THE RELATION OF GEOLOGY
TO
COAL STRIPPING IN SOUTHEASTERN KANSAS.

By

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PREFACE.

In choosing the subject for this thesis the author was actuated by one principle and motive, the explanation of new development in coal mining in southeastern Kansas. While this subject has been treated in other places with considerable attention, there has been nothing written during the last few years. Handicapped with limited time to do the field work necessary for the preparation of this thesis, the author will attempt to explain this theme clearly and fully.

The purposes of this theme are two-fold, erudition of the author himself on this matter, and a hope that it may benefit those who may read it.

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Lawrence, Kansas.
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INTRODUCTION.

The topography of southeastern Kansas is comparatively even, there being no hills except in central and northern Crawford County, where the Ft. Scott limestone covers the surface. This evenness of surface is an essential feature in the coal mine possibilities of this area, as the dip of the rocks, which is about twenty feet to the mile, permits coal stripping for a long distance.

There are some disadvantages connected with the fact that the country is so flat, particularly the trouble with water in the pits. There is one noteworthy instance in the case of a contractor having trouble with water in a strip-pit. His shovel was covered at one time with nine feet of water above the roof which covers the machinery, (See Pl. VI). This is an extraordinary case, however, and not by any means to be considered a common occurrence. The geology of the area has been mentioned above only incidentally, and will be treated in considerable detail below.
I.

A General Review of the Essential Features of
The Geology of Southeastern Kansas.

The important feature of the structural geology of this area is the fact mentioned above, namely, a dip in general of twenty feet per mile. This, coupled with the fact that the coal outcrops near the Missouri line, is what makes it possible to mine the coal so cheaply and so rapidly. The base of the geologic structure of this area is usually taken as the Mississippian limestone, which outcrops in the southeast corner of the state, in and around Galena, Cherokee County. The coal measures lie immediately above the Mississippian limestone and the Cherokee shales at the base of the coal measures or Pennsylvanian.
PLATE I.
The Cherokee shales are graphically depicted in Plate I. While the scale has been exaggerated to some extent in order that the coal beds should be outstanding, the drawing is essentially correct and has been taken from a generalized section in Bulletin No. 3. In examining this section one will notice immediately the limestone occurrences at the top of it, followed in succession by three beds of coal. It will be well to explain at this point that the limestone is the one which outcrops in northwestern Crawford County, namely, the Pawnee. It can be easily seen by the reader, therefore, that since the strata in Kansas dip to the west as you travel eastward across Crawford County, that the coal will eventually crop out at the surface. In order to make this perfectly clear Plate II has been drawn. The dip of the rocks as shown in Plate II makes it evident to the reader how it is that the coal can be stripped, also it shows why there are three distinct areas of mining.

First. One where the coal is stripped by horse power and scrapers.

Second. One where the steam shovel method is used.
PLATE III.
Third. The general method of coal mining, which is shafting.

Under this heading is a subject of great importance to the miner, particularly as it is one of the objectionable features of this region of mining. This refers directly to a geological freak that is called in the province of the mining region, a "horseback".

The synonym for horseback might well be a "clay vein". The best description of the probable origin of such a feature as a horseback is found in Volume 3, page 211, of the University Geological Survey of Kansas publications. It might be well to quote verbatim the words of Dr. W. R. Crane.

"From the observed conditions the writer is led to the following conclusions regarding the origin of these interesting structures. Long after the coal was formed and consolidated almost to its present state, vibratory movements of one kind or another fissured the strata including the coal beds. The great variety of fissures as above described corresponds well with different forms of fissures observed in many parts of
the world in connection with the mining of metalliferous deposits. Upon the production of such a fissure the great pressure under which the fire clay at the bottom of the coal had been existing would now be relieved on one or more sides. If the fissure passed entirely through the fire clay the surface of each wall would be relieved of pressure; if it only reached downward to the fire clay the upper surface would likewise be relieved of pressure. Considering the exceedingly unctuous property of clay and the softening to which it would be subjected from time to time by the underground water, it is very easily understood how it would soon move upward sufficiently more or less completely to fill the fissure produced by the earth's tremor. This process would simply be an exaggerated case of ordinary "creeping" so commonly known in the underground workings. The upturning of the shale laminae near the upper part of the fissure would very readily be produced by the upward movement of the clay acting under the great power which was forcing it along, while the occasional fragments of coal and sandy shale found within the clay veins can readily be accounted
for by the occasional dropping of a block which was almost broken under the first earth movements which produced the fissures.

