GEOLOGICAL SURVEY OF MISSOURI.

ARTHUR WINSLOW, STATE GEOLOGIST.

ERRATA.

Page 21, line 21 from top, for "specs," read specks.
" 31, " 21 " " after "at," for "A." read F.
" 41, " 3 " " for "Ray," read Clay.
" 41, " 4 " " after "deepest," insert operated.
" 52, " 18 " " for 18 to 20 inches, read 15 to 18 inches.
" 75, " 9 " " and in marginal reference, for "Benfield" read Benefield.
" 82, " 15 " " for "mine," read mined.
" 87, foot note 1, for "page 173," read page 180.
" 91, line 9 from bottom, for "separate," read separated.
" 93, " 6 " top, for "20," read 26.
" 102, foot note 1, for "page 371," read page 373.
" 110, line 18 from top, for "Finney," read Tinney.
" 165, " 21 " " after "1855," insert Part II.
" 196, " 2 from bottom, for "Lowery," read Lowry.
" 209, " 28 " top, for "Hellyer," read Hillyer.

NOTE.—The above corrections should be made in the book at once, to guard against the possible loss of this slip.

GEOLOGICAL SURVEY OF MISSOURI.

ARTHUR WINSLOW, STATE GEOLOGIST.

A PRELIMINARY REPORT

ON THE

COAL DEPOSITS OF MISSOURI

FROM

FIELD WORK PROSECUTED DURING THE YEARS

1890 and 1891.

WITH 131 ILLUSTRATIONS.

BY

ARTHUR WINSLOW, State Geologist.

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OFFICE OF THE GEOLOGICAL SURVEY,
JEFFERSON CITY, MISSOURI,
November 14th, 1891.

To the President, Governor David R. Francis, and the members of the Board of Managers of the Bureau of Geology and Mines:

GENTLEMEN: — I have the honor to transmit to you, herewith, a preliminary report upon the coal deposits of the State. This report embodies part of the results of such observations in the coal fields as I have personally been able to make, during the past two years, in the time which could be spared from the administrative duties of my position and from the general direction of other work of the Survey. Though thus necessarily of a preliminary and incomplete nature, I feel that it will satisfy to a great extent a demand for immediate information which is made evident from frequent applications received at this office. In the light of these considerations I trust it may meet with your favor, and I, further, earnestly hope that it may prove of immediate benefit to the important interests of the State to which it relates.

Very respectfully submitted,

ARTHUR WINSLOW,
State Geologist.

PREFACE.

The following report relating to coal in Missouri is prepared in order that something may be at hand to meet immediate calls upon the Survey for information concerning the coal deposits of the State. All that is given here is a brief, and somewhat popular statement of the salient facts, such as could be prepared from notes collected in a preliminary tour of inspection through the coal fields of the State. The descriptions of the details of sections are here omitted, and the correlation of the different coal beds is only briefly touched upon; such descriptions and the discussion of such questions of correlation involve the presentation of a great mass of material, part only of which is thus far collected. Similarly the attempt at a definition of the individual areas of the coal beds is reserved entirely until the detailed mapping shall be extended over the respective districts; such definition being only possible as a result of this detailed work. Further, the discussion of the adaptabilities of the coals for steaming purposes, for domestic use, for the production of coke or for illuminating gas is not entered into here, as this discussion can be attempted only after the analytical and experimental work on these materials is completed. The results of this work should ultimately be published in a complete report upon the coals and the Carboniferous of the State, and in such report should be included other matters above referred to as omitted here. Though not exhaustive nor elaborate this report is, however, of a comprehensive nature. It aims to present, in general terms, an outline of the conditions of occurrence and of the distribution of coal in the entire State, and it contains a descriptive reference to every county in which coal is known to exist.

Special effort has been made to obtain and include all information and results particularly relating to coal as were not obtainable at the time the earlier surveys of the State were in operation and which are, consequently, not included in the earlier reports. In order, however, that this report might also be comprehensive, some of the observations of the earlier surveys are included in part and others are often referred to. Further, the writer has had access, in the preparation of the report, to unpublished notes collected by Prof. G. C. Broadhead, and

other members of former surveys, as is referred to on several of the following pages.

Of especial value in this report are the records of the various deep shafts and drill holes which are included. These were furnished by many different individuals, and, in each case where the results are quoted, recognition of this assistance is expressed. With a few exceptions, the individuals and corporations of the State have generously contributed such results in a free, public-spirited manner. The importance of furnishing such records to the Survey, where they may be kept on file for ready reference, cannot be too strongly emphasized. Hundreds of such holes have been put down in the State for various purposes, and from comparatively few of such are reliable results now available. Such holes are generally sunk for a definite purpose and when that end is reached it occurs to few that the results may still be valuable for other purposes. But this is almost always the case. Whether a thick coal bed be encountered or not a good record establishes a series of facts concerning the geology of the locality and is, hence, valuable. For instance, the record though *apparently* barren of results of economic value, may show that the drilling stopped in a certain limestone, which, by comparison with a record obtained elsewhere, we know is 20 or 50 feet, as the case may be, above a certain valuable coal bed. Hence, from the study and comparison of these two records we are able to predict the probable existence of workable coal within a short distance of the bottom of the hole. Again, the hole may have penetrated rocks which we recognize as below any coal in the State; in this case the result is of general value in preventing further exploration below this depth. Only from the results of such deep drilling can the area of available coal in the State be exactly determined and the limits of the individual beds be defined, especially in those parts of the State where the coal beds are deep beneath the surface.

The reason why records of value are not always attainable is, however, not only because of negligence on the part of those immediately interested to preserve them, nor yet because of refusal to contribute them. It is unfortunately the case that many holes have been put down by incompetent men, or by men who know merely how to handle a drill without having sufficient knowledge of lithology or geology to be able to accurately describe and record the descriptions of the rocks they encounter, nor to interpret the meaning of all they pass through. In cases it is even worse than this, and the history of many a deep and expensive drill hole in the State shows evidence of trickery and bad faith on the part of the driller towards those in whose service he was

supposed to be working. The uncertainty attending such work has thus brought disfavor in many localities upon deep drilling as a public enterprise; many having acquired the impression that only indefinite results of small practical value could be reached. This impression is wrong and unfortunate, for such work can and should be prosecuted by every progressive community in the coal regions which is anxious to determine the existence of coal beds and to have them developed. In view of these facts the Survey suggests a possible plan of co-operation which, if adopted, would ensure a well conducted drill hole, a reliable record and an official report on the same, and would, at the same time, secure for the State complete results of the drilling in such condition that they can be unhesitatingly used and will be entirely comparable. To any private individual or community desiring to have a *deep* drill hole sunk, the Survey could arrange to recommend reliable men whom the individual or community can employ to do the work of drilling; second, it could supervise this work, and last it could furnish an official statement of the results of this drilling. In return for this service, it would be required that the Survey be allowed full and free use of the results for the benefit of the State. That this would be, in every way, a liberal offer, cannot be disputed. In addition to securing reliable results, the individual would, by this means, be put in possession of a report, which would be, as it were, negotiable. Being of an official nature, from an impartial source, others will place faith in it and will invest money on its authority, for purposes of actual development, where they would not do so, were the report of a private nature, emanating from an interested source. If such a plan of co-operation were generally adopted, the State would soon have accumulated an invaluable mass of material from which it would be possible to outline, with a high degree of accuracy, the general limits of each and every coal bed in the State. From this the prospects of finding coal at any one point could be predicted, as well as its probable depth and thickness when found. Surely the attainment of such a condition of exact knowledge is worthy of our serious efforts.

In the preparation of this report the writer is indebted to members of the Survey for field notes and for assistance in the office. Thus, from Mr. Gluck's notes part of the material for the remarks on Lafayette and Johnson counties was obtained; from Mr. C. F. Marbut's notes material relating to Randolph, Howard, Ray and Caldwell counties, and, from Mr. C. H. Gordon's, additional material relating to Randolph county. The notes for the appendix on the methods of coal mining were almost entirely collected by Mr. Gluck, under the writer's direction, and the

illustrations for the report were all prepared by the former. For assistance in preparing the manuscript for the printer, acknowledgment is due Miss S. R. Mann, the efficient secretary of the Survey; and in correcting and revising the proof, and indexing the report, Mr. J. D. Robertson has given much aid. The statistics of production introduced were all taken from the manuscript of the report of the State Mine Inspector, Mr. C. C. Woodson, kindly furnished by him, as was also the list of coal operators appended. To the officers of the various railways of the State the Survey is under obligations for much assistance extended on many occasions, and the cordial treatment which members of the Survey have received from many citizens, in connection with this as well as all other work, is gratefully appreciated.

ARTHUR WINSLOW.
State Geologist.

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THE COAL DEPOSITS OF MISSOURI.

BY ARTHUR WINSLOW.

CHAPTER I.

INTRODUCTION.

THE COAL MEASURES.

Distribution and Topography—Lithology and Stratigraphy—The Process of Deposition.

DISTRIBUTION AND TOPOGRAPHY.

Distribution. The geographical limits of the Coal Measure rocks, or of strata carrying beds of coal of Carboniferous age, in the State are outlined on the small map inserted at the end of this report. As is there seen, the whole western and northwestern portion of the State is occupied by these rocks. The general eastern and southern boundary of the formation is a sinuous line running from the northeastern to the southwestern corner of the State. Beyond this general boundary there are, further, isolated patches, or outliers of the formation, which carry its limits still farther east. The total area thus included is estimated to be about 23,000 square miles, distributed over 57 counties in whole or in part.[1]

Area of the Coal Measures.

The Topography of the Coal Measures. Topographically the Coal Measure area is a plateau in which denudation has not progressed very far. It is the product of the action of erosion upon a country of moderate elevation, composed of horizontal strata of varying degrees of hardness, in a temperate climate in which vegetation is abundant.

Topographically a plateau.

[1] The outlines shown on the map are substantially the same as those defined by the earlier Geological Surveys of the State, and their maps have been frequently referred to in constructing it. The only changes are of details, including some slight extensions of the areas in some of the border counties. The detailed work of the present Survey has not progressed far enough yet for a more exact map to be attempted; but so far as observation has gone up to the present time it in every way reflects credit upon the early and provisional delineation of the first Geological Survey.

Principal rivers.

The Missouri river traverses the area, from the northwest to the southeast and divides it into two large but unequal portions, that north of the river being considerably the greater. This is the only stream that can be considered navigable. Grande river on the north, and Osage river on the south are the next largest and are used for purposes of local transportation.

Base levelling begun.

The Missouri river has about reached its base level and corrades its channel little, but is extending its flood plain by lateral degradation. The same may be said of the lower courses of the larger streams which empty into this river. As one approaches the head waters of these streams, however, the declivity becomes greater, the flood plain narrower and corrasion more and more active. Away from the immediate vicinity of the larger streams the characteristic contour is that of a flat or

Surface a gently undulating plane.

slightly undulating plain, bordered by gentle and sometimes steep slopes along the drainage channels; in the immediate vicinity of the larger streams the horizontal area on the summits, between the depressions, is smaller and the slopes are steeper and longer. Through Lafayette and Johnson counties, and along the Kansas line, in Bates and Cass counties, mesa like hills are developed, capped by resisting horizontal strata; but these are of only occasional occurrence. North of the Missouri river, and for a

Glacial deposits soften the contour.

few miles south of it, glacial deposits tend to soften the contour of the country, but do not obliterate its distinctive features. Thus, in the immediate vicinity of the river, thick deposits of Loess form a mantel over the surface, while, farther north, a thick layer of silt covered sand and clay occupies the place of the finer material farther south. These deposits round off the ragged edges of the topography and, in places, make a level plain where, in times past, there was a large valley; but the country, as a whole, still preserves the character of an eroded plateau.

Topography adolescent and mature.

The topography may be considered as in an adolescent stage, bordering on maturity in places. The drainage channels are permanently and well established, but corrasion has not yet done all it has to do over a large part of the area; only, perhaps, along the valley of the Missouri river is there anything in the topography suggesting that advanced stage in the erosion of a country termed old age.

The difference between the extremes of altitude within the Coal Measure area is about 600 feet. The elevation of the Missouri river plain at Boonville, in the eastern border being about 600 feet, while that of the uplands, in the northwestern corner of the State is over 1,200 feet. The general elevation of the country above the adjacent drainage levels is from 100 to over 200 feet. Along the marginal line of the Coal Measures, from northeast to southwest, the following are the approximate altitudes at successive points, on the summits between drainage channels: Kirksville 975, Macon city 886, Mexico 798, Moberly 867, Fayette about 800, Boonville about 750, Sedalia 907, Clinton 807, Nevada 870, Joplin 1,018. In the interior of the Coal Measure area, the following are the altitudes at successive points, located similarly topographically: Kansas City about 950, Leavenworth about 1,000, Plattsburg, about 1,000, St. Joseph about 1,050, and Maryville, about 1,200.

Range of altitude.

LITHOLOGY AND STRATIGRAPHY.

Lithology. The rocks of the Coal Measures consist of sandstones, shales, clays, limestones and coals.

The sandstones are of white, drab, yellow or reddish colors, are generally fine grained and friable, and are often filled with specs of carbon and with impressions of leaves and stems, especially along the stratification planes; mica is almost always present. The sandstones are most abundant and prominent in the eastern and marginal area of the Coal Measures, and they there constitute a considerable portion of the section. In the interior, or central area, they are not prominent members, though arenaceous shale is abundant, and it is frequently difficult to say whether such material should properly be classed as a shale or as a sandstone.

The sandstones.

The shales are argillaceous, bituminous, arenaceous or calcareous, and frequently grade, by almost imperceptible degrees, into sandstones or limestones; they are of black, drab, gray and red colors. The shales preponderate by far over any of the other classes of rock, are widely distributed and are about equally prominent in all sections of the Coal Measures.

The shales.

The limestones occur sometimes in massive beds, three and even more feet in thickness, are occasionally concretionary in nodular forms, are sometimes laminated with uneven bedding planes, but are almost always of a fine compact texture; they are of drab color and are readily distinguished from the white, coarse grained, semi-crystalline limestones of the Lower Carboniferous.

The limestones.

The limestones are least abundant over the extreme marginal area, and become more frequent and thicker towards the interior; in the northwestern portion of the State they occur in successive beds aggregating twenty or more feet in thickness. Lime is here very abundantly represented in all the rocks, many of the shales, even the black bituminous layers, being decidedly calcareous. As with the shales and sandstones, so with the shales and limestones it is often impossible to class a rock positively as a limestone or as a shale.

The coals are all bituminous, with the exception of certain local deposits which approach cannel coal in character. The beds range in thickness from one inch to about five feet. The coals are generally soft and pyritiferous, with selenite or calcite almost always present, in thin scales, along the joint planes. They are most frequently underlain by clay, which sometimes contains stigmaria casts, and are generally immediately overlain by black shales, frequently fissile, or by a gray or drab clay shale. In this roof shale leaf impressions are found in places, but the localities are few where such are abundant. Sometimes sandstone rests directly upon the coal, or a limestone cap rock is barely separated from it by a few inches of clay or shale; but such instances are exceptional. The coal beds are most abundant and are thickest over the marginal portion of the Coal Measures, where they occur near the surface and where they have been principally and most extensively operated up to the present time. They seem here, however, to be more irregular in character and distribution than in the interior, so far as one can judge from the limited developments which have been made in the deeply seated coals of the interior region.

The coals.

Stratigraphy. The Coal Measure rocks of Missouri are arranged in a series of strata which have, generally, a slight undulating, westerly dip, such that the uppermost rocks are at

the surface in the northwestern portion of the State, and lower rocks crop out along the margin to the east. Thus, could we cleave open the earth along the line running from the northwestern corner of the State eastward through the Coal Measures there would be exposed to our view an arrangement of strata, somewhat as is represented in the adjoining Fig. 1. General cross-section.

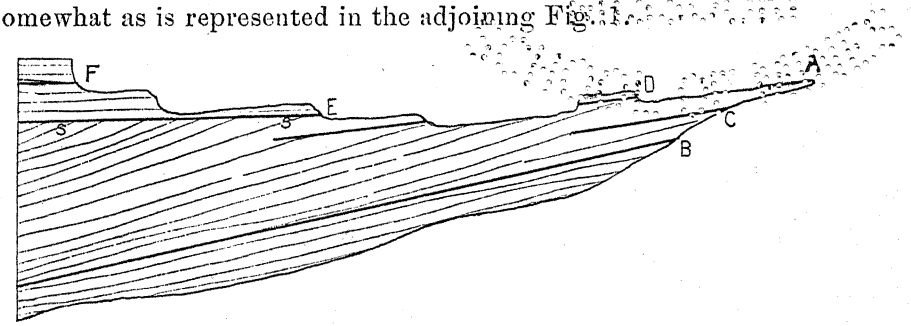


FIG. 1. Ideal section illustrating the arrangement of strata in the Coal Measures after elevation and erosion.

The estimated maximum thickness of these Coal Measure rocks is about 1900 ft. That is, to penetrate the entire section of these strata at point F, (Fig. 1) in the northwestern corner of the State, a shaft 1900 feet deep would be necessary. Eastward from such a point, the thickness of the underlying rocks constantly diminishes, owing partly to the westward tilting of the strata, above referred to, and partly to the conditions under which these strata were deposited, which is hereinafter discussed. Therefore the thickness of this formation at any point within the area of its distribution may be anywhere from 0 to 1900 feet.[1] Total thickness about 1900 feet.

[1] For the measurement of this total thickness, so deep a shaft has never been sunk at any one point; but, through the influence of the westward dip of the rocks, various strata are successfully brought to or near the surface at numerous points and, from a series of separate measurements of the individual strata, or groups of strata, the general thickness is compiled. It is as if the distance between two floors of a house were determined by adding together the height of each step of a flight leading from one floor to the other. Were each and every stratum successively brought to the surface, and were each stratum continuously of the same thickness and character, then this method would furnish an exact means of determining the true section at any point; but, unfortunately for its accuracy, some strata are probably nowhere exposed at the surface and some vary both in thickness and character as they are traced from point to point. Hence the method is recognizably a provisional one, and, though often yielding good results when applied to limited areas they are always open to correction or substantiation in detail as development proceeds.

Thus, along its margin, the Coal Measure formation may be considered to taper to a feather edge while in the extreme northwestern corner of the State, it has an aggregate thickness of nearly 2,000 feet and consists of more than 200 strata.

On the basis of the figures given on p. 21 we have an elevation of about 900 feet for the floor of the Coal Measures at the margin near Sedalia, and, in the extreme northwest, the elevation of the floor is about minus 700 feet; the consequent present slope of this floor is 1600 feet in a distance of some 150 miles, which is equivalent to about 10 feet per mile, or about one-tenth of one degree, which is almost horizontal. The elevation of the surface of Maryville is about 1200 feet, so that the thickness of the Coal Measure rocks there, *above the level of Sedalia*, is only 300 feet.

Slope of floor only 1-10 degree.

Among the most noticeable features of the stratigraphy of these Coal Measures is the variability of details. Strata are characteristically non-persistent, both as regards thickness as well as material. Beds of coal thin out and disappear; beds of shale pass into sandstone or grade into limestone, as the case may be; limestone beds fluctuate greatly in thickness or may be present or absent in not widely separated localities. These conditions are particularly prevalent over the marginal area, among what have been considered the Lower Coal Measure rocks. Swallow,[1] Norwood[2] and Broadhead[3] all refer to such variations in sections, and they are encountered in mining operations, often to an embarrassing extent. Of most conspicuously irregular distribution are the sandstones of the marginal area. These sandstones may be divided into two classes. First, there are the regularly interstratified beds, ranging from two to ten or more feet in thickness, which, though less persistent than the other beds, can yet be recognized clearly as interstratified members over considerable areas. Second, there are the great, massive deposits of sandstone, sometimes exposed to a thickness of 50 or 60 feet without displaying any bedding planes. These may be connected with the thinner interstratified beds, but where they attain their characteristic development, they cannot be classed

Strata very variable.

Sandstones especially so.

[1] Report Mo. Geol. Sur. 1855, p. 87.

[2] Report Mo. Geol. Sur. 1873–74, pp. 200 to 215.

[3] Report Mo. Geol. Sur. 1872, part II, p. 166 and elsewhere.

as interstratified beds of the Coal Measures; but, apparently, are deposits filling channels which were eroded in the Coal Measure strata presumably during the Coal Measure period.[1]

The fauna of the Coal Measure rocks indicates the existence, over the marginal area, in what have been termed the Lower Coal Measure rocks, of brackish and shallow waters; while, in the interior, among the rocks designated Upper Coal Measures, marine forms are more abundant. There is nothing at all pronounced in the fauna which would call for great priority of deposition of the rocks of the marginal area over those of the interior.

Coal Measure fauna.

THE PROCESS OF DEPOSITION.[2]

From a consideration of the facts and conclusions presented in the preceding pages it appears that the following conditions must be satisfied by any interpretation of the process of deposition which may be offered.

Essential conditions of deposition.

1. That the marginal conditions were generally those of brackish water, favorable for the formation of the coal beds.
2. That marine and deep water conditions were more frequent over the central area, permitting the deposition of thick beds of limestone.
3. That, during the process of deposition, the strata from the base to the top of the Coal Measures were, at intervals, at or near the surface of the water, permitting the growth of the coal flora and the accumulation of coal.
4. That at least some of the strata were deposited in an exactly horizontal position.

[1] These channel deposits are in places a mile or more wide and apparently 200 or more feet thick; they limit sharply the coal beds and the other regularly deposited strata. Their distribution is being carefully studied by the State Geological Survey, and they promise to prove most valuable and interesting subjects of study. Their exact age is not at present determined, and it is possible that they may ultimately be assigned to the Permian or even to a later period. On the other hand, if they can be traced beyond the limits of the Coal Measures, it is possible that at least a part of the sandstone which has been classed as the Ferruginous sandstone of pre-Coal Measure age, really belongs to this formation.

[2] The following discussion of the process of deposition, as well as the matter of the two preceding pages, is extracted from a recent communication of the writer's to the Geological Society of America. (Bull. Geol. Soc. Am., Vol. 3), to which the reader is referred for fuller treatment of the subject.

Prevalent ideas concerning Coal Measure divisions.

According to views heretofore presented the Coal Measures of Missouri have been separated into an Upper, a Middle and a Lower division, respectively 1317, 324, and 250 feet thick,[1] all having a slight dip a little north of west. The common conception regarding these divisions, as well as those of the contiguous Iowa Coal Measures, is that they underlie each other successively, and that, should the strata of the Upper Coal Measures in the northwestern part of the State be penetrated by a shaft, the members of the Middle and Lower Coal Measures would be successively encountered. The reservation is generally made, however, that some of the beds will probably thin out, disappear or be replaced by others, so that exactly the same succession of strata cannot be expected, though, whatever may be included under the indefinitely applied term "Formation," is considered to be continuous. The adjoining Figure 2 represents, in a general way, the implied and commonly conceived idea of the positions and relations of these divisions of the Coal Measures.

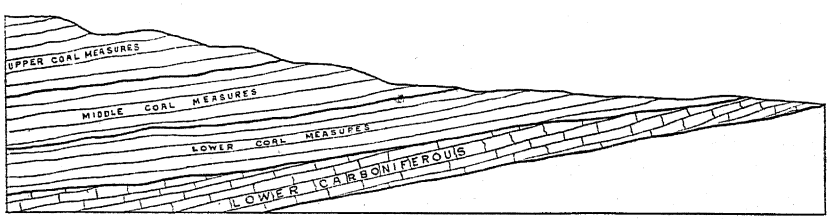


FIG. 2. Diagram illustrating the commonly conceived positions of the Coal Measure strata.

Strata originally horizontal.

The nature of some of the Coal Measure strata demands horizontality of position at the time of deposition and as, according to the above representation, the strata are parallel with each other, they must, on this interpretation, all have been deposited as horizontal layers and subsequently tilted simultaneously into the present position. Further, the existence of coal beds near the base of this formation shows that even the lowermost strata were accumulated near the surface, and, hence, to produce the conditions generally pictured, would require a regional subsi-

[1] Report Mo. Geol. Survey, 1872, Part I, p. 6.

dence of about 2,000 feet, equal in rate and amount over the whole area, with which the process of deposition kept pace equally and exactly over every portion. An ideal restoration to a horizontal position of these strata is represented in Figure 3, and it is there apparent, at a glance, that, proceeding on this

Subsidence of 2,000 feet called for.

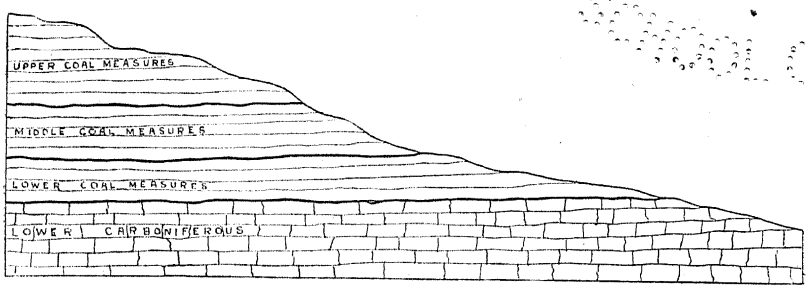


FIG. 3. Same as Fig. 2, with strata in a horizontal position.

supposition, the portions, of at least the upper parts of the Coal Measure formations, represented could be only small remnants of the whole, and that, with the indicated thicknesses, they must once have spread over the higher Ozark region, as well as over the area of lower rocks in northern Iowa. We cannot believe such extension possible without, at least, some remnant of these rocks being left over the territory where they are now never found; such hypothesis is opposed to the views which have been advanced concerning the age and history of the Ozark Uplift; it is contrary to the authoritative and generally accepted opinions concerning the original limits of the Coal Measures both in Missouri and Iowa.[1] Such representation of the relation and positions of the Coal Measure strata leading to conclusions contrary to accepted views, it behooves us to attempt a presentation of the results and of the process of deposition which will be in harmony with the observed facts and well-substantiated conclusions.

Original limits of the Coal Measures.

[1] A more detailed statement of the reasons for not favoring the hypothesis of early great extension of the Coal Measures is contained in the Bulletin of the Geological Society referred to on p. 25. A full discussion of the subject is reserved, however, for the complete report on the Carboniferous.

Strata near base of shallow water origin.

Starting with the indisputable fact, as proved by deep drilling and shafting in the western portion of the State, that at or near the base of the Coal Measures here, are strata of shallow water origin, we must allow that the floor in the interior was, at the beginning of deposition, near the surface. We will assume next that submergence began over the central area of the Coal Measures, and that, as represented in Figure 4, the margin of the early Coal Measure sea or swamp, B, was well within the present limits, A, of these deposits. As soon as this

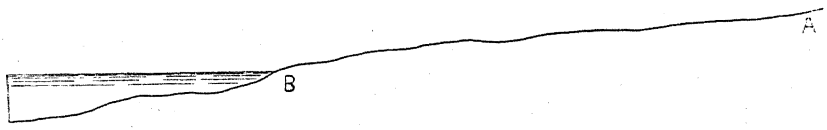


FIG. 4. Diagram illustrating conditions preceding deposition of Coal Measure strata.

area became submerged, deposition over it would begin; but, as all material is derived from or beyond the margin, the accumulation during this stage or period would be thickest along the margin and would taper thence gradually towards the interior, the character of the material changing at the same time. The marginal area would thus be the first to become a shallow water area, suitable for the formation and accumulation of coal. As the basin became gradually filled with sediment from the margin towards the interior, the coal swamp would slowly creep out horizontally, until it covered the whole surface in a continuous sheet, the coal barely unconformable with the underlying strata, which were accumulated in slightly inclined positions. Figure 5 repre-

Coal beds grow from margin outwards.

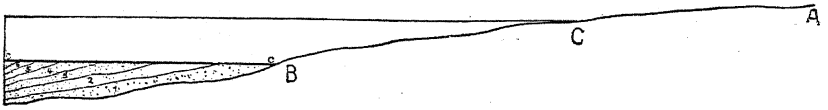


FIG. 5. Diagram illustrating early conditions of deposition.

sents the resulting conditions provided deposition is continued and subsidence is arrested. The number of deposits cannot be taken to represent, strictly speaking, so many individual and separated strata, as each one may be made up of a varying number of layers of different materials; they simply indicate the limits

reached by the deposits in successive intervals of time. The apparent dip and the consequent unconformity of the coal layer, C—C, upon these underlying strata, is also much exaggerated by the excessive vertical scale; if reduced to the natural scale neither the dip nor the unconformity would be perceptible at any one point.

Thickness and extent of coal bed dependant upon rate of subsidence.

The natural result of such a growth of sediment is that a coal bed will be thicker near the margin, where its accumulation begins and continues longest, than in the interior, and the thickness of the bed, at any one point, will depend upon the length of time during which subsidence is arrested and the accumulation is allowed to go on. The coal bed may expand over the whole area as is represented in Figure 5, and may there accumulate to a thickness of several feet and then be cut short by a submergence to the point C, when another cycle of deposition will begin, similar to the first.

Stratigraphic variations explained.

Changes in the amount and character of the sediment supplied at any time during such a cycle would cause corresponding changes in the thicknesses and character of the strata. A rapid, continuous, or a frequently recurring subsidence would prevent the accumulation of coal, or would allow of its formation only over narrow marginal areas. A subsidence, after the coal bed had expanded over a half or other fraction of the submerged area, would fix a limit to that individual bed at such point, and it would be buried beneath the strata of the succeeding cycle of deposition. A varying rate of subsidence over different areas would also affect the character of the deposits; where the rate was greatest deep water or marine conditions would be more prevalent, and where the rate was slow shallow water conditions would prevail generally and coal beds would be most frequent. If the rate of subsidence over the interior is constantly greater than that over the marginal area, the first formed and lowest beds would gradually acquire a western dip, while the uppermost bed is horizontal, and the aggregate thickness of the deposits would increase towards the interior, although the thickness of an individual stratum, or of a heterogeneous deposit formed during any selected interval of time, would diminish, proceeding from margin into interior. If subsidence were arrested along the margin and con-

tinued in the interior, the deposits would taper to a feather edge along this margin. On the other hand, if there is elevation along the margin and subsidence in the interior, the succeeding deposits would taper out within what were previously the marginal limits, and would abut against the underlying strata. If subsidence is arrested in the interior and continued over the margin, coal beds might be formed in the interior which are not represented over the margin.

Subsidence and deposition.

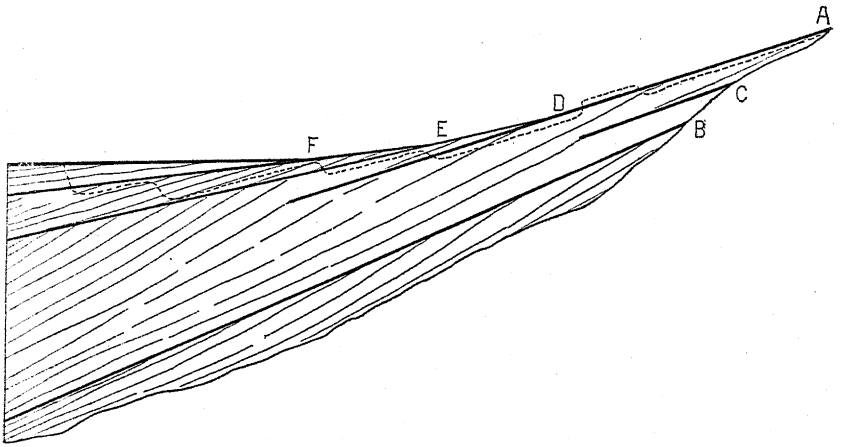


FIG. 6. Diagram illustrating final conditions of deposition.

Figure 6 is an ideal representation of what would result with a certain sequence of events of the character suggested. At B is a coal bed originally horizontal, which extended entirely across a submerged area before subsidence set in again; at C is another bed which extended, however, only a short distance before being submerged; at A is a third coal bed which had a longer period of growth than C, but which was also cut off by a sinking of the strata. From the divergence of the lines, A and B it is evident that the rate of subsidence was greater over the interior than at the margin. Before the formation of the bed, D, the margin, A, was elevated and the depression in the interior continued, and these opposite movements were kept up during the periods of accumulation of the strata E and F and of those intervening between these. Figure 1, on p. 23, represents the same group of beds after they have been elevated above the

Illustration of process of deposition.

water, such that the upper beds are lifted above the extreme margin. It is, of course, impossible to represent in any such diagram the infinitely complex association, and the varied succession of strata which resulted from all the combinations of conditions which probably prevailed during the deposition of the Missouri Coal Measures; but, always allowing for the great exaggeration of thicknesses and of angles of dip and slope, Figure 1 will probably suggest all of these.

Details impossible to represent

The careful study of the above outlined hypothesis and of the accompanying illustrations will show that it is calculated to satisfy fully all of the conditions enumerated on page 25; such a study will reveal: —

a. How a moderate amount of erosion will suffice to produce the present limitations of the upper strata.

b. How coal beds are more abundant over the marginal area.

c. How the interval between any two strata may be very different at different points.

d. That a columnar section, constructed from outcrop measurements of successively exposed strata from margin to topmost layer, will not represent the succession of rocks in such a section as at A in Figure 1.

e. That a coal bed may, at one point, immediately overlie strata which are widely separated from each other in some exposed section at another point, and, hence, that two separated outcrops of the same coal bed may easily be mistaken for outcrops of two different beds.

Conclusions from hypothesis of deposition.

f. That the strata cropping out along the margin are not necessarily the lowermost, even though they dip towards the interior, and that beds encountered at the base by drilling in the interior may be of earlier age than these marginal beds.

g. That the arenaceous character of the marginal deposits is an essential attribute of their location and not one of their age, and that sandstone, shale or limestone may be prevalent among the upper or lower beds of the Coal Measures according as they were marginal, shallow water, or marine portions of the deposit.

A true section a possibility of the future.

Something like a true section of these Coal Measures strata can ultimately be constructed by the present State Survey, after all the many sections and records obtainable have been studied and correlated. Until then we must proceed with extreme caution, with the anticipation that all the intricacies of deposition which the conditions herein referred to call for, may exist and will have to be unraveled.[1]

[1] The phenomena from which the hypothesis of deposition above outlined is deduced are not peculiar to Missouri, but have been observed and recorded in adjoining States and in other regions. Quotations from such records are included in the paper by the writer already referred to, in Vol. 3, Bull. Geol. Soc. of America, and a mere reference to the various publications cited from will suffice here. These are: —

1. Report Iowa Geol. Survey, 1858, James Hall. Vol. I, Part I, p. 135.
2. Report Iowa Geol. Survey, 1870, C. A. White. Vol. I, pp. 227, 250, 259.
3. The Stratigraphy of the Iowa Coal Measures, C. R. Keyes. Bull. Geol. Soc. America, Vol. II, pp. 282, 284, 285.
4. Report Ohio Geol. Survey, 1875, J. S. Newberry. Geology Vol. II, pp. 117, 166.
5. Report Ohio Geol. Survey, 1884, E. Orton. Economic Geology, Vol. V, pp. 135, 137.
6. Stratigraphy of the Bituminous Coal Field of Penn., Ohio and West Virginia, by I. C. White. Bulletin No. 65, U. S. Geological Survey 1891, pp. 100, 181.
7. The Upper Coal Measures west of the Alleghany Mountains, by J. J. Stevenson, Ph. D. Trans. Amer. Ly. of Nat. Hist. of N. Y., Dec. 16, 1872, Vol. X, No. 9, pp. 226 to 252.
8. On the Alleged Parallelism of Coal Beds, by John J. Stevenson. Proc. Amer. Phil. Soc., Dec. 18, 1874, Vol. XIV, No. 93, pp. 283 to 295.
9. The Structure of Coal Beds, by J. J. Stevenson, 1878. Chap. XXI, pp. 283 to 303. Report K. K. K., Ligonier Valley, Second Geol. Survey of Pa.

The inference from these references is plain, that the explanation of the general process of deposition in Missouri applies to other areas, and is doubtless of wide applicability, at least so far as the Coal Measure deposits are concerned, and perhaps with regard to other formations.

CHAPTER II.

THE COAL BEDS.

THEIR DISTRIBUTION AND CHARACTER.

The conditions restricting distribution — The conditions restricting availability.

No one coal bed in Missouri can be affirmed to be co-extensive with the area of the Coal Measures and, within a still smaller area, does any one bed possess those characteristics of thickness and quality, or is it accompanied by the other conditions which go to make it workable. The conditions of principal importance restricting the distribution of Missouri coals may be classed as follows: — Workable area of a coal bed limited.

1. The general eastward rise of the strata.
2. The results of erosion and land degradation as exhibited in the existing topography.
3. The presence of buried channels, of various ages, indistinguishable in the existing topography. Conditions restricting distribution.
4. The original limits of the individual coal basins and the consequent thinning out of the beds towards their margins.

The conditions of importance restricting their availability are: —

1. Inadequate thickness of the coal.
2. A poor roof such that the process of mining becomes dangerous, highly expensive, or both.
3. Disturbances which have produced faults or have caused a squeezing or a partial erosion of the coal bed, giving rise to what are known as slips, rolls, horse backs, clay seams or faulty coal. Conditions restricting availability.
4. Inferior quality, such as renders it unfit for use.
5. Excessive water, such as cannot be economically handled by pumping.
6. Excessive depth, such as makes the cost of shaft sinking, hoisting and pumping too great for profitable mining.

THE CONDITIONS RESTRICTING DISTRIBUTION.

Effect of dip of strata.

1. *The effect of the eastward rise of the strata* in restricting the distribution of the coal will be readily appreciated from consideration of what has been said and illustrated on p. 24 concerning the westward dip of the strata and the successive outcropping of strata as one proceeds in that direction. Thus, as

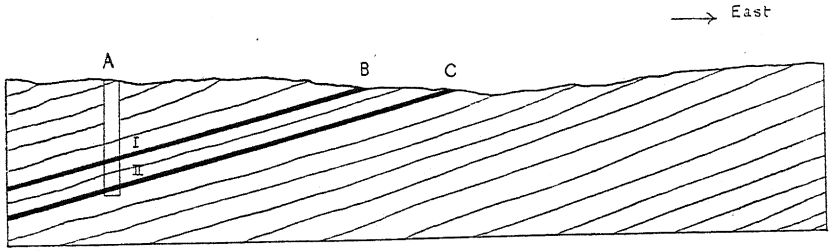


FIG. 7. Diagram illustrating the "dip" of coal beds.

illustrated in Fig. 7, a coal bed, I, penetrated by a shaft at a point, A, will, by reason of the westward dip, rise to the surface farther east at a point, B. Similarly a deeper coal bed, II, will crop out at a point, C, the distance between the points, A and B, Illustration of dip. or the points, A and C, being dependent upon the depths at which the coals are struck in the shaft, at A, upon the general angle of inclination or dip of the coal beds, and upon the relative altitudes of the points, A, B, and C. Just where the outcropping line of each or any coal bed, or its stratigraphic equivalent in the State is or may be, is a question which cannot be determined without the most detailed field work and the most careful scrutiny and comparison of shaft and drill hole records.[1]

Process of erosion. 2. *Erosion* is that process of nature by which the surface of the land is carved into valleys and hills and is gradually lowered. Its principal agents are rain, snow, ice, wind and running waters, their action is constant and their effects are everywhere

[1] Such work is being prosecuted by the Survey in connection with the detailed mapping and the results will be embodied in the resulting maps and accompanying reports. In the meantime the block map (Plate I.) at the end of this report conveys some intimation of the stratigraphic limits of the coal beds and suggests the possible relation between some of the beds operated at different localities.

observable. Viewed in a large sense erosion has had an influence of the first order upon the distribution of the coal, inasmuch as it has probably removed, during the past ages, large portions of the Coal Measure rocks and the accompanying coal beds, as is shown in Fig. 1, on p. 23. But, viewed in a narrower sense, the effects of land degradation upon the distribution of coal, as exhibited in the existing topography, are of importance only when the coal is near the surface or when the difference in elevation between hill and

Effects of erosion.

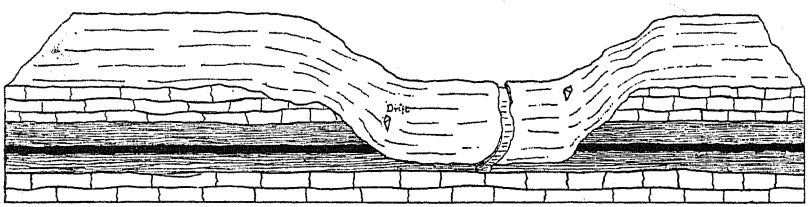


FIG. 8. Diagram illustrating the effects of erosion.

valley is great. Of very common occurrence in Missouri is such an instance as is exhibited in Fig. 8, where the erosion of a stream has carved a channel through the strata and the associated coal bed so that the coal terminates or crops out in the hill-sides bordering the valley. The larger the stream the wider the valley, and, as the stream proceeds from its source, the valley tends constantly to widen so that, in some counties, many square miles of coal have thus been removed. As if in compensation, however, such process of erosion renders the exposed coal beds easy of access and permits of their being worked without shafting, by drifts. Such drift mining is common in Macon, Randolph, Ray and Lafayette counties. It is generally along the eastern border of the Coal Measures that this effect of the process of land degradation is most apparent.

Details of erosion.

3. *The presence of buried channels* in the Coal Measures may also be considered a result of erosion; inasmuch as this cause originally produced the channels and established the limits of the coal; but they are not readily recognized as such upon the ground and are hence given separate consideration here.

Buried channels in the Coal Measures.

Two classes of such buried channels may be distinguished.

