table.

AVERAGE ANALYSIS OF MISSOURI COALS.

	Moisture.	Ash.	Sulphur.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Fixed carbon.	B. t. u.
Air dried	3.65	12.66	4.48	66.45	5.03	10.27	1.11	46.05	12154
As received	10.81								11027

COMPARISON OF THE INDIVIDUAL BEDS.

Mulberry Coal.—Only two mines in this bed were sampled. The following table shows the averages of the analyses:

AVERAGE ANALYSIS OF MULBERRY COAL.

	Moisture.	Ash.	Sulphur.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Fixed carbon.	B. t. u.
Air dried	2.17	13.80	3.30	68.38	4.75	8.56	1.21	49.80	12333
As received	10.78								11251

From the small number of samples taken it is impossible to say whether the above represents the average for the fields. It shows that the coal is better than the average of the State, except in the content of ash, which is over one per cent higher than the average for the coals of the State. The apparent advantage of the Mulberry coal over the others collectively, an advantage which needs validation by more tests, is probably due to the lower moisture in the air-dried samples, and especially to the lower sulphur.

Lexington Coal.—The average analysis of samples representing fourteen mines in six widely separated counties is as follows:

AVERAGE ANALYSIS OF LEXINGTON COAL.

	Moisture.	Ash.	Sulphur.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Fixed carbon.	B. t. u.
Air dried	5.03	12.53	3.69	64.70	5.13	12.76	1.12	45.75	11785
As received	14.52	.....	.....	.....	.....	.....	.....	.....	10615

In several ways the Lexington bed falls below the State average, but in ash and sulphur it is somewhat above the average. Its lower calorific value is probably due mainly to a larger percentage of oxygen in the organic substance of the coal. The number of mines (over 100) operating in this bed shows a great popularity of the coal, especially for domestic uses. The mines are mostly near the large markets, and the coal, though thin, is easily mined and has a relatively good appearance when marketed.

Mulky Coal.—Only four mines, representing three adjoining counties, were sampled. The average analysis is:

AVERAGE ANALYSIS OF MULKY COAL.

	Moisture.	Ash.	Sulphur.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Fixed carbon.	B. t. u.
Air dried	3.36	11.30	5.08	67.75	5.10	9.75	1.02	42.99	12429
As received	10.54	.....	.....	.....	.....	.....	.....	.....	11459

Judging from the analysis this coal is slightly better than the average for the State. Though higher in sulphur, it ranks high as regards moisture, oxygen, ash and calorific value.

Bevier Coal.—Samples from 27 mines in nine counties give the following average analysis:

AVERAGE ANALYSIS OF BEVIER COAL.

	Moisture.	Ash.	Sulphur.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Fixed carbon.	B. t. u.
Air dried	3.37	13.08	4.81	66.59	4.93	9.45	1.13	46.85	12154
As received	11.75	.....	.....	.....	.....	.....	.....	.....	11154

It will be noted that the average calorific value of the air-dried sample of this coal approximates most closely the average for the Missouri coal field as a whole. The handicap of higher percentages of ash and sulphur in the Bevier coal is fully counterbalanced by the higher rank of the fuel as shown by the higher fixed carbon and the percentage of oxygen, which is much lower. There are probably more mines in the Bevier bed than in any other in the State with the possible exception of the Lexington, and this fact, more than the analysis, shows its popularity. It is in great demand as a steam coal.

Tebo Coal.—The following table shows the average analysis of samples from seven mines in three counties, operating in this bed:

AVERAGE ANALYSIS OF TEBO COAL.

	Moisture.	Ash.	Sulphur.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Fixed carbon.	B. t. u.
Air dried	3.14	11.28	4.31	67.86	5.08	10.35	1.09	44.71	12506
As received	12.26	.....	.....	.....	.....	.....	.....	.....	11197

This coal owes its higher calorific value to the lower percentages of moisture and ash, as well as to the higher percentage of available volatile hydrocarbons.

Lower Beds.—Under this head are grouped all beds lower than the Tebo, and from the discussion under the various counties it will be seen that while their exact relations are more or less uncertain, it is probable that the samples here grouped represent several horizons.

The average analysis follows:

AVERAGE ANALYSIS OF LOWER BEDS.

	Moisture.	Ash.	Sulphur.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Fixed carbon.	B. t. u.
Air dried	3.12	13.31	4.98	66.61	4.92	8.98	1.09	45.61	12146
As received	10.70	.....	.....	.....	.....	.....	.....	.....	11104

Comparison with the average analysis of the State shows at once the rank of these beds. Although handicapped by higher average percentages of ash and sulphur, the higher percentage of available hydrocarbons and the lower moisture bring the calorific value of these coals up to the average for the State. In general the lower coals contain less oxygen and moisture, being in fact higher in rank, though often more impure.

REGIONAL AND STRATIGRAPHIC VARIATION IN THE COAL BEDS.

From a study of the coals of Kansas, Crane* concluded that the fixed carbon and calorific value of coals decreased gradually across the State from the south to the north and west. In Kansas, however, higher beds, which on the whole are naturally higher in oxygen and moisture, are mined north and west of the lower beds in Cherokee and Crawford counties. In Missouri the outcropping line of any seam is much longer than in Kansas, and several beds are mined from the southwestern to the northern part of the State by drifts and shallow shafts along the outcrop or by deeper shafts to the west of the outcrop.

The coals having the highest calorific value are those in Barton, Vernon, and Bates counties, where dynamic influences, presumably those accompanying the Ozark uplift, have had their greatest effect. The average number of British thermal units of the lower beds of the southwestern counties is 12640 as compared with 11520 for Lafayette and 11880 for Harrison county. The Bevier coal in Boone, Callaway, and Randolph counties averages 12348 B. t. u. against 11629 for the remainder of the samples from the State. This condition indicates a progressive devolatilization or carbonization of the coals towards the south, that is, progressive regional alteration of the coal through dynamo-chemical agencies with greater elimination of oxygen from the volatile matter.

This circumstance probably accounts also for the increase from south to north in moisture in the coal as received, as is shown in some

*Crane, W. R., Special Report on Coal: Kansas Univ. Geol. Survey, Vol. I, 1898, pp. 296-300.

of the samples. Many of the lower beds show more sulphur than the higher beds, the Mulberry averaging 1.75 per cent less than those grouped under "lower beds," but there is apparently no even gradation between the two as will be seen in the table under the different beds.

These conclusions are corroborated by results reached by Marx and Schweitzer,† and their tables are given here for comparison.

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†Marx, C. W., and Schweitzer, Paul: The heating value and proximate analysis of Missouri coals: The Univ. of Mo. Bull. Eng. Exp. Sta. Ser., Vol. II, No. 1, 1911, 16 pp. The samples appear to have been taken in much the same manner as those reported on in the tables in this report.

TABLE SHOWING THE EFFICIENCY OF MISSOURI COALS.

(Reported by Marx and Schweitzer.)

Rank.	Name of mine.	County.	Location.	Thickness of vein in inches.	Heat units per pound of coal.	Pounds of water evaporated from and at 212° F. per lb. of coal. Boiler efficiency 60%.
1	No. 8, Western Coal Company	Barton	Near Minden station	36	13763	8.55
2	No. 3, Weir Coal Company	Barton	Near Vernon station	36	13759	8.55
3	Brush Creek Coal Company, Upper vein	Jackson	Three miles southeast of Kansas City	16	13710	8.52
4	No. 14, Central Coal and Coke Company	Bates	Five miles south of Rich Hill	60–66	13500	8.38
5	Rush Coal Company	Bates	Five miles south of Rich Hill; One and one-half miles west of previous one	42	12824	7.96
6	Keene	Boone	Four and one-half miles north of Columbia	44	12780	7.94
7	Thompson	Henry	One mile east of Deepwater	.....	12757	7.92
8	Henry	Boone	Switzler	42	12492	7.76
9	Cooper Creek Coal Company	Henry	Three and one-half miles southeast of Deepwater	32–42	12326	7.66
10	Kingston	Caldwell	One mile north of Kingston	12–18	12292	7.63
11	Caldwell Coal Company	Caldwell	Two miles east of Hamilton	18–20	12115	7.52
12	Bowen Bros	Henry	One-half mile northeast of Louis station	30	12093	7.51
13	Watkins	Henry	One and one-half miles southeast of Clinton	24	12090	7.51
14	Excelsior	Lafayette	One-half mile west of Higginsville	16	12010	7.46
15	Vernon Coal Company	Bates	Two and one-half miles southeast of Rich Hill	36–60	11978	7.44
16	Marceline Coal Company	Linn	One-half mile south of Marceline	28	11939	7.41
17	Murlin Coal Company	Adair	One-half mile north of Stahl	48	11854	7.36
18	No. 15, Rich Hill Coal Company	Bates	Two miles south of Rich Hill	48	11834	7.35
19	Edmonds	Lafayette	One-fourth mile east of Waterloo	18	11829	7.35
20	No. 6, Farmers' Consolidated	Lafayette	One mile west of Higginsville	16	11824	7.34
21	No. 66, Kansas and Texas Coal Company	Macon	Three miles south of Bevier	56	11769	7.31
22	Silver Creek Coal Company	Lafayette	One-fourth mile west of Waverly station	48	11764	7.30

23	Elliott Coal Company	Randolph	Elliott station	48	11676	7.24
24	Buckhorn Coal Company	Lafayette	One mile west of Waverly station	48	11643	7.23
25	No. 10, Morris Coal Company	Randolph	One mile east of Huntsville	48	11642	7.23
26	No. 70, Kansas and Texas Coal Company	Macon	Four and one-half miles southwest of Excello	54	11626	7.22
27	Murlin Coal Company	Ray	Fleming station	22	11583	7.19
28	Salt Fork Coal Company	Lafayette	One-half mile east of Corder	22	11580	7.19
29	Jones & Davis	Randolph	Three miles west of Moberly	48	11574	7.19
30	Brush Creek Coal Company, Lower vein	Jackson	Three miles southeast of Kansas City	24	11524	7.16
31	No. 1, Higbee	Lafayette	One-half mile west of Higbee	44–48	11522	7.15
32	Labor Exchange	Lafayette	One and one-fourth miles west of Wellington	18	11492	7.14
33	No. 1, J. C. McGrew	Lafayette	Three and one-half miles west of Lexington	22	11395	7.08
34	Emporia	Putnam	One and one-fourth miles north of Unionville	36	11390	7.07
35	No. 61, Kansas and Texas Coal Company	Macon	Two miles southwest of Bevier	51	11372	7.06
36	Richmond and Camden Coal Company	Ray	One mile west of Camden	20	11331	7.04
37	No. 11, Richmond and Camden Coal Company	Ray	One mile west of Richmond	24	11322	7.03
38	No. 8, Mendota Coal Company	Putnam	One-half mile south of Mendota station	36	11274	7.00
	Missouri City Coal Company	Clay	Missouri City	22	11274	7.00
39	No. 14, Richmond and Camden Coal Company	Ray	One-fourth mile south of Richmond	24	11250	6.99
40	Corder Coal Company	Lafayette	Three-fourths mile west of Corder	22	11233	6.98
41	Glen Oak, Lexington Coal Company	Lafayette	Four miles northeast of Lexington	24	11220	6.97
42	Valley Mine, Lexington Coal Company	Lafayette	One and one-half miles south of Lexington	22	11209	6.96
43	Northwestern Coal Company	Macon	One mile south of Bevier	42–48	11191	6.95
44	No. 2, Higbee	Lafayette	Two miles east of Higbee	42	11147	6.92
45	Dover Coal Company	Lafayette	One mile east of Dover station	18	11018	6.84
46	Rombauer	Adair	One-half mile west of Novinger	43	10877	6.77
47	Carter	Lafayette	One and one-half miles east of Wellington	20	10770	6.69
48	Graddy-Lexington Coal Company	Lafayette	Three miles west of Lexington	20	10759	6.68
49	Grundy Coal Company	Grundy	One-half mile southeast of Trenton	18	10704	6.65
50	J. B. Seitz	Lafayette	Three-fourths mile west of Waterloo	18	10664	6.62
51	No. 2, Mendota Coal Company	Putnam	Two miles southeast of Mendota station	34	10623	6.60
52	Mayview Coal Company	Lafayette	Near Mayview station	18	10458	6.50
53	Blackbird	Putnam	Three miles northeast of Unionville	34	10437	6.48
54	Lingo	Macon	Opposite Lingo station	36–42	10224	6.35

TABLE OF PROXIMATE ANALYSES OF MISSOURI COALS.

(From report by Marx and Schweitzer.)

