Mississippi State Geological Survey

ALBERT F. CRIDER, DIRECTOR.

BULLETIN No. 3

THE

LIGNITE OF MISSISSIPPI

By CALVIN S. BROWN

BRANDON-NASHVILLE

Mississippi
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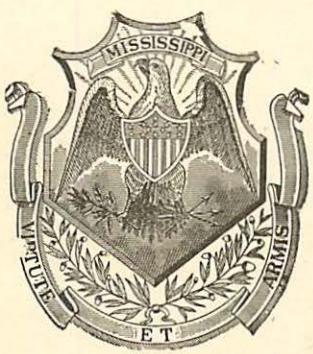

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LETTER OF TRANSMITTAL.

JACKSON, MISSISSIPPI, July 20, 1907.

To His Excellency, Governor James K. Vardaman, Chairman, and Members of the Geological Commission:

GENTLEMEN—I submit herewith a report on the lignite of Mississippi by Dr. Calvin S. Brown, and respectfully recommend its publication.

Very respectfully,

ALBERT F. CRIDER,
Director.

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LIGNITE IN GENERAL.

DEFINITIONS.

Lignite may be defined as immature coal or vegetable matter in the process of forming coal; it is a fuel intermediate in heating capacity between wood and coal. It belongs to a much more recent geological age than stone coal. Lignite is often mistaken for stone coal, especially when wet, but may be readily distinguished from it, even by the untrained observer, by noting the following differences. In general coal is black, whereas lignite is brown. When taken from water or when very moist, as many of the samples of Mississippi lignites are when first found, it appears rather black, but upon cutting with a knife exposes a brown surface; coal remains black when cut. When wet lignite is cut with a sharp knife it leaves a smooth surface or tends to do so, whereas coal when cut leaves a rough surface owing to its hardness and brittleness and tendency to fracture before the knife. Lignite upon drying cuts more like coal but is seldom as hard and compact. When a piece of dry lignite is put into water it gives out for some moments a characteristic crackling sound or click; this is not true of coal. The fracture of coal is bright and glossy, that of lignite usually dull. Lignite crumbles within a short time upon being exposed to the weather, whereas coal resists the influence of weathering much longer.

Reports of the discovery of coal in Mississippi are of frequent occurrence in the newspapers, and in most cases have their origin in the discovery of lignite. If the finder would take the trouble in the future to compare his material carefully with a piece of coal before spreading reports, many errors would be avoided. If after the first comparison there is still doubt in his mind, let him place the coal and the lignite side by side in the sun for a few days and the difference will become apparent. No true coal has ever been found in Mississippi, and judging from geological conditions there is little probability that it will ever be found.

There are within the lignite belts of Mississippi much lignitic clay and other lignitic earth. These contain more or less carbonaceous matter, but should not be confused with lignite. It is difficult of course to draw a hard and fast line between lignitic earth and earthy

lignite; still none of these earthy materials should be called lignite which have not enough carbonaceous matter to enable them to burn readily under average conditions. Lignite is sometimes called brown coal.

PHYSICAL PROPERTIES OF LIGNITE.

In color lignite is brown or in the best qualities black, shading at times toward yellow and red; the streak and powder are usually brown. Its luster varies from dull to brilliant according to the composition and the impurities in it. Its texture also varies within wide limits; in the purer, better qualities it is hard, firm, and compact; in others it is soft; in others brittle. Some specimens tend to crumble upon exposure much more readily than others. In some specimens the woody texture is obliterated; in others it is quite apparent; in some instances pieces of wood are found but slightly altered; in others pieces of logs completely silicified occur; and occasionally the same logs will be partly lignitized and partly petrified. Some samples of lignite show leaves, twigs, pine needles, and other small parts of plants. Lignite burns with both flame and smoke and gives off a disagreeable odor in the process. It does not fuse or cake upon burning, hence is not ordinarily available for making coke. Owing to the amount of earthy impurities the percentage of ash left after burning is frequently high. The specific gravity of lignite is usually less than that of bituminous coal and anthracite; sometimes, however, it is as high as that of bituminous coal, owing to earthy impurities contained. Roughly speaking we may put the specific gravity of lignite at 1.2 to 1.5. The fracture of lignite in some of the harder varieties is conchoidal, in other varieties it is irregular; in some the lignite tends to block in vertical lines, and it often has planes of cleavage parallel to the stratification; in the woody types there is cleavage parallel to the grain of the wood. Most lignites have the capacity of absorbing a large amount of moisture and when first mined the percentage may be as high as thirty-five or even fifty. When exposed to the air this moisture evaporates in part, as a result of which the lignite tends to disintegrate.

CHEMICAL PROPERTIES OF LIGNITE.

Coal and lignite are composed of carbon, hydrogen, oxygen, and nitrogen, the principal element being carbon. In addition to these

elements there are usually present as impurities sulphur and earthy matter. This earthy matter remains behind upon burning in the form of ashes. The following ultimate analyses of air-dried samples made by the St. Louis Coal-testing Plant of the United States Geological Survey in 1904 give an idea of the relative proportion of these constituents in bituminous coal and lignites:

TABLE 1.

ULTIMATE ANALYSES OF COAL AND LIGNITE.

(By U. S. Geol. Survey.)

No.	Kind	Locality	C	H	O	N	S	Ash	Total	B.T.U.
1	Bituminous coal..	Bonanza, Ark....	80.03	4.13	3.20	1.40	1.90	9.34	100	13,961
2	Bituminous coal..	Kentucky.....	78.31	5.36	8.80	1.85	1.24	4.44	100	14,319
3	Bituminous coal..	Carbon Hill, Ala..	69.24	4.79	10.87	1.55	1.02	12.53	100	12,449
4	Black lignite.....	Wyoming.....	58.41	6.09	28.99	1.09	.63	4.79	100	10,355
5	Brown lignite....	Texas.....	57.31	5.28	25.83	1.06	.71	9.81	100	9,904
6	Brown lignite....	North Dakota....	55.16	5.61	30.98	.91	.63	6.71	100	9,491

It will be observed from the preceding table that in a general way the heating or calorific value (B. T. U., British thermal units) is proportional to the amount of carbon contained in the coal or lignite. It will be observed however that the Kentucky coal has a higher heating capacity than the Arkansas coal, although the latter has a slightly higher percentage of carbon; this is due to the large amount of ash or inert matter which the Arkansas coal contains. The oxygen in coal and lignite adds nothing to its value, as might be supposed at first thought, for the air furnishes all the oxygen needed for combustion; furthermore the part of the oxygen contained in the water (H_2O) is a positive disadvantage to the coal or lignite, as the water must absorb some of the heat in the process of vaporization.

Instead, however, of the method of ultimate analysis shown above, proximate analysis is usually employed for coal and lignite, as it shows the amount of fixed carbon and volatile matter (combustible constituents) and of water and ash (non-combustible constituents). It should be remembered, however, that not all volatile matter is combustible, especially in lignite. The following table of proximate analyses made on an air-dried basis will show the position of lignite as compared with other fuels:

TABLE 2.

COMPARATIVE ANALYSES OF COAL AND LIGNITE.

(From various sources.)

No.	Kind	Locality	Fixed Carbon	Volatile Matter	Water	Ash	Total	Sulphur	B. T. U.	Authority or analyst	Remarks
1	Anthracite...	Mammoth E. M., Pennsylvania	86.38	3.08	4.12	5.92	99.50†	.50	.....	A. S. McCreath..	Average of 5 samples.
2	Anthracite...	Buck Mt., Pennsylvania.....	82.66	3.95	3.04	9.88	99.53†	.46	.....	A. S. McCreath..	Average of 2 samples.
3	Bituminous...	Straight Creek, Kentucky.....	57.08	36.56	1.92	4.44	100	1.24	14,319	U. S. Geol. Sur...	Same as No. 2, Table 1.
4	Bituminous...	Murphreysboro, Illinois.....	56.03	34.62	4.96	4.39	100	.62	13,285	S. W. Parr.....	Ill. G. S., Bull. 3.
5	Bituminous...	Carbon Hill, Alabama.....	51.74	33.15	2.58	12.53	100	1.02	12,449	U. S. Geol. Sur...	Same as No. 3, Table 1.
6	Bituminous...	Danville, Illinois.....	48.14	35.06	3.44	13.36	100	3.38	11,909	S. W. Parr.....	Ill. G. S., Bull. 3.
7	Lignite.....	Choctaw Co., Mississippi.....	42.47	34.61	11.61	11.31	100	2.66	10,071	W. F. Hand.....	E. W. Oswalt's land.
8	Lignite.....	Alba Mine, Texas.....	41.71	42.01	6.15	9.35	99.22†	.78	.....	E. T. Dumble....	Lignite of Texas.
9	Lignite.....	Texas.....	40.11	39.42	10.66	9.81	100	.71	9,904	U. S. Geol. Sur...	Same as No. 5, Table 1.
10	Lignite.....	Yalobusha Co., Mississippi.....	39.94	40.85	12.62	6.59	100	2.05	9,706	W. F. Hand.....	J. J. Milton's land.
11	Lignite.....	North Dakota.....	39.49	37.10	16.70	6.71	100	.63	9,491	U. S. Geol. Sur...	Same as No. 6, Table 1.

†Sulphur to be added.

ORIGIN OF LIGNITE.

Lignite, like coal, is of vegetable origin. The process of formation of these fuels seems to be briefly as follows: vegetable matter accumulated to considerable thickness; this was then covered by water or earth, and ultimately by earth alone; chemical changes gradually took place by which oxygen was lost and the relative proportion of carbon increased; along with this, due to these chemical changes, to pressure, and perhaps to other causes, took place a considerable decrease in volume. The process of transformation was very slow and required vast geological ages for its completion. The various stages of this change may be seen in peat, lignite, bituminous coal, and anthracite, the transformation being least in peat and greatest in anthracite. In the lignites the vegetable structure is often still plainly visible, pine needles, small parts of plants, woody branches and trunks being frequently found. The woody matter occurs in all stages of transformation from simple wood to completely lignitized matter. Side by side in the same bed of lignite may occur a trunk of but slightly altered wood and a trunk of petrified (silicified) wood containing enough carbonaceous matter to make it brown or black. Indeed the same trunk is sometimes partly lignitized and partly silicified. The clay associated with lignite often contains well defined leaf and plant impressions.

GEOLOGICAL AGE OF LIGNITE.

It has already been said that lignite is of a later geological age than true coal. The true coals, that is anthracite and bituminous coal, belong principally to the Carboniferous Age (Paleozoic Era). Coal is also found in the Triassic and the Jurassic periods (Mesozoic Era). The black lignites or subbituminous coals of Colorado, New Mexico and Wyoming, and the brown lignites of North Dakota are found in the Cretaceous (late Mesozoic). The brown lignites of Texas belong to the Tertiary (Cenozoic Era). By far the greater part of the brown lignites of Mississippi, Alabama and Tennessee belong also to the Tertiary; some deposits, however, are found in the Cretaceous.

LIGNITE OF MISSISSIPPI.

FIELD WORK.

The field work for this report was begun on the 15th of June and finished on the 5th of September, 1906. During this time I visited all the localities in the State in which lignite had been reported to exist and brought to light many outcrops of which no written record existed. I examined in all about two hundred outcrops of lignite and took samples of fifty of the most promising of these. While I tried to visit every county and locality in which lignite was thought to exist, I found it impossible during the one summer at my command to inspect every individual outcrop of lignite reported to me in some of the districts where such outcrops are of frequent occurrence. In such cases I tried always to choose the best or most representative deposits for examination.

Very few of these deposits have ever been worked or opened with a view to commercial use. Many occur in or near the bottom of creeks and ravines and others in private springs. Hence in many instances it was found impossible to make as complete an examination as was desirable without the expenditure of more time and money than were at my disposal. It resulted in many cases that instead of taking samples throughout the vertical extent of the beds I was forced to take them from the top or the first ten or twelve inches of the bed, or from the most accessible point. Nor was I always able to measure the thickness of the strata, for the frequent presence of iron pyrite in the lignite made it impossible to use the extension auger in many instances.

THE LIGNITE AREA OF MISSISSIPPI.

The lignite area of Mississippi is that part of the State lying north of a line through Meridian, Jackson and Vicksburg, and east of the "Bluff." A few outcrops of lignite are found south of this limit, but they belong to later geological formations and are relatively infrequent and unimportant. The Bluff here mentioned is part of that line of bluff extending from Kentucky to Louisiana east of the Mississippi

River and parallel with it. Between Memphis and Vicksburg the river is deflected from the Bluff, leaving between the river and the bluff the low level country known as the "Delta." No lignite is found west of this line of Bluff in Mississippi.

The lignite area on the map published by the United States Geological Survey in the first volume of the Report on the Coal-testing Plant of St. Louis (P.P. No. 48) should be greatly extended—on the west to the line of the bluff, and on the north far into Tennessee.

Under the heads of Geological Formations, Distribution in Mississippi, and List of Localities, more detailed information will be given on the subject of the lignite area in Mississippi.

TOPOGRAPHY OF THE LIGNITE AREA.

The north-central area of the State, in which the lignite occurs, is characterized by a rough, hilly surface frequently cut by deep gullies. Along the larger streams the process of erosion has gone on until the valleys are several miles wide. A large part of the material on the surface or near the surface being sand, erosion is still going on rapidly in the hills and uplands. Much of the sand and earth thus washed down is redeposited along the streams and valleys. Consequently the surface of the country is changing constantly and rapidly. The elevation of the territory is nowhere great. The following railroad elevations, taken from Gannett's "Dictionary of Altitudes," will indicate the general range:

Railroad Elevations.

	Feet.
1. Lexington	209
2. West	290
3. Louisville	536
4. Ackerman	522
5. Coffeeville	241
6. Oxford	458
7. Holly Springs	602
8. Olive Branch	387
9. Hernando	391
10. Sardis	384

Holly Springs is the only railroad town in the State with an elevation above 600 feet. A point on the Illinois Central Railroad about 1½ miles south of Holly Springs (between mile posts 544 and 545) has

an elevation of 619 feet; this is the highest railroad point in the State. It is therefore doubtful if there are many hill-tops which exceed 700 feet. On the other hand the Delta lying west of the lignitic area and through which much of the latter is drained has an average elevation of about 150 feet; so that 200 feet may be taken as approximately the lower altitude limit of the lignitic area. Thus it is seen that the elevation of this territory ranges between 200 and 650 or 700 feet, a range which is not very great, and yet which is sufficient to give considerable inequality and diversity to the landscape. In fact, the character of the two upper geological strata are such that the resulting topography may in many places be called rugged.

THE GEOLOGICAL FORMATIONS OF MISSISSIPPI.