First are those which, probably, are of late Coal Measure age and which are filled with a material, once sand but now consolidated to a more or less coherent sandstone. These channels are referred to on p. 25. They were probably formed during some temporary elevation of the Coal Measure strata above the level of the water in which the latter were previously laid down. The uppermost strata must then have been in a barely coherent condition such that they were quickly corraded by water flowing upon their surfaces; thus ravines and broad valleys could have been formed during short periods. A sinking of the strata would cause a renewed submergence and all loose and abraided material would become suspended in the waters; of these the sand, as the heavier portion, would naturally settle into the eroded channels and other depressions, even at the beginning when the waters were more or less in a condition of commotion. In Fig. 9, an attempt is made to represent a section through such a buried channel, now filled with sandstone. Its independence of the

Channels filled with sandstone.

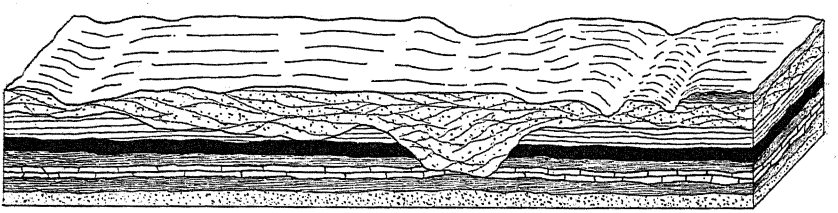


FIG. 9. Diagram illustrating buried channels of Coal Measure age.

present topography is there indicated. On the right hand side of the sketch the sandstone is shown to be directly the extension of a layer of sandstone interbedded with the other Coal Measure rocks; while, on the left, it is made to appear as an independent and superior layer to any other. Either condition may exist in nature. Buried channels of this character have been recognized in Johnson, Lafayette, Randolph and Monroe counties; they have an important bearing upon this distribution of the coal, inasmuch as they are in places over a mile wide and extend lengthwise entirely across the counties. They doubtless occur in other counties and their distribution will be defined as the detailed mapping of the Survey is extended.

Distribution of such.

The second class of buried channels are of much later age geologically and belong to what is known as the Quaternary or Pleistocene period; at least the material filling them is of this age. The channel proper may have been in process of formation ever since the close of the Carboniferous period. They differ from the first class of channels in that the filling material consists of loose clay, sand and gravel similar to that spread generally over the surface of the surrounding country with which it is contemporaneous in age. In Fig. 10 such a buried channel

Channels filled with drift.

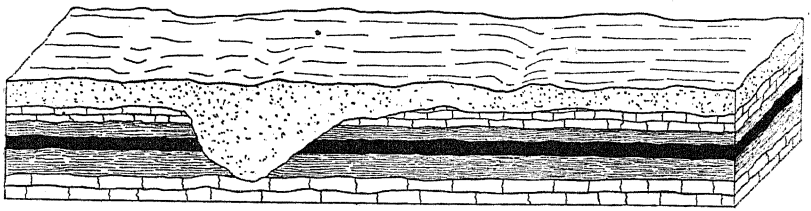


FIG. 10. Diagram illustrating buried channels of pre-Glacial age.

is represented. It is to be distinguished, further, from one of the first class, in that the filling material is not a Coal Measure rock and is never the equivalent of any one of the members of that formation, which may sometimes be the case with the first class, as is alluded to on p. 36. Such channels occur north of the Missouri river and are best developed in the drift covered area of the northern portion of the State. They have been recognized in Putnam, Sullivan and Linn counties, and doubtless occur elsewhere. When encountered in coal mining the coal is cut off abruptly, and, sometimes, the influx of water and sand is so strong as to cause the abandonment of the mine. These channels, therefore, not only reduce the area of the coal but further present obstacles to the operation of mining.

Distribution of such.

4. All coal beds have been deposited in basins of greater or less area and depth; they constituted, at the time of formation of the coal, great lagoons or swamps in which the material for the coal beds accumulated. The margins of such a swamp, or shallow sea, constituted the limits of each coal bed and towards these limits the coal gradually tapered to a feather edge. Fig. 11 illustrates this idea and shows the manner in which such a

Lenticular nature of coal beds.

Tapering of coal beds.

coal bed is subsequently covered by the succeeding deposits. In the operations of mining, such a tapering coal bed is seldom, if ever, followed to its extreme limits, but work is generally

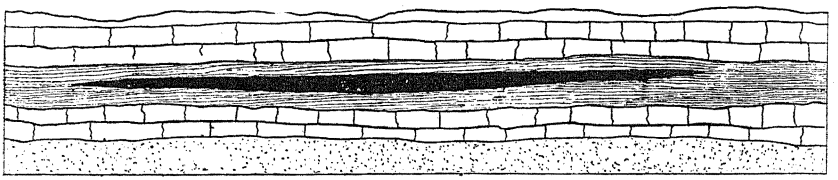


FIG. 11. Diagram illustrating the lenticular nature of Coal beds.

abandoned long before this; as soon as the coal becomes reduced below a workable thickness. An extreme illustration of such limitation of a coal area is furnished by those remarkable deposits known as coal pockets which occur in the region bordering the Coal Measures. Here the coal often attains a thickness of 20 and more feet while the area of the basin may be only a few acres. Such deposits have apparently accumulated in ravines or sink holes in the Lower Carboniferous and lower rocks, which existed before and during the Coal Measure period.

Coal pockets.

THE CONDITIONS RESTRICTING AVAILABILITY.

Thickness of workable beds.

1. *Inadequate thickness* is a condition restricting the availability of a coal which will be readily understood with little explanation, though just what thickness is inadequate is a relative and a locally variable term. Coal beds vary in thickness from an inch, or less, to many feet. In a region like Pennsylvania, where beds 6 to 10 feet thick abound, a thickness of three feet has been generally considered as little as can be profitably mined. In Missouri, however, three feet is nearer an average thickness than under it, and beds as thin as eighteen inches are profitably mined on a large scale. Any bed uniformly thinner than this cannot ordinarily be considered available. About a fourth of the annual production of coal in the State is from beds not over two feet in thickness. Beds three and four feet thick are of frequent occurrence, especially in Macon, Randolph, Henry and Bates counties; but they are not so abundant nor so wide-spread

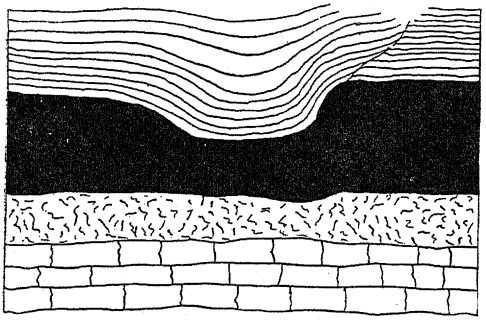
as to make the two foot bed unworthy of consideration. Other conditions leading to the mining of thin coal beds are enumerated in the chapter on the Coal Industry, on pp. 45 to 46 of this report.

2. *A poor roof* renders mining both expensive and dangerous. If the strata overlying the coal are of a loose friable material, such as falls soon after the removal of the coal, or if the overlying beds are fractured and crushed, large pillars of coal have to be left to sustain this roof and much timbering becomes necessary in both the rooms and entries. With a roof of a tough or hard material timbering can, at times, be entirely dispensed with. Difficulties in mining from a poor roof arise in Sullivan, Macon, Adair and Henry counties, but over a large portion of the coal mining area in the State the roof is excellent and offers no obstacle to mining. The quality and condition of the roof is not regional, but often varies greatly within one mining district; this is especially the case in Macon, Randolph, Boone, Clay and Henry counties.

Effects of a poor roof.

Character of roofs in the State.

3. *Disturbances* are quite common in certain Missouri coal beds and they seriously impair the value of the coal. They are particularly noticeable in the mines of Audrain, Montgomery, Boone, Caldwell, Adair, Schuyler and Clay counties. The most common form of disturbance is that resulting from



Disturbances in coal beds.

FIG. 12. Diagram illustrating roof "rolls" of Coal beds.

unequal pressure, producing partial faulting and crushing of the coal. This is illustrated by Fig. 12. Sometimes such disturbance extends entirely through the coal bed, elsewhere it only slightly indents the roof; but almost always the coal under it is

crushed and worthless, and the clay or coal on the sides of the fault is highly polished. A somewhat similar effect is produced when, through the action of erosion, hollows or channels have been scooped out in the upper portion of the coal bed, and subsequently filled by the material of the roof. This action sometimes noticeably diminishes the thickness of the coal, but it is distinguished from the preceding in that the coal is not crushed and polished; it is generally not so injurious in its effects as the action last referred to.

Erosion of coal bed.

4. *An inferior quality* of coal is generally the result of the presence of an excessive amount of iron pyrites ("sulphur") or of an excessive amount of clay, shale or ash; or it may be due to the fact that the physical character of the coal is such that it crumbles or slacks readily on exposure. Pyrite in coals indirectly produces slacking, causes spontaneous combustion, injures it for the production of gas, causes clinkering of the ash, damages grate bars and boiler flues and produces a suffocating smoke. Shale and clay diminish the amount of fuel in every pound of coal and increase the amount of ash to be handled. All Missouri coals are bituminous, with the exception of the cannels, which are found in local and small deposits. The bituminous coals have, as a rule, a high percentage of ash, as compared with the best bituminous coals; they are comparatively soft, suffering much from excessive handling or long exposure, and they almost always carry pyrite, either in lenticular or nodular concretions or in thin plates between the joints of the coal. The last, accessory, as stated, injures them for use in the manufacture of illuminating gas, though many of the coals have an abundance of hydro-carbons of high candle power.

Impurities in coals, and effects.

Character of Missouri coals.

5. *An excessive amount of water* in a mine makes the cost of pumping proportionately great, and it further embarrasses the process of mining by making entries and rooms wet, necessitating constant expenditure in providing for proper drainage throughout the mine. Missouri coal mines are not much troubled by such excess of water, in fact, many of the mines are so exceedingly dry that they are actually dusty.

Excessive water.

6. *Excessive depth* is entirely a relative term. The thicker and the better a coal bed and the more favorable the surrounding

conditions, the greater the depth at which it can be profitably mined. Most of Missouri's coal mines are less than 200 feet deep. The Randolph shaft in Ray county is 420 feet deep to the coal and is the deepest which is, exactly speaking, within the State. At Leavenworth, in Kansas, along the State line, however, a coal bed of only 22 inches is extensively worked at depths varying from 700 to 800 feet. This is, probably, near the limit of depth at which a bed of good coal, of this thickness, with a good roof, can be profitably mined, at least at the present date and with the present condition of the coal industry.

Depth of profitable mining.

CHAPTER III.

THE COAL INDUSTRY.

The coal production — The coal market — The uses and adaptabilities of the coals — The available tonnage and duration of supply — The value of coal and coal lands.

THE COAL PRODUCTION.

Production of 1881, 2,650,028 tons.

The total production of coal in Missouri for the year ending June 30th, 1891,[1] was 2,650,028 tons, valued at 3,480,867 dollars. According to Bulletin No. 10 of the Eleventh Census, Missouri ranks second as a coal producer among the States west of the Mississippi river, Iowa being first with a production of a little over four million tons. Colorado is ranked next after Missouri, her production being 2,544,144 tons, and Kansas is fourth with a production of about 2,200,000 tons per annum. After these, no other of the western States approach Missouri in the amounts of coal produced. According to the same Bulletin Missouri ranks ninth as a coal producer among the States of the Union, Pennsylvania leading off with the magnificent figure of over 80,000,000 tons, Illinois being next with about 12,000,000 tons, Ohio third with nearly 10,000,000 tons, West Virginia next with over 6,000,000 tons, and then Iowa, Alabama, Maryland, and Indiana preceding Missouri in the order given.

Missouri second west of Miss., ninth in the Union.

The amount of coal produced in the State is, thus, both absolutely and relatively large. Its value is greater than that of any one other mineral product in the raw state, the production of lead for the year ending June 30th, 1891, according to the State Mine Inspector's figures, being valued at $2,411,399, that of zinc at $2,673,073, and of iron at $331,665.

Coal value.

According to the list of coal mine operators appended to this report there are, in all, 385 individuals and corporations engaged in mining coal. Of these, one organization mines *about a fourth* of the total amount produced each year; ten companies

385 operators.

[1] According to the figures kindly advanced by the State Mine Inspector.

mine together nearly two thirds of the total amount and sixty individuals and companies mine together about five-sixths of the total, leaving for 325 individuals and companies the production of one-sixth.

The principal coal producers, in the order of the amounts of their products, are: The Rich Hill Coal and Mining company, the Western Coal and Mining company and the Lexington Coal and Mining company, these three being under one management, with mines in Bates and Lafayette counties; the Kansas and Texas Coal company, with mines in Macon, Ray and Linn counties; the Keith and Perry Coal company, with mines in Henry and Bates counties; the Richmond Coal company with mines in Ray county; Loomis & Snively, with mines in Macon county; the Mendota Coal company, with mines in Putnam county; the Interstate Coal and Mining company, with mines in Randolph county, and the Randolph Coal company, with mines in Randolph county. Principal coal producers.

THE MARKETS FOR MISSOURI COALS.

The conditions affecting the market of the coals west of the Mississippi river are, in some respects, different from those in the eastern part of the country. The Western Bituminous Coal Field is surrounded on all sides by large expanses of country destitute of merchantable coal.[1] These great areas with their constantly increasing population and needs, must, under natural conditions, draw their supplies of coal largely from the mines of Iowa, Missouri, Kansas, Arkansas, Indian Territory and Texas. Area to be supplied with coal.

These geographic conditions are illustrated in Fig. 13, which shows the area of the Coal Measures in the respective States. The area of *workable coal* is much more restricted, however, especially in Kansas, Arkansas, Indian Territory and Texas,

[1] In eastern Texas and southeastern Arkansas are large areas unlain by lignites, or brown coals. These have been in the past, only of limited, local use. Recent investigations, by the Geological Survey of Texas, have shown that these lignites are equal in character to those which are widely used in Europe. They will probably become merchantable in the future. That they will be extensively substituted for bituminous coals in the most important uses of the latter, is, however, an expectation which does not seem at present warranted.

only a small portion of the Coal Measure areas there being productive. East of these areas their coals are brought into competition with the coals of Illinois, Indiana, Kentucky and Ohio in the north, and with those of Tennessee and Alabama in the south; even the anthracites of eastern Pennsylvania are sold within the very limits of these western coal fields, on account of their special adaptabilities. The natural facilities for transport-

Competing areas.

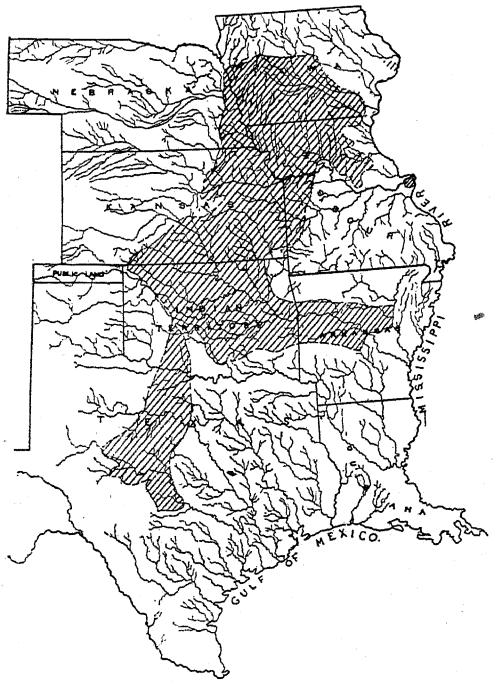


FIG. 13. Sketch map showing the Coal Measure area and the contiguous barren area in Missouri and adjacent states.

ation provided by the Ohio and Mississippi rivers enable the coals of western Pennsylvania and of Ohio to compete very successfully with the geographically much nearer western coals, especially along the lower Mississippi. Further, through the distribution of railway lines and adjustments of rates, Illinois coals force the competition line much farther west than would seem possible from geographic considerations. Thus the

Influence of Ohio and Miss. rivers.

territory affected by this competition to the east, is large, and it will probably always be considerable, though subject to variations.

Towards the west, however, there stretches a great area of country in Nebraska, Kansas, Indian Territory and Texas, which is not only destitute of coal, but which has, further, a sparse supply of timber to answer as a substitute for such mineral fuel. This is especially the case in Kansas, and its effects upon the Missouri coal industry is important. West of this coal-barren area are the deposits of Dakota, Wyoming, Colorado and New Mexico, which are to a certain extent competitors in the market and which may become more so in the future. It is not to be anticipated, however, that this competition with the coals of Missouri and adjacent States will reach very far east, for the latter coals are generally superior in quality to those farther west, which are largely lignitic, and the supply of superior coals in Colorado and New Mexico appears to be not more than is needed to satisfy the home needs and the more imperative demands for coal still farther west.

Markets to the West.

Thus the coal-barren area surrounding the Western Bituminous Coal Fields may be looked upon as a most promising market for the future, especially that to the west where the population is destined to increase rapidly in the next few years, with a proportionate increase in coal consumption.

In addition to the foreign market, however, there is in Missouri a good home market; one which is destined to increase greatly in the future and which will always be a steady consumer of coal and the most substantial supporter of the coal industry. The coal fields of Missouri are not located in a mountainous, rugged, or sterile country; on the contrary they are in a country of moderate elevation, with gently undulating surface, where bluffs and steep declivities occur only along the largest streams; a country with a most fertile soil in a well advanced stage of cultivation. It is already well populated, a network of railways traverses it, small towns are numerous and cities occur at short intervals. These conditions furnish consumers for the coal at the very mouth of the mine, they cause small operations to be numerous and to be profitably prosecuted, and they further

The home market large.

permit the mining of coal for local uses under conditions which would not be profitable for the general market. In addition, these conditions furnish opportunities for obtaining labor, and inducements for retaining it, which are entirely absent in many coal mining regions.

THE USES AND ADAPTABILITIES OF THE COALS.

The uses of Missouri coals. The railways of the State constitute, without doubt, the largest class of consumers of coal. Hence the greatest single use to which coal is put is for the production of steam in locomotives; but, for manufacturing purposes, a large amount of coal is also used in steam production. Domestic consumption in stoves and furnaces ranks next in importance. For the production of illuminating gas a few coals of the State have been roughly experimented with, but not with generally satisfactory results and very little of the coal product is used for this purpose. Thus coal from the vicinity of Moberly has been used there at the gas works and, when well purified, the gas from it was excellent, but the cost of purifying it from sulphur was too great. The coal mined at the Hamilton Coal Co.'s shaft in Caldwell county has been tested for gas production and is reported to have yielded an abundance of gas, but it would not coke in the retorts and, therefore, could not be profitably used. The coal mined at Trenton, in Grundy county, has also been tested with similar results. In Henry county are several coals which have been used for gas production, with reported favorable results. The thick coal bed south of Lewis station is such a coal and also that from the Pitcher mine south of Clinton. These coals have been used, not only in the immediate vicinity of the mines, but have been shipped to remote points in the State for this special purpose. The coal mined at Minden, Barton county, also gives promise of being a gas producer, inasmuch as coal from the same bed mined at Cherokee and other points farther west in Kansas, is largely used for that purpose.

Coals used for steaming and domestic purposes.

A small amount for gas.

No coke manufactured.

No coal in the State, to the writer's knowledge, is used for coke manufacture. Partial tests have been made of a few coals,

but the results were not encouraging. The coal from the Excelsior Coal and Coke Company's shaft, at Higginsville, in Lafayette county, was thus experimented with. The product was of fair quality for domestic use, but was too weak and contained too much sulphur for furnace use.

Concerning the adaptabilities of Missouri coals we know, therefore, little even in a general way, and practically nothing in a detailed and authoritative way. As steam producers we know that they are extensively used, but what their relative evaporative powers are as compared with each other we can say nothing at present; and we are equally in the dark as to how they compare, in this respect, with the coals of other States with which they are brought into competition. We know that the same coal burnt in different furnaces will yield very different results, and, *vice versa*, that the same furnace fired with different coals produces different amounts of steam; yet we are unable to say of the various Missouri coals in just what furnaces the best results may be attained with each. We know that some coals are better for steaming purposes, some for domestic purposes than are others; but which are the best domestic and which the best steaming coals of Missouri we cannot say. Gas coals and coke are imported into this State from Pennsylvania and are sold here at necessarily high prices. It is by no means improbable that there exist coals in the State which could be used more economically for the purposes for which these coals are imported. It is, therefore, in the interest of both the owners of coal lands and the producers of coal, as well as of the consumers, that the adaptabilities of the Missouri coals be first definitely established and then that the various coals be applied to those uses for which they are best suited.[1]

Little detail known of adaptabilities.

More accurate knowledge desirable.

[1] The Geological Survey has already collected a large number of coal samples, and the results obtained from the analyses of these, together with those which have been previously made, will furnish data for a preliminary classification of the coals of the State. After this work is done it is proposed to undertake exhaustive tests on a working scale of the representative coals, including boiler tests for evaporative power, attrition tests for resistance to handling, and also tests of the coking and gas making qualities, where such seem advisable. Only by such working tests can satisfactory results be obtained whereby the merchantable value of a coal can be determined. The results of this work are to be embodied in a future report.

THE AVAILABLE COAL TONNAGE AND THE DURATION OF SUPPLY.

Estimates have been made in publications of past years of the probable amount of coal in the State. Such estimates have been made by assuming an average thickness of coal for the whole area of the Coal Measures and then multiplying this thickness into such area. This method does not commend itself for further use, and, in general, we are of the opinion that the attempt to make such an estimate in the past was altogether premature and would still be so now. We are not in a position to make as much as an approximate estimate in this direction, even were we to leave out of the question entirely the considerations affecting the availability of the coal in the present and in the future. The data necessary for such an estimate are the number of coal beds, their respective thicknesses, the area underlain by each bed, and the depth of each beneath the surface. Some of the principal causes restricting the distribution and availability of Missouri coals have been described in the preceding chapter of this report. To properly make such an estimate it is necessary that we define the nature and extent of such limiting causes, and this can only be done by the most detailed local work.[1]

Estimate of tonnage premature at present.

The question of the distribution and of the amount of coal in the State, is one which the State as a whole, as well as the individual property owner cannot afford to neglect. Coal is, probably, of all others, the most substantial of a State's mineral possessions. Every industry is dependent upon it and it is the main spring of our Nineteenth Century civilization. In Great

Need of definite information.

[1] Such work is now being prosecuted in connection with the detailed mapping of the Geological Survey. This has already covered a large area in the coal fields. In the reports accompanying these maps, estimates of the available coal in the respective areas will be included.

Particularly important in this connection are the results of deep drilling in the Coal Measures. As already stated, in the Preface, coal beds are not continuous indefinitely and only by carefully comparing such drill records, as is there explained, can the limits of the various coal beds be defined. Hence, because of the direct bearing of such records upon this important question of the coal tonnage of the State, we would here call the reader's especial attention to what is said in the Preface to this report concerning a suggested means of obtaining reliable results from such drilling, and the value of these when obtained.

Britain, from the results of carefully executed Geological Surveys, estimates have been made by special commissions of the amount of coal in the United Kingdom, over one foot in thickness and situated within a depth of 4000 ft. beneath the surface.

An acre of ground contains for each foot of coal underlying it about 1,700 tons. With two feet of coal the tonnage per acre is 3,400 tons. With the methods of mining pursued generally in the State, certainly not less than 2,500 tons of these 3,400 tons could be marketed. This would be 1,600,000 tons per square mile, and, thus, the product from a two foot bed of coal, over an area of two square miles, would more than equal the present annual production for the whole State. Or, in other words, at the present rate of production, there is annually exhausted in the State an area of less than two square miles, and probably much less, inasmuch as the coal under a large part of the mining territory is three and four feet thick. The total area of the Coal Measures in the State, as already stated, is about 23,000 square miles. If only one tenth of this area be underlain by available coal two feet thick, the supply will be sufficient to furnish coal at the present rate of production for over a thousand years. It is allowable to assume that a much larger area of available coal exists; but, on the other hand, the rate of production is constantly increasing and will doubtless continue to do so for many years to come. Hence estimates of duration of supply can never be anything more than approximate and provisional. With the present indefiniteness as to the amount of coal present, even an approximate estimate cannot be presented. What is above given is offered merely as a suggestion.

Tonnage per acre

Less than two square miles exhausted annually.

THE VALUE OF COAL AND COAL LANDS.

The total value of the coal in the State must remain indeterminable until the question of the amount of the coal is settled. With a coal bed two feet thick the value of the 2,500 tons of available coal per acre, at $1.30 per ton, is $3,250. The value of the product of a square mile of such coal is $2,080,000. If we allow a profit of ten cents per ton, the net value of the coal from an acre of such land is $250, and for forty acres of such

Value of tonnage per acre.

and it is $10,000. The value of the coal contents of such land, based upon the present market prices of the same substance, is thus many times what the land is valued at for farming purposes. Coal, however, is a possession which is not convertible until excavated and transported to market, and, until this is done, it represents just so much capital lying idle in the ground. Moreover, the coal of any one tract cannot be opened upon, excavated and thus converted into ready money in a short time; but the work will proceed slowly and the returns will come in gradually from year to year. Thus, if a man own a property of forty acres, of which, according to our calculation, the net value of the coal is $10,000, and if he does not receive any of this $10,000 until the expiration of fifteen years, then the present value of his land is a sum, which, at compound interest at current rates, will amount to $10,000 in fifteen years; this at six per cent. interest will be about $4,160, or about $100 per acre. The exact time when a man may receive the full net value of the coal contents of his land depends upon many indefinite factors, such as the growth of facilities of transportation, the demand for the product, etc. It is thus impossible to give any one value per acre which will apply to all coal lands, even though their coal contents and the conditions under which it occurs be similar. Considering the conditions affecting the coal market already described, and, considering further, the undoubted prospect of a great growth of coal consumption in this and adjoining States, it would seem, however, a well assured fact that any and every large body of coal land may be made a profitable producer of coal during the course of a few years. Coal rights covering many square miles of land in the State have been purchased at the rate of a few dollars per acre, the amount seldom exceeding $5. In the case of a single large property, only a portion may be operated at any one time, but a moderate production from this portion, on a very small margin of profit per ton, will yield many times 6 per cent. on the amount of the original cost, not only of the area actually worked, but of a large surrounding area also. Thus, the original cost of the coal rights over ten square miles, at $5 per acre, is $32,000. If the bed be only two feet thick and if the coal underlying only 40

Value of coal lands.

Value dependent upon rate of production.

At present rates a moderate production will yield good returns.

acres be removed per year, and sold at a profit of ten cents per ton, the income would be $10,000, as above calculated, or about 30 per cent. of the total original investment. On the basis of these figures it is plain that the results of a few years work, and the exhaustion of a very small fraction of the entire tract, will suffice to return to the investor the total amount of the first cost of the coal land. The net receipts after this will continue to be large and will be clear profit.

First cost returned in short time.

Thus, the coal lands of Missouri would seem to be promising fields for investment, even at rates much higher than have been so far maintained. The statistics of shipments show that the tendency is towards large operations by companies controlling thousands of acres of lands. Pursued on this large scale mining can be prosecuted undoubtedly much more economically and larger markets can be reached. The coal can also be sold on a smaller margin of profit, which is a benefit to the consumer. The small operator is sometimes, if not generally, the sufferer through such conditions; and, further, the small land-owner is often, through lack of local competition, induced to part with his land, or its mining rights, to the adjacent large owner and operator at extremely low figues. Once the value of these coal lands well established and their extent defined, however, wide interest will be excited and strong organizations will be led into keener competition for the possession of these lands than has heretofore been the case. We may, therefore, look forward, in the march of events, to a large increase in the coal industry of the State, to profitable returns to those who invest their money sagaciously in coal lands and in the support of the dependent industry, and to an enhancement of the value of such lands now largely held and used purely for agricultural ends by private citizens of the State.

Coal lands recommended for investment.

CHAPTER IV.

A SYSTEMATIC DESCRIPTION OF COAL BEDS NOW OPERATED.

The coal mining industry of the State has its greatest development in what may be called the border counties of the Coal Measures; or that portion in which the middle and lower Coal Measure rocks crop out. Towards the interior the coal beds are deeper, thinner, and their distribution is not so well known. In the following description the occurrences of coal, in beds of the regular Coal Measures, will be described by counties successively, from northeast to southwest, and the possible connection between the beds at successive openings will be indicated where possible.

Coal mining area.

1. CLARK COUNTY.

No coal mining is in progress in Clark county at present. Mines have been operated during past years in the vicinity of Athens, in the extreme northeastern corner of the county, where the coal is reported to be between three and four feet thick. Immediately north of this, in Van Buren county, Iowa, at Farmington and other points, coals of this thickness have been and are worked on an extensive scale. Shumard[1] refers to coal 18 to 20 inches thick operated in the northeastern corner of the county and also to deposits of earthly cannel coal which occur to the east, beyond the limits of the Coal Measures.

No mining in Clark county.

Coal in Northeast.

Exactly what becomes, in Clark county, of the thick coal bed mined in the adjoining county of Iowa, the limited examination so far made will not permit us to say. On the bank of Fox

[1] Report Missouri Geol. Survey 1855–1871, p. 318.

river, in the southeast quarter of section 1, township 55 N., 8 W. the thin coal bed of the following section was measured:

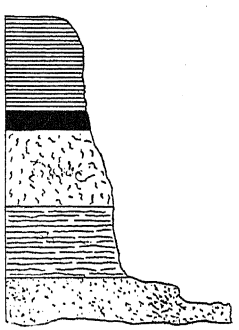


FIG. 14. Section of Coal bed on bank of Fox river.

Coal on Fox river

This bed has been mined elsewhere in the neighborhood and is reported to reach a thickness of 22 inches. Whether this be the extension of the Iowa bed, or not, cannot be affirmed; it is in a high degree probable that the distribution of the coal in the county generally is much diminished by channels filled with glacial material, inasmuch as a great mantle of drift covers all of this country and, in the town of Kahoka, a drill hole, at the pickle factory, passed through 163 feet of clay and gravel before rock was encountered.

Limitations by glacial deposits.

2. SCOTLAND COUNTY.

The same indefiniteness which exists in portions of Clark county concerning the distribution of the coal, prevails in all of Scotland county, no mines being operated here and the wide spread and thick mantle of drift effectively covering any natural exposures. It is possible that a judiciously distributed series of drill holes would demonstrate the extension here of the coal beds occurring in the adjoining counties, Davis and Van Buren, of Iowa to the north.

Distribution of coal indefinite.

3. SCHUYLER COUNTY.

PRODUCTION IN 1891.....280 TONS.

About three miles west of Coatsville, in the ravines tributary to the Chariton river valley, coal is mined on a small scale for local uses, at a number of small pits. *At Bradburn's drift*, near the middle of the north line of section 34 of township 67 N. 16 W. the following section was measured:

Coal at Bradburn's drift.

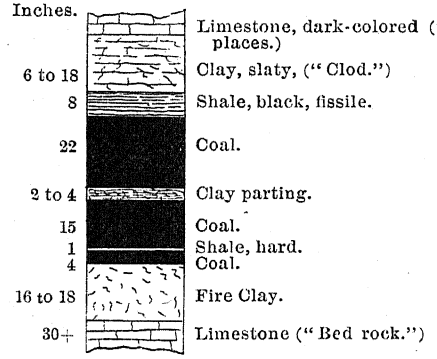


FIG. 15. Section of coal bed at Bradburn's Drift.

This bed of coal is here "faulted" (see p. 39) to an injurious extent, a very considerable fraction of the face being broken by this action, causing much loss and dead work. The coal is also reported to slack readily. The overlying limestone makes a good roof, and, when the coal and intervening shale and clay are removed, an entry of excellent height for all travelling purposes is obtained.

Coal at Hilltown, Iowa.

This bed of coal is considered by Norwood[1] to be the same as that mined a few miles north, at Hilltown, Iowa; here the aggregate thickness is only little over three feet, but the coal is less faulted and is harder. In the eastern portion of the county denudation has removed this bed of coal, and the country is covered by a thick layer of drift. Two lower beds described by Norwood as occurring in Putnam county, may possibly extend

Lower beds.

[1] Report Mo. Geological Survey, 1873–74, p. 295.

under this area;[1] but the work of the Survey has not been in sufficient detail here for such prediction to be authoritatively made.

4. PUTNAM COUNTY.

PRODUCTION IN 1891.....123,526 TONS.

The early production of coal in Putnam county was confined to the eastern portion, where the coal cropped out in the hills along the Chariton river and its tributaries. Here the same coal as that described as worked near Coatsville, in Schuyler county, on the east side of the river, was widely operated. During late years, however, the most active section of coal production has been transferred to the line of the Burlington and Kansas City railway which traverses the county near the center, in a direction from north to south. Centers of coal production.

The Mendota mines, on the railway, near the north line of State as well as of the county, are by far the most extensive. Here the coal crops out in the hill-sides and is worked by several drifts. Drift No. 1 is the scene of largest operations at present. The following section of the coal bed and associated rocks was measured here: The Mendota mines.

Feet.	Inches.	
3		Limestone, "Cap rock," earthy, weathers readily.
1+		Clayey shale, drab ("Clod.")
1		Shale, black, fissile.
	0 to 18	Shale, calcareous, black, tough ("Black Bat.")
	20	Coal, "Top bench," pyrites near top.
	2 to 3	Clay parting.
	10	Bottom coal.
	1	Clay and pyrites.
	1½	Coal ("Dutchman.")
	20	Fireclay.
6+		Limestone, Sump rock.

FIG. 16. Section of coal bed at Mendota mines.

The coal is worked by the pillar and room method and also by the long wall method. Machine cutters and wire rope haulage

[1] Opus cite, p. 299.

are used. The roof is very good and there are few "slips" or "faults" in the coal, excepting in one drift (No. 4), where the coal is fractured and pyritiferous in places. The coal is reported to slack readily on exposure, though the amount of pyrite ("sulphur") contained does not appear very great; selenite and calcite films along the joints of the coal are, however, noticeably abundant. Buried channels diminish the area of available coal here very considerably, glacial drift being encountered, cutting out the coal, in many parts of the workings.

Character of coal.

Buried channels.

On Blackbird creek, about two miles north of Unionville, coal has also been mined and preparations are now being made for extensive developments at the Blackbird Coal Company's shaft, adjacent to the railway at this point. The shaft is 53 feet deep. The following section of the coal was measured here:

Blackbird shaft.

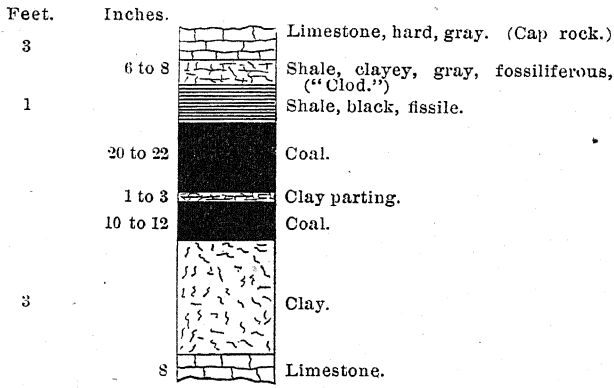


FIG. 17. Section of coal bed at Blackbird Shaft.

The bed will be worked by pillar and room, without blasting. The coal seems to be hard and contains no slips or faults, so far as was observed. Pyrites occurs in lenticular layers parallel with the stratification, and selenite and calcite films are present along the joint places.

Character of coal.

This same coal has been dug at numerous other shafts in the vicinity and, between this and Unionville, it has been struck in drill holes.

About 6 miles southeast of Unionville coal is, and has been

worked at a number of small drifts and shafts, for local sale. At Patrick Biggey's shaft the following section of the coal was observed: Biggey's shaft.

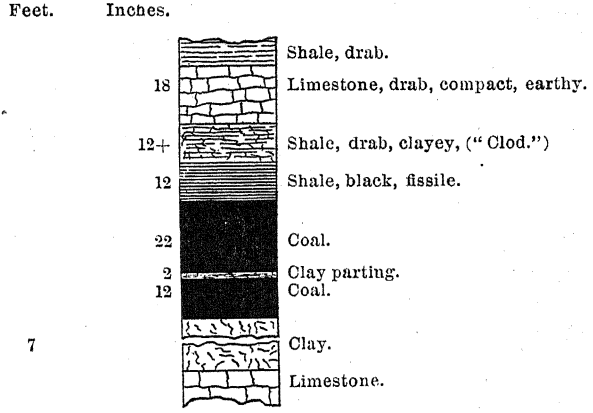


FIG. 18. Section of coal bed at Biggey's Shaft.

This coal is similar in character to that at the Blackbird shaft.

The coal beds at Mendota, Blackbird and Biggy's are, judging from their characteristics, their topographic location, and the nature and succession of the associated rocks, in all probability outcrops of the same bed; and, for similar reasons, it is probable that they are of the same as the coal mined west of Coatsville, in Schuyler county. Two other coal beds were noticed by Norwood,[1] in the eastern portion of the county, at depths of 103 and 125 feet below the Mendota coal, 24 inches and 18 inches thick respectively. Whether these beds exist elsewhere in the county cannot be stated at present writing. Correlation of beds. Other coal beds.

The distribution of coal in this county is noticeably restricted in the western portion by the erosion of a pre-glacial drainage system, which is now hidden by thick accummulations of glacial drift. Evidences of a submerged channel are found in the mines at Mendota, as already alluded to; at Howland, some four miles south of Mendota, a shaft and drill hole was sunk to a depth of 164 feet in clay and other glacial material; at Unionville over 200 feet of similar material was penetrated by a shaft, and here, Restrictions by glaciarl dift.

[1] Report Mc. Geological Survey 1873-74, pp. 282, 283.

as in the preceding case, rocks were reached much below the level of the Mendota coal; at Lucerne, about 15 miles west of Unionville, a hole was drilled to a depth of 185 feet and no coal was encountered.[1]

5. SULLIVAN COUNTY.

PRODUCTION IN 1891... ....560 TONS.

The most important coal development in Sullivan county is at the county seat, Milan, where, during last year, a shaft was sunk, in the valley, to a depth of 193 feet. It is located between the tracks of the two railways which pass through this town, and is equipped with a good steam plant. Three coal beds were penetrated by this shaft, one at a depth of 81 feet, another at 120 ft. and the last at 190 ft. The upper bed is 16 inches thick and is reported to be good coal; the middle bed is chiefly black shale, though coal was reported at this point in the drill hole sunk previously to the shaft, and about a quarter of a mile northwest from it. The lowest bed is the one which it is proposed to work and here the following section was measured:

Milan shaft.

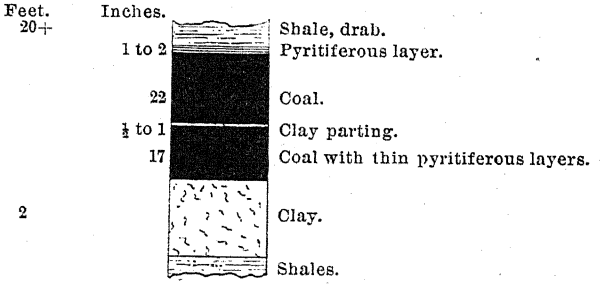


FIG. 19. Section of coal bed at Milan Shaft.

The coal is hard, and has to be blasted down, but it apparently does not slack readily. The bed is to be mined by the pillar and room system. No faults were seen in the coal, and it is probable that few will be encountered here. The roof is not

Character of coal.

[1] The distribution of these buried channels has an important bearing upon the development of the coal industry of this, as well as other counties in this portion of the State, and it will be an object of the Survey to outline them during the progress of future detailed work in this region. For the present nothing more can be attempted than the above brief allusion.

very good, as the shale flakes off readily on exposure to the air, and doubtless this will be the source of some trouble in mining. This coal bed probably underlies the whole county, but whether it is everywhere of workable thickness is a prediction which present developments will not warrant attempting. Above the mouth of the shaft, some 50 feet higher, another coal bed crops out, according to Broadhead, in the hill-sides of the adjacent country, within a radius of 2 or 3 miles, northwest and south of Milan.[1] It is generally about 2 feet thick and has been worked to a small extent for local uses.

Overlying coal bed.

In the southwestern corner of the county, on Locust creek, another coal bed has been opened, about 18 inches thick, which may possibly be the equivalent of the upper bed struck in the Milan shaft, though we have not sufficient data to substantiate this.

Coal on Locust creek.

In the northwestern corner of the county, on Spring creek, two beds of coal have been worked, which, according to Broadhead's[2] section are separated from each other by over 330 ft. The upper one is about 18 inches thick and is considered by him the equivalent of the bed found in the hills about Milan; while the lower, ranging from 2 to 4 ft. in thickness, would, according to this, be nearly 100 ft. below the Milan Coal.[3]

Coal on Spring creek.

6. ADAIR COUNTY.

PRODUCTION IN 1891.....17,110 TONS.

Coal mining, on a scale worthy of notice, is confined to two localities at present, namely, Danforth and Stahl on the Quincy, Omaha and Kansas City railway, west of Kirkville and west of the Chariton river.

The workings at Danforth are a mile or so west of the river and are in the lower coal bed. The characteristics of the coal and the associated strata suggest the possibility that this bed is the same as that at the bottom of the Milan shaft, described on

The Danforth mines.

[1] Report Mo. Geol. Survey 1873–74, pp. 222–239.

[2] Opus cite pp. 222–225.

[3] Until detailed work is done in the county, nothing further can be said, in reference to such correlation, other than that we are inclined to the opinion that this lower coal belongs much higher up in the section, even above the Milan coal.

p. 22, but further study is necessary before such an assertion can be considered of much value. It is operated by a steam plant and the shaft is 50 feet deep. The following section of the coal was measured here:

Possibly the Milan bed.