Rank.	Name of mine.	Water per cent.	Volatile matter per cent.	Fixed carbon per cent.	Ash per cent.	Sulphur per cent.	Volatile matter plus carbon.
1	No. 8, Western Coal Company	2.35	35.73	53.72	8.20	4.10	89.45
2	No. 3, Weir Coal Company	3.62	34.40	53.98	8.00	4.02	88.38
3	Brush Creek Coal Company	10.30	40.04	45.35	4.31	2.35	85.39
4	No. 14, Central Coal Company, upper vein	2.02	40.80	46.39	10.79	6.57	87.19
5	Rush Coal Company	4.07	41.05	43.22	11.66	3.38	84.27
6	Keene	6.17	40.83	45.04	7.96	3.72	85.87
7	Thompson	8.95	34.75	51.28	5.03	1.11	86.03
8	Henry	9.62	38.50	45.63	6.25	2.78	84.13
9	Cooper Creek Coal Company	7.24	34.60	48.10	10.06	2.64	82.70
10	Kingston	10.63	38.58	44.03	6.76	2.54	82.61
11	Caldwell Coal Company	9.26	36.69	43.56	10.49	3.61	80.25
12	Bowen Bros	6.65	40.27	40.68	12.40	4.67	80.95
13	Watkins	8.10	36.13	45.02	10.75	4.72	81.15
14	Excelsior	10.25	36.10	44.69	8.96	3.54	80.79
15	Vernon Coal Company	6.34	35.89	44.47	13.30	4.81	80.36
16	Marceline Coal Company	9.45	33.25	47.27	10.03	5.73	81.52
17	Murlin Coal Company	14.78	39.10	42.44	3.68	2.16	81.54
18	No. 15, Rich Hill Coal Company	5.88	35.20	44.72	14.20	4.83	79.92
19	Edmonds	9.55	35.23	46.42	8.80	3.15	81.65
20	No. 6, Farmers' Consolidated	11.95	36.14	44.70	7.21	2.57	80.84
21	No. 66, Kansas and Texas Coal Company	12.00	39.10	41.83	7.07	3.44	80.93
22	Silver Creek Coal Company	8.34	37.68	41.34	12.64	5.28	79.02
23	Elliott Coal Company	11.15	36.32	42.77	9.76	3.55	79.09
24	Buckhorn Coal Company	8.58	38.20	42.04	11.18	4.90	80.24
25	No. 10, Morris Coal Company	9.90	31.73	47.33	11.04	2.86	78.06
26	No. 70, Kansas and Texas Coal Company	10.20	36.26	43.16	10.38	4.47	79.42
27	Murlin Coal Company	13.07	37.85	41.66	7.42	1.92	79.51
28	Salt Fork Coal Company	11.88	35.76	43.64	8.72	3.76	79.40
29	Jones & Davis	11.05	36.87	41.65	10.43	6.56	78.52
30	Brush Creek Coal Company, lower vein	7.85	33.18	44.17	14.80	5.05	77.35
31	No. 1, Higbee	10.00	29.99	50.77	9.24	3.57	80.76

32	Labor Exchange	12.31	35.91	43.58	8.20	1.71	79.49
33	No. 1, J. C. McGrew	15.02	34.20	43.20	7.58	2.97	77.40
34	Emporia	17.48	36.01	42.40	4.11	2.38	78.41
35	No. 61, Kansas and Texas Coal Company	12.12	37.43	41.30	9.15	3.74	78.73
36	Richmond and Camden Coal Company	9.83	37.93	42.99	9.25	3.21	80.92
37	No. 11, Richmond and Camden Coal Company	11.97	36.36	41.65	10.02	4.36	78.01
38	No. 8, Mendota Coal Company	17.29	37.19	41.43	4.09	2.66	78.62
	Missouri City Coal Company	12.45	34.48	42.44	10.63	2.95	76.92
39	No. 14, Richmond and Camden Coal Company	10.20	36.75	41.20	11.85	5.87	77.95
40	Corder Coal Company	9.90	35.08	43.05	11.97	4.78	78.13
41	Glen Oak, Lexington Coal Company	14.39	35.00	44.58	6.03	2.01	79.58
42	Valley Mine, Lexington Coal Company	13.75	35.30	42.40	8.55	2.22	77.70
43	Northwestern Coal Company	11.00	31.77	45.74	11.49	4.28	77.51
44	No. 2, Higbee	10.84	28.28	49.30	11.58	5.68	77.58
45	Dover Coal Company	12.33	34.53	42.05	11.09	4.56	76.58
46	Rombauer	12.12	30.10	44.20	13.58	3.52	74.30
47	Carter	11.56	32.93	42.10	13.41	3.50	75.03
48	Graddy, Lexington Coal Company	12.33	31.55	42.64	13.48	3.94	74.19
49	Grundy Coal Company	10.07	31.62	43.90	14.41	5.43	75.52
50	J. B. Seitz	10.13	32.23	41.74	15.90	7.56	73.97
51	No. 2, Mendota Coal Company	17.59	34.11	39.85	8.45	3.21	73.96
52	Mayview Coal Company	10.50	32.43	40.63	16.44	3.48	73.06
53	Blackbird	13.46	34.88	38.36	13.30	4.29	73.24
54	Lingo	10.16	29.78	41.26	18.80	7.33	71.04

These writers* concluded that the amount of the fixed carbon and volatile matter puts the various coals, with few exceptions, in the same order as does the calorific value. They also state that these analyses show that Missouri coals compare well with those from Illinois.

An examination of the decreases, on the whole, in the efficiency (the calorific value) and the fixed carbon of the coals from south to north, through the Missouri coal field, as shown in the accompanying tables, is most instructive. The moisture, on the other hand, is seen to increase in the same direction, as is to be expected.

*Op. cit. p, 10.

CHAPTER VI.

TESTS OF MISSOURI COALS.

Under act of Congress approved February 18, 1904, a plant for testing and analyzing the coals and lignites of the United States was established at the Louisiana Purchase Exposition in St. Louis. At this plant tests of coals from many states were continued for several years under the supervision of the U. S. Geological Survey, and the results were made public in the reports indicated in the foot-notes contained in this chapter. Those wishing to make detailed comparisons of Missouri coals with those of other states and to obtain complete descriptions of the plant and the methods of testing should consult the original reports, especially Professional Paper 48 of the U. S. Geological Survey. It is believed, however, that the tables contained in this chapter will prove sufficient for most engineers and others interested in the efficiency of the coals of Missouri. Although the tests were made on coal taken from only a few mines, care was exercised to make them typical for the principal producing fields. One series of tests with house-heating boilers was made at Urbana, Illinois.

If the prices of various coals are considered, the efficiency of Missouri coal appears to justify its more extensive use for all ordinary purposes within the State. Its sale for domestic use could be greatly increased by putting it into the attractive briquetted form, and washing would remove most of the impurities that have heretofore proved objectionable.

SAMPLES OF MISSOURI COAL RECEIVED AND TESTED BY THE U. S. GEOL. SURVEY.

No.	Operator.	Mine.	Location.	Inspector.	Kind of coal.	Name of bed.	Tests.
1	New Home Coal Co.....	New Home..	New Home, Bates Co..	J. S. Burrows, M. R. Campbell	Run of mine partially slacked by accident.	Rich Hill.	Steaming, briquetting.
2	Northwestern Coal and Min. Co..	No. 8.....	1 mile south of Bevier, Macon county.....	J. W. Groves....	Run of mine.....	Bevier....	Steaming, washing, coking, producer-gas.
3	Mendota Coal and Mining Co....	.....	Mendota, Putnam Co..	J. W. Groves....	Slack over 1¼-inch bar screen.....	Lexington.	Steaming, washing, coking.
4	Morgan County Coal Co.....	.....	10 mile southeast of Versailles, Morgan Co. (Sec. 1, T. 42 N., R. 16 W.).....	J. W. Groves....	Run of mine broken in hauling.....	Pocket...	Steaming, coking.
5	Randolph-Macon Coal Co.....	No. 7.....	Higbee, Randolph Co...	J. W. Groves....	Run of mine.....	Bevier....	Steaming, washing, coking, cupola.
6	Randolph-Macon Coal Co.....	No. 3.....	1 mile east of Higbee, Randolph county.....	J. W. Groves....	Lump over 6-inch bar seam.....	Bevier....	Steaming.
7A.	Rombauer Coal Co.....	No. 2.....	½ mile northwest of Novinger, Adair county...	W. J. VonBorries	No. 1 nut.....	Bevier....	Steaming, washing.
7B.	Rombauer Coal Co.....	No. 2.....	½ mile northwest of Novinger, Adair county...	W. J. VonBorries	No. 2 nut.....	Bevier....	Steaming, washing.
10	Central Coal and Coke Co.....	No. 61.....	Bevier, Macon county..	K. M. Way.....	Screenings through ¾-inch shaking screen.	Bevier....	Steaming, briquetting.

SUMMARY OF STEAMING TESTS OF MISSOURI COAL AT ST. LOUIS COAL TESTING PLANT, 1904.*

Number and description, Missouri.	State of weather.	Date of trial.	Duration of time (hours).	Average pressures.				Average temperatures.				
				Steam pressure by gauge (1 pound per sq. inch).	Barometer (lbs. per square inch).	Force of draft. (Inches of water).		External air.	Fire room.	Feed water in tank.	Feed water entering boiler.	Escaping gases.
						Hood.	Furnace.					
No. 1	Rain and cloudy	Sept. 24	10.00	87.4	14.52	.40	.17	71.0	80.0	71.0	174.0	614.0
No. 1, briquet	Clear	Oct. 8	5.10	89.6	14.54	.44	.17	73.0	76.0	69.1	182.0	532.0
No. 1, washed	Clear	Sept. 28	9.91	85.9	14.50	.37	.16	88.1	91.3	75.2	173.0	635.0
No. 2	Cloudy a. m., clear p. m.	Oct. 25	9.98	82.7	14.64	.62	.20	52.4	60.0	58.5	168.0	623.0
No. 2	Clear	Nov. 2	9.98	85.6	14.56	.32	.13	59.0	66.0	57.3	198.0	483.0
No. 3	Cloudy	Dec. 12	9.95	77.5	14.53	.70	.28	25.1	41.7	45.1	159.0	591.0
No. 3, washed	Clear	Dec. 10	9.93	81.1	14.55	.65	.26	30.6	49.2	45.2	168.0	608.0
No. 4	Cloudy	Dec. 2	9.98	84.0	14.47	.52	.16	35.5	54.5	46.2	177.0	625.0
Average				84.2		.50	.19					589.0

*Breckenridge, L. P., Boiler Tests: Prof. Paper U. S. Geol. Survey No. 48, pt. 2, 1906, pp. 301-979.

STEAMING TESTS—Continued.

Missouri.	Fuel.				Proximate analyses of coal (per cent).					Ultimate analyses of coal (per cent.)							Earthy matter in ash and refuse (per cent).....
	Size and condition.	Total ash and refuse.....	Clinkers in ash and refuse (per cent)...	Ash and refuse in dry coal (per cent)...	Fixed carbon.	Volatile matter.....	Moisture.....	Ash	Fixed carbon (per cent of combustible)	Carbon	Hydrogen....	Oxygen.....	Nitrogen.....	Sulphur.....	Ash	Carbon (per cent of combustible)....	
No. 1.....	Mine run; dull....	1,720	60.0	19.00	40.64	34.88	7.28	17.20	53.81	65.23	4.62	5.81	1.08	4.71	18.55	80.08	80.15
No. 1, briquet....	Large briquettes..	663	47.0	15.73	41.85	37.60	6.38	14.17	52.67	68.52	4.63	5.69	1.16	4.86	15.14	80.74	83.81
No. 1, washed....	Nut; dull.....	990	52.0	11.90	44.21	36.81	7.93	11.05	54.56	71.50	5.06	6.37	1.18	3.89	12.00	81.25	86.47
No. 2.....	Nut; dull.....	2,084	63.0	20.58	37.33	32.88	13.09	16.70	53.17	61.93	4.35	7.76	1.09	5.66	19.21	76.66	79.80
No. 2.....	Nut; dull.....	1,310	68.0	16.02	39.76	31.77	11.57	16.90	55.59	62.38	4.37	7.84	1.10	5.20	19.11	77.12	80.17
No. 3.....	Nut; dull.....	2,474	60.0	28.08	29.98	26.18	18.63	25.21	53.38	52.55	3.75	7.10	.88	4.73	30.99	76.15	83.92
No. 3, washed....	Nut; dull.....	1,047	55.0	11.98	39.61	31.18	20.78	8.43	55.95	70.03	5.00	9.52	1.17	3.64	10.64	78.37	72.46
No. 4.....	Nut; dull.....	556	37.0	6.66	42.11	40.10	12.24	5.55	51.22	76.05	5.42	9.75	.79	5.67	6.32	81.18	73.83
Average.....	.....	.....	55.0	16.24	39.44	33.93	12.24	14.40	.....	66.02	4.65	6.98	1.06	4.79	16.49	.....	80.80

STEAMING TESTS—Continued.

Missouri.	Fuel per hour (pounds).						Calorific value of fuel by oxygen calorimeter.		Quality of steam (per cent).		Factor of evaporation.	Water per hour (pounds).			Horsepower.	
	Dry coal consumed.	Combustible consumed.	Combustible consumed, figured from chemistry of ash.	Dry coal per square foot of grate surface.	Combustible per square foot of water-heating surface.	Combustible per square foot of water-heating surface, figured from chemistry of ash.	Per pound of dry coal B. t. u.	Per pound of combustible B. t. u.	Percentage of moisture in steam.	Quality of steam (dry steam=unity).		Water evaporated, corrected for quality of steam.	Equivalent evaporation from and at 212° F.	Equivalent evaporation from and at 212° F. per square foot of water-heating surface.	Developed in boiler.	Percentage of builders' rated horsepower developed.
No. 1	903.0	731.0	701.0	22.30	.36	.345	12,109	14,867	.447	99.66	1.184	6,044	7,156	3.52	207.4	98.76
No. 1, briquet	826.0	696.0	680.0	20.37	.343	.335	12,676	14,938	.710	99.45	1.1863	5,562	6,598	3.24	191.2	91.00
No. 1, washed	840.0	740.0	726.0	20.71	.364	.357	13,171	14,967	.384	99.702	1.1791	6,056	7,141	3.51	207.0	98.57
No. 2	1,014.0	805.0	777.0	25.00	.396	.383	11,500	14,234	.710	99.455	1.1956	6,088	7,183	3.54	208.2	99.14
No. 2	819.0	688.0	637.0	20.20	.339	.313	11,561	14,292	.834	99.36	1.1976	4,969	5,951	2.93	172.5	82.14
No. 3	886.0	637.0	571.0	21.85	.314	.281	9,535	13,817	.665	99.494	1.2082	4,266	5,158	2.54	149.5	71.20
No. 3, washed	881.0	775.0	758.0	21.72	.381	.373	12,602	14,102	.573	99.565	1.2091	5,413	6,545	3.22	189.7	90.30
No. 4	837.0	781.0	769.0	20.64	.384	.379	14,197	15,155	.636	99.518	1.2087	6,111	7,386	3.64	214.1	102.00
Average	.....	.....	.....	21.60	.36	.346	12,169	14,547	.....	.....	.....	.....	.....	3.27	.....	91.64

STEAMING TESTS—Continued.