The nomenclature of the geological formations of Mississippi, as adopted by the present geological survey, is as follows:

TABLE 3.

THE GEOLOGICAL FORMATIONS OF MISSISSIPPI.

Cenozoic	Quarternary			River alluvium.
				Yellow loam.
				Loess.
				Port Hudson.
				Lafayette.
	Tertiary	Miocene (?)		Grand Gulf.
		Miocene		Pascagoula.
		Oligocene		Vicksburg.
		Eocene		Jackson.
			Claiborne	Lisbon and undifferentiated Claiborne.
				Tallahatta buhrstone.
				Wilcox.
			Midway	Porter's Creek.
				Clayton.
Mesozoic	Cretaceous			Ripley.
				Selma Chalk.
				Eutaw.
				Tuscaloosa.
Paleozoic	Carboniferous			Chester.
				St. Louis.
				Tullahoma.
	Devonian			New Scotland.

It will be seen from this table that the Archæan rocks are not represented in Mississippi, and by consulting the accompanying map it will appear that only a very small portion of the State belongs to

the Paleozoic age, the Devonian and Carboniferous being found only in a limited territory in the northeastern corner of the State. West of this is a broader strip extending north and south which is Mesozoic in time, the Cretaceous. About four-fifths of the State, however, belong to Cenozoic time, the Tertiary and Quarternary eras.

The great lignite-bearing series is that named by Dr. Hilgard the "Northern Lignitic," now known in the Government Survey and the State Survey of Mississippi as the Wilcox. This formation occurs in the Eocene period of the Tertiary.

Before describing in detail, however, the Wilcox formation, and other less important lignite-bearing series, it is necessary to say a few words about the general geological conditions in that part of Mississippi under discussion in this paper.

In the northern half of the State the strata dip westward or southwestward. On top of the older formations have been deposited in Quarternary times two much more recent formations, the Lafayette and the Columbia (or yellow loam). The following theoretical diagrams will help to make this matter clear:

Section of the Strata Exposed in the Lignite Area of Mississippi.

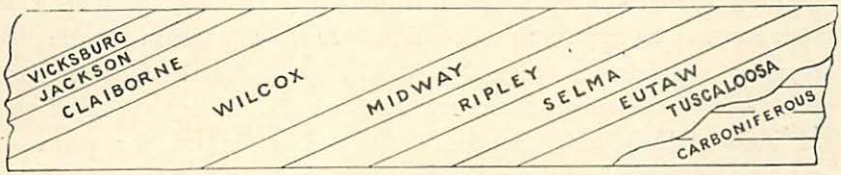

Fig. 1.

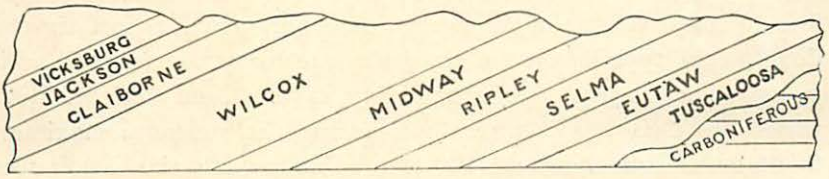

Fig. 2.

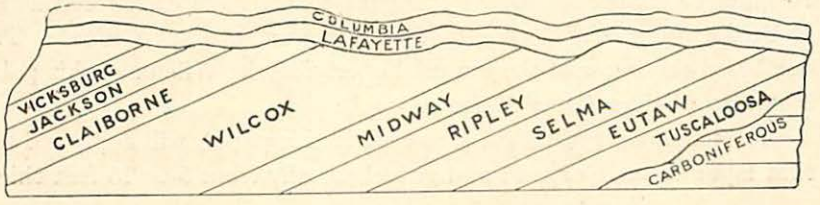

Fig. 3.

Figure 1 represents the older formations with an exaggerated dip toward the west and a surface unaffected by erosion. Figure 2 represents the same after the rains and streams have cut the surface into hills and valleys. Figure 3 represents the same at a still later period after the layer of sand and gravel known as Lafayette has been deposited unconformably upon the older formations following the surface of the hills and valleys and after a still later sheet of yellow or brown loam known as Columbia has been deposited upon the Lafayette.

The name Lafayette, from Lafayette County, Mississippi, was agreed upon in 1891 for the older name of Orange Sand used by Dr. Safford and Dr. Hilgard. But the name Orange Sand, and its equivalents, Lagrange and Lafayette, as used by Safford, Hilgard, McGee and Mabry, seems to include two entirely distinct formations, an upper thin bed of unstratified sand belonging to the Quaternary and a lower thicker formation consisting of stratified sand and other material belonging to the Tertiary. Mabry, in his paper on the Brown or Yellow Loam of North Mississippi, had, however, begun to "doubt the unity of the Lafayette." The present writer will use the term Lafayette to apply only to the upper generally unstratified member, considering the lower stratified sands and clays as Wilcox or other formations according to location. This will account for the discrepancy in thickness assigned to the Lafayette by the older writers and those of the present survey; Hilgard and Mabry speak of the thickness of the Orange Sand or Lafayette at Oxford, for example, as about 200 feet; I put it in the present paper at 2 to 8 feet, considering the stratified material below this as Wilcox. I have recently found strong evidence of the correctness of this view here in Lafayette County, the type locality of the Lafayette formation (as well as in many other places). Professor Mabry says: "Near Oxford, Miss., where the Lafayette is typically developed, it attains a maximum thickness of something like 200 feet. But towards the east it soon thins out, exposures of the Lignitic being quite common within 8 or 10 miles of Oxford." Now it happens that I have discovered a bed of lignite lying only 1 mile east of the courthouse at Oxford. The combined thickness of the material overlying the Wilcox at this point is not more than 20 or 25 feet.

The name Lafayette, then, as used in this paper, will apply only to that layer of sand, or sand and gravel, usually from 5 to 15 feet thick,

rarely exceeding 40 or 50 feet thick, which in Quaternary times has been deposited unconformably upon the older formations following the hills and slopes according to the conformation reached about the close of the Tertiary period. This sheet of sand, accompanied in some places by gravel, covers a large part of the State.

The Columbia formation is a deposit of from 3 to 15 or 20 feet of brown or yellow loam overlying in many places the sand and pebbles of the Lafayette and forming the topmost and most recent deposit in upland regions. It is usually unstratified, non-calcareous, and non-fossiliferous.

Here should be mentioned also, because of its association with the lignitic area, the Bluff loess. This is a fine gray or buff-colored calcareous deposit occurring above the Lafayette and containing calcareous concretions and snail shells and other land and fresh-water fossils. It is a narrow belt from 6 to 15 or 20 miles wide extending along the Bluff the whole length of the State, and in its typical form is easily recognized by the characteristics just given and its tendency to stand in vertical walls along roads and gullies. Whether the Bluff loess is a separate and distinct formation as held by Hilgard, or merely a peculiar manifestation of the Columbia (yellow loam) as maintained by some later writers, will not be discussed in this report. For convenience, the name Columbia will be limited in this paper to the brown or yellow loam and the name Loess or Bluff Loess used for the narrow belt or calcareous snail-bearing silt along the Bluff.

THE WILCOX.

The Wilcox is the great lignite-bearing formation in Mississippi. It belongs to the Eocene period of the Tertiary era. This formation was called by Hilgard the Northern Lignitic, and was included by Safford of Tennessee in his LaGrange or Orange Sand group and his Bluff Lignite. The name Lagrange is continued by L. C. Glenn in his recent paper on the "Underground Waters of Tennessee and Kentucky West of Tennessee River."*

The Wilcox or Lagrange is the broadest in extent and the thickest in depth of all the formations within the territory under discussion in this report, excepting always, of course, so far as extent is concerned the two surface formations, the Columbia and the Lafayette. Suffic-

*U. S. Geol. Survey, W. S. and I. Paper No. 164, 1906.

ient data for the determination of the exact thickness do not as yet exist, but it is certain that it is at least several hundred feet thick, not improbably reaching at places the depth of 600 to 1,000 feet.

The materials of this formation consist principally of stratified clays, sands and lignite or lignitic earth. The clays are usually white, whitish, cream, pink, chocolate, or light blue in color, and at a distance often give the appearance of chalk or sand banks. Frequently the clays are stained brown or black with lignitic or carbonaceous matter. Many of these clays are quite pure, others are very sandy in nature. Often they contain well defined Tertiary leaf impressions. In large masses the fracture is frequently conchoidal. The sands are usually stratified and varied in color, red, yellow and orange being the prevailing types. The lignite will be mentioned at greater length under its proper head.

The character of the better Wilcox clays may be judged from the following analyses made by Dr. W. F. Hand, and recorded in Logan's "Clays of Mississippi," 1905, and Crider's "Geology and Mineral Resources of Mississippi," 1906.

TABLE 4.

ANALYSES OF WILCOX CLAYS.

(By Dr. W. F. Hand.)

Constituents	*No.* 1	*No.* 2	*No.* 3
Silica (SiO_2)	67.70	57.79	59.82
Alumina (Al_2O_3)	19.69	26.03	27.19
Ferric oxide (Fe_2O_3)	3.04	2.98	1.26
Lime (CaO)	1.06	.44	.49
Magnesia (MgO)	.58	.10	.37
Sulphur trioxide (SO_3)	.19	.24	.31
Moisture (H_2O)	.94	1.14	1.47
Loss on ignition	6.64	9.11	9.24
Total	99.84	97.83	100.15

No. 1 is the Holly Springs Stoneware Company's clay; No. 2 is from Oxford near the negro schoolhouse; No. 3 is the Cumberland Stoneware clay of Webster County.

Typical exposures of the Wilcox (or Lagrange) may be seen at Holly Springs, Oxford, Pittsboro, Bellefontaine, Chester, Louisville, Dekalb and Lockhart.

Like the other formations within the area discussed in this report, the Wilcox is generally overlain by the Lafayette and the Columbia. The following sections give an idea of the surface appearance within the Wilcox area, it being understood that in no case is the whole of the Wilcox exposed.

Section at Oxford near the Railroad Bridge.

	Feet
Columbia, loam	8–12
Lafayette, unstratified orange sand	2–5
Wilcox, strat. white and cream sand and clay	28

A short distance south of the bridge the Columbia rests almost directly upon the Wilcox. At other places in Oxford the Lafayette is better developed than at the railroad bridge.

Section from Hill Just West of Grenada. (Crider, p. 28.)

		Feet
Yellow loam and Lafayette (capping hill)		x
Wilcox	Impure laminated gray clay	50
	Green sands with thin layers of clay	50
	Darker colored laminated clays	50

Section in I. C. R. R. Cut 1½ Miles East of Ackerman.
(Taken on north side at deepest part.)

		Feet
Columbia		9
Lafayette sand		16
Wilcox	Stratified clay and laminated shale	18
	Lignitic shale and clay	⅓
	Stratified clay, etc	10

OTHER LIGNITE-BEARING FORMATIONS.

Besides the Wilcox formation other geological formations in Mississippi contain lignite to some extent. Among the older formations the Tuscaloosa in the northeastern part of the State contains a number of beds, for instance those in Itawamba County. Among the formations more recent than the Wilcox (or Lagrange) the Claiborne and the Grand Gulf are known to contain carbonaceous deposits, and such deposits are at least associated with the Jackson and Vicksburg formations if not actually contained in them. The lignite beds of Holmes County, now assigned to the Claiborne, are among the best in the State; here the beds are numerous and attain a thickness as great as any in Mississippi.

THE GEOLOGICAL MAP.

A geological map accompanies this report. The Wilcox, the great lignite-bearing formation, is shown by the broad area with light brown hachures. The Claiborne formations, the Lisbon and the Tallahatta buhrstone, are shown respectively by the area with darker brown hachures and that with brown dots. The Tuscaloosa in the northeastern corner of the State, also a lignite-bearing formation, is represented by the field with green dots. The location of lignite beds is shown on this map by blue crosses. No attempt has been made to indicate the extent of the individual beds.

MODE OF OCCURRENCE OF LIGNITE.

As there are generally two surface formations, the Columbia and the Lafayette, overlying the lignite-bearing formation, it rarely happens that lignite appears at the surface on level ground. This can occur only where the two upper formations have been eroded and the lignite occupies the topmost member of the Wilcox or other lignite-bearing formation. More generally lignite is exposed in gullies or ravines and in the beds of streams. It is, therefore, to be sought at the foot of hills or near their bases and in cuts and ravines rather than on the hill-tops. Springs often form a good index to its outcrop, for both lignite and the clays associated with it are impervious to water; hence the surface waters which find their way readily through the Lafayette sand are deflected when they strike the lignite or the associated clay and flow along these strata till they find an outlet at some lower level. Lignite is frequently struck in digging or boring wells.

The materials most closely associated with lignite are usually the various types of sands and clays. Sands are generally found at no great distance above the lignite, for even if there is present no stratified sand of the same age as the lignite, it will not be very far up to the unstratified Lafayette sand. Immediately above the lignite, however, is frequently found a few feet of clay. No stone or slate roofing of consequence is found over the lignite beds of Mississippi. It sometimes happens, however, that the last inch or two of a sand layer resting directly upon a deposit of lignite is converted into ferruginous sandstone by a cement of iron oxide from a flow of iron-impregnated water arrested in its downward course by the bed of lignite.

Immediately below the lignite is usually found clay, sometimes of excellent quality. Not infrequently the underlying clay is deeply colored with lignitic matter. The associated sands are also sometimes carbonaceous in character.

The following partial sections will help to make clear the character of the materials immediately associated with the lignite beds of Mississippi:

Section at Chester Near the Jail. (Sample 7.)

Sandy clay	x
Lignite	21 inches.
Poor lignite or lignitic clay	9 inches.
Clay	x

Section 1½ Miles North of Dekalb. (Sample 15.)

Sand	x
Sandstone	2 inches.
Lignite	27 inches.
Lignitic clay	x

Section at Shenoah Hill Near Tchula. (Sample 23.)

Sand	x
Tough clay	2 feet.
Lignite	4–5 feet.

Section Near Shawnee, Benton Co. (Sample 29.)

Sand	15 feet.
White to bluish clay	5 feet.
Lignite	2½ feet.

Section at Shelby Creek Church, Benton Co. (Sample 32.)

Sand	8 feet.
Yellow clay	6 inches.
Claystone	4 inches.
Yellow clay	3 feet.
Lignite	1 foot.

Section at Old Wyatte, Lafayette Co. (Sample 37.)

Unstratified sand	32 feet.
Stratified sand	8 feet.
Woody lignite	scarcely 1 foot.
Stratified sand	24 feet.

Section at Camp Springs Near Pittsboro. (Sample 43.)

Good lignite	28 inches.
Fossiliferous clay	7 feet.
Inferior lignite	6 inches.