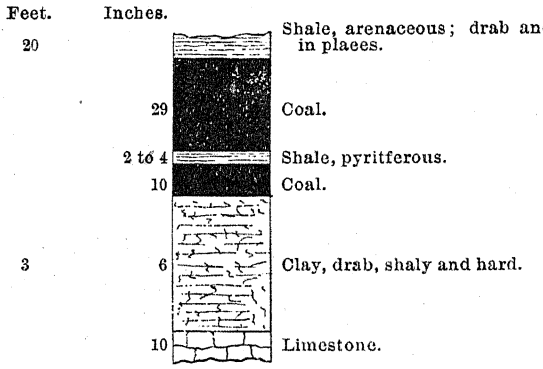


FIG. 20. Section of coal bed at Danforth Shaft.

The coal is very hard and contains streaks of pyrite. It is mined by the pillar and room method and blasted from the solid, as the underlying clay is too hard to admit of ready mining. The coal contains few if any faults and the face is comparatively clean. The roof, though variable to a certain extent, is poor in many places, the air current through the entries causing the shale in the roof to flake off constantly. Work by the long wall method is impracticable here on account of the character of roof and, further, the workings being near the surface, the amount of water which would be admitted from above, through the settling and consequent fracturing of the overlying shale, offers another objection. This coal bed has been opened at other points east of Danforth, nearer the river and farther north through the country tributary to that stream,[1] but none of these are known to have been in operation during the past year.

Character of coal.

Character of roof.

The coal mine at Stahl, about four miles west of Danforth, on the same railway, is in the upper bed. Estimates vary as to the distance intervening between the two beds. Without pretending to have reliable data, we are inclined to place the

[1] See Report Mo. Geol. Survey, 1873–74, p. 251 and 252.

distance at something near 100 ft. A future careful study of the ground and comparison of records will admit of a more exact estimate later. The mine is opened by a drift, located on a hill-side, some 50 feet above the level of the railway. The following section was obtained here from the record of an air shaft and from actual measurement: Stahl coal mine.

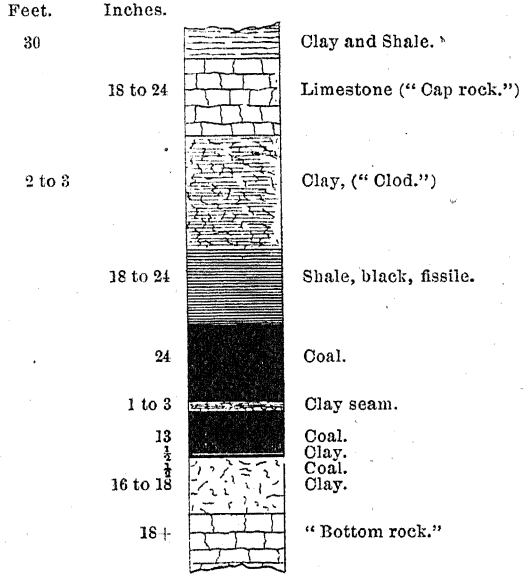


FIG. 21. Section of coal bed at Stahl Drift.

The coal is softer than that at Danforth, but is much faulted and squeezed, probably as much as one-third of the face of the coal being thus injured. The roof is good and the long wall method of mining is pursued, the coal being undermined in the clay and wedged down from the top. Character of coal and roof.

This coal has many features and associations in common with that mined west of Coatsville, in Schuyler county, and at Mendota and on Blackbird creek, in Putnam county; there is more than a possibility, even from the meagre data at hand, that it is the same bed. It has been struck and mined for local uses in past years at other points in the northwestern part of the county,[1] and, Correlations.

[1] Report Mo. Geol. Survey 1873-74, pp. 252-254.

though, probably, not extending far east and southeast of Stahl, it must, nevertheless, cover a large area.

Limitations by drift.

Neither of these coal beds is mined in the eastern portion of the county, east of the Wabash railway. To what extent they exist there is not determined. It is more than probable that their extension here is limited by the thick deposits of drift which are abundantly present over this area. A shaft sunk immediately north of Kirksville, about 200 feet deep, is reported to have been entirely in glacial material.

7. MACON COUNTY.

PRODUCTION IN 1891 .....454,029 TONS.

Distribution of mines.

Macon county is one of the most important coal producers in the State. As in Adair county, mining is at present prosecuted chiefly in the western portion, west of the "Grand Divide" and of the Wabash railway. The mines are mostly large ones provided with steam plants.

Lingo shaft.

The shaft of the Little Pittsburg Coal Company, at Lingo, is the first as we enter the county from the west. This is a regularly producing mine operated by a steam plant. The shaft is 138 feet deep to the bottom of the coal now mined. The section obtained here is as follows:

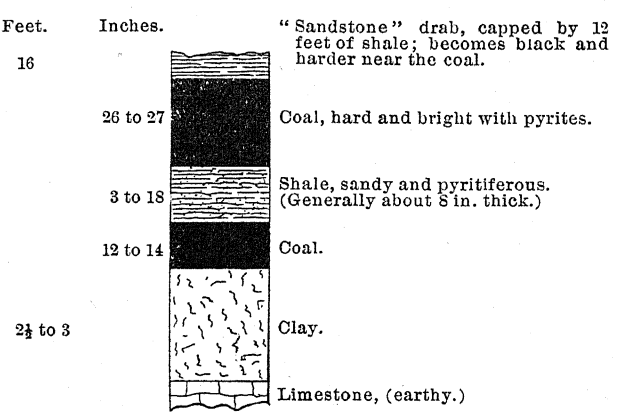


FIG. 22. Section of coal bed at Lingo Shaft, (upper bed.)

Another coal bed was struck some years ago, while shafting,

at a depth of 30 feet below the above, and, of this, the following section is reported:

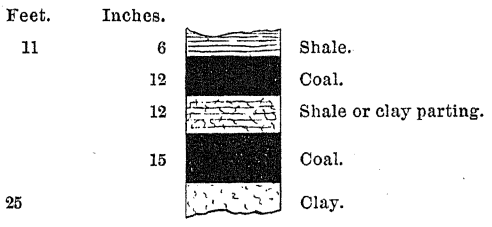


FIG. 23. Section of coal bed at Lingo Shaft, (lower bed.)

The coal of the upper bed is hard, appears to be of good quality and exhibits little sulphur. The roof is only moderately good, and necessitates heavy timbering in places; at times, in the entries, the shale falls down as high as the capping sandstone, leaving the roof of the entry in the shape of a rough, narrow, gothic arch. Long wall mining is practiced, however, the coal being cut under as much as five feet and then shot down with small charges of powder. The mine is exceedingly dry, even dusty. Character of coal and roof.

A few miles southeast of Lingo, on Rush creek, drifts have been operated during past years, for local sale, in a bed of coal the section of which indicates that it is probably the same as the Lingo coal. This bed has also been opened, about a mile farther south, on Dr. N. D. Stephenson's land. Coal is also reported to occur[1] on the west bank of Muscle Fork, northwest of Lingo, but where it belongs in the section cannot now be stated. Rush creek coal.

Bevier is about 15 miles east of Lingo and includes a group of large mines, employing together several hundred miners. The shafts vary in depth from 60 to 130 feet, and the character of the coal and the associated strata indicate that the coal bed is the same as that at Lingo. The following section was measured at the Kansas and Texas Coal Company's shaft No. 42. This shaft is 100 feet deep, from the surface to the top of the coal: Bevier mines.

[1] Report Mo. Geol. Survey 1855–71, p. 85.

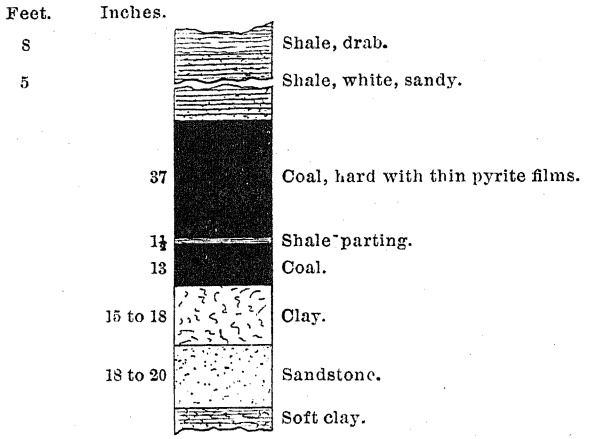


FIG. 24. Section of coal bed at Bevier Shaft No. 42.

The coal is very hard and does not appear to carry an excessive amount of sulphur. The roof is peculiar, consisting of a smooth, hard, white, micaceous sandy shale, often lithified. On the southern side of the shaft little timbering is required, while, on the northern side, the roof rock is an unevenly bedded sandstone, which sometimes cuts out half the thickness of the coal. Elsewhere the roof is shaly, and, at the extreme northern end of the works, it becomes very unsafe, requiring much timbering, and often breaking down in large blocks. Few slips or faults are found in this coal. It is mined by the pillar and room method, the coal being blasted from the solid.

Character of coal and roof.

The Eureka shaft is in the immediate vicinity of Macon City, about 1½ miles west of the town, on the Hannibal and St. Joe railway; it was quite recently opened. Five coal beds were struck in this shaft, according to the shaft record, as follows:[1]

Eureka shaft.

SECTION 1.

1.	At a depth of 26½ ft	.....	12″ coal.	
2.	" 54 "	.....	18″ "	
3.	" 74½ "	.....	24″ "	(Operated)
4.	" 108 "	.....	24″ "	
5.	" 165 "	.....	48″ "	(Operated)

[1] This record was kindly furnished by Mr. E. D. Hillyer, the superintendent.

The mine is provided with a steam hoisting plant and the shaft is well timbered. Two beds have been worked, *i. e.*, the third one, No. 3, at a depth of 74½ feet and the lowest at a depth of 165 feet. Of the upper bed the following detailed section was obtained: Eureka shaft, upper bed.

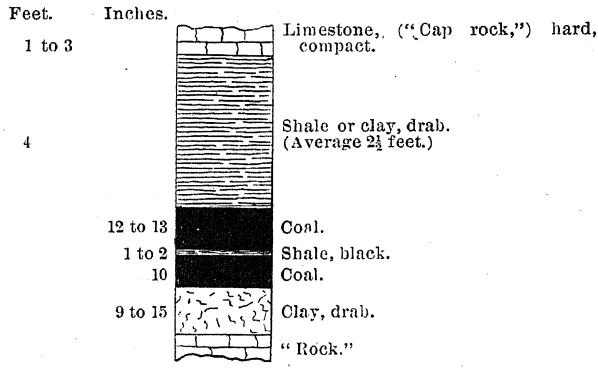


FIG. 25. Section of coal bed at Eureka Shaft, (upper bed.)

The long wall method of mining has been used, although the roof is not very good. The workings are very dry here. Of the lower bed, No. 5, the following section was measured: Lower bed.

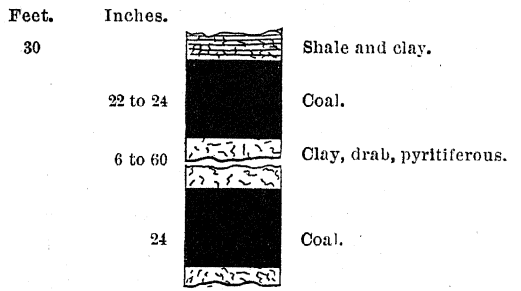


FIG. 26. Section of coal bed at Eureka Shaft, (lower bed.)

The lower bench of this coal is said to thin out and the upper to thicken in places. Pyrite, in the form of small, lenticular balls, occurs in this coal to a deleterious extent, especially in the lower bench.

Along Patton creek, some two miles southwest of Macon City, are numerous small coal mines, which have been worked at intervals during many years past to supply local demands. The coal crops out about 10 feet above the bottoms of East Fork creek. It is about 18 inches thick and is overlain by some 6 feet, or more, of black fissile shale, over which is again some 3 feet of limestone. The hurried inspection did not permit of correlating this coal with any bed of the Eureka shaft, but this will be done when the results of the past summer's detailed work are obtained.

Patton creek coal.

The Ardmore coal mines are located about three miles west of Excello, on a switch of the Wabash railway. The coal is opened by drifts and there are several large mines at this point.

Ardmore mines.

At drift No. 26 of the Kansas and Texas Coal Co., the following section was obtained:

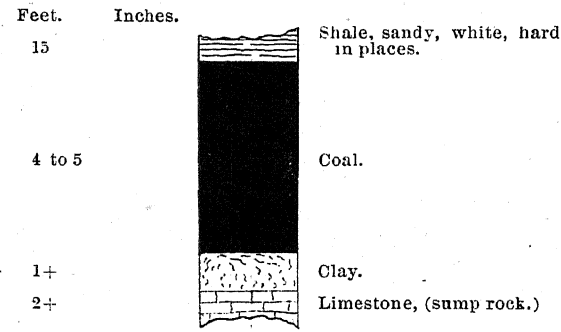


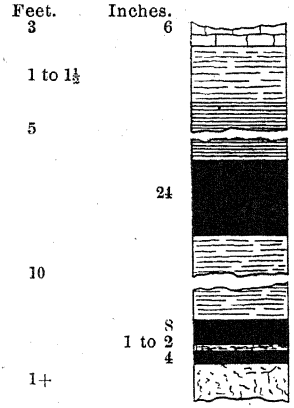
FIG. 27. Section of coal bed at Ardmore, (Drift 26.)

This is the old Mayfield drift. The coal is somewhere near 20 feet above the creek bottoms; it is worked by the pillar and room method. The character of the coal and of the associated strata lead one to believe that this bed is the same as that mined so extensively at Bevier.

Coal above drainage.

On Salt Fork, east of Macon City, there have been and are several small coal pits, at and south of Carbon. At the bridge of the county road, just south of the Hannibal and St. Joe railway, the following section was measured:

Coal near Carbon.



Section at Carbon.

FIG. 28. Section of coal bed at Carbon.

The upper coal has been considered the same as that on Patton creek referred to on p. 66, and this conclusion is probably correct. Other pits in this coal occur farther down the Salt Fork, but were not visited.

A description of numerous coal openings in Macon county is given by Broadhead in the report of the Missouri Geological Survey of 1855–71, pp. 74 to 88, and some suggestions are made as to the possible relationships of the different beds. In 1887 Mr. W. J. McGee, geologist of the United States Geological Survey, made a further examination of a portion of the county and published a report,[1] in which he gives a description of the topography, and an analysis of the stratigraphy. Recent developments have, however, demonstrated that certain modifications are needed in his conclusions. These will not be introduced here, but will be reserved until the results of the detailed work recently prosecuted in the county are published.

Broadhead and McGee reports.

8. RANDOLPH COUNTY.

PRODUCTION IN 1891.....224,758 TONS.

Coal developments in Randolph county are most active along the lines of the Wabash and the Chicago and Alton railways, west and south of Moberly; but over the entire northwestern

[1] Notes on the Geology of Macon county, Missouri, by W. J. McGee, U. S. Geologist. Trans. St. Louis Acad. of Science, Vol. V, No. 2, pp. 305–316.

Coal near Darksville.

portion of the county, in the vicinity of Darksville, the coal is known to exist, and has been operated for local demands. Coal rights here have been largely bought by coal companies.

Proceeding from north to south we find, in the hill-sides, three miles northwest of Cairo, along the creek, in section 27, township 55 N., 14 W., several coal drifts, in one of which the following section of coal was observed:

Coal near Cairo.

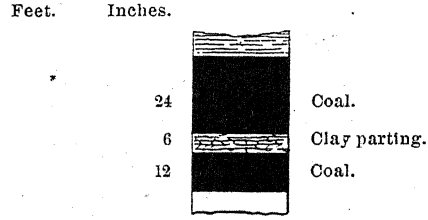


FIG. 29. Section of coal bed northwest of Cairo.

Same as Ardmore coal.

The parting is, in places, quite arenaceous. Another bed of coal, about 16 inches thick, is reported in the hill-side, between 10 and 20 feet above this lower one. The inference is that the lower bed is the same as that mined at Ardmore and described on p. 66.

Three miles southwest of the last, in section 5, township 54 N., 14 W., the following section was obtained:

Section west of Cairo.

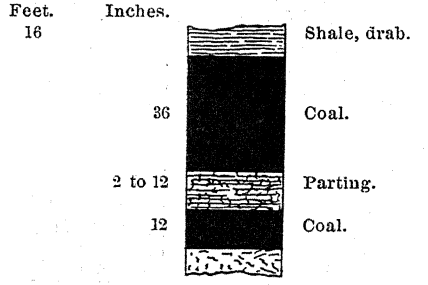
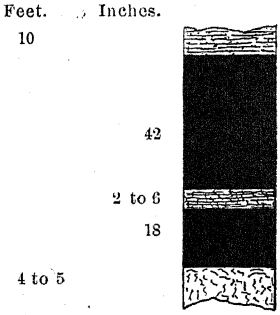


FIG. 30. Section of coal bed west of Cairo.

In section 19, township 55 N., 15 W., near Chariton creek, three miles west of Darksville, the same bed is drifted into at several places, at an elevation not much above the level of

the adjacent creek bottoms. At one of these the following section was obtained:



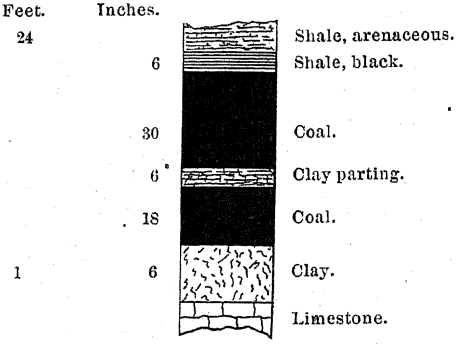
Coal on Chariton creek.

FIG. 31. Section of coal bed on Chariton creek.

The upper bench of coal is considered the best for ordinary purposes of combustion, but the lower coal is the harder here.

Millman shaft.

At Thomas Hill, on Chariton creek, the same coal bed is worked at the Millman shaft, some 30 feet below the level of the creek. Here the following section of the coal was obtained:



Section at Thomas Hill.

FIG. 32. Section of coal bed at Thomas Hill.

The coal contains some pyrite and slacks on exposure. Another coal bed, about 18 inches thick, occurs in the hill, some 55 feet above this lower bed; above this no coal is found here.

At Huntsville, some ten miles southeast of Thomas Hill, what is, apparently, the same bed of coal is worked on a commercial scale at a number of shafts, and also by drifts in the hollows. The depths of the shafts are in the vicinity of 100 feet, and they are generally located close to the Wabash railway. The follow-

Coal at Huntsville.

ing section of coal, as measured at one opening, fairly represents this bed as found at many points in this vicinity:

Representative section at Huntsville.

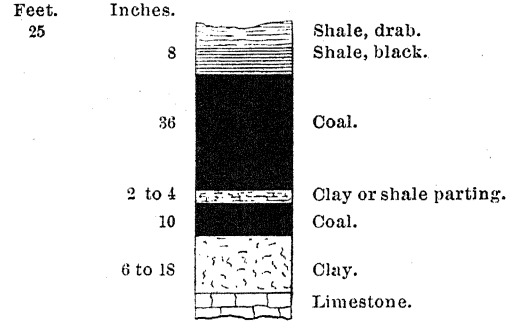


FIG. 33. Section of coal bed at Huntsville.

Coal pyritiferous and slacks.

The coal is used chiefly for locomotive purposes. It is mined by the pillar and room method. It contains a considerable amount of pyrite and slacks readily on exposure. The roof is not very good. An overlying bed, 18 inches thick, is worked in places, but it does not seem to be persistent, as it is not included in several of the shaft records which were obtained here.

The continuity of the lower bed appears to be broken west of Huntsville, but, near the west line of the county, in Chariton county, what is apparently the same bed is operated on Asa Gunn's land, in section 31, township 54 N., 16 W. Here the following section was obtained:

Coal near Chariton county line.

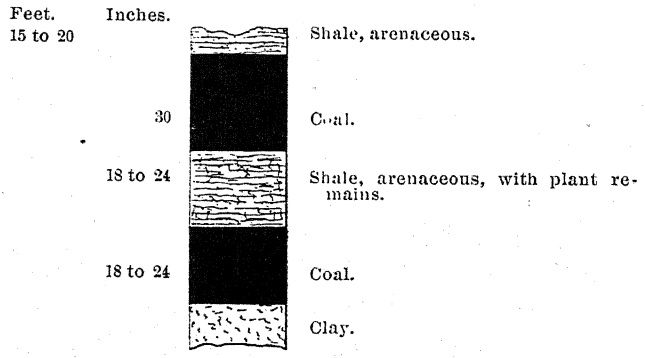


FIG. 34. Section of coal bed at Asa Gunn's drift.

Another bed of coal is reported to have been dug into here on

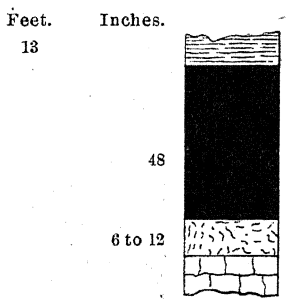
the hill-side, about 50 ft. above the lower coal. South of this point, on the Wabash railway, are two shafts, now abandoned, which probably operated the same coal bed.

East of Huntsville, towards Moberly, there are some four shafts along the Wabash railway, and others north of this road, each about 100 feet deep, operating the four foot bed. The character of the coal and the section here is essentially the same as at Huntsville. Two upper coal beds are found, the first generally about 20 feet above the four ft. bed and ranging from 15 inches to 24 inches in thickness. The other bed, 14 feet above the last, is about 18 inches thick. The last is generally good coal and is occasionally worked. Immediately adjacent to Moberly no coal is worked, and the indications are that it has been eroded here and the resulting channel replaced by sandstones and shales during the Coal Measure period, as explained on p. 36.

Coal west of Moberly.

South of Moberly there are no active coal mines nearer than at Eliot, on the Missouri, Kansas and Texas railway, about 5 miles distant. Here there is a shaft of the Kansas and Texas Coal Company 146 feet deep. The following section was furnished by the superintendent:

Coal south of Moberly.



Section at Eliot shaft.

FIG. 35. Section of coal bed at Eliot.

This coal is thought to have less ash and pyrite than that at other mines in the neighborhood. It is worked by the long wall method. Two beds of coal are found here, above the one worked. The first is about 17 feet above it and is 15 inches thick; the second is about 20 feet above the last and is from 8 inches to 15 inches thick.

Higbee is about four miles south of Eliot, at the junction of the Missouri, Kansas and Texas and the Chicago and Alton railways. A half mile west of this place is a shaft on the Wabash road, 176 ft. deep. Here the coal is reported to be $3\frac{1}{2}$ ft. thick and over it two beds were struck, one 18 inches thick, 33 ft. above the lower coal, the other 12 inches thick, 26 feet above the last. The coal mined has here the following section:

Coal at Higbee.

Section at Higbee.

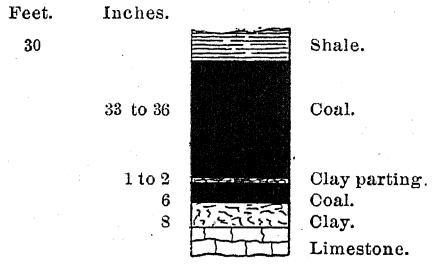


FIG. 36. Section of coal bed at Higbee.

The long wall method of working has recently been introduced here.

Some two miles south of Higbee is the McDonald shaft, of the Interstate Mining company, on the Missouri, Kansas and Texas railway. This shaft is 110 ft. deep. The coal is operated by the long wall method. The following section was obtained here:

Coal south of Higbee.

Section at McDonald shaft.

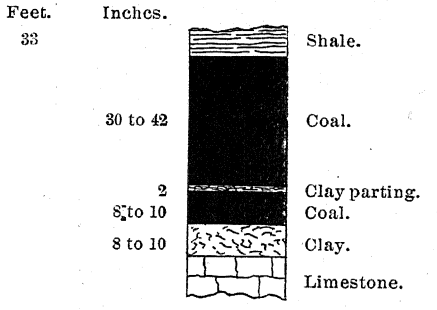


FIG. 37. Section of coal bed at McDonald shaft.

West and northwest of Higbee, this, and the overlying coal beds, have been worked by drifts and shallow shafts, in the hollows and ravines, to supply local demands. They are, at

present, practically abandoned and only serve to indicate that the coal area here is a wide one, including many square miles.[1]

At Renick, some five miles east of Eliot, on the Wabash railway, are two shafts; one an old shaft, not operated at the time of visit, the other a new shaft. The latter is 102 feet deep to the bottom of the coal. The coal is apparently the same as that mined at Eliot. The following section was furnished by the superintendent here: Coal at Renick.

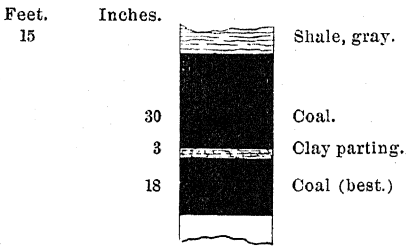


FIG. 38. Section of coal bed at Renick.

Section at Renick.

The coal contains a good deal of pyrite and is considered a poor forge coal, though excellent for steaming purposes. It clinkers in burning, is soft and slacks readily on exposure. Mining is done by the pillar and room system. Coal soft and pyritiferous.

9. BOONE COUNTY.

PRODUCTION IN 1891..... 23,577 TONS.

Boone county is located on the margin of the Coal Measures and the deposits of this formation are nowhere thick within its limits. In the southern half of the county outcrops of the Lower Carboniferous Limestones are frequent and the Coal Measure rocks are not represented there. Coal Measures thin here.

Several coal beds are known to exist in the county, but, of these, only one is extensively worked. This bed resembles very much the coal of Renick in Randolph county and is probably the same. It is worked on a moderate scale and this chiefly at points along the Centralia and Columbia railway. Only one bed worked extensively.

[1] Their location and the limits of the coal beds will be shown on the detailed maps of this area which were constructed during the past year and which will soon be placed in the engraver's hands.

Coal at Henry station.

At Henry Station the Columbia Coal Co. has a shaft 112 ft. deep to the bottom of the coal. At this shaft the following section was measured:

Section at Henry station.

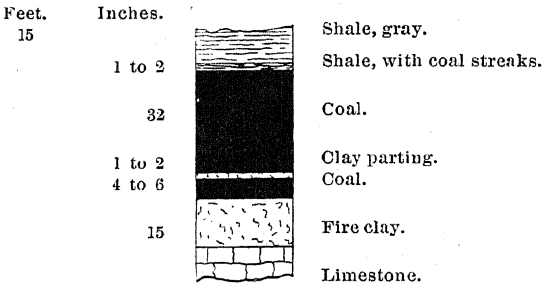


FIG. 39. Section of coal bed at Henry station.

Character of coal and roof.

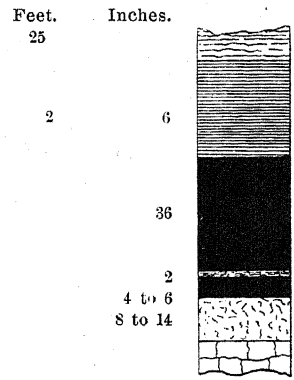
The coal is somewhat soft, slacks readily and contains iron pyrites. The mining has been by the pillar and room method, but the long wall method is now introduced and is found to work successfully even with the soft shale roof. The coal ignites spontaneously quite readily and, with the pillar and room method, this gave much trouble; but, with the long wall method, the gob is packed so closely, by the settling of the soft roof, that the air is excluded and no spontaneous combustion occurs.

At Brown Station the shaft is 165 ft. deep. An 18 in. bed of impure coal, covered by 2 ft. of black fissile shale, was found here, about 35 ft. above the lower four ft. bed.

Shaft at Persinger station.

At Persinger Station, which is some 60 ft. lower than Henry Station, the shaft is said to have been 69 ft. deep to the bottom of the coal. About 100 yards south of this shaft the entry passed from the coal into clay and was driven some 50 yards farther south, in this clay, along the bottom rock, without striking the coal again. The workings here doubtless passed into a now buried, pre-glacial channel, such as have been described as frequently occurring in the northern part of the State. Other developments in this neighborhood show the existence of this channel at other points.

Gooding shaft is located in sec. 24, township 49 N., 13 W. This shaft is about 60 ft. deep, and here the following section was measured:



Section at Gooding shaft.

FIG. 40. Section of coal bed at Gooding shaft.

Pyrite was noticeable in this coal; but, nevertheless, it is used in forges in preference to other coals from this neighborhood. The bed is worked by the pillar and room method. Slips or faults in the coal are only occasionally found and the roof is a good one. Some 35 or 40 ft. above this coal bed another is reported to exist, about 18 in. thick which is said to be very uniform in character. Another, it is claimed, lies at about the same distance below the bed worked.

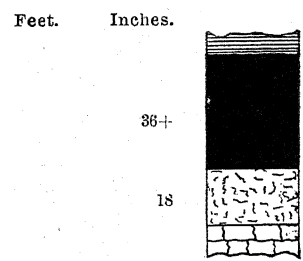
Character of coal.

Overlying bed.

At the Benfield drift this same bed is worked, in section 28, township 49 N., 12 W.; the section here is approximately the same, though the coal is a little thinner. Some 500 ft. down the stream from this drift the lower bed appears to crop out.

Benfield drift.

At the Kurtz drift, in section 33, township 49 N., 12 W., the following section was measured:



Section at Kurtz drift.

FIG. 41. Section of coal bed at Kurtz drift.

The absence of the clay parting in the coal is noticeable here.

About a foot from the top of the coal bed, a half inch band of pyrite and shale was observed. Other drifts and shafts were reported to be in this neighborhood, but they were not visited.

Mines near Centralia.

In the vicinity of Centralia, near the north line of the county, a thin coal bed is worked in several places. A few of these localities were visited.

The G. M. Wiley shaft is about 30 ft. deep, located in the middle of the northwestern quarter of section 34, township 52 N., 11 W. Here the following section was obtained:

Section at Wiley shaft.

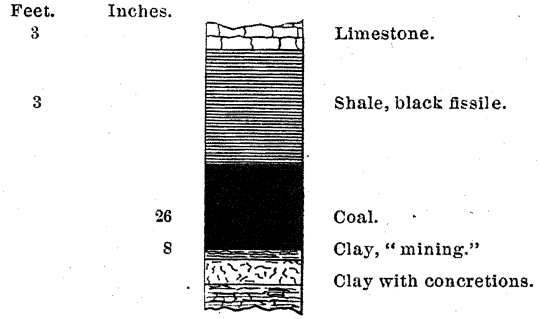


FIG. 42. Section of coal bed at Wiley shaft.

The coal is undermined here and wedged down. It is sold for local uses and is claimed to be a good forge coal with little pyrite. This same bed, which is, in all probability, distinct from the one already described as mined in the county, is worked in a small way, at a number of points in the vicinity of Centralia and has been struck in several wells in that neighborhood.

Coal near Harrisburg.

In the northwestern portion of the county, coal is dug for local uses in the vicinity of Harrisburg, where it is three or more feet thick. No openings in this bed were visited by the writer in Boone county; but, just across the line, in Howard county, the same bed was examined and measured and will be found described under that county. South of Sturgeon a shaft was recently sunk about 100 feet deep in which a bed of coal 3 feet thick is reported to have been struck. From a comparison of the sections it is probable that the coal at Harrisburg belongs to the same bed as that worked in the vicinity of Columbia.

Coal near Sturgeon.

10. CALLAWAY COUNTY.

PRODUCTION IN 1891 .....15,582 TONS.

Like Boone county, Callaway county is located on the margin of the Coal Measures. The Lower Carboniferous rocks occupy a great portion of the southern part and crop out along the valleys of the larger streams well up towards the northern line. The Coal Measure rocks are scattered in patches and nowhere attain a very great thickness.

Coal Measure area broken.

The principal coal mining in the county is done in the vicinity of Fulton, where a number of shafts and drifts are operated for the use of the town and for the locomotives of the Chicago & Alton railway.

Coal near Fulton.

At A. Harris and Company's shaft, on the railway, a mile or so south of town, the following section was measured:

Feet.	Inches.	
6		Sandstone.
9		Shale, argillaceous.
	36	Coal.
		Fire clay

Section at Harris shaft.

FIG. 43. Section of coal bed at Harris shaft.

The coal seen here is soft and will slack readily. A considerable amount of pyrite was noticed, disseminated through the coal in thin films. The coal at the other openings in this neighborhood is approximately of the same thickness, though it diminishes in some places to one foot. The overlying sandstone is, in places, very calcareous, approaching almost a limestone. A limestone, over 10 ft. in thickness, occurs above this sand-stone, though separated from it by several feet of shale. The fire clay beneath the coal is here of very excellent quality and is largely used in the manufacture of refractory materials. The coal is mined very close to the outcrops of the Lower Carboniferous Limestone, the Coal Measure rocks

Coal soft and pyritiferous.

Fire clay of excellent quality.

frequently projecting between these latter in long tongues, separated from each other by hills of Burlington or other Lower Carboniferous strata.

Coal near Calwood.

About three miles north of Calwood a bed of coal is operated to a very limited extent, which is probably the same as that found at Fulton. In section 2, township 48 N., 9 W., on Jas. Henderson's land, the following section was obtained from a miner:

SECTION 2.

	Feet	Inches.
1. Arenaceous limestone		
2. Shale (black near bottom)	3	
3. Coal	2	8

This coal cannot occupy a very extensive area, inasmuch, as the Lower Carboniferous rocks crop out both east and northwest of this point.

Coal near Stephen's store.

At Stephen's store, on Cedar creek, in section 2, township 48 N., 11 W., is the only other locality in the county where coal mining is systematically pursued. At this point a number of shafts and drifts have been operated. The following section, measured at the Oldham shaft, represents the general character of the strata here:

Section in Oldham shaft.

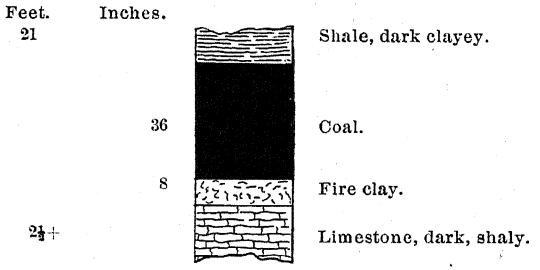


FIG. 44. Section of coal bed at Stephen's Store.

The coal is quite hard, but is reported to clinker rather freely in burning. The position of this bed and the association of strata here suggest the probability that it is the same as that worked in Boone Co., described on pp. 74 and 75.

Same as bed mined in Boone county.

A number of isolated deposits or pockets of coal exist in the southern portion of this county. The coal reaches in some a

thickness of 40 or 50 ft. They have been worked in past years. A description of such coal deposits is given at the end of this chapter.

11. MONTGOMERY AND, 12. PIKE COUNTIES.

PRODUCTION IN 1891.....13,124 TONS.

MONTGOMERY is another county situated on the margin of the Coal Measures; in fact, only in the extreme northwestern portion are such rocks represented to an extent worthy of notice. The Lower Carboniferous and underlying strata occupy the remainder of the county. Coal mining is prosecuted only at Wellsville and in the immediate vicinity.

Coal only in northwestern corner.

The shaft of the Vandalia Coal Co., at Wellsville is 100 ft. deep to the top of the coal. Here the following section was measured:

Section at Wellsville.

Feet.	Inches.	
2		Shale, black fissile.
	2	Pyrite, ("sulphur.")
	20	Coal.
	½	Pyrite.
	10	Coal.
34		Fire clay.

FIG. 45. Section of coal bed at Wellsville.

The coal is worked by the long wall method; the roof holds up well at the face, but, along the entries, it flakes off readily as it settles down upon the gob. The mine is an exceedingly dry one. Much trouble is caused by the prevalence of slips and faults which necessitate much dead work and cause a considerable loss of coal. Other shafts and a few drifts are operated in this neighborhood on a small scale, chiefly to supply local demands. Whether this coal is the same as that operated in Callaway and Boone counties, we are not at present prepared to say.

Character of coal and roof.

IN PIKE county, Coal Measure rocks occur in the southwestern corner, limestones and shales of that age being frequently found. No coal interstratified with these rocks has, however, been discovered yet.

No coal mined in Pike county.

13. AUDRAIN COUNTY.

PRODUCTION IN 1891.....19,569 TONS.

In the eastern half of Audrain county the Coal Measure rocks are very thin. The Lower Carboniferous Limestones occupy the extreme eastern portion, crop out along the larger streams up into the area of the Coal Measures, and are further struck in drill holes and wells at shallow depths within the area of these overlying rocks. In the town of Vandalia, these lower rocks occur at a depth of about 100 ft., according to the record of a drill hole put down there.

Lower Carboniferous rocks near the surface.

Coal mining is prosecuted in this county on a commercial scale at Vandalia and Farber, and, for local uses, at several points south of the railway between these points.

At Vandalia there are three shafts, viz.: Shaft No. 1, of the Vandalia Coal Company, the shaft of the Audrain Coal Company, which closely adjoins the last, and Shaft No. 2 of the Vandalia Coal Company, about one half of a mile farther west. These shafts vary in depth from 60 to 72 ft. The following is a section of coal measured in shaft No. 1, of the Vandalia Co.:

Three shafts at Vandalia.

Feet.	Inches.	
6		Shale, black, fissile with concretions ("nigger heads.")
	20	Coal.
	½	Pyrite.
	8	Coal.
	2	Clay, shaly, black ("mining.")
		Fire clay.

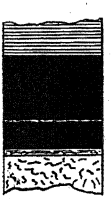


FIG. 46. Section of coal bed at Vandalia.

A lenticular layer of dark, hard, calcareous rock, known as "black bat," frequently occurs immediately over the coal, at times as much as one foot in thickness. The coal is worked here on the long wall plan. The roof is excellent where there are no slips or faults; but these are, unfortunately, quite abundant, so much so as to cause abandonment of the work in some directions; further, the concretions in the shale overhead are abundant and impair the roof. The coal contains more or less pyrite or "sulphur."

Character of coal and roof.

The conditions are similar to the above in all the shafts here operated.

At the Audrain Coal Company's shafts the mining of the fire-clay underlying the coal is carried on extensively. It is excavated to a depth of 11 ft. The clay is of excellent quality and is manufactured at the mine into fire brick. The fire-clay is mined from under the coal, the upper 20 in. bench of the latter being left as a roof.

Fire clay at Audrain Coal Co.'s shaft.

At Farber the shaft is about 100 ft. deep and here the following section was measured:

FIG. 47. Section of coal bed at Farber.

Section of bed at Farber.

The coal is here also extensively faulted, as much as one half of the face being thus injured, according to the statement of the mine boss. The long wall method of mining is used. The mine is very dry and no trouble is given by water. The roof is excellent and requires little propping. This mine is operated by horse and gin hoist and the production is comparatively small.

Coal faulted, roof good.

South of Ladonia and Farber a number of shallow shafts and drifts are operated, along the stream banks, to supply local demands. The section and the character of the coal at these pits are substantially the same as have already been described for this county, and the same prevalence of slips and faults, and of the concretions in the overlying shale is found. These conditions of the coal here make it necessary for caution to be used in the selection of a site for a shaft, as the faulted condition of the coal is less prevalent in some localities than in others; it being probably universally present, but not always to a sufficient extent to prohibit mining.

Coal south of Ladonia.

West of Mexico several small mines have been operated from time to time to satisfy local demands. Such a one is the

Oldham shaft, located some four miles northwest of Thompson Station; the coal here is said to be of good quality and to be about 2 ft. thick. It was not examined by the writer. Broadhead, in manuscript notes in the Survey office, refers to coal in the immediate vicinity of Mexico about 20 in. thick and describes its occurrence at other points, north and south of that place, about 2 ft. thick.

Coal near Mexico.

About one and one-half miles east of Centralia is another small coal shaft, about 25 ft. deep, in which the following section was measured:

Section near Centralia.

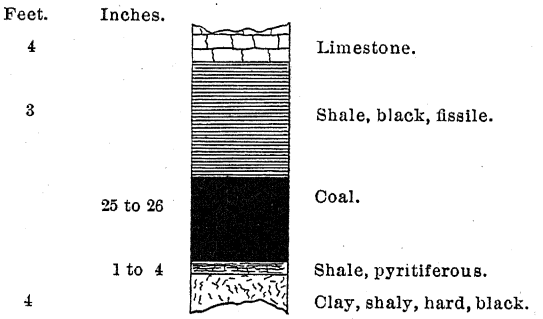


FIG. 48. Section of coal bed at Centralia.

The coal is worked by pillar and room, it is very hard and has to be blasted. It contains, apparently, little pyrite.

In the extreme northwestern portion of Audrain county no coal mining is at present prosecuted to the writer's knowledge, but it is reasonable to expect that the coal mine at Renick in Randolph county, described on page 73, also extends under this area.

Coal near Renick.

14. RALLS COUNTY.

PRODUCTION IN 1891.....614 TONS.

In Ralls county we have, in the extreme southwestern corner, a small patch of the Coal Measure rocks, which are in extension of the same strata found in Audrain county, and which spread over the hills as a thin veneer. The Lower Carboniferous rocks and lower strata occupy the central and whole northern portion of this county, and the former are well exposed in the bluffs of Lick creek in the vicinity of Perry, and along Spencer creek, south of Madisonville.

Coal Measure rocks in patches.