Missouri.	Economic results (pounds).					Efficiency (per cent).			Percentage of smoke as observed	Methods of firing.				Analysis of the dry gases (per cent.)			
	Water apparently evaporated under actual conditions, per pound of coal as fired	Equivalent evaporation from and at 212° F. per pound of coal as fired	Equivalent evaporation from and at 212° F. per pound of dry coal	Equivalent evaporation from and at 212° F. per pound of combustible	Same as last but figured from chemistry of ash	Efficiency of boiler	Efficiency of boiler, figured from chemistry of ash	Efficiency of boiler and grate		Kind of firing	Average thickness of fire (inches)	Average intervals between firing during time when fires are in normal condition (minutes)	Average intervals between times of leveling or breaking up (minutes)	Carbon dioxide	Oxygen	Carbon monoxide	Nitrogen (by difference)
No. 1	6.23	7.35	7.92	9.79	10.20	63.54	66.26	63.18	24.6	Alternate.	9.0	4.7	90	8.50	10.90	0.0	80.60
No. 1, briquet.	6.34	7.48	7.99	9.48	9.70	61.29	62.71	60.86	18.4	Alternate.	10.0	5.2	120	8.97	11.05	0.0	79.98
No. 1, washed.	6.66	7.83	8.50	9.65	9.84	62.26	63.49	62.32	34.0	Alternate.	8.0	4.5	60	7.97	11.75	0.0	80.28
No. 2	5.17	6.15	7.08	8.92	9.24	60.52	62.69	59.45	30.4	Spreading.	7.0	6.7	33	7.36	12.52	0.05	80.07
No. 2	5.40	6.42	7.26	8.65	9.35	58.45	63.17	60.68	51.0	Spreading.	7.0	8.3	29	9.48	9.65	0.16	80.71
No. 3	3.94	4.74	5.82	8.10	9.03	56.61	63.11	58.94	.....	Spreading.	6.0	6.9	26	5.42	14.62	0.02	79.94
No. 3, washed.	4.89	5.89	7.43	8.44	8.63	57.80	59.10	56.93	32.0	Spreading.	7.0	7.1	31	7.31	12.48	0.15	80.06
No. 4	6.44	7.75	8.83	9.46	9.61	60.28	61.24	60.06	56.0	Alternate.	8.0	5.6	43	7.92	11.53	0.15	80.40
Average	5.63	6.70	7.60	9.06	9.45	60.09	62.72	60.30	35.2	.....	7.8	6.1	54	7.87	11.81	0.066	.....

STEAMING TESTS—Continued.

Missouri.	Heat balance, or distribution of the heating value of the combustible (in B. t. u).						Heat balance in per cent of total of combustible.						
	Heat absorbed by the boiler	Loss due to moisture in coal	Loss due to moisture formed by the burning of the hydrogen	Loss due to heat carried away in the dry chimney gases	Loss due to incomplete combustion of carbons	Loss due to radiation and other losses	Heat absorbed by the boiler	Loss due to moisture in coal	Loss due to moisture formed by the burning of the hydrogen	Loss due to heat carried away in dry chimney gases	Loss due to incomplete combustion of carbon	Loss due to radiation and other losses	Dry coal per electrical horsepower per hour (pounds)
No. 1	9,850	125	656	2,997	.....	1,239	66.26	.83	4.42	20.16	0.0	8.33	4.41
No. 1, briquet	9,368	101	617	2,452	.....	2,400	62.71	.67	4.13	16.42	0.0	16.07	4.37
No. 1, washed	9,502	126	667	3,297	.....	1,375	63.49	.84	4.45	22.03	0.0	9.19	4.11
No. 2	8,923	245	637	3,457	53	919	62.69	1.72	4.47	24.28	0.37	6.47	4.93
No. 2	9,028	201	604	1,995	130	2,334	63.17	1.41	4.23	13.96	0.91	16.32	4.81
No. 3	8,720	437	644	4,528	28	—540	63.11	3.16	4.66	32.05	0.20	—3.18	6.00
No. 3, washed	8,334	387	665	3,484	160	1,072	59.10	2.74	4.72	24.71	1.13	7.60	4.70
No. 4	9,280	197	689	3,412	153	1,424	61.24	1.30	4.55	22.51	1.01	9.39	3.96
Average	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.66

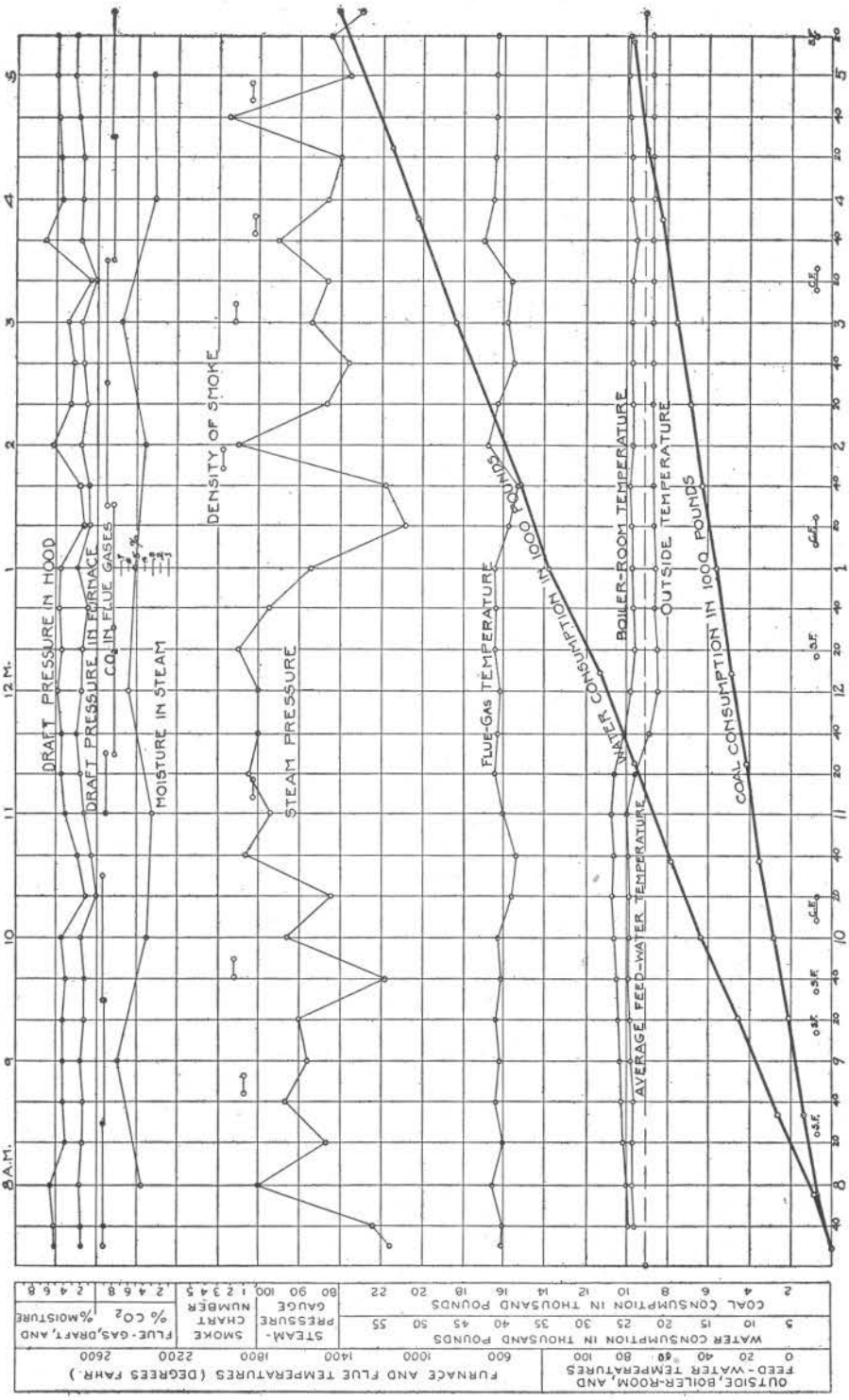

Fig. 90. Graphic log sheet, Missouri No. 1 coal (run of mine, dull).

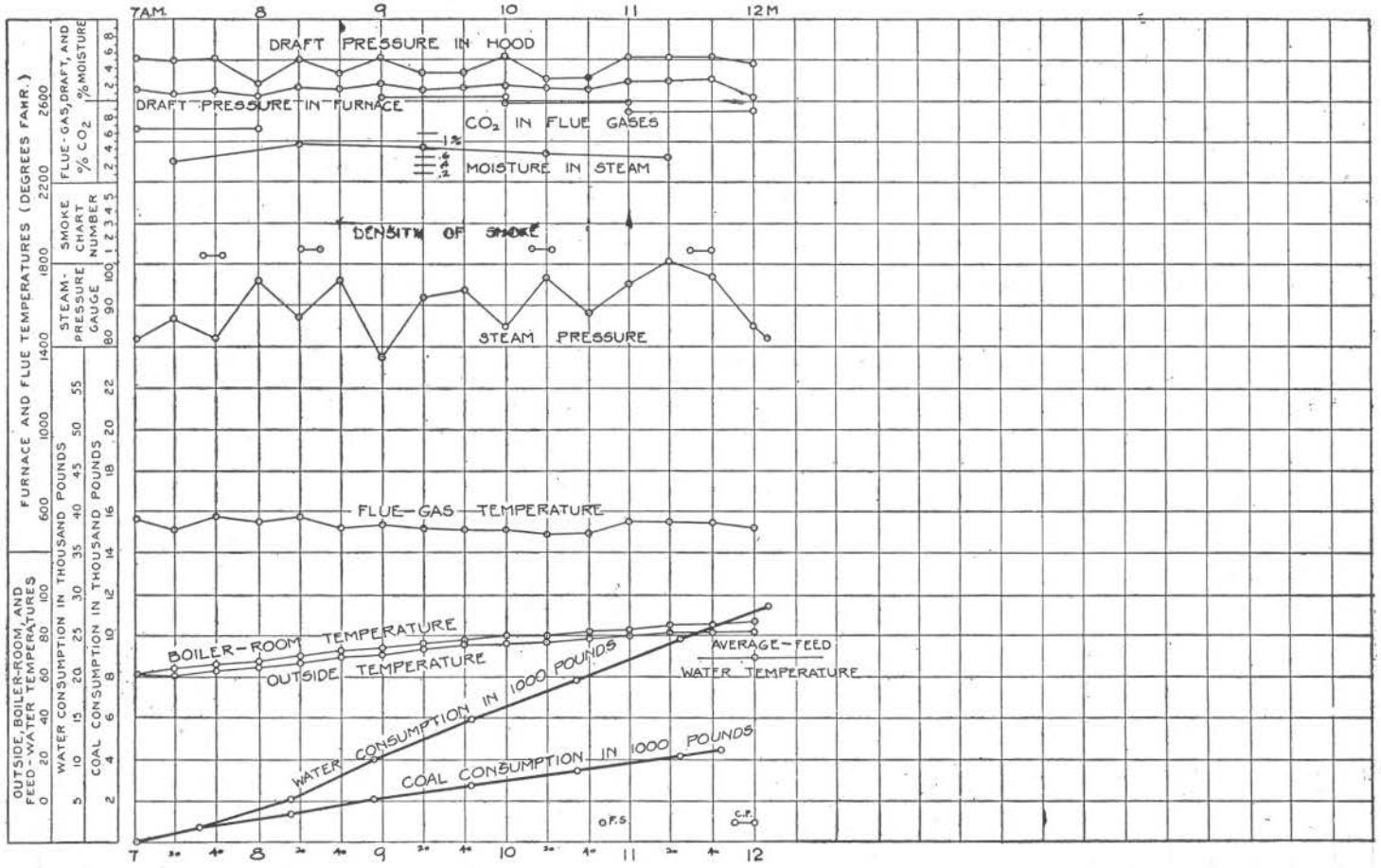

Fig 91. Graphic log sheet, Missouri No. 1 coal (large briquettes).