THICKNESS OF BEDS.

Dr. Wilder, in a report on the lignite of North Dakota (p. 12), 1905, mentions one bed in that State with a thickness of 40 feet, and adds, "three beds that reach a thickness of 25 feet are known, while beds 15 feet thick are not uncommon." Unfortunately no such thicknesses as these can be reported for Mississippi. Beds beyond 3 feet in thickness are not very common and those beyond 5 feet are very unusual. The thickest strata which the present writer has been able to find are the following:

Thickest Lignite Beds in Mississippi.

(1) "Burning bed," near Lexington, Holmes Co. (Sample No. 21), thickness 7⅓ to 8 feet.
(2) Shenoah Hill, Holmes Co., thickness 5 to 6 feet.
(3) Coal Bluff, on Pearl River (Sample No. 18), thickness somewhat over 5 feet.

It should be said that the thickness of some of the lignite beds has not been determined, and that other beds of greater thickness than these have been reported.

Casual observers are often deceived in the thickness of the deposits owing to the fact that the associated clay, shale and sand are frequently highly lignitic in character and dark in color, and hence are readily mistaken for lignite. At Coal Bluff on Pearl River, for instance, the best lignite is only 17 inches thick, and the total thickness only 4½ to 5½ feet, yet, owing to the associated material, a person rowing along the river gets the impression of a solid bed of 8 feet or more. It is, therefore, frequently necessary to take reported thicknesses with a grain of allowance. The 14, 16 and 20-foot beds of lignite mentioned by Harper (pp. 168, 199) I have not been able to find.

The thicknesses mentioned in this report are usually maximum thicknesses, unless something to the contrary is indicated.

UNCERTAINTY OF BEDS.

The persistence of the beds, both as to thickness and as to lateral extent, is by no means certain among the Mississippi lignites. Beds change in thickness with remarkable rapidity, often thinning out or even disappearing within a few yards. A good outcrop on one side

of a hill may not reappear at all on the opposite side of the hill a quarter of a mile away, or may not be found even across the valley or ravine twenty yards distant. That uniformity and continuity of stratum so desirable for mining are frequently wanting. In the railroad cut near Topton, Lauderdale County, for instance, a stratum of poor lignite or lignitic shale between 3 and 4 feet thick practically disappears in both directions at a distance of 50 yards. In the "burning bed" in Holmes County the lignite seems to thin out in every direction from a point where it is about 8 feet thick. It would seem that in general the lignite has been deposited in lenticular masses and that the diameter of the lens is often small.

Those seeking to develop lignite beds should not base their calculations on one limited outcrop, but before investing much money should determine the lateral extent of the deposit and the thickness at various places. This may usually be done by boring, and in some cases by digging with hand tools. In boring with small augers care should be taken not to mistake the pulverized borings of shale or lignitic clay for those of lignite; else the lignite will appear to be thicker than it really is, and the whole calculation will be vitiated. Having determined roughly the area of the lignite bed and the thickness of the deposit at several places an approximate estimate can be made of the quantity of the fuel present.

VARIATION IN QUALITY.

The quality of the lignite differs greatly in different deposits, running through all the gradations from lignitic shale and clay to a compact, pure, dark brown lignite. In some places it is difficult to determine whether we should call the material lignitic clay or mucky lignite, lignitic shale or shaly lignite. In some beds the deposit is moist and soft, in others dry and firm. In some beds the plant remains are abundant and wood may be found but slightly altered, in others the material is completely lignitized. In some beds much iron pyrite or other impurity is found, in others very little. The chemical composition, as will be seen further on, varies greatly in different beds. Not only do the beds differ one from another in quality, but there will often be found great difference in quality within the same bed. The upper part of a stratum may be soft and mucky, while the lower part is hard and compact. The upper part may be

comparatively pure and good, while the lower part may contain much clay or earth. Part of a bed may be completely lignitized while another part of it is but imperfectly converted; even the same trunk may be partly lignitized and partly petrified. The bed at Coal Bluff on Pearl River shows this variation in quality; at one place the partial section is as follows:

Section of Coal Bluff, Pearl River.

Lignitic shale	3½ feet.
Solid lignite	17 inches.
Laminated lignite	3 feet.

This variation within the same bed is shown further by chemical analyses; different samples often showing quite different results.

SOME COMMON ERRORS.

Several popular errors exist in connection with the occurrence of lignite One of these is that "the lignite gets better further under the hill." There is no reason for this supposition if we disregard a few inches of weathered lignite on the exposed surface. Another statement often heard is that "the lignite probably gets thicker further under the hill." It has already been stated that the lignite deposits are usually lens-shaped; a little reflection will therefore make it plain that the beds may get thicker or may get thinner, and that it is just as likely to be the latter as the former; it all depends on where the lens-shaped mass happens to be first pierced or eroded away. A third error is that "under the lignite one will find real coal if he goes deeper." This supposition is likewise without foundation either in practice or in theory. In not a single instance in Mississippi has coal ever been found under the lignite. In fact, the presence of the lignite points to the absence of stone coal, for lignite is of a much more recent geological time than true coal; hence if true coal existed at the same place as lignite it would probably be so far below the surface that its discovery would be improbable and its utilization impracticable. The true explanation of all three of these popular misconceptions lies in Shakespeare's principle, "the wish is father to the thought."

This may be an appropriate occasion to notice a question frequently put to me in the field: "How long will it take lignite to become good coal?" The discussion of this question may be of interest to the

scientist, but it does not concern the land-owner or practical miner from a commercial point of view. The rate of transformation is so slow that neither our children nor their children's children will note any appreciable change. From a practical point of view, then, the lignite must be considered as lignite and not as a prospective future coal.

BURNING BEDS.

Beds of lignite undoubtedly catch fire and burn for long periods of time. Reports of such beds have frequently been current in Mississippi; for instance, the bed on Mr. Black's land near Pleasant Hill, De Soto County; the railroad cut near Lockhart, Lauderdale County; the bed on Mr. Barron's land in Choctaw County, and several strata in Holmes County. The writer of this report found only one bed actually on fire during his investigation in the summer of 1906, the bed 6 miles southwest of Lexington, Holmes County, which will be described further on in this report. Wilder, writing of North Dakota (p. 52), says: "Evidence is at hand at nearly every point within the lignite area which shows that great quantities of this valuable fuel have been destroyed by fire. Thick masses of burned clay, red, brown, white, or vitrified to a dark glassy slag, cap many of the low buttes, or lie in confused heaps on the slopes. From Fryburg to Medora the Northern Pacific Railway passes through a region in which 'scoria,' as the burned clay is called, is particularly abundant. It makes an admirable railroad ballast."

LIST OF LOCALITIES BY COUNTIES.

DE SOTO COUNTY.

At Pleasant Hill, 5 or 6 miles south of the Tennessee line, there is a deposit of lignite at the church spring, the thickness of which I did not determine. In a well not far away it is reported to be 4 feet thick. In the ravine south of the church-yard are large pieces of thin sheets of lignite, the source of which could not be traced. Two miles west of Pleasant Hill, on Mr. P. M. Black's land, there is a bank in which lignite is said to have burnt for several months. This bank is grown up and covered over now, so that considerable digging failed to discover the bed of lignite; a number of pieces of lignitic clay and a few pieces of clayey lignite were thrown up however. On the creek on the Williamson place ½ mile north of this bank is an outcrop of 2 feet (probably not all exposed) of poor lignite.

MARSHALL COUNTY.

The present writer found no good lignite in his brief trip across the southern part of Marshall County, although he heard reports of lignite in wells. On the Malone place, 1 mile east of Lawshill, there is a deposit of 5½ feet of very poor lignite, better called lignitic sand and earth, with abundant particles of mica and some iron pyrites. A. F. Crider (p. 62) reports a thin band of lignite in the Allison Stoneware clay pit east of Holly Springs. Harper (p. 242) says lignite is found "in Marshall County, especially in the southern part, on the Tallahatchie River."

BENTON COUNTY.

On Mr. W. E. Hoover's land, Sec. 2 (?), T. 4, R. 1 W., not far from Shawnee, there is a bed of lignite in the bottom of Royston's Creek. The section is as follows:

Section on W. E. Hoover's Land, Near Shawnee.	Feet
Sand	15
White to bluish clay	5
Lignite	2½

This lignite blocks out well, and seems good. Some of it contains plant impressions. I noticed no iron pyrites. The sample (No. 29)

did not reach the laboratory. Wailes (P. 239) mentions a deposit not far from here on Snow Creek, Sec. 7, T. 4, R. 1 W., 7 miles south of Salem.

Two miles east of Floyd lignite outcrops in Mr. John C. Orman's house spring. I could not determine the thickness without disturbing the spring, but about 14 inches are exposed. The lignite blocks out well, but with some tendency to flake. It has some sand in it, but I saw no pyrites in the small amount examined. The analysis shows this lignite to be unusually high in volatile matter, but relatively low in fixed carbon. Above the lignite is a thin sheet of sandstone. Water flows out just above the lignite. (Sample No. 30.)

On Mr. J. D. Rutledge's land, Sec. 33, T. 3, R. 2 E., at an old spring in the horse-lot, is a stratum of lignite now covered by sand. I examined only the top of the deposit, which seemed firm but contained too much sand and iron pyrites. (Sample No. 31.) The analysis shows 48 per cent of ash, which would indicate that if all the bed is like the top it has no fuel value.

At Shelby Creek Church (Geddy's Chapel), on the old Tolbert place, about ¾ of a mile from the preceding and near the Tippah County line, there is an outcrop about two-thirds of the way down the ravine. Thickness 1 foot. This flakes rather than blocks out, and has a great many strips of earthy matter in it. (Sample No. 32.) Analysis yields over 63 per cent of ash or inert matter, which shows the lignite to be worthless for fuel purposes.

Lignite is reported deeper down in the gulch. Lignite is also reported at various other places in the county, which I had not the time to visit. Some of these are as follows:

Five miles north of Ashland on Mr. H. R. Littleton's place, 1 mile from Wolf River, 4 feet thick. At Glenn mill, 5 miles east of Ashland, probably 2½ feet thick, good quality. One mile south of Pinegrove, on Mr. Rennick's place; was used by a blacksmith when mixed with charcoal. On Mr. West's place, 2 miles northwest of Pinegrove.

TIPPAH COUNTY.

There are no doubt lignites in Tippah County, although I did not find them, owing to lack of time and to incompetent guides. They are reported about the headwaters of Tippah. Hilgard (p. 160) reports it on 'Squire Street's land, Sec. 29, T. 3, R. 33 E., in a ravine

between two steep hillsides, although he apparently did not see it, as he speaks of having no opportunity of observing the quality. Lignite is also reported on Shelby Creek, 2 miles south of Finger, and on the Hensley place near the latter.

TATE COUNTY.

At Sarah on the Coldwater River there is an outcrop of lignite in the railroad cut. The stratum here is not very thick and the fuel weathers and crumbles to pieces. One hundred yards further from the station in the ravine east of the railroad is a good exposure of lignite, the thickness of which was not determined. Mr. Brown, the owner of the land, says that this was once exposed 12 feet and that there was still lignite below. On the hill above he says they bored into lignite respectively 7 feet, 5 feet and 8 feet, without passing through the bed. Some of this lignite seems fair in quality, except that it contains iron pyrites and earthy matter. (Sample No. 27.) Chemical analysis shows too little fixed carbon and too much ash, resulting in a heating capacity of only 8,022 B. T. U. Lignite is also reported on Mrs. Johnson's place, near Sarah.

PANOLA COUNTY.

Panola County contains a lignite center in the vicinity of Tocowa. In a ravine a short distance behind the hotel at Tocowa, Sec. 8, T. 10, R. 8 W., is a bed of solid lignite 16 inches thick. In color it is brown with a slight tendency to red on the outside. (Specimen No. 25.) This contains very little sulphur but leaves nearly 20 per cent of ash.

Down the valley, ¾ of a mile or 1 mile further, there is a stratum of excellent lignite in the bed of a small bluff stream, thickness probably 17 to 19 inches, color dark brown, approaching black. (Sample No. 2.) This is superior to the stratum near the hotel, containing less than one-third of the amount of ash and much more combustible matter. It has 9,930 heat units per pound as compared with 8,471 in the hotel sample. Other beds are reported in the vicinity of Tocowa Springs.

At Nirvana, 2 miles east of Tocowa, Sec. 10, T. 10, R. 8 W., there is in Mr. S. E. Anderson's field a bed of firm solid lignite in the bottom

of a wash. A thickness of only 12 inches is exposed, but the sand has covered the bottom and I did not learn the full thickness.

On the Sam Darby place in the same section, about 1 mile from Nirvana, there is a stratum of lignite in the bed of a ditch immediately below the gravel. This lignite seems firm and good, resembling that at Tocowa and Nirvana. The sample, No. 26, never reached the laboratory. Near here the remains of an opening said to have been made for lignite about 1869 are still visible. It is said that the lignite found in this bed would burn.

It was somewhere near Tocowa that Harper (p. 199) reported a bed of lignite "at least 16 feet thick, and perhaps much thicker . . . an inexhaustible quantity of it." I could get no trace or rumor of such a deposit.

LAFAYETTE COUNTY.

Lafayette is one of the richest counties in lignite in the State. There are two lignitic belts trending east and west, the northern along the Tallahatchie River, the southern and more important along the Yocona River.

Under the site of the old town of Wyatte on the north bank of the Tallahatchie, a town once important but of which not a single house now remains, runs a thin stratum of poor lignite and imperfectly converted vegetable matter. This bed scarcely reaches 1 foot in thickness. (Sample No. 37.) Analysis shows over 39 per cent of ash.

Further up the river, about 3 miles above the Illinois Central Railroad bridge, there is an outcrop of lignite 18 inches thick on Mr. Tidwell's land in the south bank of the river just above water level. This lignite blocks out in large lumps but has much sand in it; when dry it is variegated with bands of earthy matter. There is a stratum of sandstone 2 inches thick above this bed and the slope of the ground back from the river is gentle. (Sample No. 34.) The analysis shows 45 per cent of ash, too much for the lignite to be of any value.

About $\frac{3}{8}$ of a mile south of the last mentioned bed near Mr. E. A. Billingsley's shop on the Tidwell land, $3\frac{1}{2}$ miles east of Abbeville, there is a bed of lignite which abounds in streaks of sand and in iron pyrites. I could not get through it with the auger because of the latter. Sand can be shaken from dry specimens of this lignite in

great quantities. The top is very impure; deeper down the quality seemed better. The analysis of a sample from near the top shows over 49 per cent of ash.