At Jas. Lambeth's, near the middle of section 27, township 54 N., 6 W., is the eastmost occurrence of coal in this county. It is found here, with the accompanying shale, near the summit of a hill, and the aggregate thickness of the Coal Measure rocks cannot be more than 40 ft. The beds lie in a horizontal position, and, beneath these, Lower Carboniferous rocks are exposed along the creek dipping to the northwest, at an angle of about 10 degrees. At this point the following section of coal was measured: Coal at Lambeth's.

FIG. 49. Section of coal bed at Lambeth's.

In the vicinity of Perry mining is prosecuted only on a very small scale, a number of small coal mines being operated for supplying the local demands. These are located within a radius of two miles of the town, on both sides of Lick creek. They invariably occur near the tops of the hills and above the creek bluffs, the Lower Carboniferous Limestones being prominently exposed below. Coal near Perry.

The coal, at all of these pits, is approximately 2 ft. in thickness and is overlain by 5 ft., or more, of black fissile shale. Above this, at a distance of perhaps 10 ft., is a bed of compact limestone about 20 in. thick. The following section was measured from an exposure on the bank of a small branch in the southwestern half of section 23, township 54 N., 7 W.

SECTION 3.

	FEET.	INCHES.
Black fissile shale	6	
Coal	1	10
Dark clay parting		2
Coal		4 to 5
Drab clay shale	8	
Black, fissile shale	1	
Coal	1	
Fire-clay		

At J. A. Gallagher's, in the southeastern quarter of section 12, township 53 N., 7 W., the following section was measured:

Section at Gallagher's.

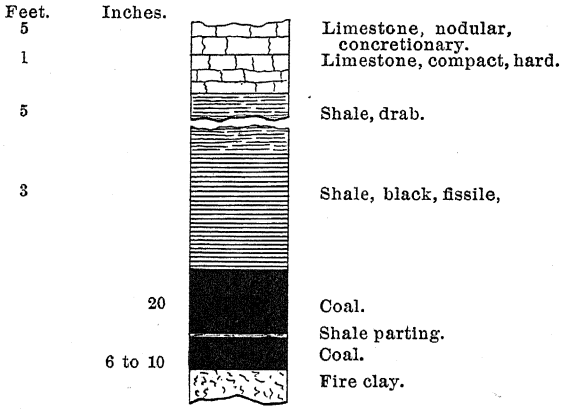


FIG. 50. Section of coal bed at Gallagher pit.

This coal contains a good deal of selenite and calcite in thin plates along the joints, and it slacks readily on exposure. The section and the characteristics of the coal and associated strata indicate that this is the same bed as the one more extensively worked at Vandalia and other points in Audrain county.

Coal same as mined in Audrain county.

15. MONROE, 16. SHELBY AND, 17. MARION COUNTIES.

PRODUCTION IN 1891.....20 TONS.

15. MONROE COUNTY has a small coal area. Coal Measure rocks occupy the extreme southern portions, while north and east of this they occur only in small patches in the hills, overlying the Lower Carboniferous strata, which latter crop out in the valleys and constitute the prevalent rocks in the county. In the northeastern corner is a small patch, a part of a Coal Measure area which extends into the southwestern corner of Marion, and into the southeastern corner of Shelby county.

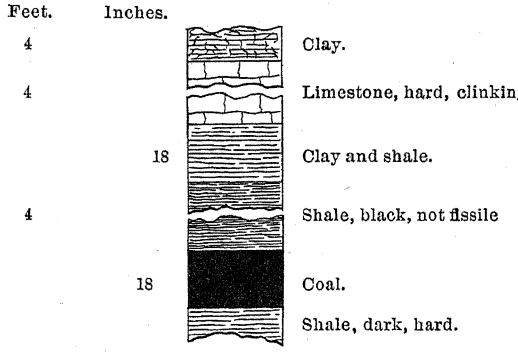
Coal measure area very small.

Coal mining is prosecuted in Monroe county only on a small scale to supply local demands.

In the vicinity of Paris, about a mile and a half west of the town, on the north side of the railway, is the *Jackson drift*.

The coal is opened in a ravine about 60 ft. below the top of the hill and, from the record of a shaft sunk in this vicinity, it is probably not more than 40 ft. above the Lower Carboniferous Limestone. The record of this same shaft shows the existence of boulder clay here, as much as 70 ft. thick on the hill-tops. In such places it occupies the place of the coal. The coal is about 18 in. thick. The following section was measured at the drift:

Coal near Paris.



Section at Jackson drift

FIG. 51. Section of coal bed at Jackson drift.

The coal is somewhat pyritiferous and the bed varies in thickness, often thinning to less than a foot, through a lowering of the roof. Another coal bed, about a foot thick, is reported by Mr. Jackson at a distance of about 6 ft. below the upper one; but it was not seen by the writer. About two miles east of Paris, on what is known as the Evan's Tract, a shallow shaft was sunk about two years ago in which coal was struck which is reliably reported to have been 7 ft. thick, two feet of which was a so-called cannel coal. The shaft was filled with water when visited by the writer. A specimen of the "cannel coal" found there proved to be a bituminous shale. From the circumstances of the location of this coal deposit as well as its character it probably does not belong in the regular Coal Measures, but is an outlying deposit of limited area.

The "Evans" shaft.

In the vicinity of Madison, some twelve miles west of Paris, a number of coal pits are operated in a small way, principally south of the railway.

The C. L. Butler drift is about two miles south of Madison, on Elk Fork creek, about ten feet above the flood plane. The following section was measured here:

Section at Butler drift.

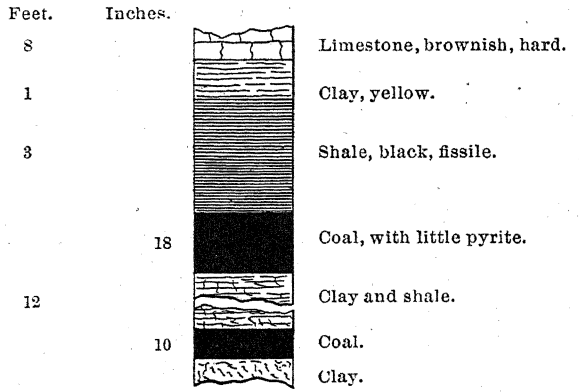


FIG. 52. Section of coal bed at Butler drift.

Three coal beds here.

Another bed about 18 in. thick, is reported by Mr. Butler about 15 ft. below the last, in the bed of the creek. A comparison of this section with that obtained at Jackson's drift, near Paris, shows that the coals operated at the two points belong, in all probability, to the same horizon.

John Branham's coal pit is about a mile and a half south of Butler's, but was not visited by the writer. The coal here is reported to be of the same thickness.

Garrett's drifts.

Garrett's coal pits are about two miles south of Middle Grove. They are, at present, abandoned and no measurements of the coal could be made, but the section of other rocks exposed here leaves no doubt as to this coal's being the same as that at Butler's.

Other coal pits.

Other coal pits, including Thomas's, Todd's and Hartgrove's, are reported a few miles north of Madisonville, at which points the coal is of about the same thickness as that found south of the town. Such occurrences are also noted in manuscript relating to Monroe county by Prof. Broadhead, on file in the Survey office.

16. IN SHELBY COUNTY, a thin seam of coal crops out at several points in the southeastern corner. No pits are now

known to be operated, excepting a small pit a few miles north of Shelbina.

Broadhead,[2] refers to a coal pit about two miles north of Shelbina, and to another about six miles east of the same point where the coal is about 1 ft. thick. Of these the pits immediately north of Shelbina were recently visited by the writer. Coal near Shelbina.

At James S. Barker's pit, the following section was measured: —

SECTION 4.

	FEET.	INCHES.
1. Shale, *black with bituminous layers*	2	
2. Shale, *sandy, micaceous, dark drab*		6 to 14
3. *Coal*	1	6
4. Clay, *white*		

Section at Barker's pit.

The coal is reported to vary from 6 to 26 inches in thickness. It rises rapidly to the east, apparently. Other small pits occur within a mile of this to the east and northeast, in which the coal is said to be of about the same thickness. About a mile northeast of the Barker pit is one on Mrs. Given's land, in which bituminous coal, cannel coal and black shale, aggregating over five feet in thickness are reported to occur. The Barker coal is at a level not much above the bottom of Salt river to the north, and here Lower Carboniferous Limestones crop out in bluffs which rise much above the level of the coal. They demonstrate that the coal area is of limited extent here. Coal area limited here.

17. IN MARION COUNTY, no coal mines in the regular Coal Measures are at present known to be operated, but coal beds exist there over a small area, in the southeast corner and have been worked during past years. Such an opening is referred to by Swallow,[1] about six miles northwest of Monroe City. The coal exposed there was about 18 in. thick. Coal near Monroe City.

18. HOWARD COUNTY.

The Coal Measure rocks cover nearly the entire area of Howard county, but do not attain a great thickness there, excepting in the northern portion. In the south and west, along the river,

[1] Report Mo. Geological Survey 1855. Part I, p. 173.
[2] MSS. Notes.

Lower Carboniferous rocks are exposed in the hills and bluffs and their outcrops extend thence up the streams into the limits of the Coal Measures.

Earlier descriptions of Howard Co.

A description of the general geology of Howard county, including specific reference to the coal beds and their correlations, is contained in the report of the Missouri Geological Survey for 1873–74, prepared by G. C. Broadhead and C. J. Norwood. The occurrences of coal about Russell, Sebree, Fayette, Boonsborough, Glasgow and Roanoke are noticed and many sections are described which are not now accessible.

Coal of variable thickness

Coal is widely distributed in the county, but is of fluctuating thickness. The principal developments, at the present date, are in the vicinity of Russell, in the northeastern corner; in fact this is the only point from which coal is mined and shipped on a commercial scale.

Bain and Company's slope is situated in the town of Russell, on the Missouri, Kansas and Texas railway. The pillar and room method of mining is followed, the roof being poor. The following section was measured here:

Section at Bain & Co.'s slope

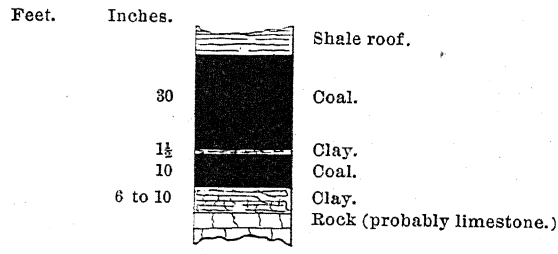


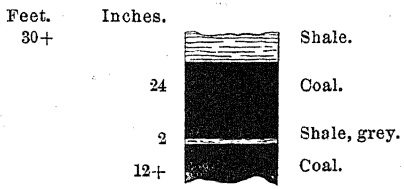
FIG. 53. Section of coal bed at Russell.

The same coal crops out and has been opened upon at other points in this vicinity but is not operated at present.

Coal near Sebree and Harrisburg.

In the immediate vicinity of Sebree no coal is at present mined. Near Harrisburg, Boone county, recent developments have been made, which are referred to in the description of Boone county, on p. 76.

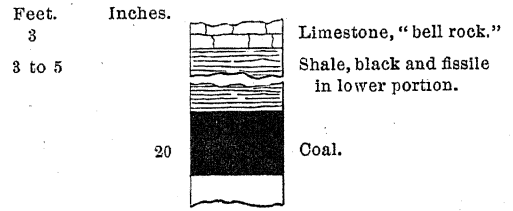
The John T. Gilvin drift is about two miles west of Harrisburg, and is located in the bottom of a hollow. Here the following section was measured:



Lower bed at Gilvin drift.

FIG. 54. Section of coal bed at Gilvin drift (lower bed.)

The coal is claimed to attain a thickness of $3\frac{1}{2}$ feet elsewhere. Another bed of coal crops out farther up the creek, about forty feet above the last. The following section was measured of this:



Upper bed at Gilvin drift.

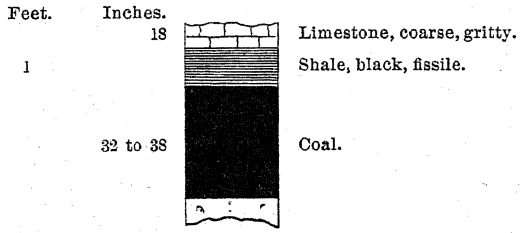
FIG. 55. Section of coal bed at Gilvin drift (upper bed.)

A shaft sunk on the hill top, about a mile south of the Gilvin drift, penetrated the lower coal at a depth of 100 ft. A comparison of the sections leaves little doubt but that this lower bed is the same as that operated at Russell.

In the vicinity of Fayette coal is operated at several points, in a small way, for the purpose of supplying local demands. The bed most generally worked is about 18 inches thick, but thicker coal has been struck in places.

Coal near Fayette.

At Pierce's coal pit, about two miles east of Fayette, the following section was obtained from Mr. Pierce:



Section at Pierce shaft.

FIG. 56. Section of coal bed at Pierce shaft.

The shaft was filled with water at the time of visit and the coal could not be actually measured.

The Elkin's coal drift is close to Pierce's and is situated about 60 ft. above the latter. The following section was measured here:

Section of Elkin's bed.

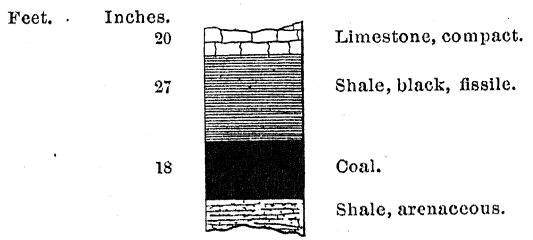


FIG. 57. Section of coal bed at Elkin's drift.

This bed is worked at a number of points in the neighborhood and the coal is preferred to that of the lower bed at Pierce's. It is reported to exceed 18 inches in thickness at other points.

West of Fayette, no coal developments are now in progress. Several abandoned localities, were, however, recently visited. Harkley and Tatum coals. At the old Harkley coal pit, some 8 miles southwest of town, everything is filled in and no measurements could be made. At A. Tatum's, some eight miles west of Fayette, the same was the case, but the coal here is reported by Broadhead to be from 24 to 33 in. thick.

In the vicinity of Boonsborough, some three miles west of the town is the old H. L. Brown pit, now the property of B. H. Coal near Boonsborough. Tanner. About two feet of coal is exposed here in the bed of a branch. It is said to have been dug into for a depth of 6 ft. and not entirely penetrated. The coal and associated shale have a dip here of ten degress or more N. W. and there are other evidences of much local disturbance.

In the vicinity of Glasgow, coal is reported by Broadhead, in the bluffs, 20 in. thick, and this has been recently worked.

At Armstrong, between Glasgow and Russell, no coal mines are operated. East of the town, however, on the head waters of Coal near Glasgow and Armstrong. the various creeks, beds crop out and are worked at intervals. The Briggs coal stripping is probably the most important of

these. It is about three miles due east of Armstrong. The coal here is 30 in. thick and is overlain by shale. North of Armstrong are several occurrences of coal which do not exceed 1 ft. in thickness, however.[1]

19. CHARITON COUNTY.

PRODUCTION IN 1891.....1,170 TONS.

Chariton county is entirely underlain by the Coal Measure formation, yet very few coal mines occur within its limits.

Along the border line of Randolph county Asa Gunn's drift and a few other small pits are operated north of the Chicago & Alton railway which have already been noticed in the description of Randolph county on page 70 of this report. The two abandoned coal shafts of Hammat and others on the railway, south of Gunn's drift, are also in Chariton county. These mines are presumably in the Huntsville coal bed and the probable extent of this bed over the eastern portion of the county will be displayed in a forthcoming map and report of the Geological Survey.

Coal near Randolph Co. line.

About a mile south of Salisbury, on P. D. Vandeventer's land, a coal bed has been mined for local uses in past years, but the drift was abandoned at the date of inspection and no measurements could be made. The thickness of the coal is creditably reported, however, to be about 18 inches. At the same locality the owner of the land states that a drill hole was put down and a lower bed of coal was struck at a depth of about 60 ft. beneath the upper one. This lower coal was composed of two benches, each about two feet thick, separate by about two feet of shale; or, in other words, the section is thought to be similar to that at the Gunn drift, a few miles east, and described on page 70. A well was subsequently sunk at this point, but, before the coal was reached, work was stopped, and hence the results of the drilling were not confirmed, so far as the thickness of the coal is concerned. About 800 ft. northeast of this, however, a shaft was sunk and the lower coal encountered at a depth of 50 ft. According to the owner's

Coal on Vandeventer land.

[1] This northern portion of Howard county has been mapped in detail by the Survey and full descriptions of the various coals will be contained in the forthcoming report, and their relations will there be defined.

statement, however, a "horseback" was encountered here, and the condition of the coal was not such as to permit profitable mining. The unsatisfactory nature of these results prevents their being of much value in determining whether the Huntsville coal really exists under this and adjacent country. General considerations lead one to favor this view, however.

Cunningham coal pits.

In the vicinity of Brunswick are a number of small coal pits, some of which are now operated for supplying local demands. J. F. Cunningham's pits are adjacent to the Wabash railway, about two miles northwest of the town, the coal being about 15 ft. above the track. The following section was obtained here, though the full thickness of the coal was not seen:

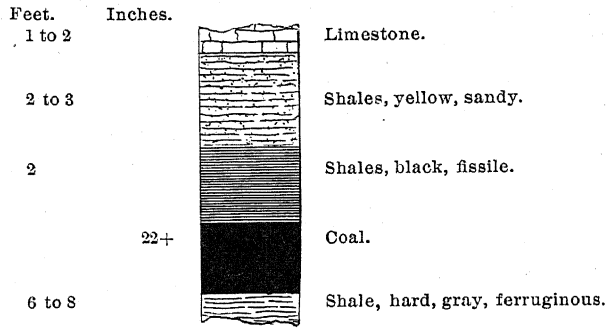


FIG. 58. Section of coal bed at Cunningham pit.

This pit was formerly operated for locomotive use on the adjacent railway.

Other coal pits.

Other coal pits in the neighborhood with reported thicknesses of coal approximately the same are: John Bundy's, about a mile northeast of Cunningham's; Kealer's, about nine miles north of Brunswick, and Rucker's, four or five miles northeast of the town.

Coal near Lingo and Marceline.

In the northern part of the county, west of the Chariton river, the coals operated at and in the vicinity of Lingo, Macon county, doubtless occupy a considerable area here; they are described on pp. 62 to 63 of this report. Similarly the coal operated at Marceline in Linn county, described on pp. 94 and 95, undoubtedly extends into this county and must underlie a large territory.

Coal along Grande river.

In the northeastern portion of the county, along Grande river, the coals described in the following pp. 107 and 108, as occurring in Carroll county, in all probability extend into Chariton.

20. LINN COUNTY.

PRODUCTION IN 1891.....28,036 TONS.

Coal has been known to exist in Linn county for a number of years. Some twenty years ago[1] Broadhead described a bed about 20 in. thick, about four miles southwest of Laclede, and also 10 in. of coal cropping out four miles southeast of Browning.[2] Norwood in the same Vol., p. 263, describes coal 18 to 20 in. thick, some 2½ miles northeast of Bucklin. From these occurrences, together with the facts of the record of a shaft and drill hole at Brookfield, Broadhead defines three coal beds as occurring in this county. Distribution of coal.

At Brookfield coal mining is not, at present, conducted on a very large scale. About two miles east of the town, on the east bank of Yellow creek, is Geo. Clark's shaft, about 140 ft. deep, in which the following section was measured:

Feet.	Inches.		
50			Shale, drab.
	16 to 18		Coal.
	¼		Clay parting.
	8		Coal.
			Clay and shale.

Section at Clark shaft.

FIG. 59. Section of coal bed at Clark's Shaft.

The coal is worked by the pillar and room system, the roof not being of first quality. The coal is not good for forge uses, it containing too much pyrite, but it is claimed to be an excellent steam coal. Two coal beds were struck in this shaft at distances of 63 and 84 ft. above the lower coal, they being respectively 14 and 5 inches thick. Character of coal.

Other shafts have been sunk in close proximity to these and adjacent to the railway, but they were not visited by the writer, as they are operating the same bed and the character of the coal is similar. This coal is also mined some three or four miles southeast of Brookfield, at the Shafer shaft, which is about 160 ft. deep. Shafer shaft.

[1] Report Geological Survey, 1873 to 74, p. 261.

[2] Opus cite, p. 266.

Shaft at St. Catherine.

At St. Catherine, about 5 miles east of Brookfield, mining of coal has been prosecuted in the past years, but is not now in progress. The coal worked was, probably, the same as that mined near Brookfield and was similar in character, according to a miner's statements. One of these St. Catherine shafts was 140 ft. deep. About 300 ft. east from the foot of this shaft the coal was cut off and the entry passed directly into quicksand, which flowed so rapidly into the mine as to cause its abandonment. The coal here had evidently been eroded, and the entry was driven into a pre-glacial channel, such as have been previously described as occurring in Putnam, Sullivan and other counties.

Glacial channel encountered.

Bucklin drill hole.

At Bucklin, some six miles east of St. Catherine, near the county line, a drill hole was put down some 350 ft., and the report is that a coal bed 32 inches thick was struck at a depth of 200 ft., and that above this an 18 inch bed was found. Until more reliable data can be obtained, these results must be accepted with caution.

At Marceline is, however, by far the most important development of coal in the county. It is in the extreme southeastern corner, on the Santa Fe railway. The shaft is 185 ft. deep. In it the following section was measured:

Section at Marceline.

Feet.	Inches.		
16			Shale, drab.
	26		Coal.
2 to 3			Fire clay.

FIG. 60. Section of coal bed at Marceline.

Overlying beds.

Above these beds two others were penetrated by the shaft, one 4 in. thick at a distance of about 55 ft. above the lowest, and the other 14 in. thick, some 6 ft. above the last.[1] The roof is not a very strong one; but the long wall plan of working is followed with success, and, along the entries, a portion of the overlying shale is brushed down up to a parting plane which

[1] According to a record kindly furnished by Mr. Jno. R. Braidwood, Supt. of Mines of the Kansas & Texas Coal Co.

makes a remarkably smooth and unbroken cover. No slips or faults were observed in this coal, but it appears to contain a large amount of pyrite; this is picked out so far as is possible, but, nevertheless, gives some trouble in combustion. The indications are that this bed is the same as that reported to have been struck at Bucklin and that mined at St. Catherine and Brookfield, though detailed examinations will be necessary before this can be asserted with confidence.

Coal pyritiferous.

Correlations.

21. LIVINGSTON COUNTY.

PRODUCTION IN 1891.....200 TONS.

In Livingston county very little coal mining is prosecuted, and the facts in possession of the Survey are not sufficient for us to be able to express, at present, the possible relationship between the beds that are worked here and those operated on a more extensive scale in the adjoining counties. Coal occurs near the surface and has been described in the earlier reports of the Survey, in the vicinity of Utica, but it is only from 10 to 15 in. thick.

Distribution of coal.

A bed more worthy of consideration also occurs southeast of Bedford, close to Grande river, where it is about 20 in. thick; it is, however, operated only to supply small local demands.

Coal on Grande river.

At the Cox mines, about six miles north of Chillicothe, is perhaps the most noteworthy development of coal. Here there are a number of drifts and small shafts. At one of the latter, 63 ft. deep, the following section was measured:

Feet.	Inches.		
44			Shale, gray, argillaceous.
	18		Coal.
	4 to 6		Fire clay.
5+			"Hard rock."

Section at Cox shaft.

FIG. 61. Section of coal bed at Cox Shaft.

The coal is thinly laminated and breaks into slabs, but is clean and sharp and is much esteemed for forge purposes. Pyrite is not abundant, and appears irregularly in seams. According

Coal thins out.

to the developments here this bed is found to thin out entirely between the overlying shale and the underlying fire-clay within a distance of a quarter of a mile from the shaft, and, south of this, excavations have failed to find coal.

About six miles northeast of Chillicothe are coal pits in which the coal is reported to be as much as 28 in. thick. It is, however, not considered of so good a quality as that at the Cox mines.

Chillicothe drill hole.

Deep drilling has been done in this county for the purpose of prospecting for deeper coals and a record of such a drilling is given on p. 313 of the report of the Mo. Geological Survey for the year 1872. More recently, however, a shaft was put down about two miles northeast of Chillicothe to a depth of 275 ft. with the following results:[1]

SECTION 5.

1.	At a depth of	110 ft	16 to 20″ coal
2.	"	136 "	8″ "
3.	"	160 "	12″ "
4.	"	275 "	33″ "

Coal of uncertain thickness.

The bottom bed was the one for which the shaft was sunk, as the 33 in. thickness was first obtained from drilling, but, when reached by the shaft, according to the report of parties who were interested in this sinking, the bed proved to be of very variable thickness. A sandstone roof was found over the coal, of so undulating a character that it frequently almost cut out the coal entirely and, generally, materially diminished its thickness. A hole was drilled 122 ft. below the bottom of the shaft and no other coal bed was encountered.

22. GRUNDY COUNTY.

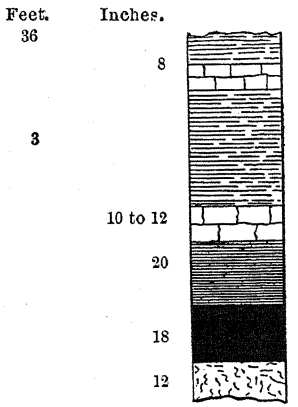
PRODUCTION IN 1891.....28,983.

Surface coal.

Mining is prosecuted only at one point in Grundy county, viz. at Trenton, and this at a depth of 200 ft. Coal crops out at the surface near the town of Alpha and also near Trenton, according to notes of Prof. Broadhead in the Survey office, but this coal is stated to be only about 9 in. thick.

[1] The above is only an approximately correct record. It is prepared from information kindly given the Survey by Mr. Stewart of Chillicothe.

At Trenton the old shaft is 210 ft. deep and is located close to the Rock Island railway station. Here the following section was measured:



Section at Trenton shaft.

FIG. 62. Section of coal bed at Trenton.

Three other coal beds are reported to have been struck in this shaft, two above the bed operated and one below. The first is 18 in. thick and is about 120 ft. from the surface. The second is 14 in. thick and is about 145 ft. from the surface. The third varies from 6 in. to 2 ft. and is about 15 ft. below the bed operated, according to the statement of the proprietor of the mine. The bed is worked here by the long wall method, the roof being excellent and requiring hardly any propping, either along the entries or at the face. It appears to be a hard and clear coal and is reported to stand exposure well and to make few or no clinkers in burning.

Other coal beds here.

Character of roof and coal.

It is esteemed superior to the neighboring Iowa coals for locomotive use. Between the black shale and the coal there are frequently layers of the so-called "black bat" (black calcareous shale) which often reach a thickness of three ft. and, where this occurs, roof falls are frequent. The other, 18 in. coal has been experimented with, but is found to be soft, slacking readily on exposure.

"Black bat."

A new shaft is being sunk by the Company about a mile south of town. When visited, it had reached only the upper 18 in.

coal. Some 30 feet of micaceous sandstone overlies this bed in both shafts.

Coal Measures 550 feet thick here.

Sufficient data are not at present at hand for us to be able to state what the exact stratigraphic relations are between the coals worked here and those found in adjoining counties. A drill hole put down at the bottom of the old shaft showed that the total thickness of Coal Measure strata here is about 550 feet. Below the bed operated, only one seam of coal was encountered, this only 2 inches thick, and 110 feet deeper.

THE NORTHWESTERN COUNTIES.

Including 23. Mercer, 24. Harrison, 25. Daviess, 26. DeKalb, 27. Gentry, 28. Worth, 29. Nodaway, 30. Atchison, 31. Holt and 32 Andrew.

PRODUCTION IN 1891.....2,222 TONS.

Northwestern counties non-producers.

The northwestern counties of Missouri, above enumerated, cannot be ranked as coal producers although they are all well within the limits of the Coal Measures. In fact, not in one of them, to the writer's knowledge, is there a single coal mine which is constantly operated.

Coal beds not persistent.

These counties are all immediately underlain by the upper strata of the Coal Measures, which are characteristically barren of coal. The lower strata can be reached only by deep shafts and few are inclined, with the present incentives, to incur the necessary expense of sinking them. Further, there is hardly any room for doubt but that the coal beds, which are well developed in the lower strata of the Coal Measures, along the border to the east, do not extend under the entire area of the upper rocks; thus, even if a shaft or drill hole be sunk to the requisite depth, it is still a question as to whether a particular coal will be found.

Careful drilling necessary.

We are, however, of the opinion that, over many portions of these counties, where now no coal is operated. coal beds will ultimately be found at depths. A carefully directed series of diamond drill holes over this country would yield results of great value and any prospective developments should be preceded by such drilling.

21. In Mercer County, no coal is, at present, operated, to the knowledge of the writer. Prof. Broadhead, in manuscript notes of the Survey, refers to coal 6 inches to a foot in thickness cropping out at various points, south, southeast and north of the town of Princeton, which was worked at a few places for temporary local use at the time of his visit. Coal near Princeton.

It is possible that the coal beds of Putnam county, to the east, extend into this county: but it is further probable that the distribution of all the upper strata of the Coal Measures here is much restricted by the channels of the pre-glacial drainage system which are so abundant under this drift covered portion of the State. Pre-glacial channels.

22. In Harrison county there is as great a dearth of readily available coal, as in Mercer county; beds 2 to 4 in. thick, east of Bethany, being the only ones of which we have any notice. A diamond drill hole was put down a mile west of Bethany, in the bottom of the East Fork of Big creek, in 1885, to a depth of 650′. According to the record furnished no coal over nine inches in thickness was struck.[1] Some doubt is felt, however, concerning the reliability of this record. Bethany drill hole.

23. Daviess county has been credited with as little coal as Harrison county. In the report of the Missouri Geological Survey of 1873–74, seams a few inches in thickness, cropping out in the vicinity of Gallatin and Winston, are the only beds referred to. At Gallatin, a few years ago, a shaft was sunk to a depth of some 700 or 800 ft. No record of this shaft could be obtained; but the results are reported to have been unsatisfactory, so far as the determination of the existence of workable coal bed was concerned. At Winston, recently, a shaft was sunk to a depth of 260 ft. Black shale was struck at the bottom but complications with the contractor arrested further developments. The coals operated at Hamilton, in Caldwell county, described on pp. 105, 106 of this report, in all probability underlie the southern portion of Daviess county. How far north and how far west they extend of a workable thickness, can be determined, however, only by careful and systematic drilling. The results Gallatin drill hole. Winston shaft.

[1] From a record sent the president of the State University and furnished the Survey by Prof. G. C. Broadhead.

Cameron drill hole.

of the deep drilling at Cameron, later described on page 104, suggest that the coals thin out materially before reaching that point, though the discordance between the two records and the obstructions attending the drilling diminish the weight of that evidence.

Coal near Union Star.

24. In DeKalb county, the only reference which we have to the existence of coal is of an outcrop of a bed three inches thick, north of Union Star. The results of the deep drilling at Cameron, described under Clinton county have also bearing upon this county.

25. Concerning Gentry county we have reference in notes of Prof. Broadhead's to the existence of coal at the surface in the extreme southwestern corner, of a thickness varying from 4 to 10 in. Further, a bed of coal 18 in. thick was reported in the northeastern corner but the bed was not seen when the locality was visited. At Gentryville, a few years ago, a diamond drill hole was put down to a depth of 500 ft. and the record shows that a bed of coal 26 in. thick was struck, at a depth of 477 ft., and another over it, only 7 in. thick at a depth of 383 ft.[1] During the past year deep drilling has also been prosecuted at Stanberry. Nothing definite could be obtained from the company, here, however, but it was intimated that the results were similar to those reached at Gentryville. Another drill hole is in prospect at this place.

Drill hole at Gentryville.

Drill hole at Stanberry.

26. Worth county is apparently destitute of any coal near the surface. The Survey has no records of any such being found there nor is it probable that such will be found in the future. Concerning the existence of the deeper coals this county shares the uncertainty existing in the other northwestern counties.

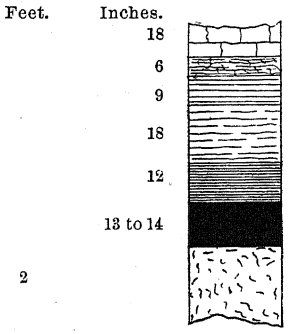
No record of coal in Worth co.

27. Nodaway county is somewhat exceptional among the others around it in that coal occurs near the surface and is operated intermittently at a number of pits for local uses. The locality of chief prominence in this connection is in the vicinity of Quitman, in the western portion of the county. Two pits were in operation here at the time of inspection.

Coal at Quitman.

[1] The record of this hole has been kindly furnished the Survey by Mr. E. E. Ennis of King City.

At Pierson's drift, about a mile southeast of the town of Quitman, the following section was measured:



Section at Pierson drift.

FIG. 63. Section of coal bed at Pierson's Drift.

At Casinger's shaft, 35 ft. deep, about a mile south of Quitman, a similar section was measured. Coal occurs north of Quitman along the Nodaway river, as far as City Bluffs post office. It continues approximately of the same thickness as at Quitman. Thin surface coal also occurs in the southwestern corner of the county, along Carbon and Whitecloud creeks. No operations there were heard of, however, when the county and this section was visited.

Coal at other points.

At Maryville, about the year 1888, a diamond drill hole was sunk to a depth of one thousand feet in the search of deep coal. The core of this hole was preserved at the county court house and was examined and sampled by the writer this year. Only one seam of coal is shown in the core, and this at a depth of 306 ft. and only three inches thick. The record of the boring is exceedingly valuable as affecting the question of the existence of coal, within the depth reached, this far west in the State.

Maryville drill hole.

28. ATCHISON COUNTY has no coal mines. Broadhead, in the report of 1872, refers to coal having been prospected for in the southeastern part of the county, near Langdon, and Swallow found 8 in. of soft coal in the northeastern corner. As already affirmed by Broadhead there is little probability that coal of workable thickness, within accessible depths, will ever be found in this county; and it is further probable that no coal beds of

Coal near Langdon.

workable thickness exist here within the whole Coal Measure section.

Coal near Forest City.

29. In Holt county thin coal is found near the surface in the vicinity of Forest City, but is, according to Broadhead (Report 1872) from 2 to 4 in. thick and, hence, is entirely unworkable. A shaft and drill hole were sunk to a depth of 650 ft., near Oregon, over twenty years ago and the record is published in Broadhead's report on that county. According to this record the following coal seams were encountered:

Section at Oregon.

Section 6.

1.	At a depth of	202	feet	18	inches	of rotten	coal.
2.	"	342	"	6	"	"	"
3.	"	372	"	1	"	good	"
4.	"	438	"	15	"	"	"
5.	"	651	"	54	"	"	"

Concerning the lowest seam, Prof. Broadhead states that he examined specimens of the drillings and concludes that it is chiefly bituminous shale with thin coal seams intercalated.[1]

Coal near Savannah.

30. Andrew county is another non-producer of coal; a few thin seams in the vicinity of Savannah and along Niagara creek being all that we have any record of. The beds in the vicinity of Savannah do not exceed five inches in thickness, according to Broadhead, while the bed in Niagara creek is about 10 in. thick [2] and has been occasionally worked for local uses.

33. BUCHANAN COUNTY.

Surface coal.

Buchanan cannot at present be considered a coal producing county, but it so closely adjoins a coal mining area that hope may be entertained that a bed of workable thickness may yet be struck within its borders. No surface coal of noteworthy value exists there, however. In the vicinity of Hall's station a bed crops out above the level of the railway, and has been worked at several places to a very limited extent. According to Prof. Broadhead's measurements, it is about nine inches in thickness. The record of a boring is further given by him, in the Survey

1 Report Mo. Geological Survey, 1872, p. 371.
2 Report Mo. Geological Survey, 1873-74, p. 310.

report of 1872, p. 354, which reached a depth of 467 feet. According to this the following coal beds were encountered:

SECTION 7.

1.	At a depth of	125 feet	24	inches of coal.	
2.	"	240 "	18	" "	Drill hole at St. Joseph.
3.	"	340 "	10	" "	
4.	"	370 "	30	" "	

He suggests, what is very probable, with reference to these reported beds, that bituminous shale may be included in the thicknesses given.

In the year 1884 a churn drill hole was put down at St. Joseph, by the Turner Coal Company to a depth of 1,308 feet. Black, bituminous shale was encountered in this drill hole at depths of 122 ft., 184 ft., 229 ft., 338 ft., 361 ft., 529 ft., 693 ft., 1,013 ft., and 1,083 ft. These beds varied in thickness from one foot to seven feet, and it is possible that some coal was associated with them. Thin laminæ of coal were recognized at depth of 950 ft., and 1,083 ft. At a depth of 1,200 ft. limestone was encountered, presumably of Lower Carboniferous age, and was drilled into to a depth of 108 ft.[1] Drill hole at St. Joseph.

34. CLINTON COUNTY.

No coal mining is at present prosecuted in Clinton county and the probabilities are that the only coal that can be obtained there is at great depths. No surface exposures of coal are known to the Survey and, though the upper beds of Section 7 reported to have been struck in the drill hole of St. Joseph, in Buchanan county, might be expected to reach the surface here, they have not, up to the present time been located. Surface coal.

[1] A record of this hole, made up of imperfect notes kept by the driller, Mr. E. M. Riddle, of St. Joseph, was kindly furnished the Survey by Mr. R. E. Turner, of St. Joseph, the complete record having been mislaid.

Other deep holes have been put down in this county, one at Hall's station among others. The Survey has not been able, so far, to gain possession of reliable records of these, and until this is done judgment must be deferred as to whether the Leavenworth coal bed was reached by these holes, whether it extends this far north, and, if it so extends, whether it is of workable character and thickness.

Drill holes at Lathrop.

At Lathrop, on the Hannibal & St. Joseph Ry., in the southeastern portion of the county two churn drill holes were put down nearly five years ago, to depths of over 600 ft., for the purpose of determining the existence or non-existence of coal. In both of these holes only one coal bed was struck and this at depths of 544 and 590 ft. The thicknesses as determined by each of these holes was 15 in. and 28 in. respectively.[1]

This coal bed must underlie a considerable area and it can possibly be made use of later. Lathrop is located at a high point in the county and the bed can be reached in other places where it is considerably nearer the surface.

At Cameron, in the extreme northeastern corner of the county, two diamond drill holes were put down in the autumn of 1887, to depths of over 600 ft. One of these was sunk from the bottom of a shaft 430 ft. deep and went to a total depth of 601 ft.[2] In this the following coals were encountered, according to the sworn record:

SECTION 8.

Cameron drill holes.

At a depth of	450 ft.	36	inches of	coal and shale.
"	544 "	14	"	coal.
"	565 "	6	"	coal.
"	586 "	12	"	slate and coal.

In the other drill hole, which reached a total depth of 648 ft., only 7 inches of coal is reported, at the bottom. The discrepancies between these results is attributed, by the parties for whom the work was done, to careless drilling. The suggestion that the two upper coal beds of the one hole are the equivalents of those mined near Hamilton, in the adjourning county of Caldwell, is not improbable, if it is demonstrated that these beds were actually encountered here.

Unsatisfactory results.

[1] The driller's records of these holes were furnished the Survey by Mr. A. T. Staples, of Lathrop.

[2] The original notes of these drill holes were kindly placed at the disposal of the Survey by Capt. S. H. Corn, of Cameron.

35. CALDWELL COUNTY.

PRODUCTION IN 1891.....22,661 TONS.

Coal mining is prosecuted in Caldwell county on a commercial scale in the vicinity of Hamilton, near the north line of the county. Mining near Hamilton.

The Tom Creek shaft, of the Hamilton Coal company, is located about two miles southeast of the town in a valley. The shaft here is 300 ft. deep and, in it the following section was measured:

Feet.	Inches.	
	20	Limestone, "cap rock."
	4 to 5	Shale, drab.
	6	Shale, black.
	12 to 24	Shale, drab.
	12	Shale, black, fissile.
	10	Coal.
	1 to 3	Shale parting, black.
	15	Coal.
	12+	Fire clay.

Section at Tom Creek shaft.

FIG. 64. Section of coal bed at Hamilton Coal Co.'s Shaft.

The roof is poor and, in the northwestern portion of the mine a brown bituminous sandstone replaces the shale and sometimes reaches down into the coal. The black shale and the coal, where this sandstone occurs, contain a great amount of bitumen which exudes in drops. This coal bed is broken by many faults and slips which seriously increase the cost of mining and limit the extent of the workings. Bituminous sandstone in roof.

A lower bed, 110 ft. deeper, has been shafted to here. It is 19 in. thick and is covered by about 10 in. of black shale which is overlain by drab shale. This lower bed is not much faulted, but is reported to contain a good deal of pyrite. Lower bed.

The Caldwell Coal Company's shaft is about two miles east of Hamilton, on the main line of the Hannibal and St. Joe Ry. The extreme depth of this shaft is 472 ft. to the bottom bed of

coal, and to the upper bed of the coal it is 365 ft. deep. Of this latter the following section was measured in the shaft:

Section at Caldwell Co.'s shaft.

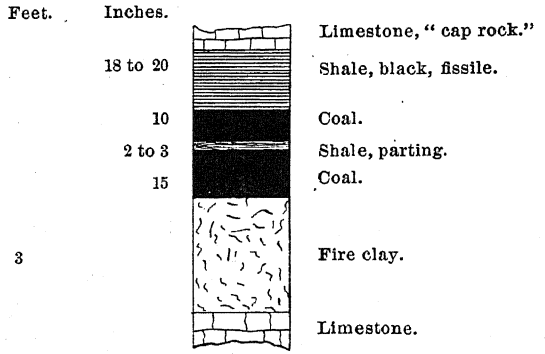


FIG. 65. Section of coal bed at Caldwell Coal Co.'s Shaft (upper bed.)