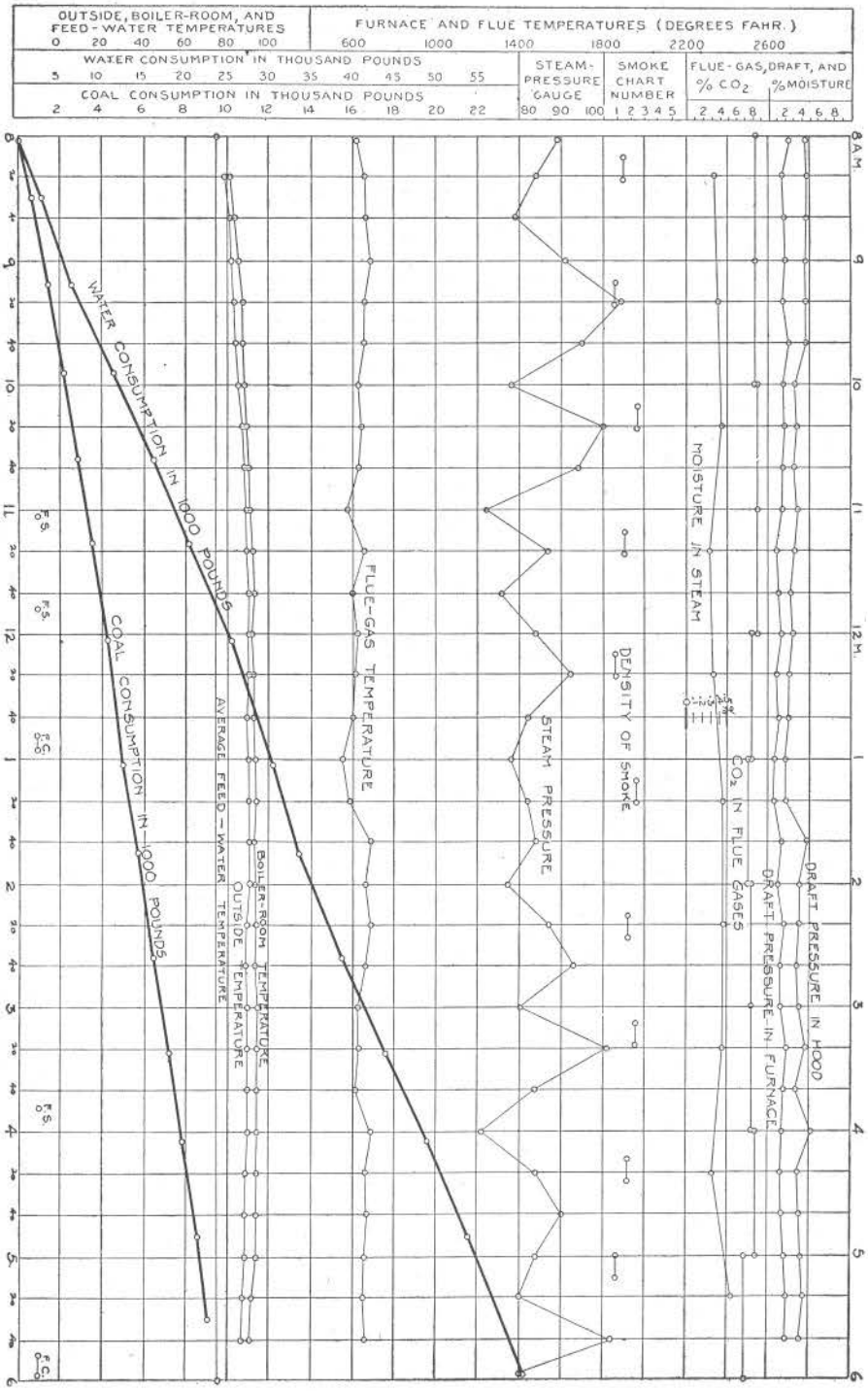

Fig 92. Graphic log sheet, Missouri No. 1 coal (washed nut, dull).

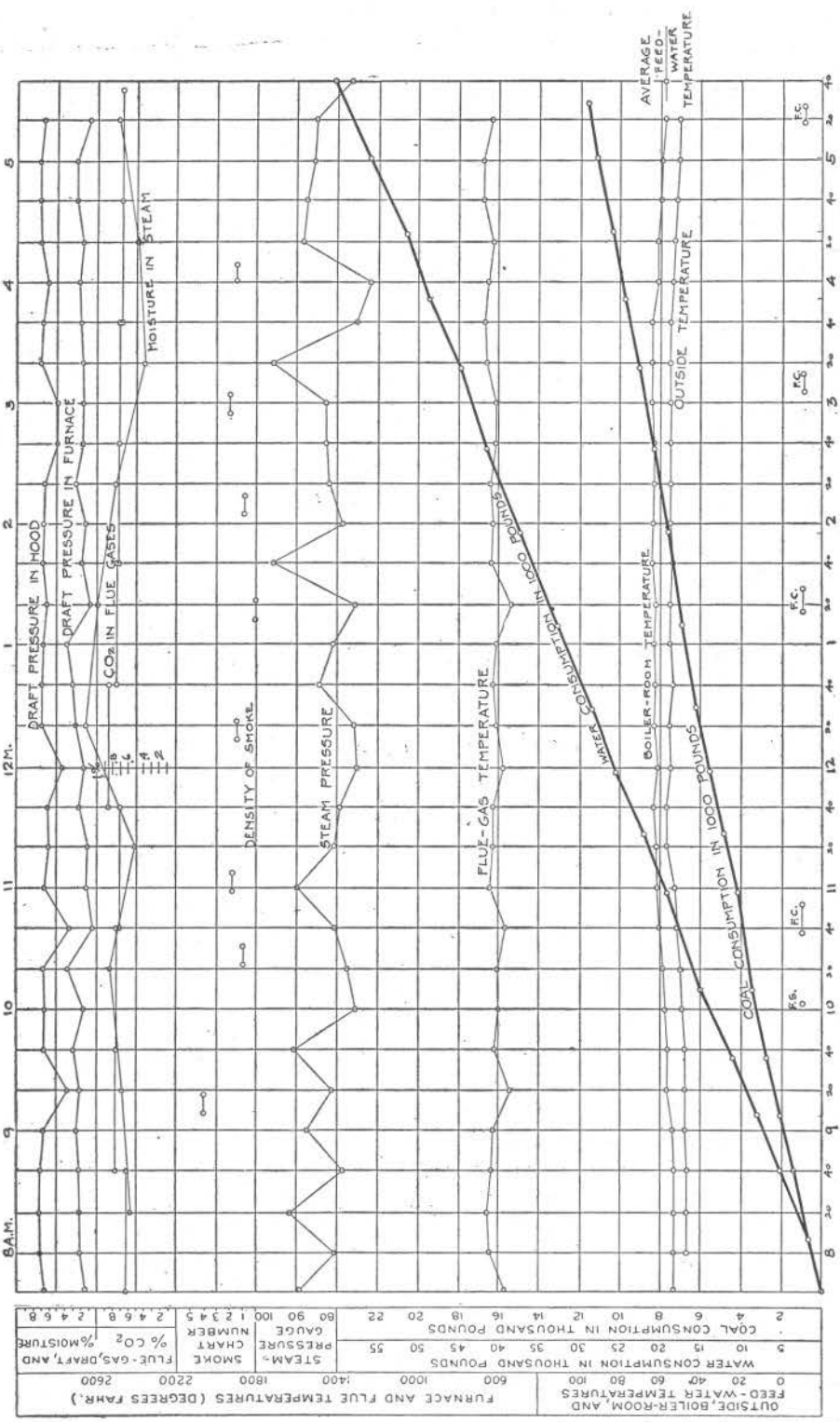

Fig. 93. Graphic log sheet, Missouri No. 2 coal (nut, dull).

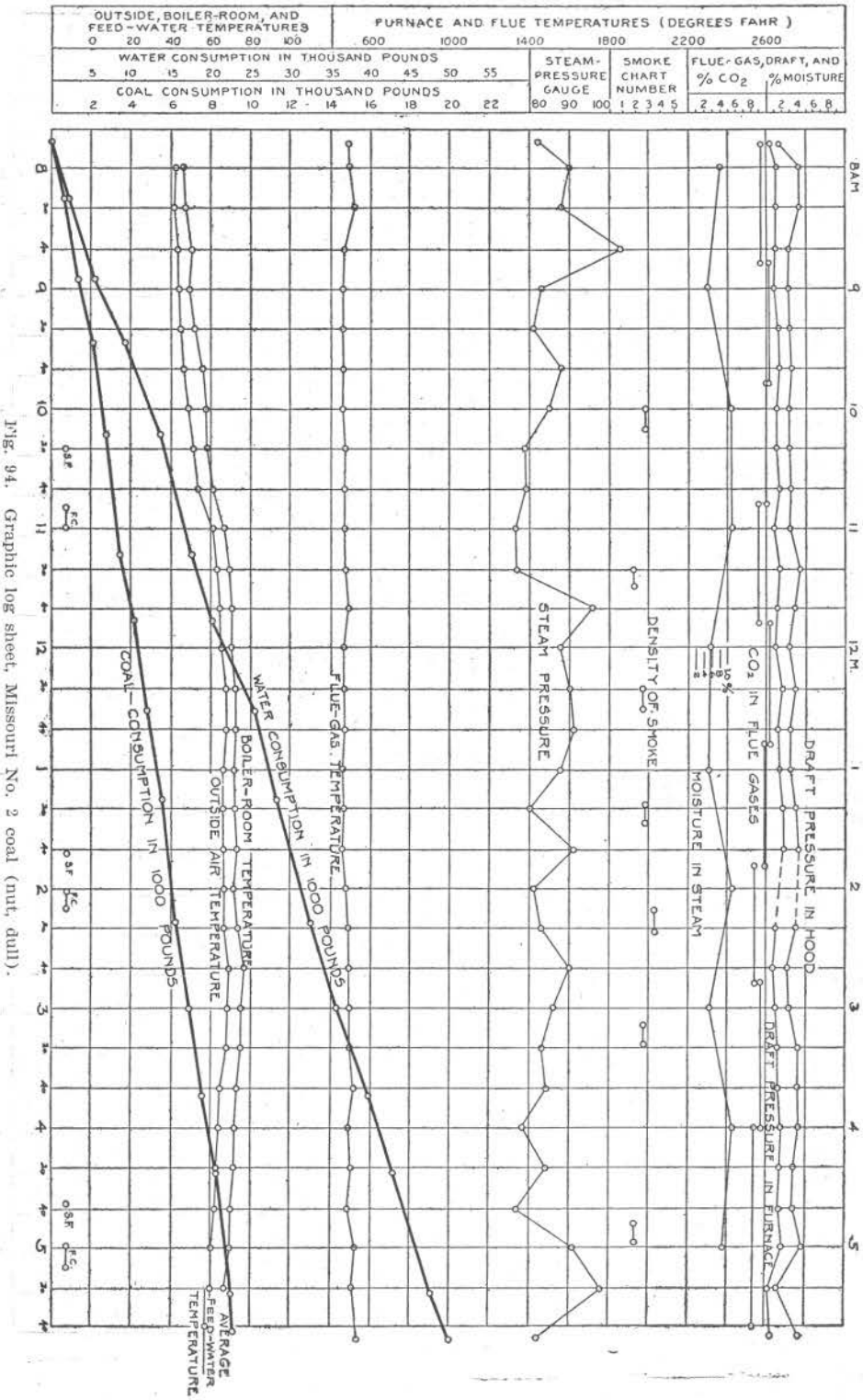

Fig. 94. Graphic log sheet, Missouri No. 2 coal (nut, dull).

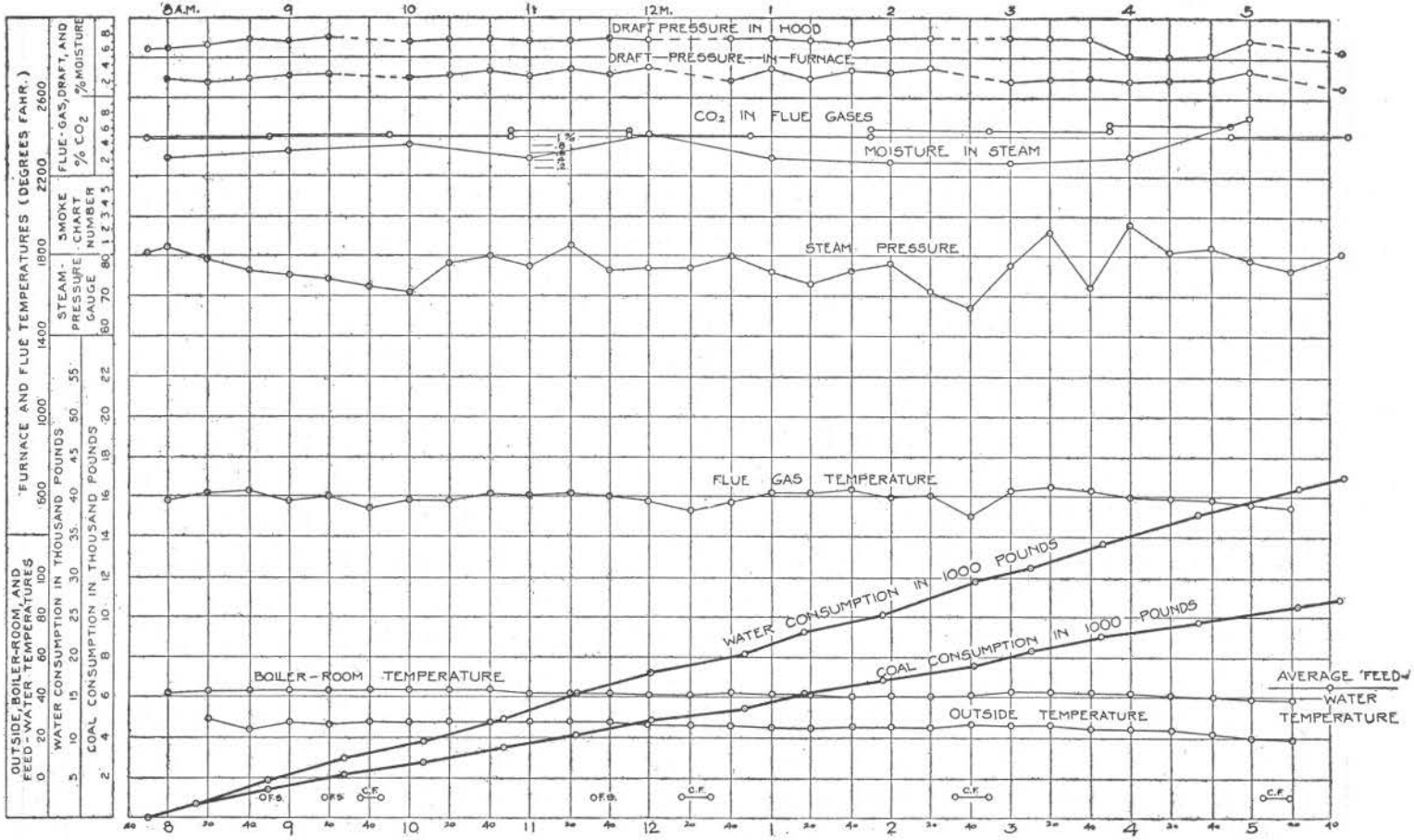

Fig. 95. Graphic log sheet, Missouri No. 3 coal (nut, dull).