About 1 mile west of Caswell postoffice, on Mr. Jesse Barry's land, in the bed of a stream right on the Abbeville and Pontotoc road, is a stratum of lignite remarkable in the number of forms it assumes. In some places it is merely lignitic earth, then there are all varieties up to firm good lignite. In some places the woody structure is retained. One piece of wood occurring under good lignite is scarcely altered from its original condition. Another log is partly lignitized and partly petrified. This stratum extends up the nearly dry bed of the stream a distance of 100 yards or more; the ground is level on one side and the hill is very gentle on the other. Thickness 21 inches where bored. (Specimen No. 35.) The analysis of a sample including several different types from this bed shows an inferior lignite. Analysis from selected samples would no doubt show better results.

It is thus seen that the lignites of the northern belt of Lafayette County are not very promising, at least so far as examined. Among the better beds in the southern lignitic belt may be mentioned the following:

On Mr. W. J. Hogan's land, Sec. 32, T. 9, R. 2 W., nearly 2 miles southwest of Oliver's bridge, there is an outcrop of lignite in the bed of a stream (usually dry). Some of it is rather earthy, and some of the remainder is incompletely lignitized and shows woody structure, pine needles, plant impressions, etc. The bed may be called 2 feet thick, although the lower part passes into lignitic clay in such a way that it is hard to draw the line between the two. The analysis shows very little sulphur. It is easily accessible. (Sample No. 47.)

On Mr. A. D. N. Lancaster's land, near Delay, Sec. 33, T. 9, R. 2 W., there is an exposure of good lignite about 28 inches thick, in a narrow ravine part of the way down a steep hill. The analysis shows 9,398 thermal units per pound. (Sample No. 48.)

Lignite is also reported further west or down the Yocona than the two beds just described. Mr. W. J. Thweatt, for instance, reports 20 inches of lignite on his place about 5 miles west of Delay. The specimen brought to me at the University contained too much earthy matter to burn.

One mile east of Tula on Mr. W. W. Grimes' land, Sec. 7, T. 10, R. 1 W., in his fine spring near the house, there is a bed of firm lignite apparently good which he says he knows to be at least 1½ feet thick. It contains some earthy impurity and some pyrites.

A little further east on his farm in the bed of Sandy Creek there is a stratum of hard firm lignite in which there seemed to be very little impurity, although I have not examined a dry sample of it. The auger went about 30 inches before striking the clay; apparently 18 inches of this was firm and solid and 12 inches of a softer nature with perhaps more earthy matter. This bed is quite accessible and would be very convenient for local use in Tula.

Lignite is also found in Mr. Jack Coleman's spring, ½ mile south of Tula. I took out a small piece, which seemed of excellent quality, but could do no more without disturbing the spring.

On Mr. R. V. Edward's land, in a tributary of the Potlockney, Sec. 26, T. 10, R. 2 W., 1 mile north of the county line, is an extensive exposure of lignite, the most extensive I have seen in the State. It forms the bed of the creek for a long distance, sometimes being 10 to 15 feet wide and rising at places 3½ feet above the bed of the stream while still forming its floor. It is of varied quality, much of it is solid and good; some of it retains its woody structure; but I saw none of the wood silicified. Some of the lignite contains sand and other impurities, and, according to Mr. Edwards and his son, iron pyrites. At some places where there seems to be much clay the lignite has a conchoidal fracture. This bed lies near the public road and is easily accessible. (Sample No. 50.) A dry sample of this gave a good welding heat in the University forge. When taken fresh from the bed it contains from 25 to 51 per cent of moisture. Mr. Edwards says he strikes lignite in all his wells.

On Mr. M. A. Garner's land, Sec. 30, T. 10, R. 1 W., about 1 mile north of the county line, in the bank of Patison Creek, is heavily lignitic shale and clay more than 4 feet thick. Near by a hole has been dug from which much better samples are said to have been taken, and the pieces which I saw bore out this testimony; unfortunately my examination was incomplete owing to the fact that the hole is now largely filled. There are reports of very good lignite from this place, even sufficiently good for welding. Dr. Hilgard (pp. 160, 161) mentions still other places in the southern part of the county where lig-

nite is found. A 6-foot seam is reported in a well at Paris (Crider, p. 88.)

A mile east of Oxford, in a gully in front of a house occupied by a negro named Allen Burt, there is a 6-inch bed of poor lignite, the greater part of it more properly called lignitic earth perhaps.

PONTOTOC COUNTY.

My drive southeast from Oxford extended no further than the Pontotoc County line, as I could learn from no one in the vicinity of outcrops in the adjacent parts of Pontotoc County. Hilgard says (p. 160): "Lignite beds probably occur in R. I, E., TT. 9 and 10, S. W. Pontotoc, as they do in the adjoining portions of Lafayette, but I have no *definite* knowledge of outcrops anywhere in Pontotoc County." Mr. Crider (p. 88) also mentions lignite in southwestern Pontotoc County, but whether the lignite at the two places noted on his field map occurs in outcrop or in wells he does not now (June, 1907) remember.

ITAWAMBA COUNTY.

Lignite is reported at a number of places in Itawamba County, not all of which could be examined by the present writer.

Four and three-fourths miles southeast of Fulton, 75 yards to the east of the Tilden road, there is a bed of lignitic matter on Mr. Huston's land, Sec. 18, T. 10, R. 9 E., with a thickness of 20 to 21 inches. This is soft on top, almost lignitic clay, but harder toward the middle, and contains iron pyrites. It is smooth and glossy, showing plainly the clay which it contains. This bed thins out to nothing 20 feet to the south and apparently does so to the north at a short distance. (Sample No. 3.) The chemist reports that the sample contains 25 per cent of ash, over 3 per cent of sulphur, and that it failed to burn.

On Mr. E. A. Palmer's land, Sec. 9, T. 10, R. 9 E., I examined two beds, one about 13 inches thick, the other near the church about 12 inches thick. (Samples No. 4 and No. 5). Both beds contain too much sulphur, as is evident to the eye. Chemical analysis shows No. 4 to be a worthless sample, with 61 per cent of ash, and No. 5 to be a sample of only medium quality. Mr. Palmer reports a third bed on this piece of land, which I did not have time to examine.

On Mr. Wm. Reed's land, Sec. 17, T. 10, R. 9 E., there is an opening into the hill which he made for lignite, but sand has fallen into it and it contains water, so I was unwilling to enter it. Mr. Reed gives the thickness as about 30 inches. Sand lies above the bed.

Lignite is also reported to exist south of Tilden and north or northeast of Fulton in this county.

MONROE COUNTY.

Mr. Dean reports that he struck lignite in two wells about 1½ miles from Greenwood Springs; the first he abandoned after going into the lignite about 6 inches, in the second he passed through 3 feet of lignite. He reports troublesome gas in the wells. By digging in the old well-heap I found pieces of the lignite, which showed distinct woody structure.

Lignite is reported to exist at several places southeast of the Greenwood Springs station across the Buttahatchie River, but my brief visit led me to believe that the quantity is small.

CALHOUN COUNTY.

The Calhoun County lignites are among the very best in the State. Several beds are reported in the extreme northern part of the county, Sections 11 and 12, T. 11, R. 2 W., only one of which I examined, and that superficially. Mr. Crider (p. 88) reports that the outcrop on Mr. J. A. Head's land, near the one I examined, is 5 feet thick. A sample of this lignite was exhibited at the Exposition in St. Louis. Mr. Head informs me that there are two outcrops on his land.

At Reynold's gin and mill, near Trusty Postoffice, there is a 7-inch stratum of lignite in the stream. At Parker's (?) spring, 1 mile from Trusty, there is a 17-inch seam with plant impressions, iron pyrites and sand. At Rock Branch school-house, 2 miles from Ellard, I found a small quantity of highly laminated lignite in a recent well-heap.

Pittsboro, in the central part of the county, and Slate Springs, in the Southern part, are centers of good lignite containing very little sulphur.

Sample No. 42 is from a well-heap in Pittsboro just east of the city square. This lignite is said to lie 15 feet below the surface and

to be 4 feet thick. In color it is black or almost black. It leaves only 7½ per cent ash and contains but little sulphur. Lignite crops out again in the spring 200 or 300 yards north of the square as a poor shaly material and is reported to be struck in many wells. Harper says (p. 214): "The inhabitants meet the lignite stratum everywhere, about 30 feet below the surface, and find it to be in some places of the unusual thickness of 30 feet; the latter is especially the case eastwards of the town, in which direction the stratum of lignite seems to increase in thickness."

At Camp Spring, ½ mile northwest of Pittsboro, the water runs over about 28 inches of good lignite. (Sample No. 43.) One log of wood in this bed is comparatively little altered. This lignite stands the wear of water well. It contains, according to analysis, a very high percentage of volatile matter. About 7 feet of clay underlies this stratum and below the clay is a 6-inch stratum of inferior lignite.

Both 42 and 43 could be used for heating and power in Pittsboro. For instance, an electric plant could be located at Camp Spring for lighting the town and would have both water and fuel convenient. Water could also be pumped into town from this spring. Of course a more thorough investigation should first be made as to the total amount of lignite present and the proper machinery for lignite consumption should be employed.

Another outcrop is found in a spring on Mr. B. F. Harrelson's land, not far away; thickness of stratum undetermined, and no sample taken.

The lignites of the southern part of the county show a still higher calorific value than those of the vicinity of Pittsboro. On Mr. John McPhail's land, 2 miles from Slate Springs, a shaft was sunk for lignite, which has now fallen in, so that I could not see the fuel in place. I took my sample, No. 44, partly from the exposed heap and partly from the coal-house, each part being 18 months old. The lignite is said to lie about 18 feet below the surface and to be about 8 feet thick and of uniform quality. It crumbles upon exposure, as most lignites do. Its color is black, or almost a solid black. As the analysis shows, this is an excellent lignite.

In the house spring on the Tom Walton place, 1 mile west of Slate Spring, there is an outcrop of 1 foot of good solid lignite which blocks out well. The analysis shows this (Sample No. 45) to have

next to the highest number of heat units of any specimen examined. The lignite occurs just below sand and has a high hill above it.

The Calhoun County lignites when dry will burn well in an open grate. The writer tried a scuttle of this fuel, composed of a mixture of samples 42, 43, 44, 45, in his own grate and obtained a steady, good fire, which burned up completely.

There are reports of lignite in the vicinity of Burke, both in wells and in outcrop, one outcrop being in the bank of Schouna River. Hilgard (p. 161) mentions lignite in the vicinity of Sarepta, and in township 12, range 2 west, and also on the river just below Old Town.

YALOBUSHA COUNTY.

Yalobusha County contains considerable lignite. In the extreme eastern part of the county there are two beds, one 19 inches thick on Mr. B. French's land 1 mile west of Airmount, the other 15 inches thick on Wash Hamblett's land not far away. Both of these lignites are firm and solid, but seemed from a field examination to contain considerable earthy impurity, and the latter much iron pyrites. They are capped by a thin shell of sandstone and lie under high hills. Lignite is struck in many wells about Airmount, according to the reports of the citizens.

Six and a half miles east of Coffeeville, on J. J. Milton's land, Sec. 5, T. 24, R. 7 E., there is a bed of excellent lignite outcropping in a big spring. This lignite is firm, compact and uniform in character so far as examined; the thickness is from 22 to 29 inches. Two inches of sandstone roof the bed, the hill above is gentle, and the location accessible. Sample No. 46.

There are reports of lignite at Vann's old mill race 3 miles south of Yalobusha across the Schouna River, and at or near Pine Valley. Wailes (p. 239) reports lignite at McElroy's mill on Turkey Creek.

TALLAHATCHIE COUNTY.

On Mr. B. M. Baker's place, 4 or 5 miles north of Charleston, Sec. 3, T. 25, R. 2 E., there is a bed of very poor lignite. I could not take the depth with the auger on account of the iron pyrite, which exists here in greater quantities and larger pieces than I have seen elsewhere in lignite. The sample, No. 24, shows over 6 per cent of sulphur after the lumps of pyrites were removed.

Three miles north of Charleston is a deposit of lignite which was opened some years ago but is now covered over. The fragments in the heap were badly weathered and flaked into thin layers, and contained leaf impressions. Mr. Craig is of the opinion that this bed was about 3 feet thick, and that is was tried in the shops with only moderate success.

A bed is reported to have been exposed in the creek north of Mr. Sherman's, but to be now covered with sand. Thin layers are reported also southeast of Payne's.

WEBSTER COUNTY.

Lignite is found in the central and northwest parts of Webster County. At Bellefontaine there is a bed of good lignite, measuring 19 inches thick where it crops out in the road. (Sample No. 40.) This contains very little sulphur and at the place where the sample was taken is quite dry. The University blacksmith tried a fire of this lignite under my direction and found it to give a good welding heat. It gave off numerous sparks in burning. This bed is very convenient for local use in Bellefontaine.

At the base of the same hill, in a gully, is a thinner and poorer stratum of lignite.

Lignite is reported to exist 1 mile southeast of Bellefontaine; at McCain, 2 miles northwest of Bellfontaine; on Mr. A. P. Magnes' place, 2 miles northeast of Bellfontaine, and at a place 1¾ miles northwest of Embry. Mr. L. L. Hammond says that he always strikes lignite in his borings about Dabney.

At the old Carver place, 3 miles northeast of Alva, there is an exposure of lignite in the stream not far from the bridge. The thickness could not be determined. This lignite is inferior to the Bellefontaine sample, having more extraneous matter. Sample No. 39 was taken from the upper part and was water worn.

Farther north, near the northwest corner of the county, on the Mr. W. M. Jenkins' place, there is said to be considerable lignite from 7 to 16 feet below the surface, and from 4 to 5 feet thick. There is no outcrop, but I saw a small quantity of small fragments at the house, and it seemed to indicate a good quality. This is said to burn in the forge.

CHOCTAW COUNTY.

Choctaw County is relatively rich in lignites. The six samples collected from this county all show over 9,000 B. T. U. and four of them show over 9,400. The sample from Mr. Oswalt's is the only one found in the State with over 10,000 B. T. U. The Choctaw County lignites contain more sulphur than the Calhoun County samples, but somewhat less moisture.

Sample No. 6 is from Mr. W. A. Collins' land in the southeastern corner of the township, 6 miles from Ackerman. The bed is 29 inches thick, the upper part of it showing a decidedly woody structure.

Sample No. 7 is a good lignite from the town of Chester, occurring at the spring just below the jail. It contains rather too much sulphur but is very convenient for local use. The thickness is 20 to 22 inches, with 9 inches of poorer lignite or lignitic clay below. There are at least three other exposures in Chester.