This coal is undoubtedly the same as the upper bed operated by the Hamilton Coal Company and has the same general characteristics.

Of the lower bed the following section was measured:

Lower bed.

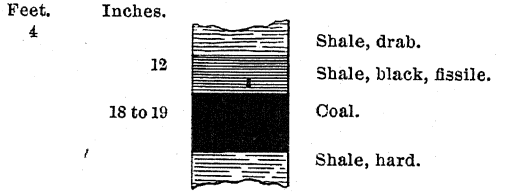


FIG. 66. Section of coal bed at Caldwell Coal Co.'s Shaft (lower bed.)

The coal is harder here than in the other beds and seems to be free from faults. At about 50 or 60 ft. below this lower bed, the superintendent of the mine reports another bed of coal about 12 in. thick.

Correlation with Cameron and Lathrop coals.

Which one, or whether any of the beds of these shafts represent the one struck in the drill holes at Lathrop or Cameron, in Clinton county, cannot be affirmed here; but, as the detailed work of the Survey progresses we hope to be able to establish definitely such relationships.

At Kingston, near the center of the county, a shaft has recently

been sunk about 240 ft. deep to a bed of coal which is reported 27 in. thick. Whether this coal is the same as either of the Hamilton beds, cannot be confidently stated at present by the Survey. Shaft at Kingston.

At Cowgill, near the south line of the county, on the Chicago, Milwaukee and St. Paul railway is a shaft 337 ft. deep to the coal. The Bethany Falls limestone was encountered in the shaft and was passed through at a depth of about 85 ft. Hence this coal is about 240 ft. below that rock. The shaft was not in operation when visited, but the following section was obtained from Mr. Gray, of Cowgill, who superintended part of the work here and who is familiar with the details: Shaft at Cowgill.

	Feet.	Inches.
Limestone cap rock	6	
Shale, black fissile	1	
Coal		8 to 10
Shale parting about		1
Coal		16 to 20
Clay	2	

The close similarity between the section here and those of the upper bed at the Tom Creek shaft and the Hamilton Coal Company's shaft, leaves little doubt but that they are of the same bed. Further, the details of this section, combined with the facts of the position of the coal with reference to the Bethany Falls limestone, point strongly to the conclusion that the coal is the same as that mined in Ray county to the south and in Lafayette county, or that it is the Lexington coal bed. Coal is the Lexington bed.

36. CARROLL COUNTY.

Carroll county, though underlain by Coal Measure strata over its entire area, is, at present, not ranked as a coal producer. No mines operating on a commercial scale exist here; developments are confined to small pits worked to supply local demands. A few occurrences of coal in this county are referred to on pp. 59 to 61 and p. 74 of the Report of the Geological Survey for 1872, Part II. Coal developments small.

In the vicinity of Little Compton, in the northeastern corner of the county several coal pits are intermittently worked. Of

Farr's coal pit.

these Ralph Farr's is probably the largest. This consists of a stripping which covers several acres, over which 10 or 15 ft. of shale and clay have been removed for the purpose of reaching the coal. The following section was measured at this point:

Section at Little Compton.

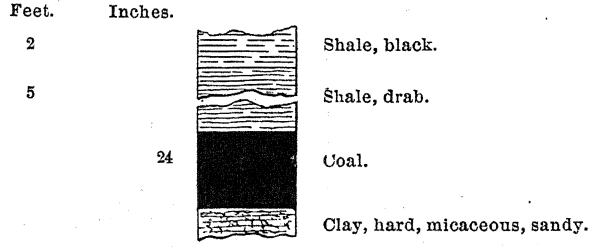


FIG. 67. Section of coal bed at Little Compton.

A drill hole has been sunk to a depth of 70 feet below the coal and black shale was reached at the bottom, but was not penetrated. Other coal pits occur above this, along Grande river up to Bedford in Livingston county (see p. 95) They probably all operate the same coal though it is reported to be generally thinner in these than at Farr's pit.

Coal near Bedford.

On the west bank of the Grande river, about five miles south of Little Compton, some prospecting has been done for coal and, at an abandoned drift, the following section was measured:

Coal on Grande river.

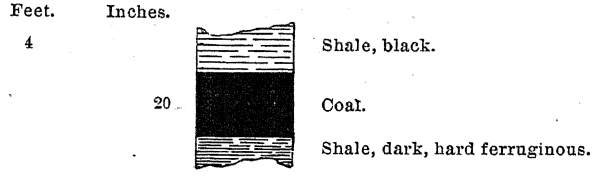


FIG. 68. Section of coal bed on Grande river.

This bed of coal, according to barometer readings, is about 80 feet below the level of the coal at Little Compton, and belongs probably to an underlying bed. Up in the hills, about a mile west of this prospect drift, coal is reported to have been dug in past years at a point of about the same elevation as the Little Compton coal and is probably the same bed.

Two coal beds.

Near Miami station, in the southeastern corner of the county, coal has been worked at several places, in the hill-sides above the river bottom. The thickness of the bed generally worked is about 18 inches. Another bed, 2 ft. thick, was reported by a miner, to underlie this upper one, separated from it by only 18 inches of shale. The opportunities for observation did not admit of confirming this report, however. Sandstone of great thickness occurs at White Rock quarry, close to this place, which probably represents a channel deposit, such as is described on p. 36. This undoubtedly diminishes the area of the coal here. At the quarry, however, a coal bed about a foot thick is reported to have been struck, in a shaft, at a depth of about 20 feet below the foot of the bluff.

Coal near Miami station.

White Rock quarry.

About seven miles southeast of Carrollton, on Wakenda creek, are several small coal pits, of which a few were visited. At Hardwick's mill is a drift in which the following section is exposed:

Coal near Carrollton.

Feet.	Inches.	
3 to 5		Limestone, drab, hard.
4		Shale, drab.
	18	Shale, black, hard.
	20 to 28	Coal, thickness fluctuating.
8		Clay, sandy.

Section at Hardwick's mill.

FIG. 69. Section of coal bed at Hardwick's mill.

The roof over the coal is here fairly good.

Glick's drift is about a mile west of Hardwick's, but the coal, as exposed, was only 10 to 15 in. thick and the roof is very poor. It is said to thicken here, however, to 18 and 20 in. in places.

In the immediate vicinity of Carrollton, west and northwest of town, a thin bed of coal has been worked in a very small way. The bed is from 15 to 18 in. thick. On the edge of town, about 70 ft. below the level of the court house yard, drill holes were put down to a depth of about 300 ft. and passed into some 60

Coal at Carrollton.

ft. of Lower Carboniferous Limestone, showing that the total thickness of the Coal Measure rocks beneath the summits here is not much over 300 ft. Some 12 in. of slaty coal was encountered at a depth of about 70 ft., and, again, about 5 in. of coal at a depth of 240 ft.[1]

Drill hole at Carrollton.

37. RAY COUNTY.

PRODUCTION IN 1891.....282,247 TONS.

Ray county ranks among the large coal producing counties of the State, and undoubtedly contains large areas of coal lands, at present undeveloped. The area of chief production, to-day, is in the country around Richmond. The Lexington coal bed is mined here exclusively, it being the same as that so extensively operated across the river in Lafayette county.

Lexington coal bed mined.

In the southeastern corner of the county adjacent to Carroll county, the coal has been and is worked in numerous drifts, in the hillsides, north of the Santa Fe railway, the bed being here above the level of the river bottoms.

In the northeastern portion of the county is only one opening of importance, namely, the Sater Shaft, located between Georgeville and Finney's Point. This shaft is 146 ft. deep to the coal and exposes the following section:

Section at Sater shaft.

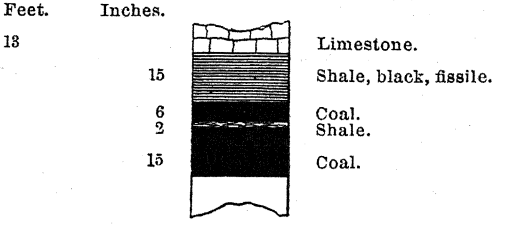


FIG. 70. Section of coal bed at Sater shaft.

This is undoubtedly the Lexington coal bed.

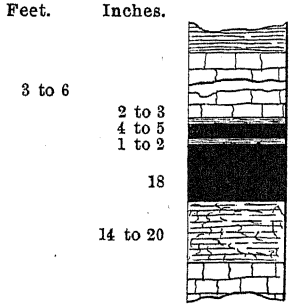
Immediately about Richmond, and between that place and Lexington Junction, some seven companies and individuals mine coal on a large scale. Over a dozen shafts and other openings

Coal near Richmond.

[1] The record of this drill hole was furnished the Survey by Mr. S. M. Wilcoxson of Carrollton.

are in operation here, mostly adjacent to the St. Joseph branch of the Santa Fe railway. The Shafts vary in depth from 50 to 100 ft. They all operate the same coal bed and no other overlying coal bed is encountered in the shafts. The long wall method of mining is generally followed, the roof being well adapted to this. Coal at Richmond.

At No. 10 shaft, on the west edge of town, the following section was measured. The shaft is 100 ft. deep:

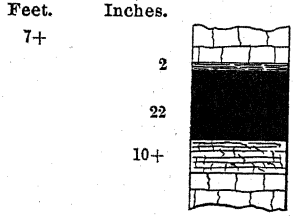


Section at Richmond.

FIG. 71. Section of coal bed at Richmond.

Along the entries the bottom clay is lifted and about 3 ft. of the roof rock is shot down in order to obtain the requisite height.

At Swanwick, about four miles northwest of Richmond, is the R. J. Williams' shaft, on the St. Joseph branch of the Santa Fe railway. The shaft is 95 ft. deep and operates the same bed as that mined at Richmond. The following section was measured here:



Section at Swanwick shaft.

FIG. 72. Section of coal bed at Swanwick.

The coal is mined by the long wall method. It is clean, hard and brittle, with a little pyrite (sulphur), in thin films, and with Character of coal.

selenite along the joint planes. The roof is good, no timbering being ordinarily required excepting at the face of work.

Coal in southwest of county.

In the vicinity of Camden, near the southwestern corner of the county, west of Richmond, are several large mines. No. 8 shaft is about two miles west of the town, and is operated by the Kansas and Texas Coal Co. (No. 30). It is 80 ft. deep. The following section was obtained here:

Section at Camden.

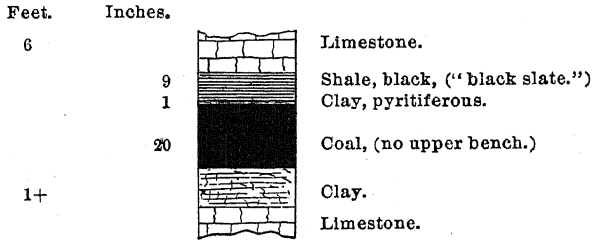


FIG. 73. Section of coal bed at Camden.

The long wall method of mining is followed.

Just west of the town are two shafts, on the edge of the river bottoms, belonging to the Richmond Coal company. They are both about 50 ft. deep. The section of the bed and of the associated strata is about the same here as at No. 8. The long wall method of mining is pursued here also.

38. CLAY COUNTY.

PRODUCTION IN 1891.....8,289 TONS.

No surface coal.

No coal worthy of notice occurs at or near the surface in Clay county. Owing to its proximity to Kansas City and other points of large consumption, efforts have been made to discover and develop workable coal within this county by drilling and shafting.

Randolph drill holes.

At Randolph, close to the Missouri river, about ten miles northeast of Kansas City, two diamond drill holes were put down to depths of over 800 ft. and one shaft has been sunk to a depth of about 400 ft. In one of the drill holes, at this point, the following coals were encountered, according to the record, and, so far as the shaft reached, their positions and thicknesses were confirmed by the sinking of the shaft subsequently.

SECTION 9.

1.	At a depth of 247 ft.....	9 inches of coal.			
2.	" 280 "	10 " "			
3.	" 387 "	21 " "	(operated)		Record at Randolph.
4.	" 433 "	5 " "			
5.	" 469 "	4 " "			
6.	" 482 "	15 " "			
7.	" 512 "	14 " "			
8.	" 543 "	8 " "			
9.	" 614 "	10 " "			

At a depth of 700 ft. the Lower Carboniferous rocks were encountered and penetrated for a distance of over 100 ft. It is thus conclusively demonstrated that no coal beds exist at greater depths here.[1] Lower Carboniferous at 700 ft.

The shaft is located on the hill-side, some 30 ft. above the drill hole, and hence is 420 ft. deep to the bottom of the third coal from the top. The following detailed section of the bed was made here:

Feet.	Inches.		
			Shales, drab, somewhat arenaceous.
	19 to 21		Coal.
	6 to 18		Clay, shaly.
	10 to 12		Shale, hard, calcareous.
			Limestone.

Section at Randolph shaft.

FIG. 74. Section of coal bed at Randolph shaft.

The coal is in a horizontal position. It is hard and breaks with a sharp and clear fracture, but is streaked with fine seams of pyrite (sulphur) and shale, which are picked out, so far as possible, before shipping. It makes cinder in burning, but it is claimed that it will coke. The roof is poor, falling readily and necessitating heavy timbering in the entries. A modification of the long wall method of mining has been used. A good steam plant is provided here and the mine is fitted for large shipments. Character of coal and roof.

The drill hole above described was begun at the foot of a bluff of the Bethany Falls limestone. Hence the coal bed operated is nearly 400 feet below that rock. The bed numbered 2, imme-

[1] The records of these drill holes were obtained through the courtesies of Mr. L. J. Talbott, of Kansas City, the president of the company.

diately above the last, is, similarly, about 280 ft. below the Bethany Falls limestone. This distance corresponds closely with the interval between that rock and the Lexington coal bed in Lafayette and Ray counties; further the details of the section here and the nature of the rocks associated with the coal bed go to confirm the idea that this bed, No. 2 of the section, is the Lexington coal bed. Just what position bed No. 3 occupies in the Lafayette county section cannot be definitely stated at present; in fact it is doubtful whether this bed is represented at all that far east.

Correlation of Randolph coal beds.

39. PLATTE COUNTY.

Platte county, like Clay county, is destitute of any important surface exposures of coal, nor is it probable that such will ever be found. In the report of the Geological Survey for 1872 reference is made to thin coal seams about 9 in. thick, in the northwestern corner of the county, and the writer has reports of such having been dug about four miles north of Weston. Similarly, in the same volume, coal some ten inches in thickness, is referred to as having been mined near Platte river ferry, about a mile and a half southeast of Farley; more recent reports refer to coal pits some three miles east of Farley, from which coal was hauled to Leavenworth in past years. Another occurrence of coal near the surface is reported about nine miles southeast of Platte City.

No important surface coal.

At Leavenworth, Kansas, immediately across the river from Platte county, an extensive coal industry has sprung up during recent years. Inasmuch as the coal operated here undoubtedly extends under a large part of Platte county, the results of the developments deserve consideration under this heading. From the northern limits of the city to about six miles south of it, there are four separate shafts, situated along the river banks, each a little over 700 ft. deep and controlled by different companies. The southmost of these is the State mine which is 713 ft. deep to the coal. About two and a half miles west of the last is another shaft 804 ft. deep. At the State mine the following coals were encountered in sinking the shaft:[1]

Leavenworth coal under Platte county.

[1] From the published record printed in pamphlet form.

SECTION 10.

At a depth of	511	feet	1	inches	of coal.
"	512	"	2	"	"
"	575	"	8	"	"
"	606	"	7	"	"
"	670	"	10	"	"
"	713	" (bed operated)	21	"	"

Record of Leavenworth shaft.

At the Riverside mine, another bed of coal 16 to 18 inches thick, is reported to occur about 22 ft. below the last one given above. At the Leavenworth Coal Co,'s shaft, in the northwestern corner of the town, several coal beds were struck at still greater depths, by shafting and drilling. The following record of the work here was kindly furnished the Survey by Mr. John E. Carr, the superintendent of the mine:

Lower coal beds.

SECTION 10a.

1.	At a depth of	566	feet, in shaft	8	inches	of coal.	
2.	"	597	" "	12	"	"	
3.	"	617	" "	6	"	"	
4.	"	639	" "	6	"	"	
5.	"	662	" "	14	"	"	
6.	"	676	" "	6	"	"	
7.	"	707	" "	24	"	"	(operated.)
8.	"	888	" "	5	"	"	
9.	"	916	" "	13	"	"	(three seams.)
10.	"	992	" "	10	"	"	
11.	"	999	" "	26	"	"	
12.	"	1029	" in drill hole	28	"	"	(impure.)
13.	"	1086	" "	12	"	"	(fossiliferous.)
14.	"	1096	" "	5	"	"	
15.	"	1127	" "	6	"	"	

Total depth of hole is 1171 feet, and drilling stopped in sandstone.

In the Riverside mine the following section of the coal bed operated was measured:

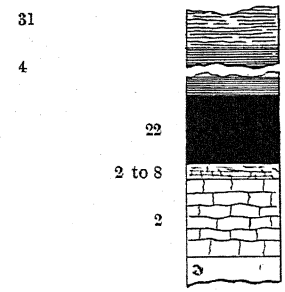


FIG. 75. Section of coal bed at Leavenworth.

Section at Riverside shaft.

This mine, like the others in this neighborhood, is equipped with a complete steam plant and is operated on a large scale.

Method of mining.

The coal is worked on the long wall plan, the roof being such as to admit of this. The bed is undercut about 22 inches and the superincumbent weight then splits it from the face. In the entries the shale is brushed down for a height of about four feet above the coal, thus providing an ample roadway at moderate cost. The shale in these entries does not seem to flake off to an embarrassing extent when exposed to the action of the air. Between the coal and the shale there are frequently interposed lenticular layers of a hard, black, calcareous shale ("black bat") which causes some trouble in the process of mining. These layers are as much as three feet thick, and taper to feather edges from the center and outwards; they frequently cause falls of the roof and necessitate careful timbering. The limestone beneath the coal, has a very undulating and warped surface, so much so that no clay remains, at points, between the limestone and the coal, while closely adjoining this there may be as much as 8 inches of clay. The coal is ordinarily about 22 inches thick, but it has been known to reach a thickness of three ft. over limited areas.

Character of coal and roof.

40. JACKSON COUNTY.

No coal mining is at present prosecuted in Jackson county and there is no probability that a thick, workable bed will ever be opened there near the surface. In the western portion of the county a thin layer, varying from one to five inches in thickness, is reported to crop out in the hills, but it is of no economic value.

No surface coal.

In the eastern portion of the county, the Lexington coal bed, which is mined in Ray and Lafayette counties, must underlie the county at moderate depths, but no developments are known which demonstrate whether it is here in a workable condition or not.

Lexington coal here.

In the vicinity of Kansas City, in the northwestern portion of the county, the coal beds encountered in the shaft and drill holes at Randolph, Clay county, (see p. 113), may be expected at closely corresponding depths. Indeed, coal beds have been struck in

Randolph coal here.

almost all of the numerous deep drill holes which have been put down in and about Kansas City. Reliable records of many of these are yet to be obtained by the Survey and, until this is done, it would be premature to attempt a correlation of the different strata encountered in each. None of the results reached up to this year have, apparently warranted an attempt at mining.

Kansas City drill holes.

During last spring, however, a drill hole was put down south of Kansas City, to a depth of about 600 feet, by the Kansas City Clay and Coal company. Several beds of coal and fire clay were encountered, but detailed and reliable information concerning these could not be obtained by the Survey. The results appeared sufficient, however, in the minds of those prospecting, to justify further developments and a shaft has now been sunk on Blue river, about half a mile below the mouth of Brush creek, to a depth of 400 ft. or more, to a coal bed about 18 in. thick. The following section was measured here:

Recent shafting on Blue river.

	Feet.	Inches.
1. Limestone	4	
2. Shale, gray	1	6
3. Shale, black	3 to 4	
4. Coal		18 to 20
5. Clay	2	

41. LAFAYETTE COUNTY.

PRODUCTION IN 1891.....352,603 TONS.

Lafayette county is one of the principal coal producers of the State. Along the river and the Missouri Pacific railway, mining is prosecuted principally in the vicinities of Lexington, Wellington, Waterloo and Napoleon, while, in the interior, the openings are along the Chicago and Alton railway, in the vicinities of Corder, Higginsville and Mayview.

Important coa producer.

Several different coal beds are known to occur in this county. Of these, what is known as the Lexington bed is, at present, of greatest industrial importance. In the southeastern portion of the county, however, in the vicinities of Concordia and Aullville, an underlying coal bed, known as the Mulky bed, is worked and is there of chief importance. Recently, what is presumably another lower lying coal bed, has been opened at Waverly.

Three coal beds operated.

Again, at other localities, deep drill holes have been put down in which thick coal beds are reported to have been struck; but the results from such deep drillings at different places are conflicting, and it will take a closer study than this article purports to be the result of, a more careful sifting of facts, before the reported results of such drillings can be reliably judged of.[1]

Distribution of Lexington coal.

THE LEXINGTON COAL BED occurs under nearly the whole western portion of the county, west of the longitude of Aullville. East of Aullville it rises higher above water level and is found only near the hill-tops in comparatively limited patches. Hypsometrically it is in such a position that its outcrop is almost always above the adjacent water level. It lies in a gently undulating sheet, with a slight northwesterly dip, which crops out along a sinuous line on each side of the main drainage channels.

At the Dover Coal Company's drift, in the river bluff north of Dover, the following section was measured:

Section at Dover.

Feet.	Inches.		
			Limestone.
	2½		Top slate.
	6½		Top coal.
	3		Clay band.
	17½		Bottom coal.
	3		Dark clay, "mining."
2	4		Fire clay.
			Limestone.

FIG. 76. Section of coal bed at Dover.

Character of coal and roof.

The drift is in the hill-side, about 75 feet above the level of the railway. The long wall method of mining is pursued here successfully, though the roof is somewhat irregular. The coal is faulted and squeezed in places and contains pyrite, both in nodules and in films along the joint planes. Along the entries the bottom clay is taken up to obtain the requisite height.

[1] In the detailed maps and accompanying reports on Lafayette county, soon to be published, all the information obtainable concerning these various coal beds will be included.

At Corder, in the western edge of the town, is the shaft of the Corder Coal Co. It is 90 ft. deep and is located immediately adjacent to the Chicago and Alton railway.

Here the following section was measured:

Feet.	Inches.	
		Limestone.
	16½	Shale, black, fissile, with concretions.
	16	Top coal.
	½	Clay band.
	3½	Bottom coal.
3	2	Fire clay.
		Limestone.

Section at Corder.

FIG. 77. Section of coal bed at Corder.

The mine is equipped with a steam plant and is operated on a large scale. The long wall method of mining is pursued, the roof being very good. The coal contains a good deal of pyrite and cakes and clinkers in burning. "Rolls" of the roof and floor obstruct the mining in places. To obtain traveling way along the entries the bottom clay is sometimes taken up and the roof is generally brushed down.

Character of coal and roof.

In and about Higginsville there are ten or more drifts and shafts operating the Lexington coal bed. Of these, the shaft of the *Excelsior Coal and Coke company* is one of the most important. It is located on the line of the Chicago & Alton railway on the west edge of the town. It is 70 ft. deep and is equipped with a steam plant. The following section was measured here:

Coal near Higginsville.

Feet.	Inches.	
		Limestone.
23		Shale, black, fissile, with concretions.
	5	Top coal.
	½	Smut and pyrite.
	8½	Coal.
	½	Clay band.
	3	Coal.
	12	Fire clay.
		Limestone.

Section of bed.

FIG. 78. Section of coal bed at Higginsville.

Character of coal.

The roof is good and the long wall method of mining is successfully followed. The coal is pyritiferous but is comparatively clean otherwise. It cakes and clinkers in burning. The coal was experimented with here for coking and, though a fair product was obtained, suitable for domestic use, it was too weak and had too much sulphur to be of value in the furnace. No rolls or squeezes in the coal were noticed. Owing to the thinness of the underlying clay, the roof has to be shot down to make passage way in the entries.

Coking experiment.

About a mile east of Mayview, on the Chicago and Alton railway, is the *Strasburg shaft*. This is 90 ft. deep and here the following section was measured:

Section at Mayview.

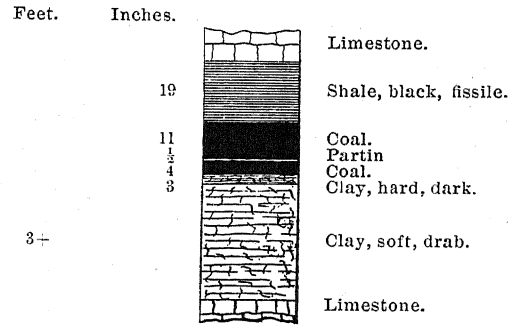


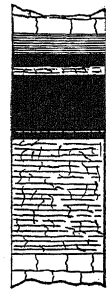
FIG. 79. Section of coal bed at Mayview.

Character of coal.

The coal is mined by the long wall method, the roof being good. It is pyritiferous, but not noticeably crushed or faulted at the face.

Coal at Lexington.

At Lexington and in the adjacent country are a dozen or more different coal mines. Of these the *Riverton drift No. 1*, is important and representative. It is located about a mile east of the town, on the Missouri Pacific railway. The drift enters the river bluff at about 15 or 20 ft. above the railway. The following section was measured here:



Section at Lexington.

FIG. 80. Section of coal bed at Lexington.

The long wall method of mining is pursued here, the roof being good. Rolls of the roof and bottom are frequently encountered which cause some loss in mining. The coal is pyritiferous and has clay seams which impair the product. In the entries the bottom clay is taken up, the roof being left intact.

Character of coal and roof.

In the immediate vicinity of Wellington are some four coal mines and, between this place and Lexington, and west of it to Napoleon, are several others operating the same coal bed by shafts or drifts in the river bluffs.

Coal near Wellington.

The Wellington Coal Company's shaft is in the town of Wellington. The shaft here is 40 ft. deep and in it the following section was measured:

Section at Wellington.

FIG. 81. Section of coal bed at Wellington.

The roof is good and the long wall method of mining is used. The coal is somewhat pyritiferous and the partings are objectionable.

THE MULKY COAL BED is developed exclusively east of Aullville. West of this, drill hole records or other results of deep explorations are too scarce, and the country has not, as yet, been sufficiently studied for one to attempt to define the distribution of this coal, or even to assert its existence or absence over this area. The thickness of the Mulky bed, where opened upon, is seen to be very nearly the same as that of the Lexington bed. At three different openings, a few miles west of Concordia, the thicknesses measured were respectively; nineteen inches, twenty-two inches, and twenty inches. At the Elling shaft, nearly four miles west of Concordia, the thickness is reported to be between twenty-two and twenty-four inches.

The Mulky coal bed.

The Kresse slope is about four miles southwest of Concordia and is one and a half miles south of the railway. The coal is of good quality and has a large sale for local uses. Pyrite occurs here in thin films, along the joint planes. The pillar and room method of mining is followed though the roof is probably quite good enough to admit of the use of the long wall method. No squeezes or faults of the coal were observed. The following section was measured here:

Coal at Kresse slope.

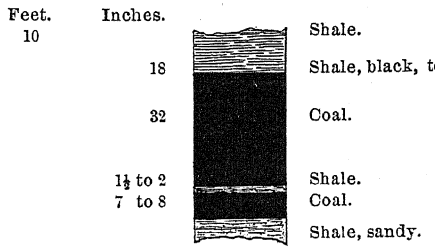
Section at Kresse slope.

Feet.	Inches.	
2		Limestone.
1		Clay, yellow.
6	6	Shale, dark.
	21 to 22	Coal.
		Clay.

FIG. 82. Section of coal bed at Kresse slope.

At Waverly, in the extreme northeastern corner of the county, a shaft was sunk last spring, adjacent to the Missouri Pacific railway, on the river bank, at a depth of 72 ft. A coal bed about three feet thick was struck. In a shaft of the Waverly Coal and Mining Company sunk since this discovery, for the purpose of developing the bed, the following section was recently measured:

Coal at Waverly.



Section at Waverly.

FIG. 83. Section of coal bed at Waverly.

The character of the roof seemed good so far as could be judged from the limited exposure near the bottom of the shaft. The coal is somewhat pyritiferous, but not more so than at many mines in the county which are worked with profit. The establishment of the existence of this coal bed added a new fact to our knowledge of the geology of Lafayette county. As a result two shafts have been sunk in this neighborhood in preparation for regular shipments. These will be further referred to in the report on the Higginsville sheet and the probable distribution of this bed will be there discussed. Character of coal.

The coal area of this county is not continuous. This is due to two causes. One is a cause at present in action and, though extending back far into geologic time, is yet posterior to the deposition of all the Carboniferous rocks in the county; namely, the process of erosion along the lines of flow of the now existing streams. But, in addition to what may thus be called the erosion area of these streams, a sinuous strip of country destitute of coal, can be traced on the map from the south line of the county, near Tabo post-office, northwards, through Higginsville and Page City to the river. In this strip, which in the vicinity of Higginsville, is between one and two miles broad, no Lexington coal bed is found. On the contrary, deep drill holes have been put down hundreds of feet into the ground here and have struck nothing but sandstone and shales. It has all the appearances of being the site of an ancient river channel, eroded during some period of elevation and afterwards filled by deposits of sand and finer material, during a subsequent period of submergence. Studies prosecuted in Johnson county, in the extension of this line, go to confirm this interpretation. Effect of erosion. Sandstone deposits.

42. SALINE COUNTY.

PRODUCTION IN 1891.....7,981 TONS.

Distribution of Coal Measures.

The Coal Measure rocks underlie nearly one half of Saline county. From Lafayette county on the west quite a wide belt of these rocks occupies the country on each side of the Chicago and Alton railway and extends eastwards nearly to Marshall. Between Marshall and the river, to the east, a narrow strip runs north and south through Slater, and, in the vicinity of Sweet Springs, in the southwestern corner of the county several patches of Coal Measure rocks occupy the hill-tops. Between these areas are the Lower Carboniferous limestones, which are abundantly exposed in the valleys and along the bluffs of the streams.

Meek's report.

In the report of the Geological Survey, containing the results of work between the years 1855 and 1871, Saline county is well described by Mr. F. B. Meek, on pp. 157 to 188. He there refers to coal about Slater 18 to 20 inches thick, at Miami 18 inches, and about Blackburn 12 to 20 inches thick. He describes some of the openings of that date in detail and gives several valuable sections.

At present coal mining is prosecuted only on a small scale in Saline county, to supply local demands. The principal developments in the past few years in the regular Coal Measures were in the vicinity of Slater and Sweet Springs. Coal was mined at other points from outlying deposits or pockets, but these will be referred to later.

In the vicinity of Slater several coal pits have been operated during past years, for local purposes. At the *Copeland drift* some two miles southeast of town the following section was measured:

Section at Slater.

Feet.	Inches.		
11			Shale, clayey, drab, replaced by sandstone in places.
	18 to 20		Coal.
5+			Fire clay.

FIG. 84. Section of coal bed near Slater.

The shale makes a poor roof. The sandstone is better in this

respect. The latter is brown, friable and micaceous, and is as much as 20 ft. thick. It is frequently present over the coal in this neighborhood, often forming the roof of the bed in such cases. Though false bedded, in evidence of rapid flow, it is never known to cut out the coal. Roof at Slater.

At the Thompson drift, a mile south, a similar section is exposed, and pyrite in lenticular layers was observed here in the coal.

The Hagner and Auer pits are east of the Thompson pit, about a mile distant. The coal at both is about 18 in. thick and is overlain immediately by the friable sandstone, which is in places quite shaly. In Slater, a drill hole was put down a few years ago and this same bed is reported to have been struck at a depth of about 120 ft., but it was thought to be thin and pyritiferous. Coal pits near Slater.

In the vicinity of Sweet Springs several coal mines have been operated during past years on a small scale to supply local demands. These are mostly southwest of the town, within a distance of two miles. Coal near Sweet Springs.

The Marmaduke shaft is located about half a mile southeast of Sweet Springs proper, on the hill-top, south of Blackwater creek, about 75 ft. above the creek bottoms. The shaft is 54 ft. deep. The following section was given by Mr. Henry Marmaduke:

SECTION 11.

Record of Marmaduke shaft.

	Feet.	Inches.
1. Soil and clay	8	
2. Sandstone, white and reddish friable and micaceous	4	
3. Clay, shaly, bluish, clinking	18	
4. Limestone, earthy, clinking "bell rock"	8	
5. Shale, black fissile	17	6
6. Shale, black, bituminous with thin layers of coal		6
7. Coal		29
8. Clay and black shale.		

The coal contains a good deal of pyrite and slacks readily; spontaneous combustion of the "gob" gives much trouble, especially if the long wall method of mining is followed. The shaft supplies the Sweet Springs hotel with coal and furnishes a limited amount to the town. Character of coal.

Coal pockets in Saline county.

South of Marshall, and generally throughout the southeastern portion of the county, are numerous isolated pockets of bituminous and cannel coal. Some have been worked for many years for local uses. One of these is described at the end of this chapter.

Drilling at Grand Pass.

In the vicinity of Grand Pass, in the northwestern corner of the county, a drill hole was put down this year, about a mile west of the town, on the hillside, adjoining the Missouri Pacific railway, and about 25 ft. above it and the Missouri river bottoms. The object was to determine the presence or absence of the coal bed mined at Waverly, in Lafayette county. At a depth of 38 ft. a seam of coal 6 in. thick was passed through, and at a depth of 50 ft. a seam 17 in. thick was reached. At the time of inspection the hole had reached a depth of 151 ft. and no other coal bed had been encountered. We are inclined to the opinion that the Waverly coal is represented by the bed penetrated at a depth of 50 ft., and thus that the bottom of the hole is well below the horizon of that bed.

43. PETTIS COUNTY.

Coal Measures only in west.

Pettis county, like Saline county, occupies a position on the extreme margin of the Coal Measures, and, only in the westmost portion, do strata of this formation occur. Here they lie in patches and prongs over the hill-tops, outliers of the great Coal Measure area to the west.

Mines at Lamonte and Dresden.

During past years coal has been taken out at a number of points in the northwestern corner of the county and along the Missouri Pacific railway, in the vicinity of Lamonte and Dresden. The coal described as occurring near Sweet Springs, in Saline county, extends into Pettis. In the report of the Geological Survey of 1872, Part II, on pp. 162–165, descriptions are given of the occurrences of coal at several points in the vicinity of Lamonte. Of these, the Newport and Westlake mines seem to have been most important. The shafts here were about 35 ft. deep and the coal, which is reported to have been of good quality, was from 27 to 30 inches thick.

These mines, were, however, all comparatively small affairs,

the product of all being largely for local uses and the shipments never reaching anything comparable with that of the larger coal mines now operated in the State. During the past year no coal mining has been in progress in this county of sufficient magnitude to have been brought to our attention. No coal mining.

44. COOPER COUNTY.

PRODUCTION IN 1891.....2,200 TONS.

In Cooper county the area of Coal Measure strata is very limited, being confined to a patch of a few square miles immediately about Boonville. In the report of the Geological Survey for 1855 is a special chapter, by Prof. Swallow, on Cooper county, accompanied by a small map. In this a number of coal openings are described, including several in local deposits of abnormal thickness. Prof. Swallow recognizes six regular coal beds within the section of regular Coal Measures, one of which is 6 ft. thick. The accessible exposures at the time of his examination were not abundant nor good and he must thus have been led into assigning to the regular Coal Measures a bed of coal which belongs to one of the local or pocket deposits. Developments since his time have failed to demonstrate the existence of any continuous coal bed as much as 6 ft. thick. Swallow's report.

East and south of Boonville, within a radius of a few miles, are the only coal mines in the regular Coal Measures which are now operated. These include the *Hutchinson* shaft, 2 miles east, and the *Tucker*, *Hazell* and *Smith* drifts about half a mile south of town. The coal in all of these is about of the same thickness, varying from 14 to 20 in. and being generally about 15 in. thick. It contains a good deal of pyrite and cannot be considered a first class coal. It undoubtedly underlies the whole Coal Measure area here, which includes perhaps a dozen square miles. *At Hutchinson's shaft* the following section was measured: Mines near Boonville.

Section at Hutchinson shaft.

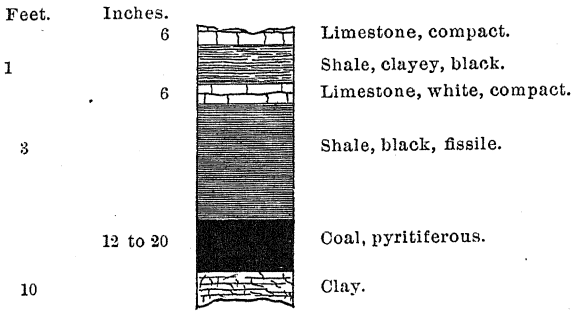


FIG. 85. Section of coal bed at Boonville.

Coal pockets in Cooper county.

Coal pockets are of very frequent occurrence in this county and they have supplied a large amount of coal for local uses. During the past year such isolated deposits have been operated near Bunceton, near Pilot Grove and about four miles west of Boonville, in the river bluffs. Coal from the last point is shipped over the railway to Kansas City and other places. This deposit is described at the end of the chapter.

45. JOHNSON COUNTY.

PRODUCTION IN 1891.....10,530 TONS.

Mining of past years.

Johnson county, though underlain entirely by Coal Measure rocks, is, at present, one of the small coal producing counties of the State. Along the eastern border, the Lower Carboniferous rocks are not far beneath the surface. In past years coal was mined in this county on a large scale in the vicinity of Montserrat, but these mines have now been abandoned for over eight years. In the report of the State Geological Survey for 1872, Part II, reference is made to the coal in the vicinity of Dunksburg, Knobnoster, Montserrat, Warrensburg and Holden and, in some instances, descriptions of the mines and sections of the beds are given.[1]

[1] During the past year detailed mapping has been prosecuted in the county by the Survey and the results, together with an accompanying report will soon be prepared for publication. In the meantime the following notes will give a general idea of the distribution and character of the coals.

In the northeastern corner of the county, in the vicinity of Dunksburg are a number of small coal mines operated for supplying local demands. They are mostly drifts, located not far from the hill-tops, well above the valleys. The Serang's, Park's and Shank's pits are such. Coal near Dunksburg.

At *Serang's pit* the following section was measured:

Feet.	Inches.	
4+		Shale, black, fissile, with hard, calcareous band.
	12	Shale, drab.
	8	Shale and coal.
	30	Coal.
		Clay passing into sandstone downwards.

Section at Serang's pit.

FIG. 86. Section of coal bed at Serang's pit.

At other pits in this vicinity the coal is of about the same thickness and the section is similar. The coal is considered to be of superior quality to that mined at Montserrat; to be hard and not slack readily on exposure. Drilling and other exploration has been prosecuted in this county, but few of the results have been obtained thus far, by the Survey. Prospecting here.

In the vicinity of Knobnoster coal is mined both east and west of the town. About two miles east, on the old Knaus place, are several drifts and a shaft. In these the coal is about 30 in. thick. Coal near Knobnoster.

Above the coal is about four feet of shale, of which the lower portion is black and fissile. Above the shale is limestone.

The Boyd shaft, about two miles south and west of the town, is, however, the most important in this neighborhood. It is connected with the railway by a switch and tramway, and coal is shipped from here in car load lots. The shaft is about seventy feet deep and the coal is hoisted by a steam plant. The pillar and room method of mining is followed here, the roof and coal not being such as to permit the adoption of the long wall method. The coal is somewhat pyritiferous. Towards the east it is The Boyd shaft.

reported to grow more shaly. The following section was measured here:

Section at Boyd shaft.

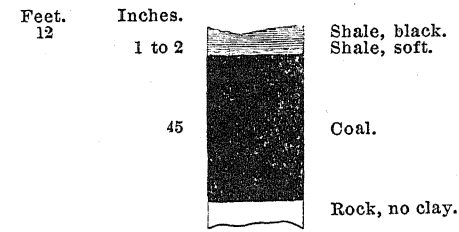


FIG. 87. Section of coal bed at Boyd shaft.

Coal at Montserrat.

At Montserrat, five or more shafts have been sunk during past years which were connected with the railway and from which a large amount of coal was taken. Shaft No. 1 was one of the deepest of these, it being located near the railway, near Montserrat depot. In sinking this shaft the following coal beds were encountered, according to the statement of the superintendent, Mr. J. A. Gallaher.

Section Shaft No. 1.

SECTION 12.

1.	At a depth of	20′	12	inches	of coal.
2.	"	65′	15	"	"
3.	"	78′	8	"	"
4.	"	94′	12	"	"
5.	"	109′	4	"	"
6.	"	125′	48 to 60	"	"

A drill hole was put down 85 ft. below this last bed, but no deeper coal was encountered.

The lowest of these beds is the one generally operated here, and it is locally known as No. 9. The topmost is known as No. 4, and is exposed in the railway cut east of the depot. The other beds have intermediate numbers. The lowest bed is overlain by black shale similar to that at Boyd's shaft. The pillar and room method of mining was pursued here as it is at Boyd's.

Character of coal.

Clay occurs under the coal. The coal is reported to contain a large amount of pyrite, which impaired its value, causing it to slack readily and to ignite spontaneously. The lower 3 ft. of the bed included the best coal and, in places in the mine, the upper portion was thrown out. These are among the considera-

tions which caused the abandonment of these mines, but, besides these of the quality and extent of the bed, conditions of the coal trade are reported to have contributed towards bringing about this result.

Causes of abandonment of mines.

About a mile west of Montserrat is the May shaft, now abandoned. This operated the same bed as that worked at Montserrat. The shaft was about 60 ft. deep.