The vibratory movements producing so many fissures must have been comparatively gentle in character as few vertical displacements of any consequence have been recorded. Also the general results were of a nature to elongate and stretch the strata horizontally rather than to compress them. The aggregate increase in horizontal dimensions has not been determined, as the mining operations have covered but a few miles in an east and west direction. But from the large number of clay veins with an average of from three to five feet it can be seen that the actual increase in horizontal dimensions has been very considerable. These fissures are best recorded in the coal beds because of the brittle nature of the coal. The clay veins well illustrate nature's method of filling up and obliterating fissures of this general character when produced in ordinary shales, although the latter may be interbedded with limestones.
The age of the clay veins cannot be determined by internal evidences. It is possible that they were produced at various periods separated by considerable time epochs. But it is probable that the greater number of them and the more important of them were produced at the time of the Ozark uplift to the southeast. The general character of this uplift seems to have produced a dome shaped elevation which would require an elongation of horizontal dimensions. The stretching of strata so marked is therefore accounted for. A careful study of the horsebacks shows that their prevalent direction is northeast and southwest, approximately tangential to the Ozark dome, with the next most common direction nearly at right angles to this. The greatest fault observed is a vertical displacement of about 8 feet exposed in a mine of the Mount Carmel Coal Company. Great as this displacement is it is surprising that so few other displacements have been found. It may incidentally be remarked that the general direction of these fissures is nearly parallel to the most
prominent fissures in the lead and zinc mining district to the southeast, which adds to the probability of all of them having been made at the time of the Ozark uplift."

Plate IV illustrates a typical horseback. It will be noticed that the horsebacks are cutting in two the vein of coal and would naturally, in case there were many, produce a series of ridges in the bottom of a pit. The writer has had occasion to see these horsebacks as they actually occur, and would describe them best in saying that they appear to lie in a series of miniature mountain ranges running transversely across the pit of the mine.

One objectionable feature to the horseback is the fact that you do not know whether your coal vein is thinning out or not when you come across them. Also, the most important objection is that it costs a great deal of money to operate a steam shovel and when you have taken the trouble to remove eighty cubic yards of dirt from an area where you expect to find coal, it is not considered a good business proposition to find a lot of fire clay.
As an instance in detail, and one which drives the point home, it would be well to mention that one particular shovel the author knows of costs $100 a day for its operation. The repair bill for one month alone is $1000, and the initial cost of a suitable shovel for mining is approximately $100,000. Consequently, a number of horsebacks occurring in an area where the shovels are operating is a very serious cause for discouragement to the operator.

II.

Economic Relations between Thickness of Overburden and Coal Strata.

The chief objection is any business feature is to make the sum upon the profit side of the sheet more than that upon the cost side of the sheet. Consequently, this chapter is devoted to an explanation of the opinions and theories of practical business men as to the profit in coal stripping.

There seems to be among the operators in steam shovel mining a general feeling that they are misunderstood. The prevailing impression is that all
you have to do is to go and buy a steam shovel and
find a place to locate your mine, and from then on
the sailing is easy. However, an experienced oper-
ator in coal stripping would tell you an entirely
different story. He does not feel that he is par-
ticularly singled out for hardships, but he does feel
that it is unkind to suggest that he has no troubles,
while the shaft miner is burdened with them all.