Sample No. 8 is from the old Moses Bridges place, now belonging to Mr. J. R. Ray's mother, Sec. 33, T. 18, R. 10 E., presumably the place mentioned by Hilgard (p. 162). The bed of the creek has been turned aside and the lignite is now covered. A sample was taken from a heap thrown out two years ago. The thickness was not determined; Hilgard gives it as about 4 feet (if the beds are identical), which is more than Mr. Ray remembers it to have been when he opened it two or three years ago. Some of the lignite was lighted with a small wood fire by the side of the road; it ignited with difficulty, but was still burning two hours later.

Sample No. 9 is from Mr. Patrick Ray's land, Sec. 32, T. 18, R. 10 E., about 1 mile from the preceding. This bed is probably 12 to 15 inches thick and is underlain by an equal thickness of lignitic shale.

Sample No. 10 is from Mr. E. W. Oswalt's place, Sec. 2, T. 17, R. 11 E. There are four outcrops of lignite on this farm, two of which I saw. The sample is from the second, which I examined, the first being in a spring. In color it is from brown to black. The analysis shows for this the highest heating capacity of all the lignites examined, the result of a very high percentage of fixed carbon. The bed is 32 inches thick, the lower 10 inches not being so good. Beneath is a blue clay. This lignite when tried in the University forge came rapidly to a sharpening heat and soon gave a good weld.

Mr. Oswalt thinks the two other outcrops in the next hollow of about the same character. On Mrs. Dora Oswalt's place, about ½ mile away, is another outcrop of similar character, Mr. Oswalt reports.

Sample No. 11 is from a spring in Mr. P. M. Snow's field, Sec. 15, T. 17, R. 11 E. This bed was visited late in the afternoon, when I did not have time to reach the bottom of it; hence the thickness cannot be given. This is an excellent lignite with a small amount of ash and a large amount of volatile matter.

At Mr. Snow's house in Section 14 of the same tract, the well-borers report striking lignite 4 feet thick at a depth of 24 or 25 feet. This thickness may include lignitic shale or clay. One hundred yards away in the railroad cut lignite of a poor quality crops out.

A 2-foot bed of lignite on Mr. W. Y. Barron's land, 6 miles northeast of Ackerman, is reported to have caught fire in the summer or fall of 1905 and to have burnt for 2 months, causing a disagreeable odor for 1 mile or farther.

On the old Henry Wood place, at the spring, 1½ miles north of Chester, Sec. 35, T. 18, R. 10 E., there is an outcrop of about 3 feet of hard, laminated lignitic shale or clay, scarcely to be called lignite. It contains pyrites and plant impressions. (See Hilgard, page 162.)

Another outcrop is reported 3 miles from Chester and 1½ miles from the Woods place, where shaly lignite outcrops; this is said to be sufficiently good for sharpening but not for welding. Lignite is also reported on the Busby place 10 miles north of Ackerman and 3 miles west of Reform. I failed to find it in the brief time at my disposal.

Hilgard (p. 162) records that a stratum of lignite 4 feet thick was struck in a well at a depth of about 45 feet at Black's well, Sec. 23, T. 17, R. 10 E., and (p. 161) that dark lignitic clay with a vein of lignite crops out on a bluff ½ mile southwest of Bankston.

WINSTON COUNTY.

"North Winston abounds in lignite. It is found in a stratum 4 feet in thickness, in wells near New Prospect Postoffice and east of the same on the headwaters of Noxubee, where it crops out abundantly in gullies and is struck in wells north of Webster. I have had no opportunity of observing these beds personally." (Hilgard, p. 162.) In a hurried drive from Louisville to Webster and vicinity I

found no lignite, but only lignitic clay, beyond Drip Spring, although there are still reports of such beds. A more careful search might reveal them.

Louisville, the county seat of Winston County, is in a lignitic area. Reports indicate lignite in a number of places. The well-borers, who were sinking a well at the livery stable at the time of my visit, reported striking lignite at a depth of about 40 feet.

On Mr. W. E. Huntley's land, 2½ miles west of Louisville, Sec. 31, T. 15, R. 12 E., is a bed of 1 foot of fair lignite. (Sample No. 12.) It has nearly 3 per cent of sulphur and rather too much ash, but a relatively small amount of water. Mr. Huntley says he did all his blacksmith's work, including welding, for two or three years with this lignite. He reports two other outcrops in the southeast corner of the same section.

The box of Drip Spring, 2½ miles north of Louisville, is cut in lignite of good quality. The thickness is probably about 2 feet. The analysis shows this to be higher in fixed carbon than any other Mississippi lignite analyzed, and it is the best of the Winston County lignites examined. (Sample No. 13.) If it should prove to be present in sufficient quantities it could be used for heat and power in Louisville. No doubt it could be used to advantage in the forge.

On Mr. C. L. Taylor's land, 3 miles northwest of town, there is a bed of good lignite, whose thickness is undetermined, but which is at least 41 inches. (Sample No. 14.) This contains but little sulphur. Dried samples show light splotches of earthy matter.

Eleven and one-fourth miles east of Louisville, near Perkinsville, is a very thin, insignificant sheet of lignite on Mr. J. W. Chapel's land. There are reports of lignite in other parts of the county.

NESHOBA COUNTY.

No outcrops of lignite were found by the present writer in Neshoba county, but the well-diggers and others report lignite as occurring in wells in and about Philadelphia. Wailes (P. 239) mentions a deposit on Sec. 30, T. 11, R. 12 E., near Philadelphia.

KEMPER COUNTY.

Two samples of good lignite were obtained from Kemper County. No. 15 is from Mr. H. A. Hopper's land 1½ miles north of DeKalb.

A horizontal opening has been made into the side of the hill following this stratum some distance and the lignite is shown to be fairly uniform. Measurement showed the thickness to be 27 inches, which Mr. S. O. Bell, chancery clerk at DeKalb, thinks increases further back. This lignite contains too much sand and earthy matter, otherwise it is good. Mr. Bell says it has been used in the forge for welding. A 2-inch sandstone cap covers the bed, above which is sand; below the lignite is black lignitic clay. Mr. Bell reports that lignite crops out in several places in this same hollow; I saw one other, where the stratum seemed about 1 foot thick.

There is another outcrop on Mr. Hopper's land about a mile north of town in a spring near a tenant house. This seemed of good quality from a field examination; thickness unascertained.

On Mr. L. J. Wimberley's land 4½ miles north of DeKalb is an outcrop of lignite of about 29 inches in thickness. The quality did not appear so good as Mr. Hopper's. There is no roof of stone about it. Mr. Wimberley reports another outcrop about a mile north of this, which he thinks is probably better.

At Pool's mill 4 miles southeast of DeKalb, Sec. 14, T. 10, R. 16 E., there is a 2-foot outcrop of good firm lignite which blocks out in large lumps. It seemed to be of uniform quality so far as exposed, and contains some iron pyrites. Mr. Pool says he cannot use it to advantage in his shop. That is perhaps because he did not dry it sufficiently. The percentage of sulphur is also rather high. The quantity of ash is unusually small for Mississippi lignites and the percentage of fixed carbon unusually high; hence its heating power is greater than that of the Hooper lignite north of DeKalb.

Mr. Pool reports another outcrop ½ mile away on his place, of about the same quality, but a little thinner. Lignite is also reported near Cullum and Spinks in the southern part of the county.

LAUDERDALE COUNTY.

At Lockhart, in a spring behind Mr. E. P. Brown's store, there is an outcrop of 11 inches of lignite apparently good except the top inch or two, which is soft and mucky. Below is lignitic clay, above is yellow sand. Mr. Brown says there are other outcrops and that it also occurs in wells about Lockhart.

There is considerable lignitic clay between Lockhart and the deep cut on the Mobile and Ohio Railroad 2 miles above town. This cut is reported to have been on fire for some time, but there is now no trace of present or past burning. There is much lignitic earth, but very little true lignite here.

In the railroad cut ¼ mile north of Topton there is a stratum of lignitic shale which can perhaps be called lignite, especially at the bottom. At the thickest it is between 3 and 4 feet. It seems to be lenticular in shape and practically disappears at fifty yards right and left. Within this stratum petrified logs appear completely surrounded by lignitic matter. These are brown to black in color. Within 5 feet of the largest of these logs is another log slightly enough changed from its original condition to be easily whittled with a knife. Below the lignitic stratum is a compact stratified green (or bluish) slightly micaceous sand, which splits off and lies in the stream like great stones. The cut just beyond, at the 145 mile-post, is said to have burnt for many years, the fire being hidden but the smoke showing above the ground.

Hilgard (pp. 118, 162) reports lignite in the wells at and about Marion and on Sowashee Creek, 2½ miles north of Marion. Mr. J. R. Hobgood, who lives about 4 miles north of Marion Station, says he struck two or three feet of lignite in digging his well ten years ago, and that his brother who lives near him found it in a well more recently dug.

In Russell I was informed that lignite of various thickness is struck in digging wells and that it outcrops in the creek near by with a thickness of 1 foot.

In the deep cut on the railroad east of Russell just before reaching the 287 mile-post there are two strata of about 1 foot each of heavily charged lignitic earth or lignite.

About 2 miles east of Russell on the railroad there are several abandoned shafts and galleries formerly used by the Meridian Fertilizer Co. In the cut between two of these workings there is exposed a 3½ foot stratum of poor lignite, with plant remains and much clay —no doubt the same stratum as the one used by the fertilizer company. The use of this lignite as an ingredient in the Meridian fertilizer has been abandoned for some years. Twenty or twenty-five

feet above this stratum in the same cut is another stratum about 1 foot thick, which being difficult of access was not examined.

Hilgard (p. 162) mentions the report of "black mud" found in Daleville; this may mean lignite, but more probably lignitic earth.

JASPER COUNTY.

Near Garlandville, Jasper County, on Suanlovey Creek, there is a bed of lignite, showing upon analysis a high percentage of volatile matter. I visited the vicinity but it was not convenient to examine the deposit, so the sample (No. 17) was sent to me later by Dr. Loughridge. This bed was visited in the early days by Dr. Hilgard, who reported it (pp. 127, 163) as occurring between the Claiborne and Jackson group and being exposed to the thickness of 2 feet above the bed of the stream with a probable continuation below; he speaks of the quality as good.

RANKIN COUNTY.

A stratum of lignite less than one foot thick occurs in the cut just east of Rankin. Mr. J. A. Spears of Rankin informs me that a test well at the tank struck 3 feet of lignite at a depth of 30–33 feet. The well at the mill struck two thin sheets of lignite and a thicker one. In Mr. S. R. William's well 3 miles east of Rankin 18 inches of solid lignite is reported.

Dr. Hilgard (pp. 108, 140) reports lignite at and north of Brandon, but the quantity seems small. I could get no trace of any beds of importance there. Harper (p. 168) reports it "in Rankin County, where it crops out in a cut on the railroad."

HINDS COUNTY.

Hilgard and others have reported lignites in the vicinity of Jackson, but these reports are so unpromising as to have led me to consider it unnecessary to make further investigation. Dr. Hilgard (pp. 130, 131, 163) reports 1 foot of earthy lignite at Moody's Branch near Jackson. He also reports (p. 163) finding "chunks of good lignite at a sandy bluff on Pearl River, about 1 mile (by land) above Jackson," without being able to ascertain the dimensions of the bed in place.

Wailes says (p. 239): "Mr. Fairchilds informs me that in sinking a well on Sec. 11, T. 4, R. 3 W., he encountered a bed of considerable thickness, 35 feet below the surface." Harper mentions lignite in the same township and section as "about 20 feet thick, and perhaps connected with the Vicksburg deposit."

Mr. Crider (p. 36) reports a 6-inch bed of lignite in a deep branch in the southern part of Sec. 15, T. 4, R. 1 E., not far from Byram. This, he thinks probable, marks the break between the Vicksburg and the Jackson formations.

CLAIBORNE COUNTY.

In Claiborne County there is lignite occurring within the Grand Gulf formation. In T. 13, R. 3 E., about 2½ miles southwest of Mr. Bagnell's, is a deposit between the sandstone strata of the Grand Gulf. This lignite is about 1 foot thick, closely laminated, weathers into flakes and contains many lumps of iron pyrites. Apparently it contains much impurity and would leave a high percentage of ash. Another outcrop is reported about 3½ miles southwest of Hinkinson on Foster and Dochterman's land, and is said to be about 1 foot thick.

Wailes (p. 239) mentions a 2-foot exposure of lignite near Big Black River occurring between two strata of the Grand Gulf sandstone, but there is some error in the text as to the geographical location, as it is placed in Sec. 47 [sic], T. 13, R. 2 E. Harper (p. 168) reports lignite on Big Black River, T. 13, R. 3 E.

WARREN COUNTY.

On account of the high stage of the river at the time of my visit I was unable to examine the lignite stratum reported at Vicksburg. Wailes (pp. 237, 238) says:

"The most considerable deposit of lignite, by far, which has come under my observation, is that at Vicksburg. This I had a favorable opportunity of examining on the 10th of October, 1852, owing to an unusually low stage of water in the Mississippi, it being rarely exposed to view. On that occasion I measured 500 yards on its surface, along the margin of the river, and obtained specimens of it. . . . The thickness of the bed I had no means of ascertaining, no excavation having been made."

Dr. Hilgard (pp. 141, 164), on the authority of Prof. Moore, speaks of this as solid, lustrous lignite not exceeding 3 feet in thickness.

YAZOO COUNTY.

At Mr. Joe Dilley's house half way between Phoenix and Mechanicsburg I found one small outcrop of lignite 2 to 3 inches thick in the bottom of a stream. Another small outcrop is reported further down the creek, equally insignificant.

Harper (p. 168) says: "Another remarkable stratum of very fine lignite is found on Sec. 27, T. 9, R. 4 W., in Yazoo County. It is about 14 feet in thickness, lies between two strata of green clay. . . . and extends all under the hill, cropping out again on the opposite side of it; it covers about one-fourth of the area of a square mile." I made a search for this bed but failed to find any trace or rumor of it.

At Freerun in the northern part of the county there is an outcrop of 11 inches of poor lignite in the valley behind Mr. Gunn's store. (Sample No. 19.) The analysis shows nearly 39 per cent of ash.

MADISON COUNTY.

"In Madison County lignite beds of great thickness have been struck in wells bored by order of the Rev. J. R. Lambuth, both at Canton and at his residence, Sec. 2, T. 7, R. 2 E., near Calhoun Station. At a depth of 375 feet a ledge of rock was penetrated, beneath which, for 46 feet, the auger brought up lignite, with only an occasional band of clay." (Hilgard, pp. 163, 192.) My inquiries at Canton failed to elicit any knowledge of lignite outcropping or in wells near by. A gentleman informed me that in the northeastern part of the county, between Couparle and Kirkwood, lignite was struck at about 40 feet in a well on Mr. J. R. Sherrard's land, and that it made a gas in the well so strong that the men could not work.

SCOTT COUNTY.