About five miles south of Montserrat, are several small country mines from which coal is dug and hauled to Warrensburg and other points. The bed varies from 20 to 30 in. in thickness and is considered a superior coal. These mines are worked quite constantly and, though the haul to Warrensburg is a long one, this is offset by the ready sale which the coal commands.

Coal south of Montserrat.

About four miles north of Montserrat, near the wagon bridge over Clear Fork creek, are several pits and outcrops of coal. At one of the latter the following section was measured:

Feet.	Inches.	
	12	Shale, black, fissile.
	2	Shaly clay, black.
	34	Coal.

Section on Clear Fork creek.

FIG. 88. Section of coal bed at Clear Fork creek.

This coal is presumably the same as that worked at Montserrat and called No. 9.

In the immediate vicinity of Warrensburg are several coal mines operated in a small way for local sale. The bed at these mines is about 20 inches in thickness. They are mostly small drifts, only intermittently worked. *At Miley's drift*, which is located in a hollow, about a mile northeast of town, the following section was obtained:

Coal about Warrensburg.

Feet.	Inches.	
7		Shale, drab, clayey.
	20	Coal.
	1 to 2	Clay.
		Limestone.

Section at Miley's drift.

FIG. 89. Section of coal bed at Warrensburg.

Other pits in this neighborhood are Henry's, Evan's and Wood's and in these the coal is of about the same thickness. Some ten miles northeast of Warrensburg, north of Blackwater creek, are Gilger's and others coal pits, in which a bed of coal 20 to 30 inches thick is worked.

Coal pits near Warrensburg.

In the neighborhood of Holden, in the western part of the county, are also a number of small coal pits in which the coal is genera ly about a foot thick. An occurrence is described by Broadhead, on page 191 of the report of 1872, where the coal is as much as 16 inches thick and, at other points, miners report the bed to be fully 18 inches.

Coal near Holden.

Away from the line of the railway, both in the southern and in the northern portions of the county, are other outcrops of coal which have been inspected. They are, however, not of sufficient prominence to merit description here, but this is best reserved for the detailed report on this area. In the southeastern corner of the county the coals later to be described as mined in the vicinities of Windsor and Calhoun, in Henry county, undoubtedly extend into Johnson county.

46. CASS COUNTY.

Cass county is not a coal producing county, though it is entirely underlain by Coal Measure strata. In the northeastern corner of the county these are nearly 700 ft. thick. A drill hole put down at Pleasant Hill to a depth of over 600 ft. passed at least 50 ft. into Lower Carboniferous Limestone. In this hole the following coal beds were encountered:

Not a coal producer.

SECTION 13.

Section at Pleasant Hill.

1.	At a depth of 193 ft.....	18	inches	of dark shale with coal.
2.	" 211 "	12	"	shale and coal.
3.	" 323 "	12	"	coal.
4.	" 360 "	18	"	good coal.

At Harrisonville a drill hole was put down to a depth of 505 ft. in search of gas, and here only one seam of coal mixed with slate was struck at a depth of 292 ft., the whole aggregating about 18 inches in thickness. It is not probable, however, that

Drill hole at Harrisonville.

careful attention was given to the character of the strata passed through in this drilling, inasmuch as this was aside from the main object.

Occurrences of coal at the surface in the county are rare and are hardly worthy of notice. In the neighborhood of Pleasant Hill a seam two or three inches thick occurs and has been encountered in shallow wells. About Strasburg, near the forks of Big creek, Broadhead, in the report of 1872, reports a coal bed about one foot thick, in the bed of the creek. South of this near Gun City, another occurrence of coal of about the same thickness is mentioned. Surface coal.

The proximity of workable coals in Henry and Bates counties, lends color to the hope that some thicker bed may yet be discovered in the southern and southeastern portions of this county. Nothing more definite concerning such prospects can, however, now be said by the Survey. After the detailed work in the southeast is extended into this area more authoritative predictions can be made. Possibilities in south and southeast.

47. HENRY COUNTY.

PRODUCTION IN 1891..... .. 144,139 TONS.

Henry county may be classed as one of the large coal producing counties of the State. It contains over twenty coal mines, many of which are constantly in operation. The larger portion of the county is underlain by Coal Measure strata; but, along the eastern border and in the southeastern corner, the Lower Carboniferous rocks reach the surface. Still farther east, the Lower Silurian rocks are exposed in the bluffs of Grand river and the Osage. The coal beds of the county are thus characteristically marginal beds and, it is probably due to this fact that they are, at least in some instances, of limited distribution and have been formed, apparently, in estuary-like basins. Several coal beds are recognized in continuous sections but mining operations are chiefly restricted to two coal beds, according to the common interpretation of the stratigraphy of this county. These are what was called the "Hydraulic Lime- Large Coal Measure area. Estuary deposits.

"Hydraulic Limestone" and Jordan beds.

stone" [1] bed and the "Jordan" bed. The indications are that the implied correlation of exposures is in the main correct, but, whether it is so in all cases, and just what the position of the one bed is with relation to the other cannot be stated by the Survey at present, nor will an attempt be made here to define the areas of the two beds. Detailed mapping is now in progress in this county, and, on the sheets resulting from this work, and in the accompanying reports such detail will be included.

Detailed mapping.

In the report of the Geological Survey of the year 1872, Part II, pp. 15 to 30, Prof. Broadhead describes a number of occurrences of coal in Henry county. Both north and south of Windsor, in the extreme northeastern corner, outcrops of coal 2 and 3 ft. thick are referred to within two or three miles of the town. About two and a half miles east of Calhoun, at Henry Neff's, coal ranging from 2 to 3 ft. in thickness is reported.

Broadhead report, 1872.

The occurrence of coal at Munn's mine, about four miles southeast of Calhoun is described; the coal is there about 28 inches thick, and is considered to belong to the Jordan bed. *Jordan's mine* is on Grand river, about four miles south of Clinton. As this is the type locality, the following section of the bed as given by Broadhead, is presented for purposes of reference:

Section at Jordan mine.

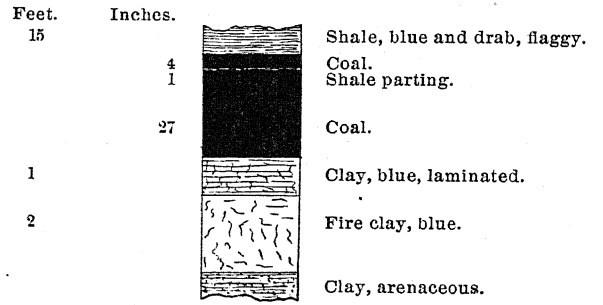


FIG. 90. Section of coal bed at Jordan's mine.

1 In place of this name, it being somewhat cumbersome and, further, as it implies characteristics of occurrence which may not be constant, we propose here as a substitute the geographic name of "Tebo," from the developments of this bed on Tebo creek.

In the vicinity of Calhoun, in the northeastern portion of the county, several mines are now operated.

George's pit, or stripping is about a mile north of the town and furnishes coal for local uses. From the limited examination which was made we feel unable to decide just where this coal belongs in the section of the Coal Measure strata here, but we are inclined to think that it is not the "Hydraulic Limestone" or "Tebo" coal, later to be described. The following section was measured at George's pit: George's pit.

Feet.	Inches.	
	6 to 12	Coal.
4		Shale and clay.
2		Shale, black, fissile.
	36	Coal.

Section.

FIG. 91. Section of coal bed at George's pit.

Park's drift is situated in a ravine, about two miles west of Calhoun. Here the following section was measured:

Feet.	Inches.	
	12 to 18	Limestone, drab, hard, compact.
2 to 3		Shale, dark, fissile.
	3 to 12	Shale, calcareous, black, hard.
	30	Coal.
	½ to 1	Clay, pyritiferous.
	5 to 6	Coal.
	6+	Clay, dark, hard, shaly.
		Clay, ("mining.")

Section at Park drift.

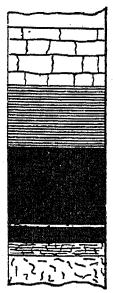
FIG. 92. Section of coal bed at Park's drift.

The coal is clean, with a sharp cuboidal fracture. It is reported to be highly esteemed in local use. No excessive amount of pyrite was noticed.

The Gedney shaft is about two miles southwest of Calhoun, on the Missouri, Kansas & Texas Ry. The shaft is about 55 ft. deep. An 18 inch bed of coal was passed through at a depth of about 30 ft. At the bottom is the Tebo coal bed, of which the following section was measured:

The Gedney shaft.

Section.



Feet.	Inches.	
1 to 2		Limestone, (Cap rock.)
	15 to 24	Shale, black, fissile, sometimes calcareous and hard in part.
	22 to 26	Coal.
	½ to 1½	Shale.
	4 to 6	Coal, shaly.
	1 to 6	Clay, shaly, dark.
		Fire clay.

FIG. 93. Section of coal bed at Gedney Shaft.

This coal bed, as exposed here, and also at the Tebo company's shaft, at the Co-operative Coal company's shaft and elsewhere contains numerous thin, lenticular layers of shale which have to be picked out before the coal can be considered of good merchantable quality.

Character of coal.

The mine is provided with a steam plant and shipments of coal are made regularly to Sedalia and Kansas City. The long wall method of mining is followed.

The Tebo Coal and Mining Company's shaft is situated about a mile southwest of the Gedney shaft, on the line of the railway. It is about 40 feet deep. The section of the shaft is similar to that at the Gedney shaft. The shaft is equipped with a steam plant and is a regular producer.

The Tebo mine.

The Pigg drift is about a mile and a half west of the Tebo company's shaft, and is about half a mile north of the railway, to which the coal is hauled on a tramway for shipment.

Pigg drift.

It is located on the bank of Little Tebo creek, about ten feet above the creek bed. The Tebo coal is operated here. The

roof is excellent and the long wall method of mining is followed. Occasional "slips" and squeezes occur in the coal bed, both here and at other points where it is mined, which depreciate its value; there are fewer shale layers in the coal here, however, than at other points in the neighborhood, which is a circumstance in its favor. The following section was measured here:

Character of coal and roof.

Section at Pigg drift.

FIG. 94. Section of coal bed at Pigg drift.

Near Lewis station a shaft of the Cooperative Coal company, has been sunk to a depth of 67 ft., to the Tebo coal. The shaft is about a quarter of a mile south of the railway and is connected with it by a switch. Three coal beds are reported to have been struck in sinking. The first was at a depth of about 20 ft. and was 16 in. thick; the second was at a depth of about 60 ft. and was 18 in. thick; the third was the Tebo coal at the bottom of the shaft, and is here 30 in. thick. A detailed section of this shaft is given on p. 62 of Bulletin No. 5 of this Survey, but we are inclined to doubt its accuracy, in all particulars, as originally furnished.

Section at Lewis station.

South of Lewis station, running in a northwesterly and southeasterly direction, is what appears to be a narrow coal basin, in which what is distinctively known as the "Lewis" or "Mammoth" coal bed is mined. The width of this coal basin, or trough, does not exceed a few hundred feet, while, in the direction of its length, it has been operated for a distance of several miles. In the center of the trough the coal bed attains a thickness of $4\frac{1}{2}$ ft., while towards the sides it tapers to a feather edge and dips towards the center, in evidence that the present limits are the original limits and are not the result of

"Mammoth" coal bed.

Sandstone floor.

erosion. This coal basin is underlain by a micaceous, ferruginous sandstone which crops out beyond the limits of the coal basin. A number of shafts and strippings have been opened in this coal; but, owing to the narrow limits of the basin, operations are not continued long at any one place.

At the Evans stripping the following section was measured:

Section at Evans stripping.

Feet.	Inches.	
3 to 4		Shale, black, fissile.
	48	Coal.

FIG. 95. Section of coal bed at Evans stripping.

The coal is considered to be high in pyrite, but this is in such a condition as to be readily separated from the coal.

Coal north of Clinton.

North and west of Clinton are several openings in the Tebo coal bed. Broadhead refers to such about four miles north and west of town, on Britts's and Munson's land, in which the coal varies from 25 to 30 inches in thickness. Grant's and Sallee's pits are also in this immediate neighborhood, and the coal is here reported to reach 33 inches.

At Hartwell, about twelve miles northwest of Clinton, on the Kansas City, Ft. Scott and Memphis Ry., is the Blevens shaft, operating the Tebo coal. The shaft is about 35 ft. deep. The following section of the coal was measured here:

Section at Hartwell.

Feet.	Inches.	
	14	Limestone, (Cap rock.)
3		Shale, black, fissile, with hard calcareous layers at times.
	32 to 34	Coal.
	2	Shale, clay, black.
		Fire clay.

FIG. 96. Section of coal bed at Hartwell.

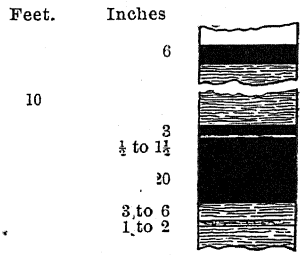
Another bed a few inches thick was struck in sinking the shaft, about 10 or twelve feet above the lower one.

Near Garland, about 6 miles N. E. of Hartwell, on the Kansas City, Osceola and Southern Ry., is the Foster Coal stripping, which is also in the Tebo coal. It is reported to be nearly three feet thick here. Coal near Garland.

West of this, north of Grand river, between the lines of the two railways, are a few small coal pits, operating an overlying bed, in a small way, for country uses. A description of these will be deferred until the detailed report on this area is published.

South of Clinton, between it and Grand river are a number of small coal mines which are worked to supply the town with fuel. Immediately south of the river is a large mine which is connected with the railway, and still farther south, in the vicinity of Deepwater, are several shafts and strippings from which large quantities of coal are shipped. In fact, Deepwater is by far the largest coal mining center in the county. All of these mines operate the same bed of coal, which is known as the Jordan bed. Coal south of Clinton.

The Kinney slope is about two miles southeast of Clinton. It is a small mine, from which the coal is hauled to town for domestic uses. The Jordan coal is operated here. The following section was measured:



Section at Kinney slope.

FIG. 97. Section of coal bed at Kinney slope.

The shale overlying the coal here contains numerous plant remains and a large number of fine specimens have been obtained here, by Dr. J. H. Britts of Clinton, who has distributed them to many prominent paleontologists in the country. Plant remains abundant.

The Pitcher shaft is about a mile and a half southwest of the Kinney slope and is about three miles from Clinton. The same

bed is operated here. The shaft is about 32 ft. deep, but, in the hollows closely adjoining, the coal crops out at the surface and is obtained by stripping. The section here is as follows:

Section at Pitcher shaft.

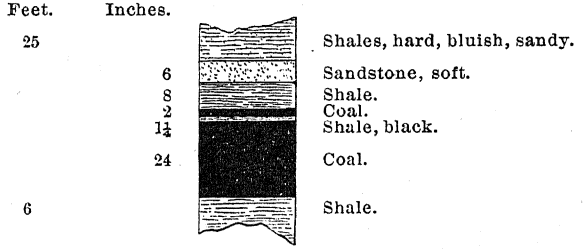


FIG. 98, Section of coal bed at Pitcher shaft.

The coal is of excellent appearance, and is in part very black, lustrous and highly bituminous, with a semi-conchoidal fracture.

Several other openings, by shafts and strippings, have been made in the coal in this immediate neighborhood and the thickness and character of the coal is essentially the same in all. Plant remains are also abundant and large collections have been made from the strip pits here.

Shaft at North station.

Wood and North shaft No. 3 is located near North station, less than a mile south of Grand river. It is connected with the Kansas City, Ft. Scott and Memphis Ry. by a switch about half a mile long. The new shaft is 59 ft. deep to the bottom of the coal. According to the record preserved by the superintendent, a three inch bed of coal was struck at a depth of twenty feet. At the bottom is the Jordan coal, 26 to 28 inches thick. The interval between this and the overlying bed consists entirely of shale, chiefly arenaceous; of this the lower two feet, immediately above the coal, is argillaceous with thin laminæ of coal. A foot of soft clay directly underlies the coal. In the adjoining old shaft both the pillar and room and the long wall methods of mining have been used, but, with the latter method, the influx of water through the fractured roof caused its abandonment.

Character of coal and roof.

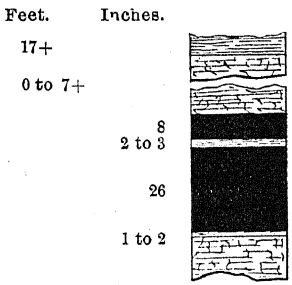
Noble shaft.

The Noble shaft is about two miles west of North station. The shaft is 65 feet. It is operated by a horse and gin. The Jordan bed occurs here also, and is over three feet thick. Shales overlie the coal as they do in the Wood and North shaft,

and the section is in all respects similar, with the exception that the thin overlying coal is not more than 30 ft. above the lower one. The coal contains pyrite in thin, lenticular layers. It is hauled to Clinton in wagons for steam and domestic uses.

Blair Diamond No. 2 shaft is one of the important mines in the vicinity of Deepwater. It is located about a mile southwest of town. The shaft is about 70 feet deep. The following section was measured here:

Coal at Deepwater.



Section at Blair shaft.

FIG. 99. Section of coal bed at Deepwater, Blair shaft.

The coal is considered to belong to the Jordan bed and the same bed is worked at all the openings in this vicinity. The roof in the mine is poor and the pillar and room method of mining is followed. Water seems to give much trouble, also, the entries being very wet. The inferior character of the roof, over much of the territory here, is a serious embarrassment to mining operations; in fact it makes the coal under some areas practically unavailable, inasmuch as the cost of keeping up the roof is too great for the coal to be mined with profit.

Jordan bed.

Character of coal and roof.

The Keith and Perry shaft No. 1 is another important mine in this neighborhood. It is about a mile north of the Blair shaft and, like it, is connected by a switch with the main railway line. It is 60 ft. deep. The following section was measured here:

Section at Keith and Perry shaft No. 1.

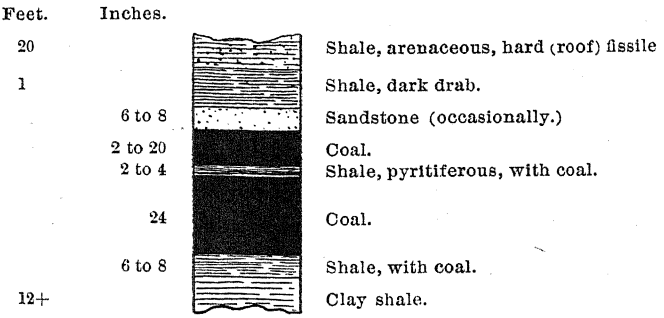


FIG. 100. Section of coal bed at Deepwater, Keith & Perry shaft No. 1.

Character of coal and roof.

The roof at this point is excellent and the long wall method of mining is followed. Water gives little or no trouble. The coal does not appear to be of superior quality, however. About 40 ft. above this coal bed another thin seam was encountered while sinking the shaft.

Besides these shafts there are, about Deepwater, a number of strippings from which a large amount of coal is taken. As much as 20 ft. of overlying clay and shale is removed from over the coal in such operations.

Stripping extensive.

The inferior roof, already alluded to, accounts in part for this; for, as the coal cannot be obtained in places by underground work, stripping is carried to the greatest practicable depth. The Boydson, Stephens and Dunlap strippings are all within a mile or two of Deepwater. The thickness of the coal is generally about 3 ft., but it sometimes reaches 4 ft., and elsewhere contracts to 1 ft. A peculiar feature of this surface coal is the manner in which it undulates, frequently dipping as much as 10° and causing

Coal undulating.

the coal, at closely adjacent points, to be at noticeably different elevations. In such cases it is generally thicker in the depressions and is sometimes contracted to 1 ft., on the summits of the rolls. This would indicate that the coal was originally deposited upon an undulating floor.

This coal is worked eastwards to Brownington, on the Kansas City, Osceola and Southern railway.

Coal southeast of Deepwater.

Southeast of Deepwater, south of Otter creek, stripping is carried on extensively, and the coal is hauled thence in wagons.

The bed here is of about the same thickness as at Deepwater, and the conditions of mining are similar.

Over the southwestern corner of the county, south of Grand river and west of the Kansas City, Ft. Scott & Memphis railway, coal mining has been prosecuted in a desultory way for local sale. No mines were in operation here at the time of inspection. The bed worked is thought to be the Tebo, the same as that described at Lewis and Hartwell.[1]

Coal in Southwest.

48. BATES COUNTY.

PRODUCTION IN 1891.....726,273 TONS.

Bates county is the largest coal producer in the State. It is entirely underlain by Coal Measures. According to the mine inspector's report, there are over 30 mines in operation, producing all the way from 500 to 50,000 tons per annum. The principal developments are in the vicinity of Rich Hill, Sprague, Hume and Foster, in the southwestern portion of the county, and also about Amoret, north of the Marais des Cygnes river, near the Kansas line. Coal occurs, however, in other portions of the county and has been worked at a large number of points to supply local demands. In the Report of the State Geological Survey for the years 1873–74, pages 162 to 175, Prof. Broadhead gives a general description of the occurrences of coal in the county, together with a small map, showing the location of the individual outcrops and coal pits.[2]

General distribution of mines.

Geological Report of 1873-74.

In the southeastern portion of the county, as described in the Report of 1873–74, coal crops out at several points. North of Papinville, about three miles, is coal 18 in. to 20 in. thick. A few miles south of Hudson, on Panther creek, are outcrops and

Coal in the Southwest.

[1] The mapping of the coal beds over this area is now in progress by the Survey and when finished, we shall be able to publish more detailed results concerning the character and distribution of the coals in this vicinity.

[2] Little in the way of general description will be attempted here, in addition to what is contained in that report, concerning the occurrences of coal away from the localities where developments have been actively prosecuted during the past few years. The limited time available for the preliminary inspection, upon which the present report is based, allows a statement of only the general facts. The detail can only be expressed as a result of such detailed work as is now being prosecuted in Henry county adjoining Bates county to the east.

openings on coal two to three feet thick. Just east of Lone Oak is coal about a foot thick. These occurrences are thought by Broadhead to represent two or three different beds, one over the other.

Farther north, on South Deepwater creek, a few miles south of Johnstown, coal over a foot thick is found. North of Johnstown, on North Deepwater creek, coal also occurs of about the same thickness. Recent drilling about 7 miles west of Johnstown demonstrated the presence of two beds of coal. One of these was $4\frac{1}{2}$ ft. thick, at a depth of 42 ft.; the other was $2\frac{1}{2}$ ft. thick, at a depth of 82 ft. There is probability, however, that at least a portion of what was considered coal was black shale, as the drilling was with a churn drill and all of the material was finely pulverized. The report merits further investigation. Still farther north, near Mayesbury, on Cove creek, coal about 14 inches thick crops out, and is also exposed along the creeks west of this, as far as the railway.

Coal near Johnstown.

Near Mayesbury.

In the vicinity of Butler, there have been a few coal pits working thin beds. One about four miles northwest of the town operated a bed 30 inches thick. Some ten years ago a churn drill hole was put down about half a mile south of the town and in it, according to the record, seven coal beds were struck as follows:

Coal near Butler.

SECTION 14.

Record of Butler Drill hole.

1.	At a depth of	109 ft	8	inches	of coal.
2.	"	128 "	6	"	"
3.	"	185 "	24	"	"
4.	"	213 "	8	"	"
5.	"	226 "	2	"	"
6.	"	240 "	5	"	"
7.	"	296 "	4	"	"

This record necessarily removes the feeling of confidence that thick coal will be found in this immediate vicinity; but, considering the character of drill used, and also the variable nature of the coal beds of the region, it should by no means be taken as conclusively settling the question.

Significance of record.

About Adrian, in the northern part of the county, coal beds less than a foot thick crop out at several points. About a mile and a half northeast of the town, Broadhead gives a section of

Coal near Adrian.

a shaft about 30 ft. deep in which 4 ft. of coal was struck. There is some doubt, however, concerning the thickness of this coal.

About six miles a little north of west of Adrian, a drill hole was put down about nine years ago to the depth of over 350 ft., in which the following beds were struck, according to the certified record. Coal northwest of Adrian.

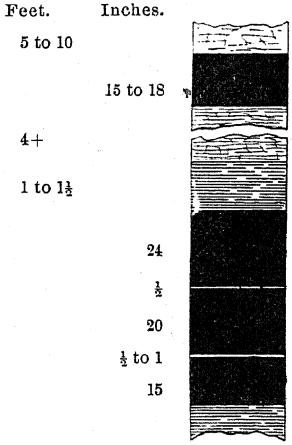
SECTION 15.

Record of drill hole.

1.	At a depth of	98 ft.	8	inches	of coal.
2.	"	112 "	2	"	"
3.	"	155 "	10	"	"
4.	"	233 "	2	"	"
5.	"	256 "	8	"	"
6.	"	321 "	27	"	"
7.	"	346 "	½	"	"

About Rich Hill, within a radius of five miles of the town, are more important mines than are in operation in the whole remaining area of the county. These mines are all strip pits or shafts and all operate, presumably, the same bed of coal. A description of a few will convey a good general idea of the character of the coal bed in all. Coal about Rich Hill.

The Martin stripping is on the southern edge of town and the coal is only from 5 to 10 feet beneath the surface. Here the following section was measured:



Section at Rich Hill.

FIG. 101. Section of coal bed at Rich Hill.

At Keith and Perry shaft No. 7, a few miles south of Rich Hill, at the county line, the following coal beds were encountered:

SECTION 16.

Record of Keith and Perry shaft No. 7.

1.	At a depth of	26 ft	4 in	of coal.
2.	"	69 "	9 "	"
3.	"	86 "	8 "	"
4.	"	103 "	51 "	"

Near the middle of the bottom coal a thin band of pyrites is frequently found, but it is not persistent. At these mines, as with those about Deepwater in Henry county, the coal bed undulates very decidedly and this, together with the circumstances of topographic location permits the coal to be mined in deep shafts or to be dug in strip pits, at closely adjoining localities.

Coal very undulating.

The Keith and Perry shaft No. 5, is about five miles northwest of Rich Hill. It is 50 ft. deep. The following section was measured here:

Section at K. & P. shaft No. 5.

Feet.	Inches.	
4		Shale, black, homogeneous.
	54	Coal, with ⅛" pyrites, one foot from bottom.
		Clay.

FIG. 102. Section of coal bed at Rich Hill, Keith & Perry shaft No. 5.

This is undoubtedly the Rich Hill coal bed. A number of "slips" were observed in the coal here, some being merely fractures, some being accompanied by faulting and some with changes of roof. The bed undulates a good deal making underground slopes necessary at times. The coal is generally thicker in the depressions of such undulations. Shaft No. 6, closely adjoining this, is now abandoned. The shaft here was 246 ft. deep, and the record of the diamond drill hole put

Character of coal and roof.

down at this point shows the following coal beds to be present:[1]

SECTION 17.

1.	At a depth of	31 ft.	3 in.	of coal.
2.	"	74 "	5 "	"
3.	"	162 "	12 "	"
4.	"	190 "	10 "	"
5.	"	199 "	18 "	"
6.	"	214 "	33 "	"

Record of Keith and Perry shaft No. 6.

In the vicinity of New Home, some five miles west of the last, a number of diamond drill holes have been put down. From one of these the following results are taken:

SECTION 18.

1.	At a depth of	34 ft	4 in.	of coal.
2.	"	51 "	5 "	"
3.	"	99 "	13 "	"
4.	"	185 "	4 "	"
5.	"	207 "	11 "	"
6.	"	255 "	30 "	"

Record near New Home.

Other drill holes put down in this immediate vicinity showed the lowest, or Rich Hill coal bed to range in thickness from 20 to 50 inches. In one instance, a record shows only 4 inches of coal at the proper depth; this is, however, an exceptional and extreme case.

At Sprague, south of New Home, on the Mo. Kans. & Texas railway, mining has been prosecuted by stripping a coal bed which occurs here near the surface. The bed is, apparently, not the Rich Hill bed, but an overlying one, separated from it by an interval of about 250 ft. It is probably the same as that termed the Mulberry bed by Broadhead, in the Report of 1873–74. Beneath this, other coal beds were encountered in a diamond drill hole as follows:

Coal at Sprague.

SECTION 19.

1.	At a depth of	15 ft	28 in.	of coal.
2.	"	92 "	6 "	"
3.	"	137 "	11 "	"
4.	"	222 "	13 "	"
5.	"	247 "	11 "	"
6.	"	267 "	12 "	"
7.	"	271 "	18 "	"
8.	"	294 "	8 "	"

Record near Sprague.

[1] The record of this drill hole as well as of many others in Bates and Vernon counties, were generously placed at our disposal by the Keith and Perry Coal company, through Mr. G. R. Sweeney, superintendent, and Mr. George H. Copeland, driller.

Another drill hole closely adjoining, gave a thickness of 20 in. for the bed, No. 7 and this is thought to be probably the equiv-
Other drill holes. alent of the Rich Hill bed. This inferred correlation must, however, be accepted with caution, as well as other similar conclusions, until substantiated by detailed work.

About two miles southwest of Sprague, in section 18, a drill hole was put down which yielded results abundantly confirming those obtained at Sprague. The work here was apparently begun below the horizon of the Mulberry coal worked at Sprague, the first given in the last record. The results are as follows:

SECTION 20.

Record south of Sprague.

1.	At a depth of	58 ft.	5 in. of coal.
2.	"	96 "	6 " "
3.	"	107 "	4 " "
4.	"	188 "	8 " "
5.	"	212 "	12 " "
6.	"	221 "	10 " "
7.	"	231 "	22 " "

The last bed, No. 7, is probably the equivalent of No. 7 of Section 19, or the Rich Hill bed.

At Hume, about 8 miles west of Sprague, the Mulberry coal is similarly worked by stripping. As exposed some two miles
Coal near Hume. south of the town it is described by Broadhead as varying from 20 to 34 inches in thickness. A few miles north of the town, on the headwaters of Walnut creek, it reaches 3 ft. in thickness.

At Foster, coal is stripped on a large scale, at several points. The bed is in all probability the Mulberry coal. A section measured at the Walnut Land and Coal Co.'s stripping is as follows:

Section at Foster.

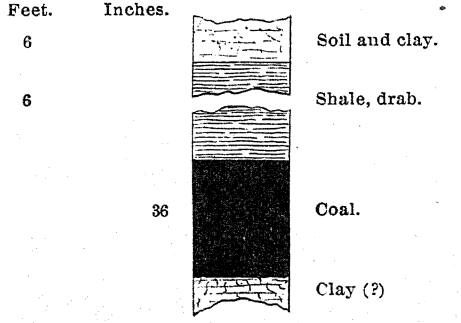


FIG. 103. Section of coal bed at Foster.

Limestone crops out quite close to the coal stripping here, and is well exposed in an abandoned railway cut. It probably closely underlies the coal and undulates with it, which would account for its being, in places, at a higher elevation than the coal at adjacent points. The limestone is, apparently, about 6 ft. thick or more, has a very irregular fracture and contains a good deal of chert and remains of the coral *Chætetes*. It is immediately underlain by about two ft. of hard, dark compact limestone, and under this is black fissile shale.

Limestone under Foster coal.

West of Foster, and south of the Marais des Cygnes river, are several other occurrences of this same coal bed, along Walnut creek and its tributaries. The thickness remains almost constantly about 3 ft.

Coal along Walnut creek.

At Amoret, west of the Marais des Cygnes river, mining on a large scale has recently been started. A coal bed, about 3 ft. thick, has been worked in this neighborhood for many years, and, from its occurrence on Mulberry creek here, it has been named the Mulberry coal.

Coal near Amoret.

Shaft No. 1, of the Missouri Coal and Construction Co. is situated about a mile and a half south of the town. Work had just been started here at the date of inspection. The shaft is 35 feet deep and, in it, the following section was measured:

Feet.	Inches.	
10		Shale, dark blue, hard, (good roof.)
	24+	Coal.
	18 to 30	Clay.
		Rock.

Section at Amoret.

FIG. 104. Section of coal bed at Amoret.

The coal, near the foot of the shaft, is much faulted and is traversed by fractures which injure the roof. In consequence it is reduced in thickness, in places, to 8 and 10 inches. At other points, in the immediate vicinity, at old shafts, the coal is reported to reach a thickness of 3 feet, and the roof is found to be uniform and to require no propping. It is probable that the disturbed condition seen in shaft No. 1, is only of local significance.

Coal faulted.

North of Amoret, for a distance of eight miles, along Mulberry creek, and in the adjacent country, this coal bed has been opened and worked for local uses at a large number of points. These pits are described or referred to by Broadhead. The thickness of the coal is generally in the neighborhood of 3 ft.

Coal north of Amoret.

On the Miami Fork, northeast of Amoret, and east, between that place and Butler, this coal is found at several points on the creek.

On Miami Fork.

From the description that has been given, it will be apparent that coal exists over a large portion of this county of workable thickness. It is also apparent, however, from the results of the drilling given, as well as from the experience in mining here, that the thickness of the beds is subject to great variation. Thus, while in one portion of a forty acre tract the coal may be of good thickness and in every way workable, in an adjoining portion it may be entirely too thin for profitable mining. This characteristic is a fact to be borne in mind in all prospective or actual developments; the showing of a single opening or drill hole should always be applied to the surrounding area with caution and should be checked by additional investigation. Thus, while on the one hand, the finding of a great thickness of coal at one point is not a guarantee of an equal thickness over the whole of any tract of land; on the other hand, the finding of a much attenuated bed at one location should not be considered a necessarily disparaging result for the whole surrounding country.

Variations in thickness of coal to be expected.

49. VERNON COUNTY.

PRODUCTION IN 1891.....64,303 TONS.

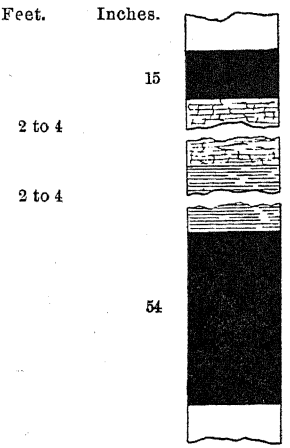
Vernon county is entirely underlain by Coal Measure rocks, excepting in the extreme eastern portion, along the east fork of Elm creek. It cannot, however, be ranked as a large coal producing county. In the report of the Geological Survey for 1873–74 pages 119–154, is a chapter on Vernon county, containing a description of the then known occurrences of coal, similar to that on Bates county previously referred to. Notes are there given descriptive of exposures and coal pits in nearly every section of the county.

Geological Report of 1873-74.

At the time of inspection, the only locality in which noteworthy developments were in progress were at Carbon Center, near the north line of the county; at Timbered Hill, a few miles farther south; at Moundville, and in the southwestern portion of the county, near Milo and Sheldon.

Coal openings visited.

At Carbon Center, the Rich Hill coal bed is operated in several strip pits and a large amount of coal has been hauled away from there for shipment. At G. S. Hoss's stripping the following section was measured:



Section at Carbon Center.

FIG. 105. Section of coal bed at Carbon Center.

West of this, in the direction of the railway, other similar pits are opened in which the coal is of approximately the same thickness.

In section 33, township 38 N., 31 W., about a mile southeast of Carbon Center a drill hole was put down with the following results:

SECTION 21.

1. At a depth of 31 ft	.....	10 inches of coal.			
2. " 59 "	.....	14	"	"	
3. " 68 "	.....	40	"	"	Rich Hill bed.

Record southwest of Carbon Center.

Other drill holes were put down closely adjoining this in which the Rich Hill coal bed was encountered of varying thicknesses, ranging from 5 ins. to over 40 ins. In the majority of cases, however, it was about 3 ft. thick.

In township 38 N., 32 W., about 5 miles west of Carbon Center, two drill holes were put down which furnished valuable and interesting results concerning the distribution and thickness, of the coal beds. One, the eastmost, is located in the N. W. of the N. W. quarter of section 26, the other, the westmost, is in the N. W. of the N. E. of section 27 and they are, consequently, about half a mile apart. The results are displayed in the following plat:

Drill holes west of Carbon Center.

Records.

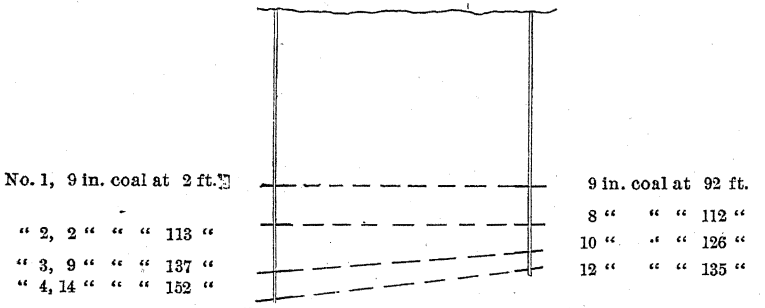


FIG. 106. Plat of drill holes west of Carbon Center.

Both of these holes indicate a thinning of the Rich Hill bed here, and the results of the two compared show a thickening of the interval between Nos. 2 and 3, in evidence of an increase of subsidence of the Coal Measures, towards the west as is referred to on pp. 29 to 31.

Along the Little Osage river, and its tributaries, south and west of the locality last described, are a number of outcrops and pits where coal has been worked for local sale. The exposed beds are thin, however, ranging from 12 ins. to 15 ins. in thickness.

Coal along Little Osage.

Timbered Hill is opposite the mouth of the Little Osage river, about four miles south of Carbon Center. Here several shafts have been sunk and a large amount of coal has been mined and hauled to Nevada. In one of these shafts the following coals were encountered:

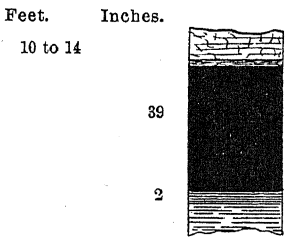
Coal at Timbered Hill.

SECTION 22.

1.	At a depth of	22 ft	12 inches of coal.
2.	"	38 "	18 " "
3.	"	60 "	42 " "

The lowest coal bed is possibly the Rich Hill bed, and the same as that mined at Carbon Center. If this be the case the bed is considerably lower at Timbered Hill than at Carbon Center which would call for a southward dip from the latter to the former point. More detailed study is necessary, however, before this can be reliably affirmed. The detailed section of the bed here is as follows:

Bed same as at Carbon Center.



Section at Timbered Hill.

FIG. 107. Section of coal bed at Timbered Hill.

The coal is hard and cannot be easily undermined with a pick, but has to be blasted down.

South and east of Timbered Hill, at a number of localities, coal has been worked in past years and is described by Broadhead in the report above referred to. The reported thicknesses are from 18 to 20 inches. Mines have been operated here adjacent to the Mo. Kans. & Texas railway, but none such were reported to be in operation at the date of inspection and were, hence, not visited.

Coal south and east of Timbered Hill.

In the vicinity of Milo, south of Nevada is the Ferry coal pit. Here some 10 ft. of cover is stripped from the coal, and it is dug in an open cut. The bed is from 3 to 3½ ft. thick. It lies apparently, in an elongated basin, the longer axis running from N. E. to S. W. The area stripped is from 200 to 300 ft. wide. The bed undulates noticeably, being found at very variable depths within short distances. The overlying material is generally a dark shale or clay, which makes a poor roof for underground mining. In places sandstone is found immediately overlying the coal. South of this, half way to Sheldon, but west of the railway, Broadhead describes the coals at Maxwell's 2½ to 4½ ft. thick, which probably belongs to the same bed.

Coal near Milo.

About four miles southeast of Milo, on Little Clear creek and

Cargill pit.

adjacent streams, coal crops out well up in the hills and has been opened and worked at a number of points for local use. Of these the Cargill pit was opened at the date of inspection, and was visited. The following section was measured:

Section near Milo.

Feet.	Inches.	
		Sandstone, thick bedded and flaggy.
4		Shale, with sandstone layers.
	12	Coal.
	1 to 2	Shale parting.
	9	Coal.
	2 to 18	Sandstone parting, not persistent.
	9	Coal.
	3 to 4	Shale, black, soft.
		Clay, reddish, hard.

FIG. 108 Section of coal bed near Milo.

There are four pits here within a half mile of each other, all operating this same bed. The roof is in some places of solid sandstone. The coal contains pyrites and is not a good forge coal. North and east of this point, near Montevallo and down Clear creek, are other openings in coal beds; these are, however, generally not over 12 inches thick. They are referred to in the Report of 1873–74.

Coal on Clear Creek.

At Moundville, in the southwestern part of the county, coal is now mined and has been worked in the past for over twenty years. Several coal beds occur here, but the area of some of them appears to be quite limited. The limit of a thick coal bed is aproximately defined in the Survey Report of 1873–74.

Coal near Moundville.

The Hill mine is situated on the summit of a low hill, in the northern part of Moundville. The shaft is 25 ft. deep. Here the following section was measured:

Section at Hill mine.

Feet.	Inches.	
20		Shale, argillaceous, sandy in places, fissile and black at bottom.
	6	Coal.
	½	Shale parting.
	24	Coal.
	6	Clay.

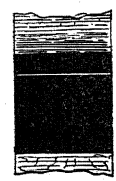


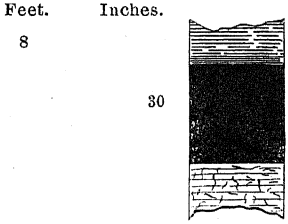
FIG. 109. Section of coal bed at Moundville, (Hill mine.)

This same coal is operated at several neighboring points and also on the southwest edge of Moundville. Immediately under the bottom clay shown in the figure, the following beds are reported to occur and to have been dug through by the miners. They were not visible at the time of inspection. Coal near Moundville.

SECTION 23.