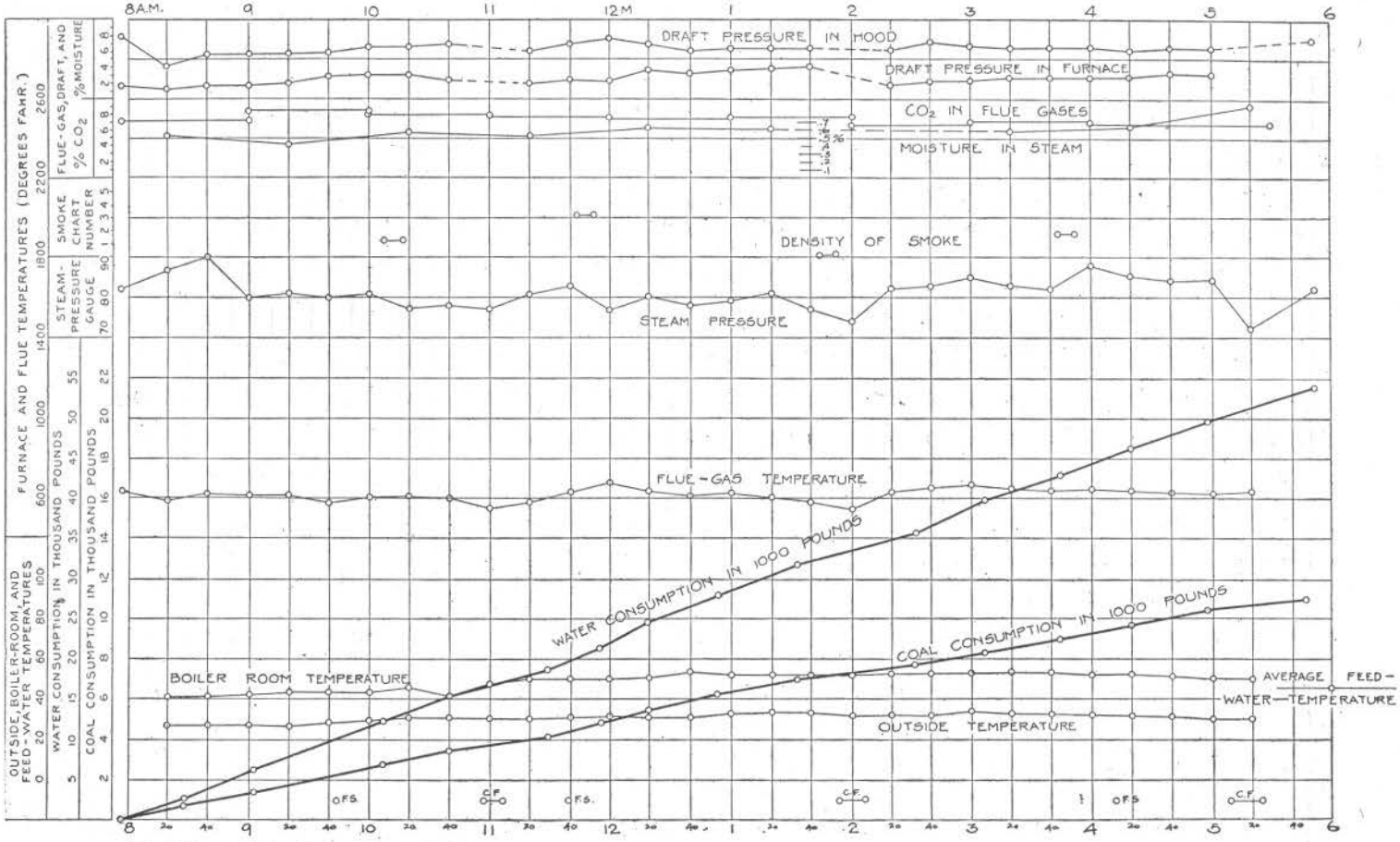

Fig 96. Graphic log sheet, Missouri No. 3 coal (washed nut, dull).

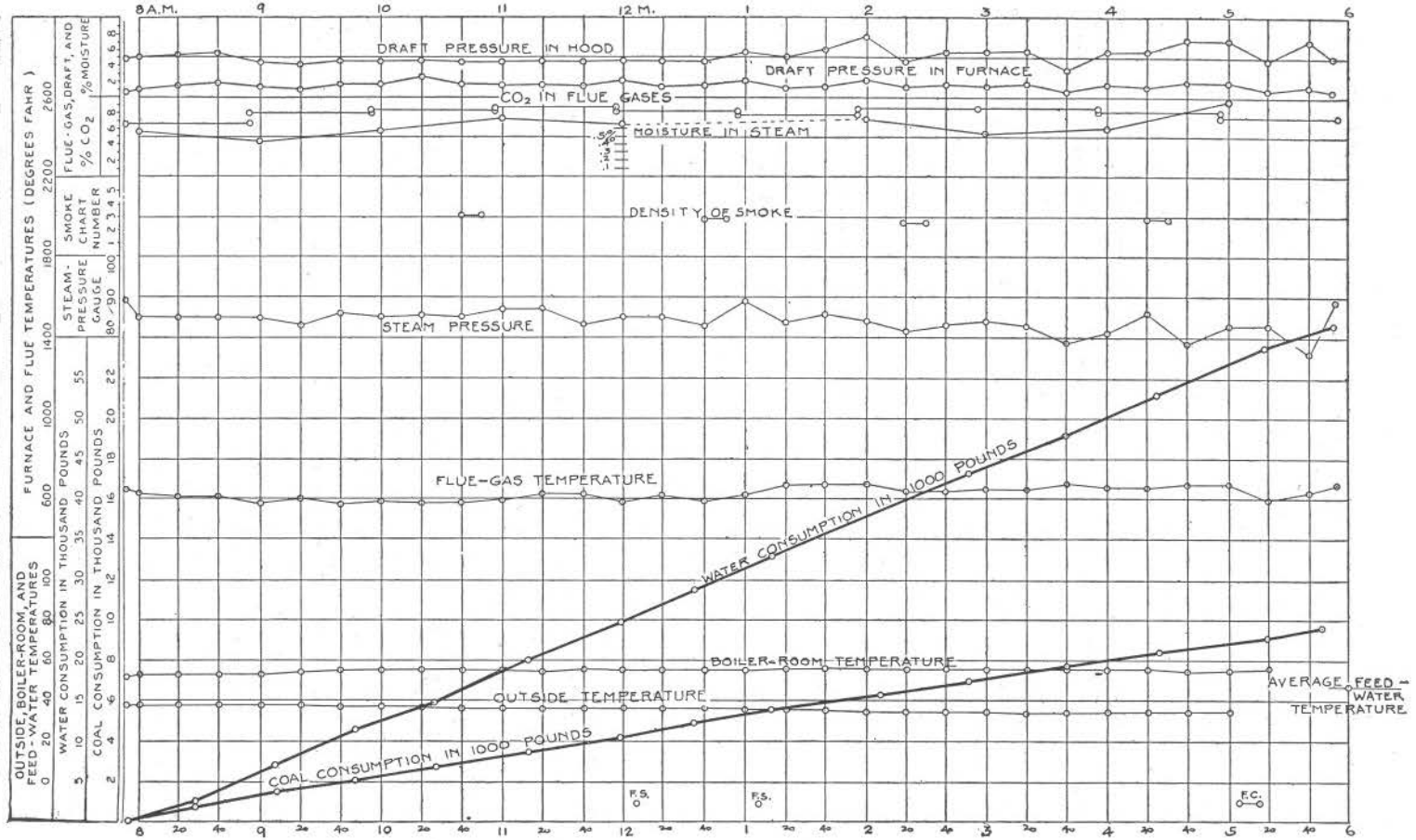

Fig. 97. Graphic log sheet, Missouri No. 4 coal (nut, bright).

STEAMING TESTS MADE AT ST. LOUIS COAL-TESTING PLANT JANUARY 1, 1906, TO JUNE 30, 1907.*

MISSOURI NO. 5.

CHEMICAL ANALYSES.

	Mine samples.		Car sample.	Steaming tests.†	
				319.	320.
Laboratory No	2795	2796	2865	.....	.....
Air-drying loss	10.80	11.50	11.40	.....	.....
Proximate—					
Moisture	13.38	13.89	12.92	13.37	12.24
Volatile matter	34.17	33.36	33.64	31.46	31.55
Fixed carbon	42.43	41.23	39.82	39.78	40.10
Ash	10.02	11.52	13.62	15.39	16.11
Sulphur	4.48	4.19	5.03	5.35	5.33
Ultimate—					
Hydrogen	.....	.....	5.43	4.43	4.40
Carbon	.....	.....	57.16	63.53	63.13
Nitrogen	.....	.....	0.90	1.01	1.00
Oxygen	.....	.....	17.86	7.90	7.04
Ash	.....	.....	.....	17.76	18.36
Sulphur	.....	.....	.....	6.18	6.07
Calorific value (as received)—					
Determined (calories)	6,158	.....	5,860	.....	.....
Determined (B. t. u.)	11,084	.....	10,548	.....	.....
Calculated from ult. analysis (calories)	.....	.....	5,834	.....	.....
Calculated from ult. analysis (B. t. u.)	.....	.....	10,501	.....	.....

STEAMING TESTS.

	Test 319.	Test 320.
Size as used—		
Over 1 inch.....per cent	23.5	20.1
½ inch to 1 inch..... do.	22.9	21.0
¼ inch to ½ inch..... do.	19.3	18.8
Under ¼ inch..... do.	34.3	40.1
Duration of test.....hours	9.63	8.35
Heating value of coal..... B. t. u. per pound dry coal	11,747	11,668
Force of draft—		
Under stack damper.....inch water.	0.61	0.73
Above fire..... do.	0.22	0.34
Furnace temperature.....°F.	2,368	.....
Dry coal used per square foot of grate surface per hour.....pounds	18.64	22.24
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds	2.79	3.38
Percentage of rated horse-power of boiler developed.....	87.1	94.7
Water apparently evaporated per pound of coal as fired.....pounds	5.39	5.54
Water evaporated from and at 212°F—		
Per pound of coal as fired.....pounds	6.49	6.67
Per pound of dry coal..... do.	7.49	7.60
Per pound of combustible..... do.	9.36	9.60
Efficiency of boiler, including grate.....per cent	61.57	62.90
Coal as fired—		
Per indicated horse-power hour.....pounds	4.36	4.24
Per electrical horse-power hour..... do.	5.38	5.24
Dry coal—		
Per indicated horse-power hour..... do.	3.77	3.72
Per electrical horse-power hour..... do.	4.66	4.59

*Breckinridge, L. P., Steaming tests: Bull. U. S. Geol. Survey, No. 332, 1909, p. 299.
†Proximate analysis of fuel as fired; ultimate analysis of dry fuel figured from car sample.

MISSOURI NO. 6.

CHEMICAL ANALYSES.

	Mine samples.		Car sample.	Steaming tests.*	
				326.	327.
Laboratory number	2817	2818	2904	.....	.....
Air-drying loss	11.80	8.60	11.60	.....	.....
Proximate—					
Moisture	14.01	11.38	13.80	13.73	12.93
Volatile matter	33.49	37.10	34.29	32.82	34.21
Fixed carbon	42.21	43.07	40.17	39.96	41.63
Ash	10.29	8.45	11.74	13.49	11.23
Sulphur	5.23	3.57	5.60	6.05	5.31
Ultimate—					
Hydrogen	.....	.....	5.48	4.44	4.65
Carbon	.....	.....	58.09	65.24	68.33
Nitrogen	.....	.....	0.96	1.08	1.13
Oxygen	.....	.....	18.13	6.59	6.89
Ash	.....	.....	.....	15.64	12.90
Sulphur	.....	.....	.....	7.01	6.10
Calorific value (as received)—					
Determined (calories)	6,128	.....	5,998	.....	.....
Determined (B. t. u.)	11,030	.....	10,796	.....	.....
Calculated from ult. analysis (calories)	.....	.....	5,926	.....	.....
Calculated from ult. analysis (B. t. u.)	.....	.....	10,667	.....	.....