About 16 miles east of Canton on the further side of Pearl River in Scott (?) County there is a large vertical lignitic bank descending into the river. This is called Coal Bluff, and is reached by rowing on the river. The lower end of the outcrop dips sharply down stream and is merely stratified lignitic sand. At the highest point of the bluff

the strata are practically horizontal. At this point the section is about as follows:

Section at Coal Bluff, on Pearl River.

Columbia loam (?)	9 feet.
Unstratified sand	9 feet.
Lignitic shale	3¼ feet.
Solid lignite	17 inches.
Laminated lignite	3 feet.
Clay	x feet.

About 17 inches of this lignite is very solid. The strata vary considerably at different points. The thickest lignite, properly so called, is somewhat over 5 feet. Some of this bed is almost black. Part of the lignite near the water, and much of the underlying clay, is perforated or honey-combed with small holes. Sample No. 18 shows a high percentage of sulphur. The upper member of this section is marked doubtfully as Columbia. I could not reach it to examine it. Looked at from below it suggested Columbia, but that formation would scarcely be expected in a broad river bottom.

This lignite is very convenient for water transportation to Jackson. Mr. Wm. Richards reports considerable lignite above Alligator Lake, 2 miles further up the river.

Dr. Logan reports lignite and lignitic clay to the thickness of 6 feet in the Jackson formation at Morton.

HOLMES COUNTY.

The lignite beds of Holmes County compare favorably in thickness with any in the State, but in quality they do not seem to be equal on the whole of those of Calhoun County or of Choctaw County. The chemical analyses show both more sulphur and more ash than are to be found in the Calhoun County lignite. Analyses from four beds were made, the lowest showing 8426 B. T. U. and the highest 9201. Of these four beds the least thickness was 3 feet and the greatest 8.

On the old Stainback place now owned by Mr. G. F. Nixon, T. 14, R. 1 W., by following up a bluff stream, with pieces of lignite for my guide, I found a bed of fair lignite about 3 feet thick, shaling to some extent and breaking into blocks. Some of the blocks which had washed down stream seemed to stand weathering well. Below the main bed is a lens of unusually hard and bright lignite about 2 inches thick, preserving its woody structure and breaking evenly at right angles to the grain. Sample No. 20 included some of the latter.

The lignite rests on several feet of clay. Some distance from here in the bottom of the main stream is another stratum of apparently good lignite which seems to be about 2 feet thick.

Mr. Nixon informs me that there are three streams coming down the bluff on his place and that all bring down pieces of lignite.

A mile and a half west of Tolarville on land belonging to Mr. Henry Eakins' mother there is an outcrop of 4 feet of solid lignite high in volatile matter, but unfortunately gaining its solidity by inert earthy matter. This bed seems to be of considerable extent, both up and down the ravine. Mr. Eakin thinks the thickness persistent. (Sample No. 22.) Mr. Eakin reports that about 60 yards below this place the bed caught fire and burned 2½ years, and that it was finally extinguished by heavy rains.

In the ravine on the other side of the house some distance away there is a layer of 2 feet of mucky lignite. Mr. Eakin reports another outcrop of lignite ½ a mile north of here on the Mark Shettleworth place, which also burnt for some time.

An interesting bed of lignite is the one lying 6 miles southwest of Lexington to the west of the Ebenezer road. This bed has been on fire for some time; different people state different periods; a negro who lives near says he has known it to be burning for the past 12 years; others say 7 years, 5 years, etc. At present the lignite is burning at two different places some 40 yards apart. The mephitic fumes come up through joints in the Columbia loam, which is rendered too hot to be handled. I could see no flame, but both negroes and whites assure me that they have seen the fire. A negro living near the place says that he has seen the ravine lighted up at night like a little town. I let down a piece of rope a short distance, not to the lignite bed however by several feet, and the end of it was charred. All agree that in wet weather and in winter it burns more than in dry summer, which would seem to indicate a chemical action of water upon some material, yet there seems to be unmistakable evidence of fire. More probably the rainy season gives rise to more steam from the bed, which causes people to believe it is burning more in such weather. As has just been seen, in speaking of the bed near Tolarville, Mr. Eakin stated that the fire in that stratum was extinguished by heavy rains. The deposit around the vents and the odor from the burning indicate considerable sulphur. The ash indicates a heavy residue,

in some places even retaining the shaly stratified structure of the lignite. Much of the deposit has already been consumed.

This bed is 7⅓ feet thick where I measured it and probably a foot or two more at its greatest depth, but it soon becomes thinner in every direction. The lignite has abundant plant impressions and splits readily into thin flakes, in fact it seems almost impossible to get out good solid blocks of it. The edges that are exposed crumble badly. (Sample No. 21.) Below the lignite is a tough jointed clay.

On Rankin's Branch under a gravel bluff about 1 mile south of Howard occurs a stratum of lignite 2 feet thick, possibly thicker. This lignite contains veins of earthy matter, but otherwise seems good from a field examination of wet samples. The blocks in the branch appear to weather well. Following is the section:

	Feet
Columbia loam	7
Lafayette gravel, sand and clay	16
Solid lignite	2

As one ascends the hill toward Howard, an inch or two of lignite is seen cropping out above a blue clay.

At Shenoah Hill, 3 or 4 miles north of Howard and 2 or 3 miles east of Tchula on Mrs. Julia Harris's land, is one of the thickest beds of lignite I have seen in the State. This mine was opened several years ago and a quantity of lignite taken out; the old tunnel has since fallen in, so that it was dangerous to enter it. The fuel is still visible in part and is said to be 4 or 5 feet thick. Some of the larger lumps lying outside seem to have withstood weathering well; it was from one of these that sample No. 23 was taken. This sample upon analysis shows a high percentage of volatile matter and leaves comparatively little ash. Tried in the University forge, it gave a good welding heat and did not burn out too rapidly. The approach to this mine is easy and its location convenient to the railroad.

In the road near the old tunnel the lignite is again exposed, and also at several places up the ravine. A short distance up the ravine from the tunnel the stratum is 5 to 6 feet thick; still further up it is 2½ feet thick. Lignite is also said to show at two places across the ridge.

Above the lignite at the tunnel is a 2-foot stratum of excellent clay, an analysis of which is given in Table 13.

On the Pine Grove plantation Mr. McGee reports a 7-foot outcrop of lignite on the southeast side of the Funnigusha Creek.

Dr. Eugene Smith in his field notes of 1871 records a stratum of lignite 4 to 6 feet thick in Sec. 36, T. 15, R. 1 E. The seam of lignite was sometimes 2 feet above the bed of the branch, sometimes formed the bed of it. No doubt there are many other outcrops along the streams and ravines of the Bluff in this county. Fragments of lignite are not infrequently seen in the streams issuing at the foot of the Bluff.

In the northeastern corner of the county are some deposits of inferior lignite. I visited several outcrops on Mr. F. M. White's land 4 miles west of West, Sec. 24, T. 16, R. 4 E., and Mr. White also states that he struck lignite in several wells near his house. Sample No. 38 was taken from a spring about ¼ of a mile south of the house. I could not determine the thickness, but Mr. White says it is at least 3 feet. When dry this has a red earthy look. The analysis shows it to contain too much earthy matter and too little fixed carbon to be of any fuel value. Another bed on Mr. George Nabors' place seemed to be thin and impure.

CARROLL COUNTY.

I saw no lignite in Carroll County. I was told of its presence at Brock in the southeastern part of the county, but if it exists there it is probably no better than that in the northeastern part of Holmes County near it. Dr. Hilgard (p. 163) notes: "I have received specimens of iron pyrites, evidently derived from a lignite bed, from Carroll County, but have been unable to ascertain the locality, or particulars."

ANALYSES OF MISSISSIPPI LIGNITE.

SAMPLES AND ANALYSES.

About 50 samples of lignite were collected during the summer of 1906. In two or three cases it was not practicable for me to get the sample myself, in which cases I had to rely on others to collect the sample and send it to the University. It was the purpose to take representative samples throughout the thickness of the beds, but this could not always be done; often I had to take my samples wherever I could get them. After these samples had stood in the laboratory in open wooden boxes for several months smaller samples were selected from them and sent to the Agricultural and Mechanical College of Mississippi for chemical analyses. In selecting these smaller samples several different pieces were taken in each case and all large pieces of iron pyrites were excluded. The analyses were made in the laboratory of the Agriculture and Mechanical College under the direction of Dr. W. F. Hand. Here follows a table showing the analyses of the better Mississippi lignites; they are on an air-dried basis:

TABLE 5.

ANALYSES OF MISSISSIPPI LIGNITES.

(Dr. W. F. Hand, Analyst.)

No.	*Locality*	*Moisture*	*Volatile Matter*	*Fixed Carbon*	*Ash*	*Total*	*Sulphur*	*Calories*	*B.T.U.*
2	Panola Co., 1 m. from Tocowa .	13.93	44.65	35.17	6.25	100	.70	5,517	9,930
5	Itawamba Co., E. A. Palmer, II	12.51	36.55	38.44	12.50	100	3.27	4,928	8,870
6	Choctaw Co., W. A. Collins.....	11.44	36.57	38.56	13.43	100	2.05	5,115	9,207
7	Choctaw Co., Chester.....	11.39	39.79	38.72	10.10	100	2.83	5,236	9,425
8	Choctaw Co., Moses Bridges....	14.29	38.90	37.71	9.10	100	.86	5,018	9,032
9	Choctaw Co., Patrick Ray	10.79	41.59	36.54	11.08	100	1.18	5,311	9,560
10	Choctaw Co., E. W. Oswalt.....	11.61	34.61	42.47	11.31	100	2.66	5,595	10,071
11	Choctaw Co., Snow's field.....	11.07	42.92	39.70	6.31	100	1.92	5,526	9,947
12	Winston Co., W. E. Huntley....	9.91	37.08	36.42	16.59	100	2.95	4,987	8,977
13	Winston Co., Drip Spring.....	11.59	37.49	43.76	7.16	100	1.29	5,455	9,819
14	Winston Co., C. L. Taylor.....	14.20	35.24	41.80	8.76	100	.63	5,255	9,459
15	Kemper Co., DeKalb	11.40	32.61	37.00	18.99	100	1.80	5,112	9,201
16	Kemper Co., Pool's mill.....	13.61	37.14	42.10	7.15	100	2.64	5,439	9,790
17	Jasper Co., Garlandville.....	12.51	41.40	33.93	12.16	100	2.77	5,050	9,090
18	Scott Co., Pearl River.....	13.50	39.66	36.50	10.34	100	4.10	4,972	8,950
20	Holmes Co., G. F. Nixon.....	13.20	40.16	32.24	15.40	100	1.20	5,050	9,090
21	Holmes Co., Burning bed.....	13.87	36.32	34.46	15.36	100	1.39	4,681	8,426
22	Holmes Co., Tolarville.....	10.07	41.71	22.86	25.36	100	1.64	4,831	8,696
23	Holmes Co., Shenoah Hill.....	15.22	42.38	34.91	7.49	100	.91	5,112	9,201

TABLE 5—Continued.

ANALYSES OF MISSISSIPPI LIGNITES—Continued.

No.	Locality.	Moisture	Volatile Matter	Fixed Carbon	Ash	Total	Sulphur	Calories	B. T. U
25	Panola Co., Tocowa	11.84	38.96	29.36	19.84	100	.69	4,706	8,471
27	Tate Co., Sarah	12.01	38.51	25.88	23.60	100	1.40	4,457	8,022
30	Benton Co., J. C. Orman	14.29	47.38	30.73	7.60	100	1.26	4,769	8,584
35	Lafayette Co., near Caswell	9.60	30.54	28.86	31.00	100	.57	4,021	7,238
39	Webster Co., 3 m. from Alva	13.04	36.68	35.62	14.66	100	.48	4,582	8,247
40	Webster Co., Bellefontaine	14.90	39.21	35.57	10.32	100	.56	5,065	9,117
42	Calhoun Co., Pittsboro	13.96	39.97	38.58	7.49	100	.56	5,190	9,342
43	Calhoun Co., Camp Spring	12.20	46.27	30.86	10.67	100	.76	5,096	9,173
44	Calhoun Co., John McPhail	11.46	40.74	37.59	10.21	100	.78	5,486	9,875
45	Calhoun Co., near Slate Spring	12.26	37.43	41.94	6.37	100	.94	5,533	9,959
46	Yalobusha Co., J. J. Milton	12.62	40.85	39.94	6.59	100	2.05	5,392	9,706
47	Lafayette Co., W. J. Hogan	11.84	34.15	35.68	18.33	100	.48	4,598	8,276
48	Lafayette Co., near Delay	14.61	38.51	39.10	7.78	100	1.28	5,221	9,398
50	Lafayette Co., R. V. Edwards	14.60	38.59	35.21	11.60	100	1.83	4,878	8,780

INTERPRETATION OF THE TABLE.

These analyses need no comment for the geologist or for the chemist, but a few words of explanation may be helpful for the general reader, for whom primarily this report is intended. The constituent parts are shown in the first four columns of the table, the sum of these four giving a total of 100 per cent. The second and third columns show the useful or combustible constituents, the volatile matter and the fixed carbon. The first and fourth columns show the worthless or non-combustible parts of the lignite, namely the moisture or water and the ash or inert matter left after burning. By observing the relative proportion of combustible and non-combustible constituents one gets an idea of the value of the lignite. The readiest way to do this however is to glance at the last column in the table, which shows the B. T. U., or British thermal units, per pound; the higher the B. T. U. the greater the heating capacity of the lignite in general. The calories may be found by dividing the B. T. U. by 1.8. The sulphur, which is an impurity in coal or lignite, has been determined separately and recorded in another column.

MISSISSIPPI LIGNITES COMPARED WITH OTHERS.

By comparing these analyses with those of the lignite of other States, made by the U. S. Geological Survey at St. Louis, it will be seen that the better Mississippi lignites are the equal of the brown lignites of North Dakota and Texas, and are not very greatly inferior to the black lignites of Colorado, Montana and Wyoming.

TABLE 6.

COMPARATIVE ANALYSES OF LIGNITES.

(By U. S. Geol. Survey and Dr. W. F. Hand.)