1. *Coal*..... 10 ins.
2. Clay..... 2 "
3. *Coal*..... 20 "

The Frank (?) pit is a stripping situated about two miles southwest of Moundville. The following section is exposed here:



Section at Frank mine.

FIG. 110. Section of coal bed at Moundville, (Frank mine.)

Under this the following additional strata are reported by the owner of the land:

SECTION 24.

1. Clay and Shale..... 10 ft.
2. *Coal*..... 12 ins.
3. Interval (probably shale and clay)..... 30 ft.
4. *Coal*..... 30 ins.

South of this mine, a distance of a mile or two, other beds of coal are reported in the sides of the mounds which are higher stratigraphically as well as topographically than the coal at Frank's. On the basis of the information obtained here, together with personal observation, Mr. G. E. Ladd, who collected the notes from this locality is led to conclude that there are in all, seven coal beds represented here, he correlating No. 4 of section 24 at the Frank stripping, with the bed worked at the Hill mine. This conclusion should, however, be taken as a working hypothesis rather than as an authenticated theory. Seven coal beds here.

Coal on Drywood creek.

Southwest of Moundville, in the extreme southwestern corner of the county, coal occurs on the West Fork of Upper Drywood creek. It is quite thin, however, generally about a foot thick.

At Clayton and Deerfield.

In the vicinities of Clayton and Deerfield, between the Mo. Kans. & Texas railway and Marmiton creek, coal has been struck and dug into at a number of points. North of Clayton it is reported by Broadhead to be from 12 to 18 ins. in thickness, and near Deerfield, as exposed at the Johnson and Farmer mine, it is about 18 inches thick. Nothing was known to be in operation here when inspection of the coals in the county was made, and those localities, hence, were not visited.

Near Nevada.

About Nevada, thin coal has been struck in the suburbs of the town, but nothing of sufficient extent and thickness to be continuously or extensively mined, is known to exist. Heavy sandstone beds are developed in this neighborhood and they may affect the distribution of the coal, as do similar beds in Lafayette and Johnson counties.

ST. CLAIR COUNTY.

PRODUCTION IN 1891.....3,866 TONS.

Distribution of coal.

St. Clair county is underlain by Coal Measure strata in the northwestern portion, and in the southwestern portion tongues of these rocks extend into it from Cedar county. Isolated patches also occur on the divides between the large streams. Along the Osage and Sac rivers, Lower Carboniferous and Lower Silurian rocks crop out; and, in the eastern and southeastern portions of the county these are the prevalent rocks. The county can, at present, hardly be classed as a coal producer, the mines are small and scattered and the production small. The prospects for the development of a coal industry in the northwestern part of the county are good, however, when better means for transportation are provided.

Coal near Appleton City.

In the vicinity of Appleton City, in the northwestern corner of the county, coal is worked in small country pits, to supply local demands. The thickness of the bed is generally about 2 ft. and it is immediately overlain by black, fissile shale.

A diamond drill hole was put down here about a year ago to a

depth of over 600 ft. In this the following coal beds were encountered:

SECTION 25.

Appleton City drill hole.

1.	At a depth of	20 ft.	12	inches	of coal.
2.	"	148 "	16	"	"
3.	"	175 "	6	"	"
4.	"	227 "	10	"	"

The first bed is probably the one worked about Appleton City and, as previously stated, it is generally about 2 ft. thick. Hence, the result given by the drill, in this instance, is below what is ordinarily found.

At Knowles' stripping, about a mile and a half southeast of Appleton City, the following section was measured:

Section at Knowles' stripping.

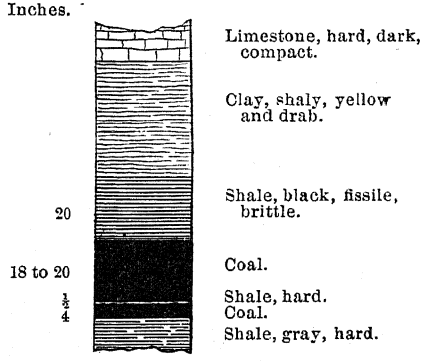


FIG. 111. Section of coal bed at Appleton City.

The coal contains pyrite in nodules and lenticular layers, but it is considered a good forge coal when these are picked out.

In the vicinity of Johnson City, about ten miles southeast of Appleton, are a number of coal pits operated for country uses. Coal near Johnson City.

J. W. Carroll's shaft is about a mile west of the post-office. It is 40 ft. deep. The following section was measured here:

Section at Carroll's shaft.

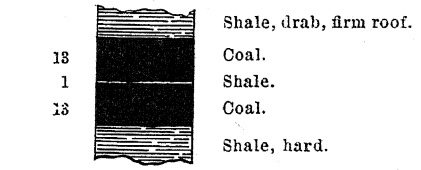


FIG. 112. Section of coal bed at Johnson City.

Coals near Johnson City.

The coal here is pyritiferous and somewhat faulted. Other pits operating what is presumably the same bed, in this neighborhood, are Short's, Allison's, Reed's and Hodson's. The coal is said to be thicker in some of these, reaching as much as 3 ft. in places. This bed probably belongs to a lower horizon than that worked near Appleton City. It is probably the same as No. 2 in Section No. 25 on p. 157.

Near Osceola.

In the neighborhood of Osceola are several coal mines operated on a small scale, some of which have been worked, off and on, for over thirty years.

The Johnson drift (Watkins and Hoover), is such a one. It is situated about four miles northwest of the town. The coal crops out not far from the summit of a hill and is probably not much above the Lower Carboniferous rocks which are exposed in the river bluffs to the south. The following section was measured here:

Section at Johnson drift.

Feet.	Inches.	
6		Sandstone, friable micaceous, thinly bedded.
8		Shale, dark, hard, fissile, good roof.
	14	Coal.
	1	Shale parting.
	15	Coal.
4+		Shale, hard.

FIG. 113. Section of coal bed at Osceola, (Johnson drift.)

Character of coal.

The coal is pyritiferous, especially the upper bench, but it has the reputation of being a superior forge coal. It is reported to slack readily on exposure. The underlying shale is too hard for cutting and the undermining is done in the coal. Several other pits are operated in this immediate vicinity, and the thickness and character of the coal is about the same in all. The section and topographic position of this coal lead to the conclusion that it belongs to the same bed as the coal last described, near Johnson City.

Same as at Johnson City.

Dr. Bell's coal shaft is about two miles east of Osceola. It is about 15 ft. deep. The coal occurs in a small outlier of the Coal Measures which occupies the summit of a hill, the lower

portion of which forms the Osage river bluff, and consists of Lower Carboniferous limestones. The following section was measured here:

Feet.	Inches.	
6+		Shale, dark, fissile, hard near bottom.
	23	Coal, thin pyrite seam near bottom.
		Clay, shaly, soft, drab.

Section at Bell shaft.

FIG. 114. Section of coal bed at Osceola, (Bell shaft.)

The coal has a somewhat uneven surface and is broken by "slips" but these may disappear as excavation extends farther under the hill.

At Vista, about five miles south of Osceola, on the Gulf railway, are several coal mines from which coal is shipped by rail to Kansas City and elsewhere. Coal near Vista.

At the Owen's drift, the following section was measured:

Feet.	Inches.	
6-8		Sandstone, brown, micaceous, thinly bedded.
	24	Coal, pyritiferous.
	4	Shale, black, with coal.
	10	Coal, pyritiferous.
		Shale, hard, drab, arenaceous, micaceous.

Section at Owen's drift.

FIG. 115. Section of coal bed at Vista.

Other mines about here are the Vannice and Dothett shafts. In one of these coal as much as 4 ft. thick was seen, but it was subject to rapid change, owing to a waving of the sandstone roof. Other mines.

At Lowry City, north of Osceola, and at Taborsville, south of Appleton City, coal is also mined. The reported thickness of the beds is about three feet. The coal in both cases is probably the same as that opened at the Johnson drift west of Osceola and in Carroll's shaft near Johnson City. Coal near Lowry City.

51. CEDAR COUNTY.

PRODUCTION IN 1891.....1,264 TONS.

Distribution of coal.

Cedar county contains only a very small area of Coal Measure rocks and these are confined chiefly to the extreme western portion of the county. Lower Carboniferous rocks occupy by far the greater area, and, even in the western portion, the Coal Measures are confined to the elevated areas between the larger streams.

Broadhead and Norwood report.

The Report of the Geological Survey for 1873–74 contains a short chapter on Cedar county, which is accompanied by a small map, the two embodying the results of observations by Profs. G. C. Broadhead and C. J. Norwood. In this report an isolated coal area, about *8 miles north of Stockton* is described, in which about 3 ft. occurs, which has been worked for local use. It lies east of the Sac river, and the whole area is shown on the map to be only about five square miles.

Coal near Lebec.

In the vicinity of Lebec, near the north line of the county, an 18 in. bed is also described; and farther west, about El Dorado, a bed 12 ins. thick occurs.

Near Jerico.

In the neighborhood of Jerico, in the southwestern corner of the county, coal varying from 8 ins. to 3 ft. in thickness is described in that Report. At the present time, mining is still prosecuted in this vicinity, at the Anderson, Cole, Daniels and Davis pits, where the coal is reported by the owners to be from 20 to 30 inches thick. This coal is, in all probability, the same as that mined in the northwestern corner of Dade county, next to be described.

52. DADE COUNTY.

PRODUCTION IN 1891 .....3,402 TONS.

Distribution of coal.

The Coal Measures of Dade county occur in the northwestern corner where they are confined, almost exclusively, to township 32 N., 28 W. They occupy here the hill-tops and ridges, and the aggregate thickness is probably not much over 50 ft. Below this the underlying Ferruginous sandstone, and Lower Carboniferous limestones, occupy the lower lying valleys and extend

under the whole of the county. Only one coal bed is mined here, and this generally by drifting. The Sharpe, Seaton, McGarvy and McClure are such, all located within an area a few square miles. These were all visited by the writer; but there are many others here which are either in operation now or have been in the past. Coal mines in Dade Co.

At the Sharpe pit, the coal is about 30 ft. below the hill summit. It has been stripped in the depressions, but is also worked by a drift. The following section was measured here:

Feet.	Inches.		
10			Shale, dark, arenaceous, overlain by 5 feet sandstone.
	4		Coal.
	½		Shale.
	24		Coal.
6+			Clay.

Section at Sharpe pit.

FIG. 116. Section of coal bed at Sharpe Drift.

The bed is worked by pillar and room, and is undermined in the clay. It ranges in thickness up to 32 ins.

The sections of the coal and associated strata at the other pits in the neighborhood are in all respects similar to the above, and need not be especially described here. The coal appears to be of excellent quality, containing comparatively little pyrite. It is somewhat fractured in places however, particularly in the upper portion of the bed. At present it is worked exclusively for local sale, being hauled in wagons to Lockwood and even as far as Lamar. Character of coal.

53. BARTON, AND 54. JASPER COUNTIES.

PRODUCTION IN 1891.....64,259 TONS.

More than three fourths of the entire area of Barton county is underlain by the Coal Measure strata. Only in the southwestern corner of the county, along Muddy Fork of Spring river, are they absent, and here the Lower Carboniferous rocks occur. The total thickness of the Coal Measure strata represented in the western part of the county is estimated to be about 300 feet, but, east- Distribution of coal.

wards, they grow thinner and finally taper out entirely along the eastern border. Despite this great expanse of Coal Measures the county is not a very large coal producer. It is only during the last few years that coal mining on a large scale has been started in the prairies, about Minden, near the Kansas line.

Coal Mining of recent date.

In the Report of the Geological Survey of 1873–74, some twelve pages (100 to 112) are devoted to a description of the coal beds of the county. Accompanying this is a small map showing the location of the principal openings and outcrops.

Geological Report of 1873–74.

In the northeastern corner of the county, about Newport and Milford, coal occurs which is probably the same as that described in the northwestern part of Dade county. The reported thicknesses vary from 18 inches to nearly 3 ft., but other coal only about 6 inches thick also occurs here. These coals are worked on a small scale for local sale. The limited time allowed for inspection here did not permit of their being specially visited by the writer.

Coal near Newport and Milford.

About Lamar some thin seams of coal are worked for sale in the town. About a mile west, near the hill-top on the west side of Muddy Fork, a bed only a foot thick is reached by stripping, though hard shale and sandstone overlie it. About 10 feet below this is another bed of coal, which is creditably reported to be 16 ins. thick, though the full thickness could not be seen. At the pumping station of the city waterworks, on Muddy Fork about two miles north of the town, coal 18 ins. thick is reported to have been struck in the well. This is probably a still lower bed than either of those above cited. South of the town, on McCullum's branch, a thin bed, about 14 ins. thick, crops out and is worked for local sale. Thence, down Muddy Fork to the county limits, and along its western tributaries, coal varying from 8 to 18 ins. in thickness occurs at a number of points and has been worked in a small way.

Coal about Lamar.

At Liberal, in the northwestern part of the county, coal has been mined at G. H. Walser's drift on a larger scale than at any of the points in the county yet described. The mines consist of drifts in the edge of the town of Liberal, connected by

Coal at Liberal.

tramways with the railway. In the eastmost of these drifts the following section was measured:

Feet.	Inches.	
7		Shale, hard, dark drab.
	29	Coal, upper 3 inches with pyrite streaks.
3+		Clay shale.

Section at Liberal.

FIG. 117. Section of coal bed at Liberal.

The clay shale underlying the coal is hard and undermining has to be done in the lowest three inches of coal, which causes just that much waste of coal. About a quarter of a mile west is the other drift. The roof is not so good here, a sandstone frequently replacing the overlying shale, the sandstone sometimes occupying channel-like depressions in the coal.

Character of clay and roof.

On the hill above this bed a drill hole was put down to a depth of 20 ft., which penetrated the coal. In the valley about 50 ft. below the level of the coal another drill hole was sunk to the depth of 135 ft. The distance from the top of the first hole to the bottom of the second is thus in the neighborhood of 200 ft. The results of these two drill holes, so far as the occurrence of coal is concerned, are combined in the following section. The record was kindly furnished by Mr. G. H. Walser.

SECTION 26.

1.	At a depth of	18 ft	25 ins.	of coal	(bed worked)
2	"	90 "	4 "	"	
3.	"	105 "	6 "	"	} (clay between)
4.	"	107 "	12 "	"	
5.	"	116 "	10 "	"	
6.	"	129 "	3 "	"	
7.	"	168 "	2 "	"	
8.	"	178 "	6 "	"	
9.	"	196 "	8 "	"	

Drill hole at Liberal.

About two miles north of Liberal coal about 18 ins. thick, has been dug in the bed of East Fork of Big Drywood creek. This is perhaps the equivalent of Nos. 3 and 4 of the last section.

Northwest of Liberal, on Big Drywood creek, south of Leroy the

coal bed mined at Liberal occurs at a lower level and has been dug on a small scale, at several points. It is here about 3 ft. thick.

South of Liberal, the Mo. Pacific railway follows very nearly the eastward limits of the coal bed.

Mines at Minden.

At Minden are three shafts within the State limits, from which coal is mined and shipped on a commercial scale. *The Kirkwood shaft* of the Wear Coal Co. is on the south edge of the town. It is about 40 ft. deep. The following section of the bed was measured here:

Section at Kirkwood shaft.

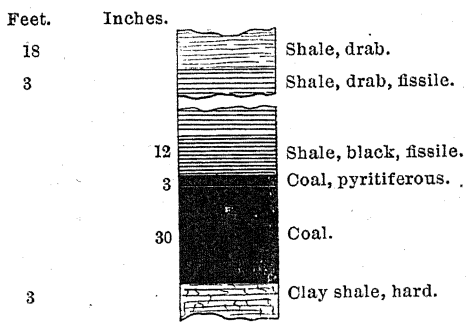


FIG. 118. Section of coal bed at Minden.

Character of coal.

The coal is somewhat faulted as observed near the foot of the shaft, and the bed was partially cut out in places by depressions of the roof. The coal is mined by pillar and room and is blasted down, the bottom clay being too hard for easy mining.

The State Line shaft, about a mile southwest of the last is of about the same depth. The aggregate thickness of the coal is reported to be 3 ft. The pillar and room method of mining is followed here also, but the bed is undermined by cutting away the lowest few inches of coal.

Coal outcrops to east.

This coal crops out within a mile southeast of these mines and the roof becomes correspondingly poor, as the outcrop is approached. Towards the west it dips deeper beneath the surface and the same coal, as worked in Kansas, is thicker and has a better roof.

At the Mo. Pacific shaft No. 1, about half a mile north of the last described, the coal is nearly 100 ft. beneath the prairies, is about 3 ft. thick and has a good shale roof. Here, further,

another coal bed, 6 to 10 inches thick, is reported to have been struck about 40 ft. above the lower bed.

About six miles southeast of Minden, on a fork of Spring river are a number of small coal pits which operated beds less than a foot thick. These occurrences are of coal below the Minden bed, and can probably be correlated with the thinner seams struck in the drill hole at Liberal, as given in Secton 26, on page 163. Coal on Spring river.

54. In Jasper county, south of the last, in the extreme northwestern corner operations in similar thin coal beds have been prosecuted for local use. They are not of sufficient significance to deserve special attention here, and, as these are the only occurrences of coal in the limited area of the regular Coal Measures of Jasper county, further reference to that county will not be made here. The total production of the county for the year 1891 was 633 tons. Coal Measures in Jasper Co.

55. ST. LOUIS, 56. ST. CHARLES AND 57. LINCOLN COUNTIES.

55. St. Louis county was, at one time, deservedly ranked as a coal producer, the coal being mined and hauled to the city of St. Louis for sale. At present no coal is worked here, excepting perhaps, incidentally to the fire-clay mining or intermittently for immediate local use. No mining in St. Louis Co.

In the report of the Mo. Geological Survey for 1855, pp. 176 to 180, Dr. B. F. Shumard has given a description of the coals and Coal Measures of this county, which is prepared from notes taken when coal mining was actively prosecuted here. On the small map accompanying the report the location of the various coal pits is shown as well as the area of the Coal Measures. The latter are in the northeastern corner of the county and occupy an area of about 160 square miles. It is an isolated patch entirely surrounded by Lower Carboniferous limestones. The coal openings have been near the margin of the area, and were most abundant a few miles southwest of St. Louis. About 10 miles north of the city coal pits have also been worked. The mines south and west of the city all worked the same bed. The average thickness was from 3 to 4 ft., and, in places, reached 6 ft., and elsewhere dwindled to 2 ft. An 8 in. bed overlying the Shumard's report.

main seam, and an 18 in. bed 20 ft. below it were recognized here by Shumard. Shale immediately overlies the coal and under it is a thick bed of excellent fire clay which is extensively used about St. Louis. North of St. Louis and northeast, at Charbonniere, coal about 18 ins. thick has been worked.

Coal north of St. Louis.

In St. Charles County the area of the Coal Measures does not much exceed 10 square miles. Like the St. Louis area, it is an isolated patch surrounded by Lower Carboniferous rocks. It lies just west of the town of St. Charles. Coal has been worked for local use within this area at several points near St. Charles: all of the openings are presumably in the same bed. The thickness of the coal varies from 13 to 30 ins., according to measurements made by Prof. G. C. Broadhead, recorded in manuscript notes in the Survey office. The following section measured near the town of St. Charles is taken from these notes:

St. Charles Co. coal.

Broadhead notes.

Section at St. Charles.

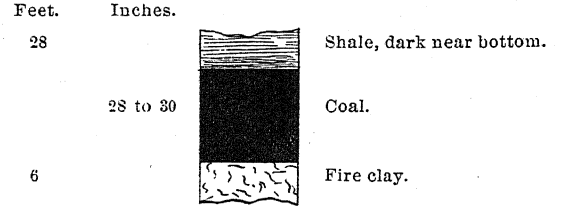


FIG. 119. Section of coal bed at St. Charles.

No mining is at present prosecuted here to the writer's knowledge.

57. In Lincoln County the area of the regular Coal Measures is not more than five square miles in the aggregate. These rocks occur in separate patches on the crests of hills in the southeastern corner of the county, between the Mississippi and Cuivre rivers. Lower Carboniferous rocks immediately surround them. On one of these hills a thin coal bed crops out and has been worked for local use. The thickness varies from 15 ins. to 2 ft.

Coal Measures in Lincoln Co.

Besides this occurrence of coal there are numerous isolated beds of coal in the county, generally known as coal pockets. They, as well as the other coals in the county, have been fully reported upon by Prof. Wm. B. Potter in the Report of the Mo. Geological Survey for 1872, Part II, pp. 263–281.

Potter's report.

ISOLATED COAL DEPOSITS OR COAL POCKETS.

It is not the province of this report to enter into a description of the many isolated deposits of coal which occur beyond the margin of the Coal Measure area. With the coal beds so far described a description of a section at one point is generally applicable to the same coal bed over an adjoining area of some considerable extent; with these isolated deposits a special description of the details of occurrence in each case is necessary in order that exact information may be conveyed. Such special description, being chiefly of local value, is therefore, properly a part of a detailed coal report on the special area containing these deposits. Their descriptions are therefore reserved till such detailed reports are prepared. In the present article all that will be attempted is to define the general distribution of these coal deposits, and, by a description of a few typical examples, to explain their general characteristics.

Coal pockets not to be described in detail.

Distribution of Coal Pockets.[1] Isolated coal deposits, including, in a few cases, deposits of bituminous shale, are known to occur in Clark, Monroe, Lincoln, Warren, Montgomery, Callaway, Cole, Moniteau, Miller, Morgan, Cooper, Saline, Pettis, Benton, Camden, St. Clair, Phelps, Dent, Crawford, Douglas, Jasper and Dade counties, and probably occur in Marion, Pike and Boone counties. In these counties, many occurrences have been already described in previous reports re-

Counties containing coal pockets.

[1] For descriptions of these coal deposits in different counties of the State, the writer is referred to the following State Geological Reports:

Cooper County, Report 1855, Part I, pp. 191–193:
Moniteau " " " " II, pp. 112-113: and Report 1873–74, p. 340.
Warren " " 1855–71, p. 64.
Miller " " " p. 132.
Morgan " " " pp. 149–152;
Saline " " " pp. 167–169;
Phelps " " " p 240·
Crawford " " " pp. 255–256;
Clark " " " p. 318;
Lincoln " " 1872, Part II, pp. 264–281;
Cole " " 1873–74, pp. 323–324, 334–336;
Callaway " " " pp. 338–340;
Jasper " " " p. 402.

ferred to in the foot note below. In addition such deposits have been visited by the Survey during the past two years in Morgan, Miller, Moniteau, Cooper and Saline counties. These last counties, with the addition of Cole, Callaway and Lincoln counties are the ones in which coal pockets are most frequent and most extensive. A description of a few occurrences recently inspected here, will therefore, give a good general idea of the nature of these very interesting deposits.

Coal pockets visited.

The Barnard coal pit, is in Miller county, north of the Osage river, about three miles west of Aurora Springs. It is located near the crest of a spur of the plateau which overlooks the Osage river to the south, at the dividing line between the undulating prairie country, drained by the Missouri to the north, and the rugged, deeply eroded country drained by the Osage to the south.

Pockets in Miller Co.

The mode of occurrence of the coal here is well illustrated in the adjoined sketch.

Sketch at Barnard pit.

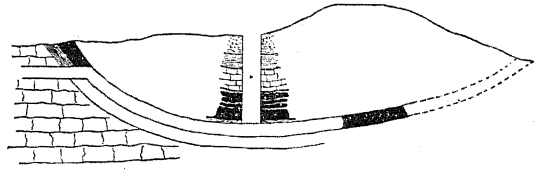
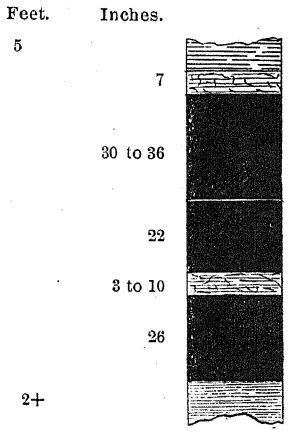


FIG. 120. Sketch of coal deposit at the Barnard pit.

As is there shown the coal lies in the form of a basin of very even curvature. Shales and clays are associated with the coal and the whole series lies in horizontal beds of the Magnesian Limestone series. Though the coal dips at a high angle at the entrance to the mine and rapidly changes to a horizontal attitude, no slips, faults, crushed coal or other evidence of disturbance were noticed. The coal has been followed a distance of about 40 yds. from the mouth and is already assuming a reversed dip to the west, so that it will reach the surface somewhat as indicated by the dotted lines in the sketch. The total width of the deposit, thus, probably does not exceed 80 yds. The following section of the coal was measured here:

Coal in Magnesian limestone.



Section at Barnard pit.

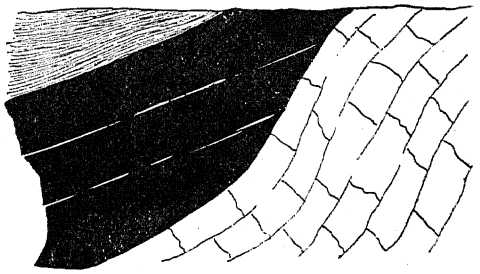
FIG. 121. Section of coal bed at the Barnard pit.

West of this, along the same topographic divide, other occurrences of coal in isolated deposits are frequent and they are also struck in wells north of this line. Southeast of Versailles, in Morgan county, is a group of these deposits, of which the Stover bank is a member. The coal is here creditably reported to be 70 ft. thick, as proved by a shaft. It occurs on the side of a hill of Magnesian Limestone, where it has been stripped and drifted into. A face fully 20 ft. thick was exposed here at the time of inspection. Similar deposits are worked in the immediate vicinity of Versailles and also occur west and north of that place.

Pockets in Morgan Co.

The Simpson coal bank, is in Moniteau county, about ten miles northeast of Versailles on the road to California. The conditions of occurrence here are illustrated in the following sketch:

In Moniteau Co.



Sketch at Simpson pit.

FIG. 122. Sketch of coal deposit at Simpson pit.

Coal at Simpson pit.

The deposit is located on the foot hill of the valley of Barro Fork, and has been exposed by the erosion of the valley. The contact with the limestone country rock is only seen on the north side. The coal is of the cannel variety. Pyrite occurs in sheets along the joint planes, and also in thin films in the finer crevices where it is more difficult to remove. Zinc blende occurs also in a similar manner.

Pocket in Cooper Co.

The Missouri Valley Coal Company's mine is in Cooper county, adjacent to the Mo. Pacific railway, on the Missouri river bluff, about four miles above Boonville. The coal lies in a trough excavated out of horizontal Lower Carboniferous Limestone, the trough being about 100 ft. wide and of undetermined length. It has been followed, however, for a distance of about 500 ft. in an east and west direction. The coal crops out in the railway cut and its relation to the surrounding limestone is there seen. Two shafts have been sunk on the hill-side above the railway, and here about 22 ft. of coal was penetrated. The total depth of the shaft is above 70 ft. The following sketch, taken in the interior of the mine, will illustrate the conditions of occurrences:

Sketch at Mo. Valley Coal Co. mine.

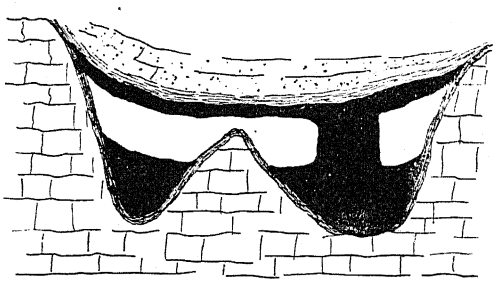


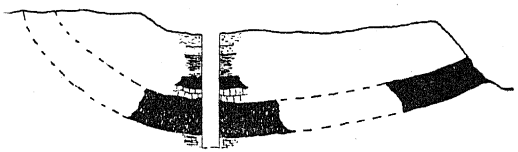
FIG. 123. Sketch of coal deposit of Mo. Valley Coal Co.

Character of coal.

The coal is of the cannel variety, but contains a large percentage of ash. It contains small concretions of pyrite in places. It is stratified, the layers lying horizontally in the middle, but curving upward as they approach the limestone walls. Crushed coal and clay with *slickensides* along these walls testify to considerable movement here. The coal is immediately overlain by 30 inches of fissile shale, and above this is sandstone about 10 ft. thick.

The Cordell coal shaft is at Napton, in Saline county. It is located in a small hill adjacent to a stream. The position of the bed and the character of the associated strata is well shown in the sketch below:

Pocket in Saline Co.



Sketch at Cordell shaft.

FIG. 124 Sketch of coal deposit at Cordell shaft.

The total thickness of the coal is claimed to be 22 ft. Of this a portion about 8 ft. thick was being worked and was seen at the time of inspection, both at the bottom of the shaft and at the foot of the hill where the bed crops out. The shaft is 65 ft. deep. The coal dips on the south side quite strongly to the north, but soon flattens, as is shown in the sketch. The lower bed is bituminous coal of excellent quality, while the upper is reported to be a deposit of the bituminous shale and cannel coal.

Thickness of coal.

Bituminous.

The question of the possibilities and value of these local coal deposits seems one destined never to be entirely settled in the public mind. They have been described again and again in public reports, and their limitations have been frequently defined. Yet we see constantly advertised the discovery of new coal fields in the State in which the beds are of enormous thickness and of great extent. They have heretofore been overlooked by Geological Surveys is an explanation offered; the report of geologists of past years was wrong, is another, and "coal pockets" are myths created by careless examinations or malicious intentions. And so with all the sophistry of a "boom" the bubble is inflated, sometimes with knavish design, sometimes from pure ignorant, sanguine enthusiasm, until, growing too thin to hold together, it collapses. Collapses sharply and decisively, leaving many maimed victims; leaving vacuity and barrenness where imagination had already pictured a teeming industry; leaving blasted with a bad reputation a country which is, above all things, in need of honest substantial credit for those

Possibilities and value of coal pockets.

Exaggerated estimates.

possessions which the glittering picture of the mammoth coal has cast into insignificance.

That any one of these coal deposits will furnish enough coal to warrant the building of special railway lines to it, there is absolutely no probability; hardly will any so far known justify the erection of an expensive plant for taking the coal out of the ground. For local use in the country they have proved of no small value in the past and will continue to do so in the future. When located close to a railway, the product has also been shipped to distant points with profit, thus furnishing some traffic to the road. In some of the counties referred to, these coal deposits are numerous and a line of railway passing through such country would doubtless lead to their development. In such instances they would be a source of considerable income to the road, though probably of an intermittent character. They can never be regarded as the principal inducement to railway construction though they may, in cases, become incidental inducements of considerable importance.

Coal pockets as inducements to railway construction.

APPENDIX A.

NOTES ON THE MINING OF THIN COAL SEAMS IN MISSOURI AND KANSAS.

BY ARTHUR WINSLOW, STATE GEOLOGIST

AND

LEO GLUCK, ASSISTANT.

The fact of the prevalence of thin coal beds in some parts of the State has already been referred to in the preceding chapter on the coal industry of the State. Some of the reasons why such beds can be worked with profit were there given. It is here proposed to describe the processes by which these beds are mined, in order that their entire availability may be appreciated and understood.

Reasons why thin coal beds are mined.

The data from which the following article is prepared are derived chiefly from a study of the mines in Lafayette county, Missouri, where the coal bed is about 20 inches thick, and from an inspection of such at Leavenworth, where the coal is 22 inches thick, and at Osage City, Kansas, where it is only 14 inches thick; these three localities being in the districts in which such thin beds are most extensively operated.

Localities studied.

For reference in connection with the various problems incidental to this mining, the detailed sections of the various thin coal beds given in the preceding descriptions of mines are referred to, especially those on pp. 115, 119 and 121.

Coal sections.

The general system of mining adopted is the long wall method. The prominent recommendation of this method is that it admits of all the coal in the mine being excavated, none being lost in pillars, as in the pillar and room method. Hence the amount of coal taken out in the former case, from any given area is greater than in the latter case.

Recommendation of long wall method.

Peculiar conditions in Missouri.

In the past the belief was general that a tough and somewhat flexible roof was an essential condition for the successful use of the long wall method. The conditions in Missouri and adjoining States necessitated, however, a removal of this restriction and, as mining progressed, a system of long wall working has developed by which the coal is taken out from under comparatively weak and unstable roofs. We hence recognize a division of the process of mining these thin beds into the following two parts:

First, where the roof is strong and flexible.

Second, where the roof is comparatively weak and brittle.

Essential conditions.

The former condition is, of course, the preferable one and, under the latter conditions, work cannot be prosecuted when the roof is extremely soft and weak, and it is always more expensive and somewhat more dangerous than with the first. An essential condition, with either method, is that there be enough material available, either from the roof or floor, to supply the packing necessary for partially supporting the roof. This will be better understood after the following description of the methods of work is read.

Ideal location.

The ideal location in these flat beds, where the question of drainage is not the preponderating one, and when the system of mining alone is considered, is at the center of the property, or, more properly, in the center of the coal area.

METHOD OF MINING WITH A STRONG AND FLEXIBLE ROOF.

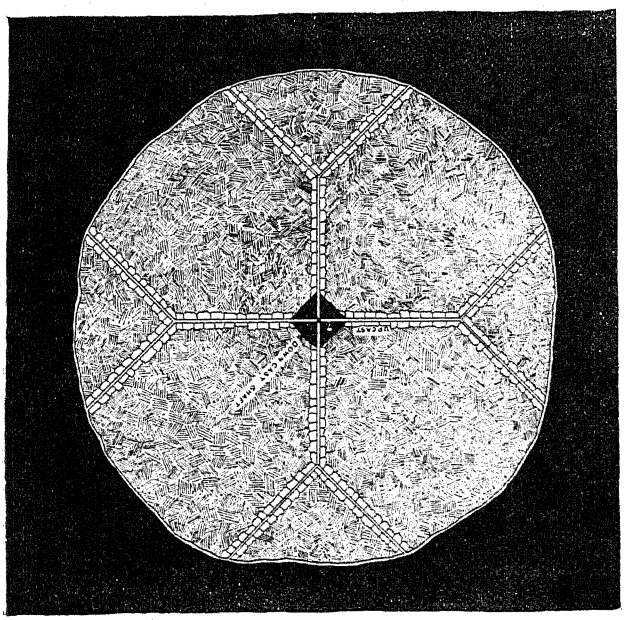
With the most approved practice, when the roof is strong and flexible, the following is the general line of procedure when the mine is operated by a shaft.

Method of starting work with strong roof.

From the bottom of the shaft four entries are driven in the coal at right angles to each other for a distance of from 20 to 50 feet, this distance depending on the character and strength of the roof, the depth of the coal beneath the surface, upon the nature of the underlying clay and also upon the anticipated period of operation of the shaft. From the ends of these rudimentary entries cross cuts are then driven connecting the former with each other, as is illustrated in Fig. 125 on page 175.

From the exterior sides of these cross cuts the coal is next mined radially from the shaft, the main entries advancing with the face and being kept open by gob walls and packing. This process continues until the face has advanced some 800 feet and until the distance between the ends of each two adjacent entries is about 1200 feet. When this stage is reached the face is still pushed forward in the same direction as before, but instead of one entry being left open and packed, two are now left, which radiate from the main entry, one on the right hand side, one on the left hand side, each at an angle of 45° with the original direction of this main entry. In the angle between these two new entries a triangular gob wall is built, as a permanent pillar, and beyond it the mining of the coal continues as before. When this has proceeded to such a distance that the haul along the face of the coal to the entries again becomes excessive, bifurcation of the entries is again resorted to, although the angle at which the new entries separate from the original direction will be different from what it was in the first case.

Method of advancing face.



Plan of mine with a strong roof.

FIG. 125. Plan of mine operated by longwall method in strong and flexible roof.

The process continues until the limits of the property are reached, unless the coal be at such a shallow depth that it is more economical to sink a new shaft than to have a very long underground haul.

Method illustrated.

In illustration of the general process of mining above directed the preceding outline sketch of the map of a mine operated by this method is presented in Fig. 125. The position of the shaft and of the adjacent pillars will be readily recognized, the packing of gob is indicated by the irregular shading, while the face of the coal is plainly shown by the black band surrounding the whole.

METHOD OF MINING WITH A WEAK AND BRITTLE ROOF OR "THE ROOM" METHOD.

Difference of method with a weak roof.

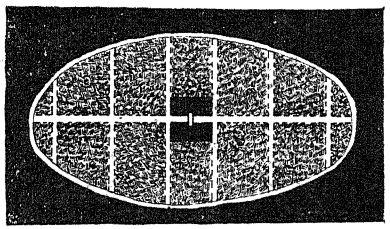
When the roof is comparatively weak, and brittle, a method of mining is pursued which differs from the last described in that less space is left between the advancing face and the packing which follows it. Thus, while, in the former case, a track is laid along the face between the entries, over which the coal is pushed in boxes, in the latter case no track is laid along the face, but the coal is removed directly along numerous subordinate entries. By this means much less open space need be left at any one time between the packing and the face, with consequent less strain upon the roof.

The general mode of proceeding is as follows: From the foot of the shaft entries are driven in opposite directions for a short distance in the coal. As soon as a sufficient length of face is exposed for mining operations to proceed, the coal is attacked on both sides of the entry along the whole length. As the face

Method of starting work.

advances the waste material or gob is thrown behind and, at the same time, ways are left with packed walls on both sides at intervals of about 40 feet. With the best practice these passage ways are run at right angles to the main entry. Between two passage ways, along the main entry, walls of packing are carefully built. The interval between two such is known as a room, and is generally operated by one miner.

The general plan of thus starting such work is shown in the accompanying figure:

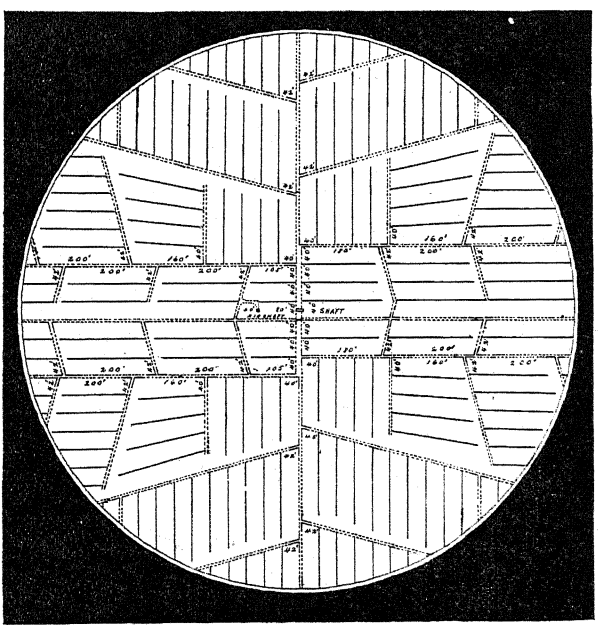


Plan showing method of starting work.

FIG. 126. Plan showing method of starting work by longwall with a weak and brittle roof.

At a distance from the shaft of about 100 feet cross entries parallel with the room ways, are started, on each side of the main entry, which are kept open by packed walls continuously to the limits of the workings.

Between these cross entries the rooms are continued in a



Plan of mine with weak roof.

FIG. 127. General plan of mine operated by longwall method with a weak roof.

direction at right angles to the main entry, while, beyond these cross entries, rooms are now started parallel to the main entry. Each room is made about 200 feet long and beyond this cross entries are opened from which new rooms are started. This method is more difficult to describe than the last. A study, however, of the diagram on p. 177 will make the method of work plain. The double broken lines there shown are entries, whereas the single solid lines are roomways. Between these are the packing and gob. The heavy black band around the margin is the face of the coal. The object in having the various entries and in not running the rooms to an indefinite length, is manifestly to limit the distance which the miner has to push his boxes of coal, and to gather the various boxes into entries at frequent intervals.

Explanation of Fig. 127.

The two methods of work above outlined are both with shafts. With drift mines the method of working is the same, only the length of face subtends a smaller angle than with the shaft mining.

DETAILS OF LONG WALL MINING.

Having now given a description of the general principles of mining in these thin coal beds, we will proceed to a discussion of the details.

Methods of driving entries. The method of entry driving in these coal beds, varies with local conditions.

As the coal bed itself is not sufficiently thick for a traveling way to be confined to it, it is generally necessary to cut down the roof, or to take up the floor in order to acquire the requisite height. The section of such an entry is illustrated in the following sketch. In the larger mines a height of about 6 feet

Methods of driving entries.

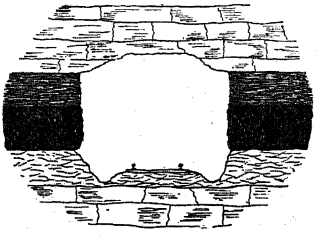


FIG. 128. Cross section illustrating the manner of driving entries.

is usually desired in the main entries. In the mines at Osage City, however, the entry is cut only 4 feet high and 4 feet wide, but here the roof is a soft shale and generally falls down so that a height of 6 to 8 feet prevails. The entry is driven narrow here so as to prevent heavy roof falls. In the Leavenworth mines the dimensions of the entry are 5 feet wide at the base, 4 feet at the top and 6 feet high. In Lafayette county the height of the entry is about 5 feet and the width varies up to 12 feet with the double track entry; the roof here is self-supporting and there are not the same restrictions to the width of the entry that prevail in mines with weaker roofs. In minor entries and room ways, and also in very small mines where mules are not used, very little roof or bottom is taken out and the height in many cases is only about 3 or 4 feet.

Dimensions at Osage City.

At Leavenworth.

In Lafayette Co.