STEAMING TESTS.

	Test 326.	Test 327.
Size as used—		
Over 2 inches ..... per cent	.....	25.7
2 inches to 1½ inches ..... do.	.....	27.4
Over 1 inch ..... do.	36.5	.....
½ inch to 1½ inches ..... do.	.....	19.2
½ inch to 1 inch ..... do.	23.3	.....
¼ inch to ½ inch ..... do.	16.6	12.0
Under ¼ inch ..... do.	23.6	15.7
Duration of test ..... hours	9.92	10.03
Heating value of coal ..... B. t. u. per pound dry coal	12,155	12,677
Force of draft—		
Under stack damper ..... inch water	0.73	0.75
Above fire ..... do.	0.19	0.18
Furnace temperature ..... °F.	2,476	2,561
Dry coal used per square foot of grate surface per hour ..... pounds	21.82	23.06
Equivalent water evaporated per square foot of water-heating surface per hour ..... pounds	3.47	3.66
Percentage of rated horse-power of boiler developed	97.4	102.7
Water apparently evaporated per pound of coal as fired ..... pounds	5.71	5.75
Water evaporated from and at 212° F.—		
Per pound of coal as fired ..... pounds	6.88	6.93
Per pound of dry coal ..... do.	7.98	7.96
Per pound of combustible ..... do.	9.64	9.30
Efficiency of boiler, including grate ..... per cent	63.40	60.64
Coal as fired—		
Per indicated horse-power hour ..... pounds	4.11	4.08
Per electrical horse-power hour ..... do.	5.08	5.04
Dry coal—		
Per indicated horse-power hour ..... do.	3.54	3.55
Per electrical horse-power hour ..... do.	4.38	4.39

*Proximate analysis of fuel as fired; ultimate analysis of dry fuel figured from car sample.

MISSOURI NO. 7 (WASHED NUT.)*

WASHING TESTS.

	Test 152 (A).	Test 153 (B).
Size as used	No. 1	No. 2
Jig used	Stewart.	Stewart.
Raw coal, pounds	25,000	23,500
Washed coal, do.	21,470	18,600
Refuse, do.	3,530	4,900

Analyses.—Test 152 (A): For raw coal analyses see below (sample 2936). Washed coal: Moisture, 17.30; ash, 9.45; sulphur, 3.04. Test 153 (B): For raw coal analyses see below (sample 2937). Washed coal: Moisture, 19.70; ash, 11.05; sulphur, 3.07.

CHEMICAL ANALYSES.

	Mine samples.		Car samples.			Steaming tests.*		
						A.		B.
			No. 1 nut.	Slack.	No. 2 nut.	329.	330.	332.
Laboratory number	2823	2824	2936	2942	2937	.....	.....	.....
Air-drying loss	14.60	13.70	14.50	15.20	9.70	.....	.....	.....
Proximate—								
Moisture	17.19	16.19	16.36	17.30	16.39	17.26	17.74	17.76
Volatile matter	34.05	31.25	29.12	26.43	29.01	32.11	32.65	32.00
Fixed carbon	39.48	39.87	35.01	32.89	34.42	40.32	39.26	39.95
Ash	9.28	12.69	19.51	23.38	20.18	10.31	10.35	10.29
Sulphur	2.76	3.03	3.53	2.94	3.12	3.27	3.24	3.19
Ultimate—								
Hydrogen	.....	.....	5.23	5.04	5.28	4.70	4.69	4.80
Carbon	.....	.....	49.44	45.41	49.03	68.20	68.11	67.97
Nitrogen	.....	.....	0.87	0.83	0.91	1.20	1.20	1.26
Oxygen	.....	.....	21.42	22.40	21.48	9.49	9.48	9.58
Ash	.....	.....	.....	.....	.....	12.46	12.58	12.51
Sulphur	.....	.....	.....	.....	.....	3.95	3.94	3.88
Calorific value (as received)—								
Determined, calories	5,888	.....	5,004	4,578	4,970	.....	.....	.....
Determined, B. t. u.	10,598	.....	9,007	8,240	8,946	.....	.....	.....
Calculated from ultimate analysis, calories	.....	.....	4,953	4,507	4,924	.....	.....	.....
Calculated from ultimate analysis, B. t. u.	.....	.....	8,915	8,113	8,863	.....	.....	.....

*Delameter, G. R., Washing tests: Bull. U. S. Geol. Survey No. 332, 1908, pp. 171-172.
*Proximate analysis of fuel as fired; ultimate analysis of dry fuel figured from car sample.

STEAMING TEST.

	A.		B.
	Test 329.	Test 330.	Test 332.
Size as shipped	No. 1	No. 1	No. 2
Size as used—			
Over 1 inch, per cent	47.0	46.3	21.4
½ inch to 1 inch, do.	21.6	23.2	43.6
¼ inch to ½ inch, do.	14.9	15.0	21.4
Under ¼ inch, do.	16.5	15.5	13.6
Duration of test, hours	9.78	5.73	9.75
Heating value of coal, B. t. u. per pound dry coal	12,659	12,643	12,469
Force of draft—			
Under stack damper, inch water	0.60	0.71	0.71
Above fire, do.	0.14	0.13	.....
In ash pit (forced draft), do.	.....	.....	0.02
Furnace temperature, °F.	.....	.....	2,686
Dry coal used per square foot of grate surface per hour, pounds	21.90	25.92	32.03
Equivalent water evaporated per square foot of water-heating surface per hour, pounds	3.51	4.10	4.62
Percentage of rated horse-power of boiler developed	98.4	115.0	*129.4
Water apparently evaporated per pound of coal as fired, pounds	5.53	5.42	4.93
Water evaporated from and at 212° F.—			
Per pound of coal as fired, pounds	6.64	6.52	5.94
Per pound of dry coal, do.	8.03	7.92	7.22
Per pound of combustible, do.	9.32	9.29	8.36
Efficiency of boiler, including grate, per cent	61.26	60.49	55.92
Coal as fired—			
Per indicated horse-power hour, pounds	4.26	4.34	4.76
Per electrical horse-power hour, do.	5.26	5.36	5.88
Dry coal—			
Per indicated horse-power hour, do.	3.52	3.57	3.92
Per electrical horse-power hour, do.	4.35	4.41	4.84

*Test made for maximum capacity.

CHEMICAL ANALYSES.

	Mine samples.		Car sample.	Steaming test 486.*a*	Briquetting tests.*b*			
					178†.*c*	241*.	245.	246.
Laboratory No.	4196	4197	4257	4362	4515	4898	4876	4908
Air-drying loss	8.50	8.80	13.70	1.30	9.40	.....	.....	.....
Proximate—								
Moisture	15.26	15.41	15.23	4.51	11.03	8.91	7.79	7.75
Volatile matter	33.91	32.76	26.32	35.53	32.24	31.81	31.46	32.48
Fixed carbon	42.13	40.22	37.95	41.37	38.67	38.17	39.87	40.95
Ash	8.70	11.61	20.50	18.59	18.06	21.11	20.88	18.82
Sulphur	4.37	3.78	3.69	3.90	3.72	4.49	4.66	4.53
Ultimate—								
Hydrogen	.....	.....	5.02	4.34	.....	4.16	4.12	4.24
Carbon	.....	.....	49.41	64.29	.....	60.16	60.63	62.77
Nitrogen	.....	.....	0.84	0.91	.....	0.84	0.84	0.91
Oxygen	.....	.....	20.54	6.91	.....	6.73	6.71	6.76
Ash	.....	.....	.....	19.47	.....	23.18	22.65	20.41
Sulphur	.....	.....	.....	4.08	.....	4.93	5.05	4.91
Calorific value determined (as rec'd) calories	.....	5,879	5,055	.....	.....	.....	.....	.....
Calorific value determined (as rec'd) B. t. u.	.....	10,582	9,099	.....	.....	.....	.....	.....

a Proximate analysis of fuel as fired; ultimate analysis of dry fuel figured from car sample.
b Proximate analysis of fuel as received; ultimate analysis on dry basis.
c No ultimate analysis made.

STEAMING TEST.

Missouri No. 10 (briquettes).

	Test 486.
Duration of test, hours	9.63
Heating value of fuel.....B. t. u. per pound dry fuel	11,653
Force of draft—	
Under stack damper.....inch water	0.79
Above fire..... do.	0.15
Dry fuel used per square foot of grate surface per hour.....pounds.	24.69
Equivalent water evaporated per square foot of water-heating surface per hour, ...pounds	3.28
Percentage of rated horsepower of boiler developed	92.0
Water apparently evaporated per pound of fuel as fired.....pounds	5.25
Water evaporated from and at 212° F.—	
Per pound of fuel as fired..... do.	6.36
Per pound of dry fuel..... do.	6.66
Per pound of combustible..... do.	8.41
Efficiency of boiler, including grate.....per cent	55.19
Fuel as fired—	
Per indicated horse-power hour.....pounds	4.45
Per electrical horse-power hour..... do.	5.49
Dry fuel—	
Per indicated horse-power hour..... do.	4.25
Per electrical horse-power hour..... do.	5.24

Remarks.—Test made on briquettes from tests 178† and 179. These burned freely, although the rate of combustion decreased as ash formed on the surface, particularly on the English briquettes, where the ash could not be separated from the briquettes; 2.4 per cent black smoke; ash heavy, gray, and fine; no clinker.

TESTS OF BRIQUETTES OF MISSOURI COAL AS FUEL IN HOUSE-HEATING BOILERS,* MADE AT URBANA COAL TESTING PLANT.

Four series of tests were made at St. Louis and two at Urbana, Illinois, on Missouri No. 10 coal. As conditions were more constant at the latter place and the results were considered more satisfactory, an average of only the two Urbana tests is given here.

Shape of briquet. *Binder.*	Round. *Water-gas pitch.*
Percentage used	8
Flowing point	143.6
Oils by distillation up to 743° F	39.05
Extraction analysis: Pitch extracted (sample as received) by CS_2	99.66
Date of test.....June	20, 1902

	Boiler A.	*Boiler B.*
Duration of test (hours)	7.95	7.67
Average pressure—		
Steam (gauge)—		
Boiler	5.68	4.44
Receiver	1.97	1.86
Draft (inch of water)—		
Flue	0.14	0.20
Over fire	0.10	0.05
Average temperature (°F.) of feed water in weigh tank	163.1	162.7

*Randall, D. T., Tests of coal and briquettes as fuel for house-heating boilers: Bull. U. S. Geol. Survey, No. 366, 1908, p. 44. Those especially interested should consult this paper.

	Boiler A.	*Boiler B.*
Fuel as fired (pounds)—		
Wood	6.0	6.0
Briquettes	300	375
Briquets plus wood	302.4	377.4
Corrected for residual fuel	282.5	360.2
Dry fuel (pounds)—		
Total find	282.6	352.6
Corrected for residual fuel	264.0	336.5
Actually consumed (corrected for carbon in ash)	247.5	322.7
Total ash and refuse from ash pit (pounds)	57.0	62.5
Residual fuel removed (pounds)	27.0	32.0
Proximate analysis of fuel as fired (per cent)†—		
Moisture	6.56	6.56
Ash in ultimate analysis of dry fuel (per cent)	21.57	21.57
Analysis of residual fuel (per cent)—		
Carbon	51.85	37.98
Earthy matter	48.15	62.02
Ash (per cent)—		
Carbon	21.87	16.64
Earthy matter	78.13	83.36
Dry fuel per hour (pounds)—		
Total	33.21	43.89
Per square foot of grate surface	7.76	7.32
British thermal units per pound of fuel—		
Dry	11,012	11,012
As fired	10,290	10,290
Moisture in steam (per cent)	0.93	0.65
Factor for correction, quality of steam	0.9912	0.9939
Water (pounds)—		
Fed to boiler	1,243	1,557
Corrected for quality of steam	1,232	1,546
Evaporated into dry steam from and at 212° F.	1,297	1,630
Factor of evaporation	1.0532	1.0534
Water per hour (pounds)—		
Equivalent evaporation from and at 212° F.	163.2	212.5
Equivalent evaporation from and at 212° F. per square foot of water-heating surface	3.74	2.90
Horse-power developed	4.73	6.16
Mean load carried—		
Square feet of radiating surface	544	708
Square feet of radiating surface plus radiating surface of boiler	582	812
Percentage of builders' rated capacity developed (per cent)	68.0	65.9
Economic results (pounds)—		
Equivalent evaporation from and at 212° F. per pound of fuel—		
Fuel as fired	4.59	4.53
Dry fuel consumed	5.24	5.05
Fuel per hour per 100 square feet of radiating surface (mean load carried during test)—		
As fired	6.53	6.63
Dry	6.10	6.20
Efficiency (per cent)—		
Boiler and furnace (dry fuel basis)	45.96	44.29
Plant (fuel as fired basis)	43.08	42.52
Cost in cents, per 100 square feet of radiating surface per hour (mean load carried during test)‡	0.327	0.332
Cost in cents, of evaporating 1,000 pounds of water from and at 212° F.‡	10.89	11.04
Average amount of fuel fired at each firing (pounds)	75.	75.
Average interval (hours)—		
Between firings	1.91	1.42
Between time of shaking and raking	1.91	1.46
Maximum interval of maintaining 2 pounds or more steam pressure without attention (hours)	2.00	1.67
Amount of soot formed on flues	very little	very little

†Moisture only determined except in standard tests.
‡Based on fuel at $1.00 per 2,000 pounds.