There are two methods of approximation of
the paying proportion between the overburden and the
coal seam. They both result in finding the same thing,
however, and in repeating the two methods the result
is a little more clearly defined. One way is to say
that one foot of overburden to one inch of coal is ap-
proximately a paying proposition. Another is, that
seven to eight cubic yards of overburden to one ton of
coal will result in a profit to the operator. Such
general statements as this, however, would be very mis-
leading unless the explanations following were given.
Unfortunately, in geology we do not find a regular set
of conditions prevailing. The coal miner may be strip-
ping an enormous amount of coal each day and some time
come across a black sand rock overlying his coal bed,
or, he may come across the numerous horsebacks which sometimes occur in this field.

In either case he has come up against a hard proposition. The wear and tear on a shovel of hard sand rock, such as the author has seen in many cases overlying the coal seam, is enormous. Any mine machinery is expensive, particularly that of a steam shovel, since the marginal profit in any large business is dependent upon volume and not upon an excessively large profit.

The cost of operation and the interest on your money continues whether you are making a profit or not, consequently it takes a pretty keen business man to operate a steam shovel proposition. There are numerous other difficulties which will not be enumerated, due to the fact that the theme of this paper is that of geology and does not take up such things as labor problems and like matters. However, an important thing in the operation of a mine is to prevent the flooding of the pits which occur in many cases. Heavy rains and a broken down pump will result in many instances in a serious delay in the operation of the shovel.
These are a few of the difficulties that are encountered in coal stripping. From the facts noted above it is very easy to see that difficulties of coal stripping equal in many cases those of shafting, though they are unlike them in character. It has been mentioned above that there are two ways of expressing the ratio of overburden to the coal seam. It is perhaps easier to understand the ratio of one foot of overburden to one inch of coal, as a paying proportion. This, however, is of course a generalization. The important factors of the grade of coal and the fact that a thin seam of good quality will equal in value a thicker one of less fuel value, are certainly not to be disregarded.

III.

Detailed Discussion of Coal Stripping.

A comparison of Modern and Earlier Methods.

The usual mining for coal when the seam comes to the surface is started by coal stripping with horses and ordinary scrapers. This is a worldwide method and southeastern Kansas has followed the
usual trend in this matter. When a coal seam is discovered by plowing across a field, or in any other manner similarly noting the lithologic character of the soil, he simply takes a scraper and a team of horses and uncovers the coal. Lack of space forbids a lengthy historical discussion of coal mining in this area by the stripping process. However, it would be well to mention that coal mining by this method was followed back in the sixties to quite a large extent, particularly in '65. The importance of geology in such a primitive method as this is seen at a glance. When the dip of the coal strata is very slight it is quite easy to follow up a bed of coal. However, if there were a sharp angle of dip the task could not be followed, in this manner. Also, the lithologic character of the overburden would determine whether the coal could be uncovered or not.

The part this method plays today in the coal stripping business is a very minor one. However, the fact that it costs little and coal is much advanced in price, means it is not a negligible one. The small miner can utilize this scheme with great benefit to himself
because it naturally takes a large amount of capital to swing a steam shovel proposition. We will then, of course, find this method employed throughout the history of the field. But the steam shovel industry has so far overshadowed it that it will probably not play an important role.

In April, 1910, the Miller-Durkee Coal Company began using a steam shovel in their mines near Scammon, Cherokee County. The first steam shovel, however, used in this district was brought in during the late seventies. It did not prove satisfactory, probably due to its not having a full swing of the shovel beam as do modern shovels. Neither did it have their capacity. This was followed by the Miller brothers of Mulberry who in 1902 tried the steam shovel. Although the experiment proved successful it was discontinued for some reason unknown to the writer. The actual mechanics of the operation are easily explained, as nearly every one has seen a steam shovel in operation. The chief distinction between the steam shovels in this method of shoveling and the ordinary one is that the boom is so much longer than those we ordinarily see.
Also, the capacity has been increased from fifty to seventy-five per cent over the largest shovels we used a few years ago.