Entry driving in the solid coal is only done at the beginning of the work, through the pillar at the foot of the shaft. Beyond this the entry work consists in packing the walls on each side, brushing down the roof or taking up the floor and laying the track. The method of doing this and the attendant cost vary with different conditions. In the vicinity of Lexington the entry is driven through the pillar by first undercutting the coal to a distance of 18 or 24 inches and then shearing the coal on each side of the entry to a corresponding depth. The rib of coal thus left is then wedged down and removed. The coal bed here is less than 2 feet thick (see Fig. 80, page 121) and, between it and the overlying limestone roof rock, there are only a few inches of shale. Hence, in order to acquire the requisite height for hauling in the entries, the clay underlying the coal is lifted to a depth of $2\frac{1}{2}$ feet. In places, where there is more shale between the cap rock and the coal, less of the underlying clay is taken up, and the roof shale is brushed down. Elsewhere, as in the Leavenworth mines, where there is no roof rock, but a large body of shale immediately overlying the coal (see Fig. 75, page 115) the requisite height of entry is obtained entirely by brushing the roof. Under conditions such as sometimes obtain near Corder in Lafayette county, where the overlying shale and the underlying clay are both thin, the roof rock is shot down in part. This lifting of the bottom clay, or brushing and

Details of entry driving.

shooting of the roof is necessary both in the entry beyond the solid pillar as well as in the latter.

Cost of entry driving in Lafayette Co.

The cost of thus driving an entry varies with the different conditions. In the vicinity of Lexington the removal of the coal in the entry through the pillar costs about $5.00 a running yard. The lifting of the tough, hard bottom clay to a depth of 3 feet in entries costs about $2.50 per running yard. In the vicinities of Corder and Higginsville, where the roof rock is shot down to a height of about 3 feet, the cost is about $2.00 a running yard.

At Leavenworth and Osage City.

At Leavenworth and about Osage City, where fissile shale overlies the coal, $1.25 a yard is paid for brushing down the roof, in the main entries, to a height of about 4 feet above the coal. In the short room ways, in these mines, the miner brushes down the roof to a height sufficient for man haulage, without extra pay. Track-laying is done by the companies in the main entries; and such props as are necessary there are also furnished by the company. In the room ways the miner lays the temporary track there used, and the company furnishes the necessary material.

Method of Mining coal.

Method of Mining Coal. The method of mining the coal is essentially the same in both of the systems previously defined. The coal is undercut along the whole face, to a depth of about 18 or 24 inches, and is wedged down, or falls from the weight of the superincumbent strata. These general conditions are illustrated in Fig. 129, adjoining. The practice is for a certain length of face to be assigned to each miner and he is paid at a fixed rate for the amount of coal which he gets out. The undercutting is done, in almost all cases, by hand, no machine cutter having been successfully used in such mining in the districts examined.

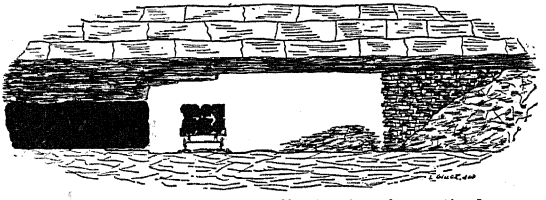


FIG. 129. Cross section illustrating the method of mining coal.

Miner paid per ton.

In addition to the work of undercutting and wedging the miner has, further, to load the coal and sometimes to push it to the entries; to pack the gob, to keep his room way open and to lay the track in these room ways and to move it along as the face advances. He, further, furnishes his lamp oil and all tools and keeps the latter in repair. When props are necessary at the face he puts these in place, but they are furnished him by the company ready for setting. The undercutting is generally done in the clay under the coal and is about 4 ft. high at the face, tapering towards the end. Where the underlying material is excessively hard, however, or where there is little or no clay the cutting is done directly in the lower bench of coal. This is, of course, objectionable in that it causes waste of coal. The length of face worked by one miner varies from 20 to 60 feet, and the length of cut per shift varies 10 to 40 feet, according to the character of the underlying material, the thickness of the coal and other minor conditions. A cut of about 20 feet is perhaps a fair average. With the strong roof, where a track is layed along the face, the distance between the face of the coal and the gob packing is generally about seven feet, and this must be kept clear by the miner.

Details of mining.

Lengths of face and cut.

With the weak roof, where no track is layed along the face, the space is generally not more than 3 feet. In Lafayette Co., and in the Leavenworth mines, the miner is paid at the rate of about 4c per bushel ($1.00 per net ton) for the clean coal which he mines. In the Osage district about a cent more per bushel is paid in consideration of the thinness of the bed and the consequent increased difficulty of mining.

Track space.

Methods of building pillars and packing gob. The method of supporting the roof is different in the two systems described in the preceding pages. Where the roof is a strong one a heavy and well packed wall is carried along by the miner on each side of the entries. Between these, continuous pillars, less carefully packed, are carried along at right angles to the face, as the work advances. These pillars are built of the heavier and larger blocks of waste material, and in between them the smaller and loose material is shoveled.

Pillar building and gob packing.

With strong roof.

The plan of work above described is well illustrated in the following Fig. 130.

Plan with strong roof.

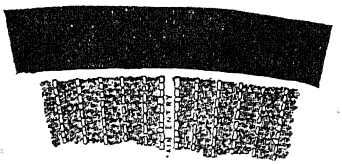


FIG. 130. Plan illustrating pillar work and gob packing with a strong roof.

The distance between each pillar is generally about 6 feet, the wall itself is usually about 2 feet thick and it is tightly wedged with the roof at the top. The miner who works adjacent to the entry builds the entry wall, generally without extra pay. The difference between this wall and the others is that it is made of the larger blocks, is more carefully packed and is built with a smooth face towards the entry. The proximity of the miner to the road head is thought to be a compensating consideration for the extra work of building this wall; in some cases, however, a small extra allowance of pay is made for this work.

Entry walls.

In mines with weak roofs pillars are carried only along the entries and, in the room ways between these, props are placed in rows running vertically to the face. In the Osage district of Kansas each prop in such a roof is 18 in. apart and each row is $2\frac{1}{2}$ to 3 feet from the adjoining one. As the work proceeds the entry walls are built of the larger material and the loose material is thrown in around these rows of props. In the subjoined figure this general plan of work is illustrated.

Pillars and props with weak roof.

Plan with weak roof.

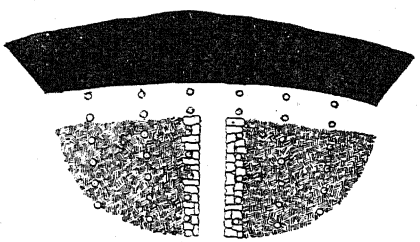


FIG. 131. Plan illustrating pillar work and gob packing with a weak roof.

The method of hauling. In the larger mines hauling in the entries is generally done with mules. They haul the coal in trips

of several cars, the number being dependent upon the grades encountered in the entries. In some large mines, where the grades are very slight, or the coal dips towards the outlet, the cars are run out singly by the miner, and this is generally the case in small mines. The capacity of the cars is generally about one-half a ton or less, they being small and low on account of the limited working space. The track in the entries is generally a light T rail, spiked to wooden ties. Where the track runs along the face, the rails are the same, but they are tied together by iron bars. As the face advances the whole track is moved forward by the miners. This track between two entries is not connected at the middle, but has loose ends. As it advances with the face, the distances between the diverging entries necessarily increases and, to allow for this, additional lengths of track are added from time to time The entry track and face track are connected by a flat iron plate on which the cars can be readily transferred from the one to the other. In some mines, where the entry is wide,a switch is laid at each road head, where empty cars or boxes are stored and full cars can pass each other. Further, in mines with soft roofs, where the cars come from a large number of different points, turnouts are provided in the entries, where empty trips coming in can pass the full ones going out. The transfer plate at the road head is not advanced with each moving of the face track, but, generally, remains in the same place for two or three days, the face track being curved back to meet it. Along the room ways, in mines with weak roofs, only temporary tracking is laid of wooden strips $1\frac{1}{2}''$ x $3''$ in section.

Methods of hauling.

Character of tracks.

Face tracks.

Room tracks with weak roof.

In mines with strong roofs the empty cars are all run in along the face track, to the various places of work, by the "pusher," and are then filled by the miner. After the cars are filled they are removed successively from the face track to the entry track by the pusher, beginning with the car nearest the entry. As each full car is removed an empty one to replace it is brought in and is temporarily turned up off of the track so as to allow the full ones beyond to pass by, as they are pushed out.

Transfer of cars.

In mines with weak roofs the car is run to the end of each roadway and is then loaded by the miner, who either shoves each block of coal separately to the face of the roadway, or

slides it on small sled like buggies to such roadways and there loads it on to the cars.

Ventilating and draining.

Methods of ventilating and draining. The system of ventilation in these mines is extremely simple; in fact it is one of the points recommending these methods of long wall work that, when properly prosecuted, the mines are so easily ventilated.

In some cases the entire fresh air current is carried from the downcast shaft out one of the entries to the face, it is then split to the right and left and carried around the whole face to the end of the opposite entry, along which it returns to the upcast shaft. In other cases the air current is split at the beginning, at the foot of the downcast shaft, and is then carried in opposite directions to the face, where each current is again split to the right and left. These currents then pass along the face around a quadrant of a circle, where two from opposite directions unite and pass back along one entry to the upcast shaft. The entries which are off the line of the main currents are generally cut off from these currents by brattices or doors, and are generally ventilated by the occasional opening of the doors or by the leakages through the brattices. In some cases small side currents are kept up constantly along side entries which are much used.

Courses of air currents.

The draining of many of the mines, in which this system of work is carried on, is a very simple matter, inasmuch as little or no water accumulates in them. Where water exists it is drained towards a sump located at a low point, and is thence pumped to the surface. For drawing the water to the these sumps, small ditches or drains are dug along the entries, and, in some cases, small drain tile is used. A large amount of water in connection with such mining is an especially serious objection, inasmuch as it tends to weaken the roof, to soften the underlying clay and to produce excessive settling and squeezing throughout the mine.

Draining very simple ordinarily.

Concluding remarks. The fact that, with the methods of mining which have been described, all of the coal can be removed from the ground, has already been referred to as the chief recommendation. The ease of ventilation has also been referred

to and the simplicity of the plan of work further recommends it to use. It is desirable, however, in order that the best results may be reached, that the work be prosecuted regularly and uniformly, so that the face advance equally in all directions and preserve approximately the shape of a circle. If this is not done the coal will not split off freely at some points along the face, while elsewhere it will split off before a sufficiently deep undercut has been made. Further, unequal settling resulting from this irregular work will produce inequalities in the floor and roof, which become obstructions in hauling the coal along the face. A greater fracturing of the roof is also liable to result, accompanied by all of the attendant difficulties. All of such long wall mining, however, causes a greater or less fracturing of the roof. On this account, it is not generally practicable to carry it on when the mining is near the surface, and when the surface is a wet one. An excessive amount of water is admitted to the mine in such cases. It can also not be practiced at a shallow depth when the overlying property is of great value, for the reason that the effects of the settling may be transmitted to the surface and cause serious damage.

Conditions to be observed.

A regular face.

Difficulties through roof fracturing.

A number of suggestions might be made in the nature of improvements upon the methods of mining these beds, both in this State and in Kansas. Among these are the introduction of rope and power haulage, and the use of machine cutters. In the direction of rope haulage nothing has yet been done. The reasons generally given, are that the properties worked are too small and the amount of coal available too little to warrant the introduction of an expensive plant. Further, the shallow depths at which the coal is found in many places, makes it cheaper to have frequent openings from the surface than to haul the coal far underground, by power or otherwise. In the future, as the industry develops and as the demand becomes greater and more regular, some of the conditions will change, and improvements in these and other directions will probably be made which will lessen the cost of production. At the Mendota mine in the northern part of the State, where the coal bed is nearly 3 feet thick, rope haulage is already successfully used, but here both the pillar and room as well as the long wall method are practiced.

Improvements suggested.

Objections to rope haulage.

Machine cutters have been experimented with to a limited extent in Lafayette county, but not with success. The Harrison machine was used. The chief reasons given for the failure of the experiment are the lack of competent and willing labor, and the excessive amount of refuse which the cutters made. The coal bed here was only about 18 in. thick, however, and the cutter took out nearly a foot of clay. This together with the overlying shale which came down with the coal was more than could be disposed of in the mine, and hence had to be hauled to the surface at excessive cost. At the same Mendota mine in the northern part of the State, in which rope haulage is practiced, machine cutters have also been introduced and are successfully used. We do not feel, at present, at all convinced that with some form of machine especially adapted to these thin beds, machine cutting may not be in the near future successfully prosecuted.

APPENDIX B.

LIST OF COAL MINE OPERATORS IN MISSOURI.

ARRANGED ALPHABETICALLY BY COUNTIES.

From manuscript sheets of the report for 1891 of the State Mine Inspector, C. C. Woodson.

ADAIR COUNTY.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Desanko's Mine	Kirksville.	
Harriot Bros	Stahl	Stahl.
Ledford, John	"	"
Novenger, J. B.	"	"
Pennsylvania Coal Co	Kirksville	*Stahl & Danforth.
Scott, D. C	"	Kirksville.

AUDRAIN COUNTY.

Audrain M'fg & Coal Co	Vandalia	*Vandalia.
Day, Geo. W	Laddonia	Laddonia.
Detienne, Owen	Mt. Carmel	Mt. Carmel.
Eastham, C. P	Laddonia	Laddonia.
Howartt, John	Mt. Carmel	Mt. Carmel.
Lynch, Owen	Laddonia	Laddonia.
Montague, James D	"	"
Oldham, Henry	Centralia	Centralia,
Robbins & Mathews	Worcester	Worcester.
Vandalia Coal Co	Vandalia	*Vandalia.
Wiley, Frank	Centralia	Centralia.

BARTON COUNTY.

Bacon, W. S	Lamar	Lamar.
Beeker, Henry	"	"
Blocher, W. C	Esrom	Esrom.
Boulware, P. G. & Co	Liberal	Liberal.
Bristow & Kimball	Lamar	Lamar.
Cameron, C. J	Liberal	Liberal.

* Employing ten or more men.

BARTON COUNTY—Continued.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Carroll, A	"	"
Clark, Wilson	Lamar	Lamar.
Cole, M.	"	"
Cox, Thomas	Liberal	Liberal.
Davery Bros.	"	"
Dixon, J. W.	Milford	Milford.
Ferguson, J. C.	Nashville	Nashville.
Foulk, Phillip	Liberal	Liberal.
Gilmore, James W.	Sheldon	Sheldon.
Gregory, Thos & Sons	Lamar	Lamar.
Hatfield, H. C	Liberal	Liberal.
Hays, Basil D	Lamar	Lamar.
Jones, Wm	Verdella	Verdella.
Lavery Bros	Liberal	Liberal.
Laws, John	Beloit	Beloit.
Liberal Coal Co.	Liberal	*Liberal.
Lucas, M. H	Pedro	Pedro.
Mack, W. L	Lamar	Lamar.
Morgan, C. H.	Minden Mine	*Minden.
Owens Bank	Lamar	Lamar.
Parry, J. C	"	"
Perkins, John	Liberal	Liberal.
Perry, W. H	Milford	Milford.
Rowes, L. J.	Sheldon, Vernon Co.	Sheldon.
Ryan, G. G	Milford	Milford.
Spear, M. M	Lamar	Lamar.
Spring, Mattie B.	"	"
Stukey, Ephram	Beloit	Beloit.
Sturdevant, J C	Lamar	Lamar.
Waite, C. G.	Pittsburg	Minden.
Wear Coal Co.	Minden Mine	*Minden.
Whitsell, H. J	Liberal	Liberal.
Wilson, John G.	"	"

BATES COUNTY.

Baldwin, L	Worland	Worland.
Bruce, W.	Rich Hill	*Shobe.
Caton, F. H.	Worland	Worland.
Farrar & Armstrong	Hume	Hume.
Funk, Benjamin	"	Foster.
Hines Bros	Rich Hill	Rich Hill.
Hocker Bros.	Amoret	Amoret.

* Employing ten or more men.

BATES COUNTY—Continued.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Hopkins, S. W	Rich Hill	Rich Hill.
Hunt Bros	Worland	Worland.
Jenkins Bank	Shobe.	
Johnson, John	Worland	Worland.
Keith & Perry Coal Co	Kansas City	*Rich Hill.
Mace, W. H	Foster	Foster.
Martin, F. M	Rich Hill	*Rich Hill.
Martin, M. K	" "	" "
Missouri Coal and Constr. Co	Kansas City	*Amoret.
Lucas, W. W	Rich Hill	*Rich Hill.
Pearson, Peter	" "	* " "
Rich Hill Coal & Min. Co., No. 2	" "	* " "
" " Wethers, No. 3	" "	* " "
" " Graham, Thos , No. 4	" "	* " "
" " Barton & Cheney	" "	* " "
Raney, F. A	Worland	Worland.
Robinson, D. L	"	"
Seawell, J. W. & Co	Kansas City	Rich Hill.
Sein, Jay	Rich Hill	* " "
Skillman, A	Foster	*Foster.
Spencer, O	Rich Hill	Rich Hill.
Springer and Gardner	Worland	*Worland.
Sullivan & Cheney	Rich Hill	*Rich Hill.
Thurman, E. H	" "	" "
Vance, J. A	Amoret.	
Western Coal & Min. Co., No. 1	Foster	*Foster.
Williams, Frank & Co	Rich Hill	Rich Hill.
Wise, J. M	" "	* " "
Woodson & Woodson	" "	* " "

BOONE COUNTY.

Benefield, E. B	Columbia	*Columbia.
Blakemore, Thos. H	Harrisburg.	
Columbia Coal Co	Columbia	*Columbia.
Davis, Isaac	Brown's Station	Brown's Station.
Gaither, James W	" "	" "
Goodding, W. A. & Co	Columbia	*Columbia.
Gordon, T. S	"	
Gossett & Bro	"	
Jones, Walter	Brown's Station.	
Kurtz, D. W. B	Columbia	Columbia.
Lowery, Geo	"	

* Employing ten or more men.

BOONE COUNTY—Continued.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Mayer, D. A. & Bros	Sturgeon	Sturgeon.
Peters, M. C	Columbia	Columbia.
Quittier, L	"	"
Redifer & Edwards	Centralia	*Centralia.
Short, J. B	Harrisburg	Harrisburg.
Stidhame, W. A	"	"
Stone, James W	Perche	Perche.
Wiley, Frank	Centralia	Centralia.
Winterholter	Brown's Station	Brown's Station.

CALDWELL COUNTY.

Caldwell Coal Co	Hamilton	*Hamilton.
Hamilton Coal Co	"	* "

CALLAWAY COUNTY.

Bishop, R. L. & Co	Fulton	Fulton.
Castle, Wm	"	"
Harris, A. & Bros	"	* "
Harris, John	"	"
Henderson, J. S	McCredie	"
Holmes, Adolphus	Fulton	"
Grey, Wm	Stephen's Store	Stephen's Store.
Griswold, Warner	Guthrie	Guthrie.
Lemers, R	Fulton	Fulton.
Maycock, Sam'l	"	"
Oldham, Wm	Stephen's Store	Stephen's Store.
Smith, James	Fulton	Fulton.

CEDAR COUNTY.

Anderson, W. O	Jerico	Jerico.
Cole, M. M	"	"
Daniels, Lee	"	"
Davis, A. B	"	"

CHARITON COUNTY.

Clark, Mathew	Marceline, Linn Co	*Marceline.
Price, E. W	Keytesville	Keytesville.
Stanton Bros	Marceline.	

* Employing ten or more men.

CLAY COUNTY.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Randolph Coal & Gas Co	Kansas City	*Randolph.

COLE COUNTY.

Elston, F. & M. & Co	Elston	*Elston.

COOPER COUNTY.

Missouri Valley Coal & Mining Co	Boonville	*Boonville.
Fork, Eli	Sylvania	Sylvania.
Palmbury, A	Bunceton	Bunceton.

DADE COUNTY.

Leonard, A	Sylvania	Sylvania.
McCluey, Robt	"	"
Riley, Jack	"	"
Sharp, R. M	"	"
Shoemaker, J. K	Cedarville	Cedarville.

GRUNDY COUNTY.

Grundy County Coal Co	Trenton	*Trenton.

HENRY COUNTY.

Baldwin & Fonda	Calhoun	*Calhoun.
Bodu, H. H	Clinton	*Clinton.
Cohen, S. B	Sedalia	* "
Co-operative Coal Co	Lewis Station	*Lewis Station.
Dunlap Coal Co	Brownington	Brownington.
Hobbs, H. B	Deep Water	*Deep Water.
Hurst, John	"	* "
Hurt, J. W	"	* "
Kay Cod Co	"	* "
Keith & Perry	Kansas City	* "
McFadden & Evans	Deep Water	* "
Noble, H. T	North	North.
Owens, B. L	Clinton	*Clinton.
Pigg, D. B. C. & M. Co	Lewis Station	*Lewis Station.
Tebo Coal Co	Lewis Station	*Lewis Station.
Thompson, John & Co	Brownington	*Brownington.
Woods & North	North	*North.

* Employing ten or more men.

JASPER COUNTY.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Williams, A. W	Joplin.	

JOHNSON COUNTY.

Boyd, Thos. H. & Co	Knobnoster	*Knobhoster.
Bullock, D. A	Warrensburg	Warrensburg.
Doffelmeyer, T. T	"	"
Evans, Jno. B	"	"
House, John	Knobnoster	Montserrat.
Macrae, A. W	Warrensburg	Warrensburg.
Meiley, M. B	"	"
Marley Fitch & Harden	Montserrat	Montserrat.
Murley, Joseph	"	
Park, John	Dunksburg	Dunksburg.
Phillips, Wm	Warrensburg	Warrensburg.
Serang, J. S	Dunksburg	Dunksburg.
Strickland, G. W	"	"
Warrensburg Electric L. Co	Warrensburg	Warrensburg.
Wood, B. F	Warrenburg,	Warrenburg,

LAFAYETTE COUNTY.

Bell & Greer	Lexington	*Lexington.
Bolen Coal Co	Kansas City	*Higginsville,
Bonanza Coal Co	Higginsville	*Higginsville.
Bruce, J. D	Kansas City	* "
Carter, Andrew	Wellington	Wellington.
Clark, Thomas	Lexington	Lexington.
Corder Coal & Coke Co	Corder	*Corder.
Dover Coal Co	Dover	*Lexington.
Elling's Mine	Concordia	Concordia.
Excelsior Coal & Coke Co	Higginsville	*Higginsville.
Fitzgerald, S. J	Aullville	Aullville.
Gasaway, L. A	Mayview	*Mayview.
Gunn & Co	Higginsville	*Higginsville.
Graham, R	Aullville	*Aullville.
Haygood Coal Co	Higginsville	*Higginsville.
Harlman, C. H	Kansas City	*Waterloo.
Hoffman, Emil	Higginsville	Higginsville.
Kelley Coal Co	Lexington	Lexington.
Kist, Joseph	"	"
Krampt, Robt	Concordia	Concordia.
Kresse, A. F	"	"

* Employing ten or more men.

LAFAYETTE COUNTY—Continued.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Lafayette Coal Co	Lexington	*Lexington.
Lexington Coal & Min. Co	"	* "
McCarty, C. F	Corder	Corder.
McGrew, J. C	Lexington	*Lexington.
Macey, Henry	Kansas City	*Lexington.
Missouri River Coal Co	Lexington	*Napoleon.
Morrison Bros	"	Lexington.
Napoleon Coal & Min. Co	Napoleon	*Napoleon.
O'Malley, Andrew	Lexington	Lexington.
Powell, E. B	Higginsville	* Higginsville.
Republican Mine	"	* "
Rocky Branch Coal Co	"	* "
Seawell, J. M. & Co	Kansas City	*Wellington.
Stealy & Fowler Coal Co	Higginsville	Higginsville.
Tate, Jno. W	"	* "
Walton, Thos	Lexington	*Lexington.
Wellington Coal Co	Wellington	*Wellington.
Wilkes, S. E	Higginsville	* "
Winson Coal Co	Lexington	*Higginsville.

LINN COUNTY.

Clark Coal Co	Brookfield	*Brookfield.
House, Peabody & Co	"	* "
Kansas & Texas Coal Co	St. Louis	*Marceline.
Schoeffer, Bernard	Brookfield	Brookfield.

LIVINGSTON COUNTY.

Cox, W. A	Chillicothe	Chillicothe.

MACON COUNTY.

Bacheldor, George	Macon	Macon City.
Bevier Black Diamond Co	Bevier.	
Kansas & Texas Coal Co., No. 26	St. Louis	Ardmore & Bevier.
Little Pittsburg	Lingo	*Lingo.
Loomis & Snively	Bevier	*Bevier.
Oakdale Coal Co	St. Joseph	*Bevier.
The Macon Coal Co	Macon	*Macon.
Watson Coal & Min. Co	Bevier	*Bevier.

* Employing ten or more men.

MILLER COUNTY.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Rusk, Louis	Eldon	Eldon.

MONITEAU COUNTY.

Kansas & Mo. Improvement Co	Topeka, Kas.	

MONROE COUNTY.

Hughes, Lad	Victor	Victor.

MONTGOMERY COUNTY.

Vandalia Coal Co	Wellsville	*Wellsville.
Whitehead, Henry	"	* "

MORGAN COUNTY.

Stover Coal Mines	Versailles	Versailles.

NODAWAY COUNTY.

Carlew & Co	Quitman	Quitman.
Dixon	"	"
Harris, Reuben	"	"
Holt, Wm	"	"
Nelson, G. W	"	"
Nichols, Joseph	"	"
Pearson, Sam'l	"	"
Pierson & Co	"	"
Resenger, Wm	"	"
Roberts, N	"	"
Tarpley, Benjamin	"	"

PUTNAM COUNTY.

Blackbird Coal Co	Unionville	*Unionville.
DeGarmo, G. E	"	"
Gorman, Pat	Dean, Iowa	Dean.
Lane & Love	Unionville	*Unionville.
Mendota Coal & Min. Co	Mendota	*Mendota.
Pherigo, Martin	Unionville	Unionville.

* Employing ten or more men.

RALLS COUNTY.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Boulware, E. L.	Perry	Perry.
Evans, J. S.	"	"
Russell, John	"	"

RANDOLPH COUNTY.

Burk, J. S.	Huntsville	Huntsville.
Cooley, J. M.	Cairo	Cairo.
Edwards, S. Emanuel	Huntsville	Huntsville.
Elmore, T. M.	"	"
Enterprise Coal Co	Renick	*Renick.
Fergerson, Allen	Huntsville	Huntsville.
Higbee Coal & Mining Co	Higbee	*Higbee.
Interstate Mining Co	"	* "
Jones, Geo. W	Huntsville	Huntsville.
Lowes, John	"	"
Milburn, Joseph & Sons	Thomashill	Thomashill.
Mitchell, W. E. & Co	Huntsville	Huntsville.
Osage Coal & Mining Co	St. Louis	Elliott.
Palson, John F	Cairo	Cairo.
Randolph Co. Coal Co	Huntsville	*Huntsville.
Rutherford, H. L. & Son	"	* "
Williams, J. B	Moberly	Moberly.

RAY COUNTY.

Black Diamond	Richmond	*Richmond.
Bovard, Brown Coal Co	Camden	*Camden.
Buchlinger, Fred	Hardin	Hardin.
Craven Coal Co	Camden	*Camden.
Darneal Coal Co	Richmond	*Richmond.
Dickson, H. A	Hardin	Hardin.
Douglas & Moore	Richmond	*Richmond.
Hartwell, Arnold & Co	Norborne, Carroll Co.	*Hardin.
Hubbell Mining Co	Richmond	*Richmond.
Hubbell, Hyatt & Hubbell	"	* "
Huston, Joseph	Hardin	*Hardin.
Kansas & Texas Coal Co	St. Louis	Fleming.
Kellenberger's Mine	Hardin	Hardin.
McCorkendale, John	Norborne, Carroll Co.	Hardin.
Osborn, Robert.	Hardin	Hardin.

* Employing ten or more men.

RAY COUNTY—Continued.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Phillips, Wm	Norborne, Carroll Co.	Hardin.
Pickering, Joseph, Coal Co	Richmond	*Richmond.
Rankin, W. O. & Co	Lexington	*Richmond.
Richmond Coal Co	Richmond	Camden.
Scrivens, Wm	Norborne, Carroll Co.	Hardin.
Sickels, Wm	" "	"
Slater & Co	Georgeville	Georgeville.
Williams, R. J. Coal Co	Swanwick	*Swanwick.

SALINE COUNTY.

Alexander, Frank	Arrow Rock	Arrow Rock.
Ames, J. F	Slater	Slater.
Beard, W. N	"	* "
Briggs, Isaac	"	"
Hedgers, Wm. T	"	"
Hodgkiss, Ed	Mount Leonard	Mount Leonard.
Hunter, Barney	Slater	Slater.
Marmaduke, H. H	Sweet Springs	Sweet Springs.
Pittman, Esther	Cretcher	Cretcher.
Tennill, Jno. W	Slater	Slater.
Thompson, R. P	"	"
Vanbuskirk, A	Cretcher	Cretcher.
Willburn Coal Co	Marshall	Napton.

SCHUYLER COUNTY.

James, W. F	Coatsville	Coatsville.
Mock, T. J. & Sons	"	"

SULLIVAN COUNTY.

Milan Land & Coal & Mining Co	Milan	Milan.

ST. CLAIR COUNTY.

Bidder, F. M	Osceola	Osceola.
Chinn, John	Lowery City	Lowery City.
Johnson, J. M	Taberville	Taberville.

* Employing ten or more men.

ST. CLAIR COUNTY—Continued.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Owen Coal Co	Vista	Vista.
Vannice, G A	"	"
Watkins, Wm	Osceola	Osceola.
Wilson, R. B	Taberville	Taberville.

SHELBY COUNTY.

Yost, W. T	Pansy	Pansy.

VERNON COUNTY.

Allen, R. E	Rich Hill	Carbon Center.
Brown, John & Bros	Moundville	Moundville.
Burke, C. M	Walker	Walker.
Burton, W. C	Bronaugh	Bronaugh.
Crawford, C. B	Walker	Walker.
Davis, Joseph	"	"
Devere, J. M	Moundville	*Moundville.
Dickson, Mine	Nevada	Nevada.
Downing, E. S	Walker	Walker.
Every, Milton	"	"
Finley, L	Nevada.	
Franks, A. H	Moundville	Moundville.
Gill, J. F	"	"
Green, Edward	Bellany	Bellany.
Gonterman, W. G	Sheldon	Sheldon.
Hightower, J. H	Walker	Walker.
Hill, Willis D	Moundville	*Moundville.
Hoss, G. S	Nevada	Carbon Center.
Hunter, E. N	Walker	Walker.
Johnsons	"	"
Larkin, W. E	Bronaugh	Bronaugh.
Linn & Co	Nevada.	
Lucas, J. C	Bronaugh	Bronaugh.
Moore, John	Moundville	Moundville.
O'Bryan, Wm. & Co	Carbon Center	*Carbon Center.
Pope, S. O	"	
Potter, Sam'l	Walker	Walker.
Powell, W. S. Coal Co	Moundville	Moundville.
Prewitt, W. H	Walker	Walker.
Robinson, W. D	Moundville	Moundville.

* Employing ten or more men.

VERNON COUNTY—Continued.

Name of Mine Operator or Company.	*Post Office Address.*	*Mine Located Near.*
Saleman, J. B.	Carbon Center.	*Carbon Center.
Seawell, J. M. & Co.	Kansas City	* "
Smith, Peter	Bronaugh	Bronaugh.
Terry, B. C. & W. T.	Milo	Milo.
Wright, J. D.	Walker	Walker.
Yaden, T. A.	"	"

* Employing ten or more men.

INDEX.

GEOLOGICAL SURVEY OF MISSOURI

Arthur Winslow, State Geologist

BLOCK MAP OF MISSOURI

SHOWING THE

AREA OF THE COAL MEASURES

THE GENERAL DISTRIBUTION OF COAL MINES

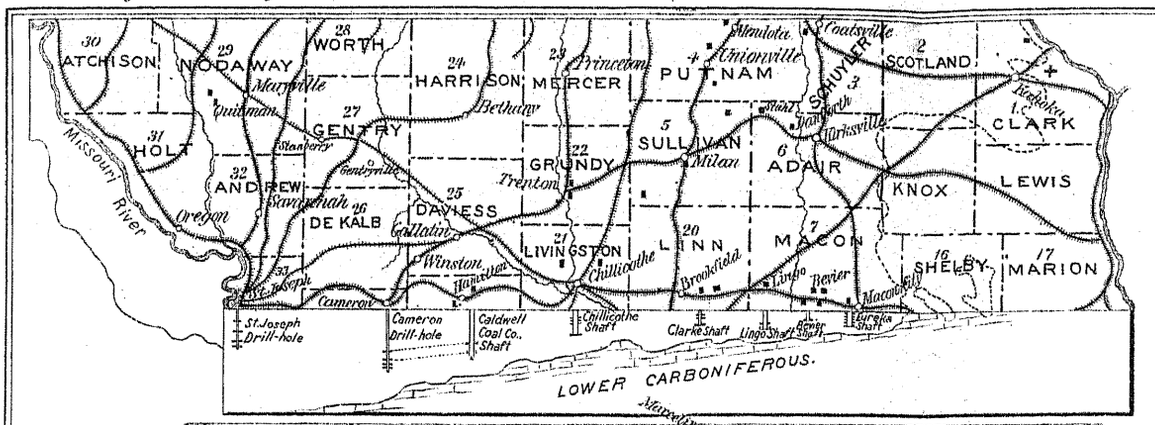
AND THE

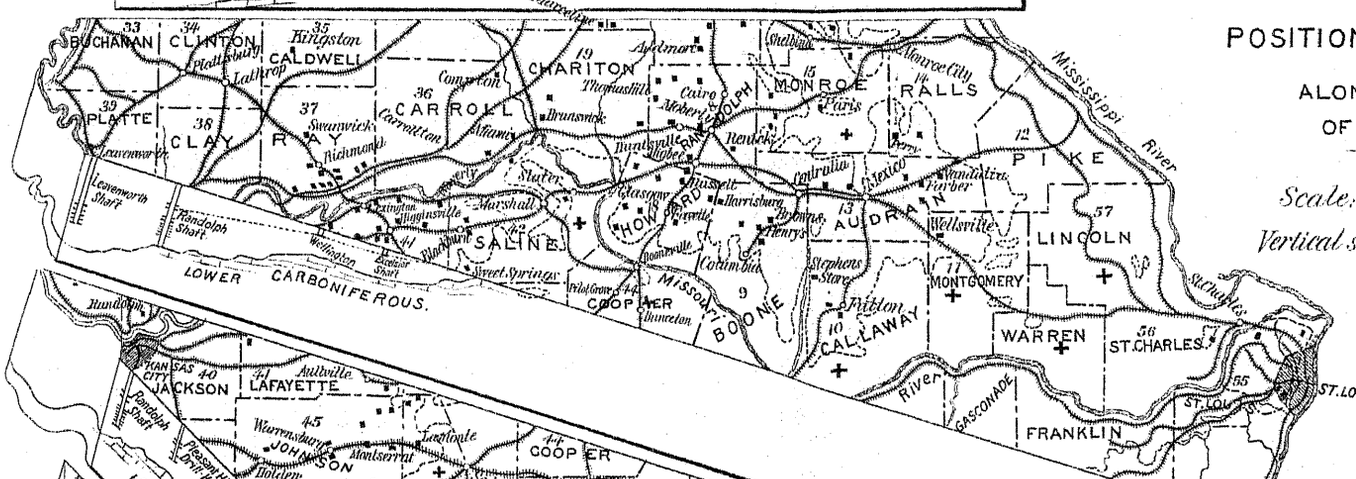
POSITIONS OF THE COAL BEDS

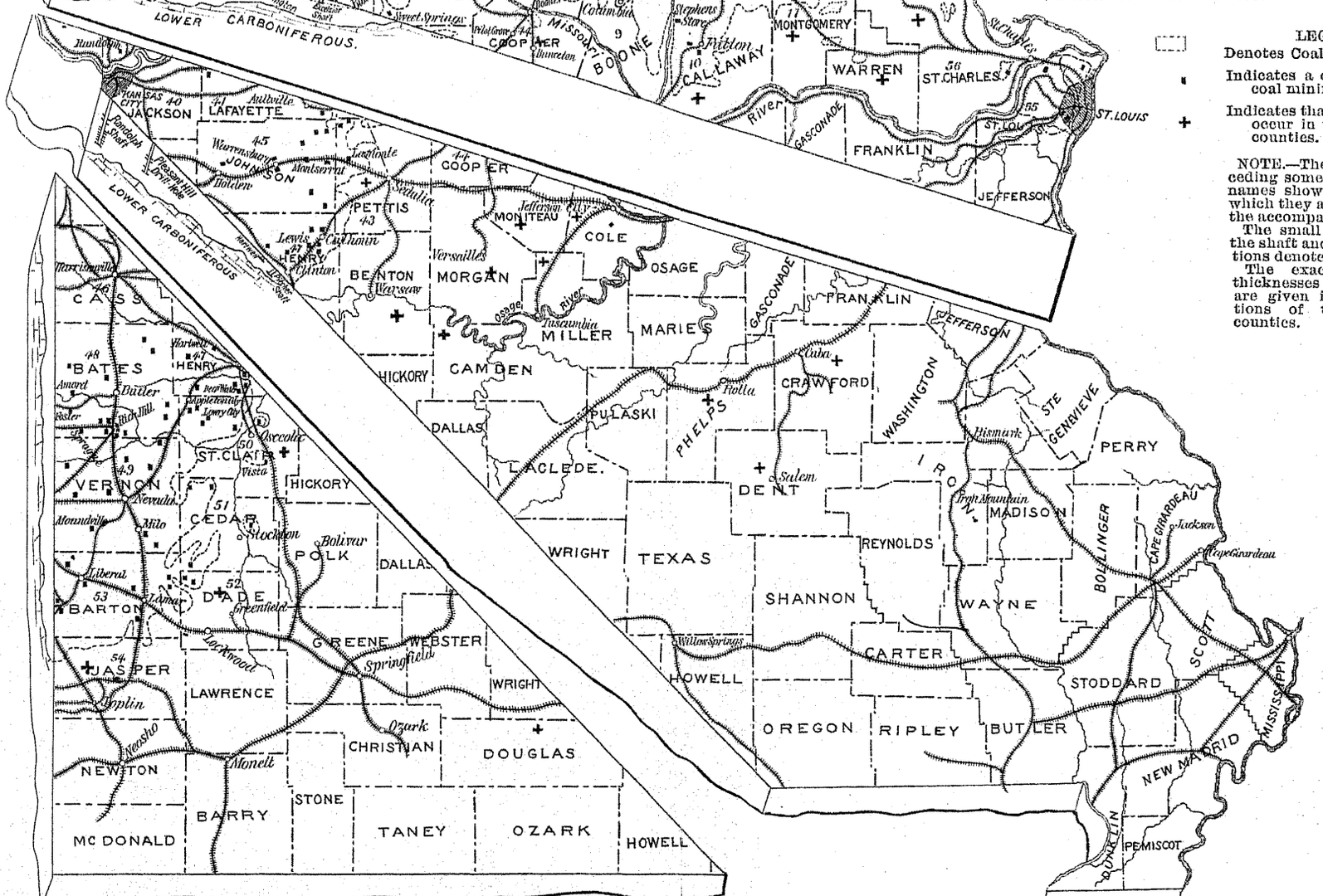
ALONG THREE LINES OF CROSS SECTIONS.

Scale: 1 inch = 40 miles.

Vertical scale of sections 1 in = 2000 ft.







LEGEND.

Denotes Coal Measure area.

Indicates a coal mine or a coal mining locality.

Indicates that coal pockets occur in the respective counties.

NOTE.—The numbers preceding some of the county names show the order in which they are described in the accompanying report.

The small black lines on the shaft and drill hole sections denote coal beds.

The exact depths and thicknesses of these beds are given in the descriptions of the respective counties.

East ST. LOUIS & N.Y.

PUBLICATIONS OF THE

GEOLOGICAL SURVEY OF MISSOURI.

SINCE THE YEAR 1889.

ARTHUR WINSLOW, STATE GEOLOGIST.

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BULLETIN NO. 2.

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BULLETIN NO. 3.

CONTENTS: The Clay, Stone, Lime, and Sand Industries of St. Louis City and County, by G. E. Ladd, Assistant geologist, 80pp. The Mineral Waters of Henry, St. Clair, Johnson, and Benton Counties, by A. E. Woodward, Assistant geologist. 8vo. Paper. 101pp. 4 cuts, 2 maps. Jefferson City, December, 1890.

BULLETIN NO. 4.

CONTENTS: A Description of the Lower Carboniferous Crinoids from Missouri, by S. A. Miller. 8vo. Paper. 40pp. 5 plates. Jefferson City, February, 1891.

BULLETIN NO. 5.

CONTENTS: The Age and Origin of the Crystalline Rocks of Missouri, by Erasmus Haworth, 37pp.; Notes on the Clays and Building Stones of Certain Western Central Counties Tributary to Kansas City, by G. E. Ladd, Assistant geologist, 43pp. 8vo. Paper. 87pp. 5 plates, 5 figures. Jefferson City, July, 1891.

BIENNIAL REPORT of the State Geologist, transmitted by the Bureau of Geology and Mines to the Thirty-sixth General Assembly. Small 8vo. Paper. 53pp. 2 small diagrams. Consists of an historical sketch of the progress of geological work in the State, and of a report of progress. Jefferson City, December, 1890.