PRODUCER GAS TESTS OF MISSOURI COAL MADE AT ST. LOUIS COAL TESTING PLANT.

"The abundance of natural gas and the multiplicity of uses to which it has been applied have led to a much greater appreciation of the advantages of gaseous fuel, and have helped to emphasize the value of the gas producer. During the past few years there has been great development in the utilization of producer gas not only for power purposes and in the manufacture of iron and steel, but in other industries as well.

"In using producer gas as a fuel one should remember that the heat value of the gas is low compared to that of the other gases used for similar purposes, with the exception of blast-furnace gas. Natural gas has an approximate average heat value of 1,000 B. t. u. per cubic foot; the heat value of artificial or ordinary city gas is about 650 B. t. u. per cubic foot; whereas the heat value of producer gas ranges from 100 to 275 B. t. u. per cubic foot, according to the method of production. This relatively low heat value must be taken into account when considering the method of application. In spite of its low heat value producer gas is usually cheaper for work requiring relatively large quantities of gas than any other fuel, with the possible exception of natural gas sold at a low price.

"The introduction of producer gas fuel for all types of service necessarily requires at the present time a certain amount of careful engineering promotion, due to the uncertainty that exists regarding its successful use in fields in which natural or artificial gas or even solid fuels have been in vogue for years. In one extensive installation in which producer gas is distributed over a large area from one central plant, perfect confidence has been established in its reliability for continuous service and in the uniformity of the heat value of the gas.

"In many possible applications of producer gas as a fuel there seems to be little if any gain over direct firing with coal. Opinions differ regarding this point, many claiming that there is always a considerable saving in favor of producer gas. The difference either way is probably small, but other considerations are frequently of such importance as to give producer gas a great advantage. Under conditions requiring uniformity of temperature for continued periods, or variations in temperature at positive intervals, the ease with which the supply of producer gas can be regulated insures results that would be entirely impossible with solid fuel. Producer gas may also be employed with comparative ease as a reducing agent.

"Under the simple conditions required for boiler heating, it is questionable whether any advantage is to be obtained by the use of producer gas except, possibly, where low-grade fuels are burned. There are many fuels that can be utilized to advantage in the gas

producer that cannot be employed in direct steam-boiler firing. An incidental advantage which may be important in urban communities is the reduction of smoke resulting from the use of the producer.

"In large plants there may be considerable advantage in using producer gas in place of coal, due to the fact that the gas can be so easily piped from the producers to different parts of the plant. This advantage is particularly marked where it is inconvenient to distribute coal to several boiler installations, and may result in a considerable financial saving. Some writers on the subject are enthusiastic enough to believe that the manufacture of producer gas by large central plants at the mines, and the distribution of this gas through pipe systems over a broad area, will become general within the next few years.

"In lime burning it is claimed that greater economy is obtained with producer gas than with coal, and that the output of a plant is considerably increased. The heat produced by the gas is readily controlled, and it is claimed that the flames from burning gas are ideal for the process. Owing to the absence of ash and clinker a much cleaner and purer product is produced, and the labor required is reported as considerably less than that demanded with solid fuel. Reduction in the repair bill is also claimed, as the life of the kilns is longer and the necessary repairs are less than when solid fuel is used.

"Although producer gas has been satisfactorily used for ore roasting, the development in this direction has been slow, owing to the fact that there is a natural hesitancy about adopting new methods.

"In forge work the substitution of producer gas for oil, city gas, and natural gas is developing, although special care is necessary regarding the methods of application. Producer gas is economical and does away with the dirt and smoke so prevalent in forge work when coal is used.

"The substitution of producer gas in place of coal for cement burning seems to offer an attractive field. Although this substitution has been made in only a few instances and has not become general, it is attracting the attention of manufacturers. It is claimed that excellent economy is obtained, that a high-grade, uniform clinker is produced, and that the ease of control, the simplicity of the equipment, and the low cost of the installation and up-keep make producer gas an ideal substitute for coal. In discussing this question cement manufacturers have expressed the opinion that the application of producer gas to clinker burning presents many of the advantages named, but at the same time they state that, as far as their information goes concerning installations of this process, there has been difficulty in getting as large an output as had previously been obtained with coal.

"The range of fuels which can be used in either the pressure or down-draft plants is much greater than that for the suction plant.

"A few companies operating pressure and down-draft plants prior to 1904 ventured to use certain well-tried bituminous coals known to be especially free from sulphur and a tendency to cake, and low in both ash and tar-producing compounds. It remained, however, for the Geological Survey to demonstrate the possibility of using in such plants practically all grades of fuels of any commercial value without reference to the proportion of sulphur or tarry compounds that they contain. Several of the poorest grades of bituminous coal showed remarkable efficiency in the gas producer, and lignite and peat were used with great facility, thus opening the way to the introduction of cheap power into large districts that have thus far been commercially unimportant from a lack of such power. Experiments with bone coal have given excellent results, showing an efficiency in the producer equal to that obtained by using good steam coal under boilers. Recent investigations with other low-grade fuels, such as roof-coal slabs, culm, and washery refuse, have also demonstrated the possibility of using such material to advantage in the producer."*

SUMMARIES OF PRODUCER GAS TESTS OF MISSOURI NO. 2 COAL.†

Duration in hours	4.33
Coal per hour (pounds)—	
Consumed in producer—	
Coal as fired	346.5
Dry coal	306.0
Combustible	255.0
Equivalent used by producer plant—	
Coal as fired	384.5
Dry coal	339.6
Combustible	283.0
British thermal units—	
Coal as fired, per pound	10,505
Dry coal, per pound	11,882
Combustible, per pound	14,280
Per cubic foot of standard gas	140.0
From standard gas per pound of dry coal consumed in producer	8,820
From standard gas per hour per brake horse-power	11,560
Cubic feet of standard gas produced (62° F., 14.7 pound pressure)—	
Per hour	19,300
Per pound consumed in producer—	
Coal as fired	55.7
Dry coal	63.0
Combustible	75.7
Per pound equivalent used by producer plant—	
Coal as fired	50.2
Dry coal	56.8
Combustible	68.2
Economic results: pounds of coal consumed in producer per horse-power per hour—	
Per electrical horse-power available for outside purposes—	
Coal as fired	1.87
Dry coal	1.65
Combustible	1.37

*Fernald, R. H., and Smith, C. D., Resumé of producer gas investigations, Bull. Bureau of Mines, No. 13, 1911, pp. 34-37, 40.

†Fernald, R. H., Producer gas tests: Prof. Paper U. S. Geol. Survey No. 48, pt. 3, 1906, pp. 981-1325.

SUMMARIES OF PRODUCER GAS TESTS OF MISSOURI NO. 2 COAL—Continued.

Economic results: pounds of coal consumed in producer per horse-power per hour—Continued.	
Per electrical horse-power developed at switch board—	
Coal as fired	1.74
Dry coal	1.54
Combustible	1.28
Per brake horse-power available for outside purposes—	
Coal as fired	1.59
Dry coal	1.40
Combustible	1.17
Per brake horse-power developed at engine—	
Coal as fired	1.48
Dry coal	1.31
Combustible	1.09
Economic results: Equivalent pounds of coal used by producer plant for horse-power per hour—	
Per electrical horse-power available for outside purposes—	
Coal as fired	2.07
Dry coal	1.83
Combustible	1.52
Per electrical horse-power developed at switch board—	
Coal as fired	1.94
Dry coal	1.71
Combustible	1.43
Per brake horse-power available for outside purposes—	
Coal as fired	1.76
Dry coal	1.55
Combustible	1.30
Per brake horse-power developed at engine—	
Coal as fired	1.65
Dry coal	1.45
Combustible	1.21
Average composition of gas by volume (per cent)—	
Carbonic acid (CO_2)	12.07
Oxygen (O_2)	0.20
Carbonic oxide (CO)	10.53
Hydrogen (H_2)	7.63
Marsh gas (CH_4)	6.33
Nitrogen (N_2)	63.23

WASHING TESTS OF MISSOURI COAL MADE AT ST. LOUIS COAL-TESTING PLANT.*

MISSOURI NO. 2.

Run-of-mine coal from mine No. 8, Northwestern Coal and Mining Company, Bevier, Mo.

A charge of about 6½ tons of this coal was washed for a coking test, with the following result:

ANALYSES SHOWING EFFECT OF WASHING MISSOURI NO. 2 COAL.

	Car sample.	Washed coal for coking.
Ash	16.86	7.76
Sulphur	5.16	3.24

*Wick, John D., Washing tests: Prof. Paper U. S. Geol. Survey No. 48, pt. 3, 1906, pp. 1471 and 1464.

MISSOURI NO. 3.

This sample consisted of a carload of slack from the Mendota Coal and Mining Company, operating at Mendota, Putnam county, Mo. Like most of the coals from northern Missouri and southern Iowa, this coal contains a large percentage of impurities, and the operators are desirous of improving their product. It was for this reason that the above test was undertaken, as the results of this test will doubtless apply to the entire field in Putnam county, Mo., and Appanoose county, Iowa.

The sample, consisting of 14,000 pounds of slack, was passed through rolls having an aperture of 1¼ inches, and then washed through the modified Stewart jig. After the coal was crushed it was sampled and analyzed, giving the figures shown in the column marked "Raw coal" in the accompanying table. After washing, it was again sampled, with the results given in the second column of the table. The refuse was also sampled and analyzed, with the results shown in the third column.

ANALYSES OF MISSOURI NO. 3 COAL AND REFUSE, SHOWING EFFECT OF WASHING.

	Raw coal.	Washed coal.	Refuse.
Moisture.....per cent	14.37	23.90	23.38
Ash..... do.	28.39	7.59	36.70
Sulphur..... do.	4.30	2.89	3.94
Weight.....pounds	14,000	.....	4,931
Calculated weight of coal..... do.	8,013	6,045	1,968

The refuse weighed 4,931 pounds. It appears from the chemical analysis that the raw coal contained 8,013 pounds of coal, exclusive of moisture and ash, and the refuse 1,968 pounds. The washed coal, therefore, must have been the difference, or 6,045 pounds.

The results given above show great improvement. The slack was extremely dirty, as the analysis shows. Washing reduced the ash from 28.39 per cent in the raw coal to 7.59 per cent in the washed coal. The sulphur was likewise reduced from 4.30 to 2.89 per cent. On the whole, the reduction in the impurities is highly satisfactory, but the amount of coal lost in the operation (1,968 pounds) is too great for economical work. Better results might possibly have been obtained if the tests had been continued, but enough has been done to show that the quality of the slack coal in this field may be greatly improved by washing.

The improvement made in this slack by washing was still further shown by steam tests of the raw and the washed coal.

STEAM TESTS SHOWING EFFECT OF WASHING ON MISSOURI NO. 3 COAL.

Coal tested.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface, per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horse-power, hour.	Dry coal per electrical horse-power, hour.
	Pounds.		*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Raw slack	10,828	149.5	21.85	5.82	4.86	6.00
Washed slack	11,044	189.7	21.72	7.43	3.81	4.70

A washing test was also made of about 6½ tons of this coal for coking purposes. No trial was made of the raw coal in the oven, so it is impossible to make a direct comparison of the coke, but the chemical analyses give some idea of the improvement produced.

ANALYSES SHOWING EFFECT OF WASHING MISSOURI NO. 3 COAL.

	Raw coal.	Washed coal for coking.
Ash.....per cent	28.39	7.24
Sulphur..... do.	4.30	2.74

DETAILS OF LATER WASHING TESTS AT THE ST. LOUIS PLANT.*

	No. 5.	No. 7A.	No. 7B.
Date of test	Feb. 10, 1906	Feb. 17, 1906	Feb. 19, 1906
Jig used	Stewart	Stewart	Stewart
Size of fuel—			
As shipped	Run of mine	No. 1 nut	No. 2 nut
As used	Through 2-in. screen	No. 1 nut	No. 2 nut
Weight of raw fuel (tons)	7.65	12.50	11.75
Amount washed fuel—			
Weight (tons)	6.45	10.73	9.30
Per cent	84	86	79
Amount of refuse—			
Weight (tons)	1.20	1.76	2.45
Per cent	16	14	21
Chemical analysis of fuel (per cent)—			
Raw—			
Moisture	12.92	16.36	16.39
Volatile matter	33.64	29.12	29.01
Fixed carbon	39.82	35.01	34.42
Ash	13.62	19.51	20.18
Sulphur	5.03	3.53	3.12

*Delameter, G. R., Washing tests: Bull. U. S. Geol. Survey No. 336, 1908, pp. 8-17.

DETAILS OF THE LATER WASHING TESTS AT THE ST. LOUIS PLANT—Con.

	N1. 5.	No. 7A.	No. 7B.
Washed—			
Moisture	13.93	17.30	19.70
Ash	9.08	9.45	11.05
Sulphur	3.62	3.04	3.07
Reduction (per cent)—			
Ash	33	52	45
Sulphur	28	14	2
Actually removed—			
Ash	44	58	56
Sulphur	40	15	22

COKING TESTS OF MISSOURI COAL MADE AT ST. LOUIS COAL-TESTING PLANT.†

MISSOURI NO. 2.