No.	*State*	*Moisture*	*Volatile Matter*	*Fixed Carbon*	*Ash*	*S*	*B. T. U.*
1	North Dakota...	10.03	38.12	39.95	11.90	1.76	9,562
2	North Dakota...	12.01	40.62	39.36	8.01	1.08	9,693
1	Texas.....	13.40	42.75	29.00	14.85	1.04	9,358
2	Texas.....	24.48	38.17	28.94	8.41	.53	8,489
10	Mississippi.....	11.61	34.61	42.47	11.31	2.66	10,071
13	Mississippi.....	11.59	37.49	43.76	7.16	1.29	9,819
23	Mississippi.....	15.22	42.38	34.91	7.49	.91	9,201
44	Mississippi.....	11.46	40.74	37.59	10.21	.78	9,875
48	Mississippi.....	14.61	38.51	39.10	7.78	1.28	9,398
1	Colorado.....	16.77	35.18	44.29	3.76	.54	10,652
1	Montana.....	9.05	36.70	43.03	11.22	1.76	10 777
1	Wyoming.....	17.89	37.81	40.75	3.55	.63	10,340

This table includes all the lignite analyses recorded by the Coal-testing Plant at St. Louis which carried with them a determination of the B. T. U. A few other analyses of North Dakota and Texas lignite records on page 264 seem to be no better. However, in Dr. Wilder's reports on the North Dakota lignites, where a much larger number of analyses are given, there are many lignites which show 43 to 45 per cent of fixed carbon, and a few 47 per cent. The calorific values were not determined. Only five lignites in the Mississippi list show above 40 per cent of fixed carbon, the highest being 43.76 per cent. The five lignites in Table 6 represent as many different counties, and with one exception are the best in their respective counties.

WORTHLESS LIGNITES.

For the sake of completeness of record there is given below a table of analyses of inferior or worthless lignites, samples of which were collected during the past summer:

TABLE 7.

ANALYSES OF INFERIOR OR WORTHLESS LIGNITES.

(W F. Hand, Analyst.)

No.	*Locality*	*Moisture*	*Volatile Matter*	*Fixed Carbon*	*Ash*	*S*
3	Itawamba Co., 4¾ m. from Fulton.....	11.55	33.70	29.52	25.23	3.27
4	Itawamba Co., E. A. Palmer, I.....	8.48	16.67	13.81	61.04	2.81
19	Yazoo Co., Freerun	8.72	34.64	22.84	33.80	2.76
24	Tallahatchie Co., B. M. Baker	10.45	32.20	30.64	26.71	6.16
31	Benton Co., J. D. Rutledge.....	7.48	23.75	20.74	48.03	.53
32	Benton Co., Shelby Cr. Church.....	5.54	19.81	11.06	63.59	3.02
33	Lafayette Co., Billingsley's shop	7.42	20.94	22.43	49.21	.87
34	Lafayette Co., Tallahatchie River	9.35	25.35	20.50	44.80	2.09
37	Lafayette Co., Old Wyatte.....	9.82	24.56	26.41	39.21	1.63
38	Holmes Co., near West.....	7.24	38.49	14.06	40.21	.76

MOISTURE.

The moisture in the air-dried samples, as will be seen by a reference to Table 5, ranges from 9.60 to 15.22 per cent. The average moisture of the 33 samples given in that table is 12.58 per cent. This denotes the moisture left in the samples after they have been dried in the air without artificial heat. When taken fresh from the earth they contain much more moisture. Many of the Mississippi lignites lie below strata of sand and thus become saturated with the water which percolates through these strata. Springs are often found flowing out just above the beds of lignite or from the beds themselves. I took no sealed samples from the lignite beds myself, but after I had finished my field work I wrote back for nine samples from as many of the best or most convenient deposits. I requested that duplicate samples be sealed in Mason fruit jars at the outcrops immediately upon removal from the strata, giving such instruction for obtaining the samples as I hoped would make the conditions of collecting as nearly uniform as possible. One of these sets of sealed samples was sent to the Agricultural and Mechanical College of Mississippi, the other to the Geological Survey of Illinois. Below are tabulated the results of the moisture determinations from these samples:

TABLE 8.

MOISTURE IN FRESH LIGNITES.

(Determinations by Dr. W. F. Hand and Dr. S. W. Parr.)

No.	*Locality*	*A. & M. Coll. of Miss. (By Dr. W. F. Hand.)*			*Geol. Survey of Ill. (By Dr. S. W. Parr.) Total.*
		Air-dried	*Further dried at 110°*	*Total*	
14	Winston Co., C. L. Taylor...	27.32	22.35	49.67	48.70
23	Holmes Co., Shenoah Hill...	10.45	21.35	31.80	43.40
25	Panola Co., Tocowa.....	11.15	21.05	32.20	47.91
43	Calhoun Co., Camp Spring...	24.20	19.70	43.90	44.09
46	Yalobusha Co., J. J. Milton..	10.19	15.26	25.45	49.25
48	Lafayette Co., near Delay...	31.33		31.33	50.66
50	Lafayette Co.,R. V. Edwards	25.54		25.54	51.58

The average of the total moisture in the fresh samples according to Dr. Hand's determination is 34.27 per cent, according to Dr. Parr's determination it is 47.8 per cent. Dr. Wilder found the average for a

large number of North Dakota samples to be 30 per cent. Thus it will be seen that the moisture in lignite is a serious consideration, especially in transportation, for a large part of the expense of transportation is for hauling useless water.

ASH.

Some of the Mississippi lignites leave comparatively little ash upon burning, while others leave a rather high percentage. See Table 5. The average of the 33 lignites in that table is 12.5 per cent of ash, or leaving out the three impurest the average of 30 samples is 11 per cent of ash. The average of the seven brown lignites from North Dakota and Texas, determined by the U. S. Geological Survey at St. Louis, is 12.7 of ash. From these purer lignites shown in Table 5 there are all grades of impurity to mere lignitic shales and clays. See Table 7. The earthy impurity which makes ash may occur in lignite in two ways; first, thoroughly disseminated throughout the mass; second, deposited in the cracks, fissures and laminæ of the lignite as bands of clay, sand or other earthy matter. In the latter case the impurity is readily observed in a dry specimen, in the former it is often difficult of detection without an analysis.

The composition of the ash from the lignites may be seen from the following table:

TABLE 9.

ANALYSES OF ASH FROM LIGNITE.

(Dr. W. F. Hand, Analyst.)

No. of Lignite	14	23	25	43	46	48	50
Silicon dioxide (SiO_2)	29.10	22.95	63.85	51.82	35.00	22.66	35.10
Aluminum oxide (Al_2O_3)	13.45	12.37	13.25	26.98	17.00	14.88	15.23
Iron oxide (Fe_2O_3)	21.00	19.00	10.95	7.12	29.00	20.62	23.35
Calcium oxide (CaO)	22.80	21.37	2.50	6.07	4.55	15.20	8.62
Magnesium oxide (MgO).....	.19	.97	.90	.22	1.50	2.90	1.99
Sulphur trioxide (SO_3)	8.53	14.70	4.46	5.45	6.34	19.89	12.30
Undetermined.....	4.93	8.64	4.09	2.34	6.61	3.85	3.41
Total.....	100	100	100	100	100	100	100

Hilgard (p. 161) gives the following analysis of the ash from a lignite found on Hughes' Branch on the edge of the Potlockney bottom, Lafayette County:

Analysis of Ash of Lignite from Hughes' Branch.

Insoluble matter (sand and silex)	59.24
Potash	trace.
Soda	2.52
Lime	8.83
Magnesia	.73
Oxide of iron, and alumina	25.79
Chloride, carbonic and sulphuric acids, and loss	2.89
	100

SULPHUR.

The percentage of sulphur in the lignites may be seen by a reference to Table 5. In some of the samples, especially those from Calhoun and Webster Counties, it is very small; in others it is larger, two samples showing over 3 per cent. The average of the 33 samples is 1.53 per cent; leaving out three samples which contain more than $\frac{1}{5}$ of the whole amount the average of 30 samples is 1.32 per cent. This seems to be considerably larger than the average for the North Dakota lignites. Five analyses of Nebraska lignites made by Mr. Ernest F. Burchard (p. 280) show an average of 1.16 per cent of sulphur. Many good coals show a higher percentage of sulphur than the Mississippi lignites.

SPECIFIC GRAVITY.

The specific gravity of a few of the lignites was determined. The results, showing an average specific gravity of 1.422, are tabulated below:

TABLE 10.

SPECIFIC GRAVITY OF LIGNITES.

(Determinations by Dr. W. F. Hand.)

No.	*Locality*	*Specific Gravity*
14	Winston Co., C. L. Taylor	1.453
23	Holmes Co., Shenoah Hill	1.326
25	Panola Co., Tocowa	1.415
43	Calhoun Co., Camp Spring	1.433
46	Yalobusha Co., J. J. Milton	1.452
48	Lafayette Co., Delay	1.452
50	Lafayette Co., R. V. Edwards	1.425

Burchard (p. 279) gives the specific gravity of Nebraska lignites, after having dried in the air, as 1.28 to 1.35.

ANALYSES BY DR. PARR.

The following analyses made by Dr. S. W. Parr of the University of Illinois were sent to me after this report had gone to the printer; hence full use of the data could not be made in the preceding pages. The method of collecting the seven samples sent to him has already been described under the head of Moisture. It will be observed that he first determined the total amount of moisture in the samples as received, and then determined the other constituents on a dry basis. The British thermal units were determined with the Mahler apparatus. The fact that they seem so much higher than in the other analyses is due to the difference in method of analyses, Dr. Parr having used thoroughly dried lignite and Dr. Hand air-dried lignite. Averages are given in the last line of the table.

TABLE 11.

ANALYSES OF MISSISSIPPI LIGNITES.

(Dr. S. W. Parr, Analyst.)

No.	*Total Moisture*	*Analyses of dry lignite*					
		Carbon	*Available Hydrogen*	*Ash*	*Sulphur*	*Calories*	*B. T. U.*
14	48.70	60.56	1.85	12.55	.76	5,548	9,986
23	43.40	59.10	2.70	14.44	.84	5,728	10,310
25	47.91	59.70	2.42	12.48	.73	5,676	10,217
43	44.09	58.83	1.86	13.35	4.18	5,488	9,878
46	49.25	64.90	2.55	5.23	1.17	6,149	11,068
48	50.66	62.96	2.03	9.00	1.28	5,815	10,467
50	51.58	57.38	1.76	13.08	2.00	5,289	9,520
Av.	47.80	60.49	2.17	11.44	1.56	5,670	10,206

USES OF LIGNITE.

GENERAL.

It would seem both from analyses and from experience that the better qualities of lignites may be used for practically all the purposes for which bituminous coal may be employed. One exception should be made to this statement; most of the lignites are unsuitable for coking. Lignite has long been in use in Germany and other European countries, and is at present being used in North Dakota, Nebraska, Texas and other parts of the United States. It should be remembered in substituting lignite for coal that modifications of fire-boxes and furnaces are sometimes desirable.

IN OPEN GRATES.

Some of the better qualities of lignite when dry produce a good steady fire in the open grate. For this purpose a chimney of good draft is desirable, otherwise disagreeable fumes may escape into the room. No series of tests of Mississippi lignites in the open grate were conducted by the Survey. The writer however tried in his own study a scuttle of fuel composed of Calhoun County lignites and obtained a very steady satisfactory fire which burnt up completely, leaving no clinkers in the grate. The four lignites which composed this fire were Nos. 42–45; by referring to Table 5 it will be seen that they contain very little sulphur, and less than the usual amount of ash, and that they all run above 9,100 B. T. U. In case of poorer qualities of lignite the addition of a little wood or stone coal would be helpful.

IN STOVES.

Good lignite may take the place of wood and coal in stoves both for heating and cooking. The same precaution should be taken as in the case of stone coal, namely to see that there are no leaks, otherwise troublesome gases may escape into the room. Mr. Thomas Pettigrew, engineer for the asylum at Jamestown, North Dakota, writes: "The use of lignite coal at this institution started in 1890. Since that time we have used it continually for generating steam, and for the past

eight years have used it exclusively for cooking in the general kitchen of the institution. Lignite coal can be burned in any furnace that burns hard or soft coal." (Sec. Bien. Report, p. 176.) Many of the large stove factories now have on the market stoves especially designed for using lignite.

IN THE FORGE.

Any of the medium lignites will give in the forge a heat sufficient for sharpening plows and drawing iron, and the better qualities will give a welding heat. Some of the failures of lignite in the forge reported in this State were no doubt due to the fact that the lignite was used too "green" or wet. The admixture of a small quantity of charcoal or bituminous coal is recommended in case the dry lignite fails to give satisfactory results. I had the following four lignites tried in the University shop under my observation:

TABLE 12.

LIGNITES TRIED IN THE FORGE.

No.	*County*	*Moisture*	*Volatile Matter*	*Fixed Carbon*	*Ash*	*Sulphur*	*B. T. U.*
10	Choctaw.....	11.61	34.61	42.47	11.31	2.66	10,071
23	Holmes.....	15.22	42.38	34.91	7.49	.91	9,201
40	Webster.....	14.90	39.21	35.57	10.32	.56	9,117
50	Lafayette.....	14.60	38.59	35.21	11.60	1.83	8,780

The samples were the laboratory specimens which had been indoors for nine months. All four gave a good weld. No. 50 was chosen especially because of its comparatively low B. T. U.; the result however was satisfactory. All gave off sparks, showing that some of the matter was being blown away by the blast from the bellows.

FOR BURNING BRICK.

Lignite is used in North Dakota for burning brick at Dickinson, Williston, Washburn, Burlington, New Salem and other places. The results obtained are 1,000 red bricks burnt at a temperature of 1,500 degrees with 1,500 pounds of lignite. In some of these plants forced draft is used, in others only natural draft. (Wilder, Sec. Bien. Report,

p. 185.) In Mississippi there are many excellent brick clays in the vicinity of lignite deposits. Doubtless there are also some good pottery clays near the Mississippi lignite beds. Three samples of clays associated with the Holmes County lignites were analyzed with the results given in Table No. 13. Clay No. 1 occurs with lignite No. 20; clay No. 2 occurs with lignite No. 21; and clay No. 3 occurs with lignite No. 23. Clay No. 3, associated with the Shenoah Hill lignite, is of excellent quality and would doubtless make good fire brick. The other two samples contain rather high percentages of iron oxide which would cause them to burn red.

TABLE 13.

ANALYSES OF CLAYS ASSOCIATED WITH HOLMES COUNTY LIGNITES.

(W. F. Hand, Analyst.)

Constituents.	1	2	3
Silicon dioxide (SiO_2)	68.64	68.56	69.67
Aluminum oxide (Al_2O_3)	11.62	9.77	17.43
Iron oxide (Fe_2O_3)	5.95	9.07	2.82
Lime oxide (CaO)	1.43	1.25	.68
Magnesium oxide (MgO)	1.53	1.30	.24
Sulphur trioxide (SO_3)	0.00	0.00	tr.
Volatile matter (CO_2)	7.25	6.32	6.70
Moisture	3.52	3.60	2.32

UNDER BOILERS.