Coking Test No. 26.—Run-of-mine coal from mine No. 8 of the Northwestern Coal and Mining Company, Bevier, Mo.

This charge consisted of 12,000 pounds washed coal, which was coked for 87 hours. It yielded 5,040 pounds of long-fingered brittle coke, having large pieces of slate mixed through it. The breeze and ash amounted to 580 pounds. The coke is high in both sulphur and ash.

ANALYSIS OF MISSOURI NO. 2 COAL.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Washed	1304	14.14	35.53	42.57	7.76	3.26	Used in coking test No. 26.

COKING TEST AND COKE PRODUCTION.

Test No.	When charged	When drawn.	Time in oven.	Coal charged (wet)	Large coke.	Medium coke.	Total coke made	Breeze and ash	Per cent of yield.			
									Large	Medium	Total	Breeze and ash
			Hrs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*				
26 (washed)	Oct.25, 5. p. m.	Oct.29, 8 a. m.	87	12,000	1,721	3,319	5,040	580	14.3	27.6	42.0	4.8

†Stammler, Fred. W., Coking tests: Prof. Paper U. S. Geol. Survey No. 48, pt. 3, 1906, pp. 1351-1353.

PHYSICAL AND CHEMICAL PROPERTIES OF COKE PRODUCED.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).	Height of furnace charge supported without crushing.	Hardness.	Specific gravity.	Chemical laboratory No.	Chemical analysis.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.
							Lbs.	*Feet.*				*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
26	11.75	20.26	44.65	76.98	48	52	207	83	2.3	1.86	1,325	3.45	1.80	80.27	14.48	2.79	0.02

This charge produced long-fingered coke, very brittle, and though the coal was washed the coke contained large pieces of slate mixed with charred coal, indicating that the washing was faulty. The cell structure was high. The coke might have been harder, though its burden-bearing qualities were excellent. The ash and sulphur were both high and they make this coke undesirable for blast-furnace use, though it would do very well for lead or zinc smelting works.

MISSOURI NO. 3.

Coking Test No. 56.—Slack coal from Mendota Coal and Mining Company, Mendota, Mo.

This slack (coal) showed no tendency whatsoever to coke, although it was washed and burned for 42 hours.

ANALYSIS OF MISSOURI NO. 3 COAL.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Washed	1528	24.15	33.10	35.51	7.24	2.74	Used in coking test No. 56.

COKING TEST.

Test number.	When charged.	When drawn.	Time in oven.	Coal charged (wet).	Remarks.
			Hours.	*Pounds.*	
56 (washed)	Dec. 6, 4 p. m.	Dec. 8, 9 a. m.	41	9,000	No coke.

This coal would not coke. The product was some charred coal, mixed with ashes.

MISSOURI NO. 4.

Coking Test No. 54.—Run-of-mine coal from Morgan county Coal Company, near Barnett, Mo.

The charge was 11,000 pounds of unwashed coal, and yielded 4,905 pounds of coke and 128 pounds of breeze and ash.

ANALYSIS OF MISSOURI NO. 4 COAL.

Character of coal.	Chemical laboratory number.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Remarks.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Unwashed.....	1513	12.04	41.35	41.34	5.27	5.14	Used in coking test No. 54.

COKING TEST AND COKE PRODUCTION.

Test number.	When charged	When drawn.	Time in oven.	Coal charged (dry).....	Large coke...	Medium coke.	Total coke made.....	Breeze and ash	Per cent of yield.			
									Large...	Medium.	Total...	Breeze and ash.
			Hrs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*				
54 (unwashed)..	Dec.3, 3 p.m.	Dec.6, 8 a.m.	65	11,000	3,838	1,067	4,905	128	34.9	9.7	44.6	1.17

PHYSICAL AND CHEMICAL PROPERTIES OF COKE PRODUCED.

Test number.	Grams in 1 cubic inch.		Pounds in 1 cubic foot.		Percentage by volume.		Compressive strength per cubic inch (one-fourth ultimate strength).....	Height of furnace charge supported without crushing.....	Hardness.....	Specific gravity.....	Chemical laboratory No..	Chemical analysis.					
	Dry.....	Wet.....	Dry.....	Wet.....	Coke.....	Cells.....						Moisture.....	Volatile matter..	Fixed carbon.....	Ash.....	Sulphur.....	Phosphorus.....
							Lbs.	*Feet.*				*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
54	12.5	17.55	47.50	66.69	63	37	87	35	2.6	1.83	1,519	2.51	1.11	85.57	10.81	4.60	0.018

The coke yielded by this coal is of fair grade, of a gray color, and of a good metallic ring, but it has exceedingly low cell structure and low burden-bearing qualities. The proportions of ash and phosphorus are normal but the sulphur is unusually high, making this coke fit only for lead or zinc works. Washing might improve it some but cannot reduce the sulphur sufficiently to produce a high-grade metallurgical fuel.

MISSOURI NO. 5 (WASHED).*

Coal used, Bevier bed at Higbee.
Duration of test (hours), 33.
Size of coal: as shipped, run-of-mine; as used, finely crushed.
Physical properties of coke—
Specific gravity: real 1.88, apparent 0.84.
Pounds per cubic foot: dry 51.82, as received (wet) 86.11.
Percentage by volume: coke 45.00, cells 55.00.
Six-foot drop test: Percentage over 2-inch mesh (four tests), 92.50, 85.50, 81.50, 78.00.

	a.	*b.*
Condition	1	2
Weight of coal (pounds)	10,000	8,632
Production (pounds)—		
Coke	4,903	4,848
Breeze	299	296
Production (per cent)—		
Coke	49.03	56.16
Breeze	2.99	3.43
Total	52.02	59.59
Chemical analysis of coal—		
Moisture	13.68	.....
Volatile matter	34.82	40.34
Fixed carbon	42.26	48.96
Ash	9.24	10.70
Sulphur	3.60	4.17
Chemical analysis of coke—		
Moisture	1.12	.....
Volatile matter	0.73	0.74
Fixed carbon	82.64	83.58
Ash	15.51	15.68
Sulphur	3.40	3.44
Phosphorus	None	None

Description: Light gray and silvery color; cell structure good; breakage somewhat cross-fractured, but pieces of good, large size; good weight coke; ash and sulphur high.

CUPOLA TEST OF COKE MADE FROM MISSOURI NO. 5 COAL (WASHED).†

CHARGE.

Coke.		Fluidity strip full.	Materials.	Divisions of charge.					Total.
Specific gravity.	Ratio iron to coke.			1.	2.	3.	4.	5.	
		Per ct.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
			Coke	190	60	60	60	60	430
1.88	7	92.36	Pig iron	570	420	420	420	420	2,250
			Scrap	190	140	140	140	140	750

*Belden, A. W., Coking tests: Bull. U. S. Geol. Survey No. 336, 1908, pp. 18-47.

†Moldenke, Richard, Cupola tests on coke: Bull. U. S. Geol. Survey No. 332, 1908, pp. 168-169.

RECORD OF MELT.

Blast pressure.		Iron.	Weight of iron.			Melting.				Recovered.	
On at—	Maximum.	running in—	Poured.	Additional melted.	Total.	Time.	Rate per hour.	Ratio iron to coke.	Loss.	Iron.	Coke.
	Oz.	*Min.*	*Lbs.*	*Lbs.*	*Lbs.*	*Min.*	*Lbs.*		*Per ct.*	*Lbs.*	*Lbs.*
3.16 p. m.	7	5	1,964	423	2,387	34	4,212	6.25	9.06	341	48

LADLE RECORD.

Ladle number.	Pounds.	Time (p. m.).	Ladle number.	Pounds.	Time (p. m.).
1	67	3.29	16	58	3.46
2	85	3.33	17	70	3.46½
3	81	3.34	18	94	3.47
4	54	3.37	19	59	3.48
5	53	3.37½	20	45	3.48½
6	92	3.38	21	90	3.49
7	62	3.39	22	70	3.50
8	66	3.40	23	56	3.51
9	69	3.41	24	90	3.52
10	51	3.42	25	45	3.52½
11	63	3.43	26	69	3.53
12	60	3.43½	27	92	3.54
13	79	3.44	28	52	3.54½
14	91	3.45	29	39	3.55
15	62	3.45½			

Remarks.—Temperature of iron, medium.

BRIQUETTING TESTS OF MISSOURI COAL MADE AT ST. LOUIS COAL-TESTING PLANT.

MISSOURI NO. 1.*

At the time this coal was tested only the hard pitch was available. Two and a half tons of this coal that had been previously washed were briquetted with 11.5 per cent of pitch A. The briquettes were black and were hard enough to stand rough handling, but as the pitch set too quickly they were insufficiently pressed and were therefore granular and porous. This coal, however, will briquet very readily, and with the softer pitches, such as pitch D and pitch H, will make briquet with about 6 to 7 per cent of binder.

The briquettes were tested under the boiler with the results shown in the table below, which also gives the results of tests of the original coal.

*Pratt, J. H., Briquetting tests: Prof. Paper U. S. Geol. Survey No. 48, pt. 3, 1906, p. 1445.

RESULTS OF STEAMING TEST OF MISSOURI NO. 1 COAL AND BRIQUETTES.

Fuel.	Chemical composition.					Duration of trial	Total coal consumed	Horse-power developed by boiler	Dry coal burned per square foot of grate surface, per hour	Equivalent evaporation from and at 212° F. per pound of dry coal	Dry coal per indicated horse-power, hour	Dry coal per electrical horse-power, hour
	Fixed carbon	Volatile matter	Moisture	Ash	Sulphur (separately determined)							
	%	%	%	%	%	*Hrs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Briquettes.	41.85	37.60	6.38	14.17	4.56	5.10	4,500	191.2	20.37	7.99	3.54	4.37
Coal, mine run	40.64	34.88	7.28	17.20	4.37	10.00	9,737	207.4	22.30	7.92	3.57	4.41

MISSOURI NO. 10 (SLACK).*

Size as used: Over ¼ inch, 3.0 per cent; $^1/_{10}$ inch to ¼ inch, 10.2 per cent; $^1/_{20}$ inch to $^1/_{10}$ inch, 17.2 per cent; $^1/_{40}$ inch to $^1/_{20}$ inch, 21.2 per cent; through $^1/_{40}$ inch, 48.4 per cent. Equally satisfactory briquettes were made with 7 and 8 per cent binder on English machine and 8 and 9 per cent on Renfrow machine. The large amount of clay present made briquettes soft when warm, but very hard when cold, when fuel was worked with high moisture content. Tests 178 and 179 were made on coal from the same car and under greater pressure than in other tests. These briquettes were harder, more cohesive, and made less slack in handling. All the briquettes had rough surfaces and broke with ragged fracture. They were of a dull gray color, owing to the amount of clay present.

	Test 178.	Test 179.	Test 241.	Test 245.	Test 246.
Details of manufacture—					
Machine used	Renf.	Eng.	Renf.	Renf.	Eng.
Temperature of briquettes ... °F.	176	185	149	149	149
Binder—					
Kind	w. g. p.	w. g. p.	w. g. p.	w. g. p.	w. g. p.
Laboratory number	4543	4543	4806	4879	4879
Amount ... per cent	8	7	9	8.5	8
Weight of—					
Fuel briquetted ... pounds	42,000	5,000	66,000	176,000	10,000
Briquets, average ... do.	0.476	4.43	0.481	0.523	3.91
Heat value per pound—					
Fuel as received ... B. t. u.	9,099	9,099	9,081	9,081	9,081
Fuel as fired ... do.	.....	11,128	10,082	10,262	10,580
Binder ... do.	16,969	16,969	16,864	16,805	16,805
Drop test (1-inch screen)—					
Held ... per cent	80.5	63.3	73.0	58.0	64.4
Passed ... do.	19.5	36.7	27.0	42.0	35.6

*Pratt, J. H., Briquetting tests: Bull. U. S. Geol. Survey No. 332, 1908, pp. 173-174.

	Test 178.	Test 179.	Test 241.	Test 245.	Test 246.
Tumbler test (1-inch screen)—					
Held ..... do.	94.0	90.9	91.5	87.0	64.2
Passed (fines) ..... do.	6.0	9.1	8.5	13.0	35.8
Fines through 10-mesh sieve, do	99.0	80.9	95.0	90.3	50.0
Water absorption—					
In 19 days ..... per cent	14.5	7.6	.....	.....	.....
In 13 days ..... do	.....	.....	9.0	13.1	6.6
Average for first—					
5 days ..... do.	1.94	.....	1.54	2.24	1.12
2 days ..... do.	.....	2.2	.....	.....	.....
Specific gravity (apparent)	1.172	1.238	1.207	1.108	1.248

Extraction analyses.

	Pitches.			Fuel.		Briquettes.				
						Test 178.	Test 179.	Test 241.	Test 245.	Test 246.
Laboratory number	4543	4806	4879	4257	4803	4515	4362	4898	4876	4908
Air-drying loss, per cent.	.....	.....	.....	13.70	10.30	9.40	1.30	.....	.....	.....
Extracted by CS_2—										
Air dried, per cent.	.....	.....	.....	0.54	0.59	8.21	7.64	.....	.....	.....
As received, per cent	99.66	96.90	94.50	0.47	0.47	7.44	7.54	8.44	8.68	7.63
Pitch in briquets as received, per cent	.....	.....	.....	.....	.....	7.03	7.13	8.27	8.73	7.62

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