Lignite is successfully used for direct firing under boilers. In some cases forced drafts are used, in others the natural draft is relied upon. Automatic stokers are to be recommended when large quantities of fine lignite are used, and in the case of dry powdered lignite the fuel might be introduced by means of a blast. When feeding fresh or "green" lignite it is desirable to fire only one side of the furnace at a time, as the high percentage of moisture tends to reduce the heat temporarily. Special modifications of furnaces are sometimes used for burning lignite; the purpose being to bring the volatile matter to a combustion heat before it escapes. One of these devices is an arch of fire brick built over the front of the fire-box, which standing at a high heat ignites the gases about it.

No boiler tests of the Mississippi lignite have yet been conducted. I quote the results of a comparative test made in August, 1894, by engineer Thomas Pettigrew between Youghiogheny coal and Dakota lignite. (Wilder, p. 19.)

TABLE 14.

LIGNITE TEST AT JAMESTOWN, NORTH DAKOTA.

(By Thomas Pettigrew.)

	Youghiogheny coal, Aug. 6, 1894.	*Lignite coal, Aug. 8, 1894.*
Duration of test, hours	7½	8
Average temperature of feed water, °F	74	74
Coal burned, pounds	1,400	3,370
Combustible, pounds	1,243	3,170
Ash, per cent	11.21	5.93
Coal burned per square foot of grate per hour, pounds	8.29	18.72
Water evaporated at temperature of feed, pounds	8,837	14,157
Water evaporated in pounds per pound of coal, actual condition	6.312	4.2
Water evaporated in pounds per pound of combustible	7.1	4.46
Temperature of flue gases, °F	510	510
Value of coal	$1.00	$0.665

Boiler 6 feet in diameter by 16 feet long, with 30 4½-inch flues; grate surface 4 feet 5 inches by 5 feet; coal 3 days from mine; cost of Youghiogheny lump at Jamestown, $6.80, of lignite, $2.80.

This with other tests goes to show that Dakota lignite has about 63 per cent of the evaporative power of Youghiogheny coal, 70 per cent of that of Missouri coal, and 75 per cent of Iowa coal. Considering the relative cost of lignite and coal it will be seen that economy may be on the side of lignite.

The following comparative table between bituminous coal and lignite under the boiler is compiled from the report of the tests made by the Coal-testing Plant of the United States Geological Survey at St. Louis in 1904:

TABLE 15.

COMPARATIVE TESTS OF COAL AND LIGNITE.

(By the U. S. Geological Survey.)

No.	*Kind*	*Locality*	*Water evaporated per hr. (in lbs.).*	*Horsepower developed*
2	Bituminous coal	Carbon Hill, Alabama	6,335	216.4
4	Bituminous coal	Wheatcraft, Kentucky	6,076	211.7
2	Bituminous coal	Bonanza, Arkansas	5,268	180.5
1	Black lignite	Wyoming	5,355	186.6
1	Black lignite	Colorado	4,311	151.0
1	Brown lignite	North Dakota	3,175	108.9
1	Lignite briquettes	Texas	1,666	57.3

The North Dakota lignite used in this test has a calorific value considerably below that of many of the Mississippi lignites.

BY BRIQUETTING.

Lignite and waste coal have long been made into briquettes in Germany and other European countries where fuel is scarce and consequently dear. By this process the waste products of mines are converted into firm hard fuel, which may be handled and burned as any other coal. Mechanical pressure is employed and generally some binding material is mixed with the powdered coal or lignite, such as pitch of various kinds, asphalt, creosote, tar, rosin, petroleum, molasses and milk of lime. It is desirable that if possible the bond should be combustible and thus add to the fuel value of the briquettes.

Specimens of Texas brown lignite were sent by Dumble (p. 223) to Europe to be tested for briquettes. The results were unsatisfactory when pressure alone was used, but were entirely satisfactory when bond was employed. A sample of lignite from Pike Co., Alabama, was sent to a briquetting syndicate in Germany and molded into briquettes with entire success. Some of these briquettes, which look much like anthracite coal, may be seen at Tuscaloosa. (Smith, private letter.)

Several experiments in briquetting American lignites with various kinds of pitch were tried by the Coal-testing Plant at St. Louis, some of which were successful and some of which were not. The following table is compiled from the report of that plant:

TABLE 16.

EXPERIMENTS IN BRIQUETTING LIGNITE.

(By U. S. Geological Survey.)

No.	*Kind*	*Locality*	*Per cent of pitch*	*General character*	*Behavior on weathering*	*Behavior on burning*
1	Black	Colorado.....	10	Hard and lustrous, but brittle	Slight deterioration.....	Satisfactory, little disintegration.
1	Black	New Mexico...	12	Very unsatisfactory.....	Crumbles.....	Disintegrates.
2	Black	New Mexico...	7	Crumbly.....	Disintegrates....	Disintegrates.
1	Brown	North Dakota.	10	Porous, little cohesion.....	Disintegrates....	Disintegrates.
1	Black	Wyoming.....	9	Fair, porous.....	Fair.....	Satisfactory.

BY COKING.

Some varieties of lignite are said to yield a coke which can be used in the production of iron. The great majority, however, do not fuse sufficiently in the oven to produce coke. Even the excellent black lignite or subbituminous Laramie coal of the Marshall district in Colorado has not been successfully used for coke. No experiments with a view to coking have been made on the Mississippi lignites, but it is highly improbable that they could be utilized advantageously in that way without the addition of some other material. Dumble (p. 231) concludes that certain varieties of Texas brown coal will form a coke, if charred, with bond of caking coal and coal tar pitch, which, even if it should not prove sufficiently firm for the blast furnace, will nevertheless answer for fuel for locomotives and for other similar purposes.

FOR ILLUMINATING GAS.

Lignite may be used for the manufacture of illuminating gas, and has been so used to some extent on the continent of Europe. Some of the Mississippi specimens run quite high in volatile matter, one having more than 47 per cent in the air-dried sample; others are high in fixed carbon. Burchard (pp. 280, 281) found lignite from Dakota County, Nebraska, to yield 12,279 cubic feet of gas per ton; this was the average result of ten tests. This is as high a yield as the cannel coals and considerably higher than the bituminous coals which he quotes. The lignite he used was comparatively low in volatile matter and high in fixed carbon. He found the illuminating power of the gas weak, however, and suggested that it would need enriching to make a good illuminant. Dumble (p. 227) considers many of the Texas brown coals capable of producing illuminating gas.

FOR PRODUCER GAS.

Recently it has been shown that the brown lignites make excellent producer gas. The Coal-testing Plant of the U. S. Geological Survey at St. Louis conducted a series of experiments upon bituminous coals and lignites with most gratifying results. The brown lignites tested came from North Dakota and Texas and are no better than many of the Mississippi lignites, and are inferior to some of them. The results

of some of these tests may be seen in the two following tables. The first shows a comparison of tests of coal made with the boiler and the gas-producer; the second shows a comparison between bituminous coal and brown lignite in the gas producer:

TABLE 17.

COMPARATIVE TESTS WITH BOILER AND GAS-PRODUCER.

(Reduced from Coal-testing Plant Report, p. 978.)

Coal	Lbs. of coal burned per sq. ft. of grate surface per hour		B. T. U. per lb. of coal used		Electrical horse-power delivered to switch-board		Lbs. of coal per electrical horse-power per hour	
	Boiler plant	Gas producer	Boiler plant	Gas producer	Boiler plant	Gas producer	Boiler plant	Gas producer
Alabama, No. 2	21.54	7.78	12,555	13,365	213.7	200.6	4.08	1.64
Colorado, No. 1	17.80	7.56	12,577	12,245	149.1	200.2	4.84	1.71
Ilinois, No. 3	21.23	8.41	12,857	13,041	198.1	199.6	4.34	1.79
Indiana, No. 1	22.39	9.08	13,377	13,037	220.0	199.9	4.13	1.93
Kentucky, No. 3	21.75	8.92	13,036	13,226	208.9	200.5	4.22	1.91
Missouri, No. 2	25.00	7.96	11,500	11,882	205.6	198.6	4.93	1.71
West Virginia, No. 1	18.94	7.36	14,198	14,396	196.7	200.4	3.90	1.57
Wyoming, No. 2	26.51	9.50	10,897	10,656	182.0	201.2	5.90	2.07

TABLE 18.

PRODUCER-GAS TESTS OF COALS AND LIGNITES.

(Reduced from Coal-testing Plant Report, pp. 1,316–23.)

Sample	Cubic ft. of gas per lb. of dry coal.	B. T. U. per lb. of dry coal	B. T. U. per cubic ft. of gas	Lbs. of dry coal per electric h'se-power per hour
Alabama, No. 2, bituminous	60.4	13,365	149.2	1.64
Illinois, No. 3, bituminous	53.9	13,041	154.8	1.79
Kentucky, No. 3, bituminous	55.1	13,226	155.9	1.91
North Dakota, No. 2, lignite	41.5	11,255	188.5	2.29
Texas, No. 1, brown lignite	42.7	10,928	169.7	2.22
Texas, No. 2, brown lignite	51.6	11,086	156.2	1.71

I quote a summary of the results from the report of the committee in charge of these tests at St. Louis (pp. 29, 30):

"Probably the most important of the results accomplished has been the demonstration that bituminous coals and lignites can be used in the manufacture of producer gas, and that this gas may be consumed in internal-combustion engines for the development of power, with a fuel economy of over 50 per cent. The use of producer gas made from

anthracite coal, from coke, or from charcoal for power purposes, and of producer gas from bituminous coal in steel works, etc., is no new story; but the demonstration of the possibility of utilizing bituminous coal and lignite in the gas engine is a decided advance in the economical combustion of coal for power. It has been shown by comparative tests that the power-producing efficiency of a number of bituminous coals, when converted into gas and used in the gas engine, is 2½ times what it is when used under boilers in the production of steam power. In other words, 1 ton of coal used in the gas-producer plant has developed, on a commercial scale, as much power as 2½ tons of the same coal used under Heine boilers with a simple Corliss engine. The results were measured by the amount of electrical horsepower per hour delivered at the switchboard.

"Of scarcely less importance are the results obtained in the use of lignite in the gas-producer plant. It has been shown that a gas of higher quality can be obtained from lignite than from high-grade bituminous coals, and that 1 ton of lignite used in a gas-producer plant will yield as much power as the best Pennsylvania or West Virginia bituminous coals used under boilers. It appears, in fact that as coals decline in value when measured by their steam-raising power, they increase in value comparatively as a fuel for the gas producer. The brown lignites on which tests were made at the coal-testing plant were from North Dakota and Texas, and the unexpectedly high power-producing qualities developed by them in the gas producer and gas engine give promise of large future developments in these and other States in the far West, where extensive but almost untouched beds of lignite are known to exist."

The character of the gas produced by lignites in the gas producer may be seen from the following analyses taken from the same report (p. 1,323):

TABLE 19.

ANALYSES OF PRODUCER GAS FROM LIGNITE.

(By U. S. Geological Survey.)

Average composition of gas by volume.

Gas	*Brown Lignites*		
	N. Dakota No. 2	*Texas No. 1*	*Texas No. 2*
Carbonic acid (Co_2).....	8.69	11.10	9.60
Oxygen (O_2).....	.23	.22	.20
Carbonic oxide (CO).....	20.90	14.43	18.22
Hydrogen (H_2).....	14.33	10.54	9.63
Marsh gas (CH_4).....	4.85	7.48	4.81
Nitrogen (N_2).....	51.02	56.22	57.53
Total.....	100.02	99.99	99.99

FOR TAR .

Tar may be made from lignite as from bituminous coal. It is obtained as a by-product in the manufacture of gas from lignite.

FOR FERTILIZER.

For several years a Meridian company used the lignite from Russell, Lauderdale County, as a constituent in the manufacture of a land fertilizer; this has since been abandoned, presumably because it was not sufficiently rich in fertilizing elements. It may well be doubted whether lignite has sufficient fertilizing value to make it of economic importance to the farmer, except perhaps locally on the farms where it occurs. In case of its local use it would be prudent to experiment with it before using it very heavily, or else by chemical examination determine that the ash does not contain enough noxious constituents to be harmful to the crops.

ACKNOWLEDGMENTS.

A list of some of the more important works bearing on Mississippi geology and on American lignite is given in the bibliography. To most of these I am indebted and to several of them deeply indebted. I wish to thank Mr. A. F. Crider, Director of the State Geological Survey of Mississippi, for many valuable suggestions and for a kindly interest in this report from the beginning of the field work to the completion of the printing. To Dr. W. F. Hand of the Agricultural and Mechanical College of Mississippi I owe the general direction and supervision of the lignite analyses. To Dr. S. W. Parr of the University of Illinois I am indebted for seven additional analyses of lignite. To many people throughout the State who gave me the benefit of their knowledge of local outcrops and showed me other courtesies during the progress of the field work I am under deep obligations.

INDEX.

LEGEND

ECONOMIC PRODUCTS

QUATERNARY

- Port Hudson and Recent alluvium — Clay loam for making common brick, tiling and road ballast.
- Loess loam — Loam for making common brick and tiling.

TERTIARY

- Grand Gulf sandstone and clays — Sandstone for building purposes; clays for common brick and fire brick.
- Vicksburg limestone — Limestone for making Portland cement and lime.
- Jackson clays and sands — Clay marls for making Portland cement; sands for building and moulding purposes.
- Claiborne-Lisbon clays and sands — Of little economic importance.
- Claiborne-Tallahatta buhrstone — Stone for road making and ballast.
- Wilcox clays and sands — Workable veins of lignite; sands for moulding, building, and making glass; clays for making pottery, fire brick and fancy face brick.
- Midway limestone and clays — Clay for making drain tile, and for mixing with the Selma chalk for making Portland cement.

CRETACEOUS

- Ripley limestone and sandstone — Of little economic importance.
- Selma chalk — Limestone suitable for making Portland cement and lime.
- Eutaw sands — Building and moulding sand.
- Tuscaloosa sands and clays — Clays for pottery, tiling, fire brick and face brick.

PALEOZOIC

- Devonian and Mississippian shales, sandstones, and limestones — Shales and clays for making paving brick, sewer pipe and tiling; limestone for lime, building stone, road making, natural and Portland cement.; sandstone for building stone and glass.

+ Lignite Outcrops.

⊗ Brick and Tile Plants.

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A PROVISIONAL GEOLOGIC AND TOPOGRAPHIC MAP OF MISSISSIPPI

This map represents the present knowledge of the geologic boundaries of Mississippi. It has been compiled from hitherto published sources and recent investigations. Special acknowledgments are due Dr. E. W. Hilgard of the former State Survey, and recent publications of the U. S. Geological Survey. The map shows the general outline of the formations, and the topography of the State as determined by the railroad and government elevations. Changes will be necessary as the work of the survey progresses and more detailed work is done.

Scale of Miles
0 5 10 20 30 40 50