The first step in opening a strip-pit proposition is the making of the "box pit". This is where the miner approaches the bed of coal at a gradual angle as he removes the surface material above it. As the shovel is advanced over the bed of coal it is usually worked in an elliptical or a circular direction, that is to say, the operator starts the process of paralleling. In doing this the machine makes a series of concentric rings and as the overburden is removed from the coal bed on the second trip around, it is dumped into the old workings. A very plain example of a similar process is that of the ordinary method of plowing, where the land that is being turned over is laid in the furrow made the preceding round. This is another expedient of the operators to economize as it naturally increases the amount of coal they can uncover in a given area. This method of paralleling is one in very general use, and practically every operator uses it.
An interesting illustration of the effect that geology has upon industry is shown in the number of shovels in the field, from an economic point of view. The writer has it on good authority that there are forty-five shovels in this field, and that only six of these are working on what is known as the upper seam. This is self-explanatory, when we find that the difference in thickness of the upper and lower seam is about fourteen inches. The upper seam of coal will run in general about twenty-two inches, the lower seam approximately three feet.

This is a natural consequence, due to the fact that any miner would rather work upon a more paying proposition than one which would not pay as well. The important role geology plays in work of this kind is not by any means to be disregarded.

Since geology is important, and it determines the capacity, the length of boom and the heaviness of the material in the steam shovels used in the coal fields, whether or not there will be many more shovels added to the fields is a question hard to answer, and it appears, due to the fact that the coal is not by any means nearly exhausted, there may be that a few more shovels will be added.
Equipment for Steam Shovel Stripping:

Top Equipment:

The top equipment must contain the following, and may have other conveniences added; A tipple house, for hoisting the coal from the pit and loading it into railroad cars for shipment; a coal hoisting engine and boiler, capacity to conform with the size of the plant; well and pump for supplying water to all boilers and for all domestic uses, office, tool shed and powder house. Usually a deep well is put down 800 to 1200 feet which obtains the same kind of water as supplies Girard, Weir and Pittsburg.

Pit Equipment:

The pit equipment must contain the steam shovel, "donkey" engine and boiler for hoisting the coal, pit tracks for steam shovel and all mine cars and pumps with boiler for draining the pit where such is necessary. Often the tipple engine does all the hoisting and the donkey engine does only the pit track hauling.

1Carpenter, Clark, and Brown, High; Southeastern Kansas Coal; Thesis, page17. 1915.
In the southern part of the area some of the mines have introduced electric power to a limited extent drawing their power from interurban electric wires. No interurban lines cross any part of the area, and none of the mines are supplied with electric power. Here gasoline engines are used to a very great extent, usually for pumping, but in some cases for hoisting into the tipple house. The tipple house usually is a simple affair on account of the temporary nature of the business. The coal is emptied through the top of the house and passes over screens as desired and dropped into coal cars properly placed on tracks beneath.

Two distinct varieties of steam shovel are used, a small one of about one cubic yard capacity used by some for loading into the pit cars, and the large shovel of six to eight times the capacity of the small one. The boom poles of the large shovels are 50 to 90 feet long and are capable of stripping to a depth probably of fifty feet. There are a variety of different combinations of capacity of shovel and length of dipper arm depending upon the conditions.
that vary from mine to mine. It seems that all of them may be operated successfully if the location is properly chosen and experienced men conduct both the mine and sales departments. The efficiency of the machines depends not only upon the size of the machines but also upon the skill of the operator. Skillful operators are half of the machine. They can keep the machine going when conditions permit night and day when such a demand is made of them. The expenses average about $1000 a month when a machine is kept in proper condition for constant use.

Method of opening pits:

Three general methods of opening pits are employed, producing the so-called "bar-pit", "box-pit" and "side-pit", the box-pit being the most popular one. In the bar-pit the overburden is generally too thick to be removed at a single try of the shovel across the pit, consequently about half of the overburden is removed and deposited on the side, then on the return trip of the shovel the depth is removed and is deposited on the unfinished pit made by the shovel's first trip.
The box-pit is the name applied when the shovel simply burrows down to the coal and then begins a cut. All pits are side pits after being opened. In opening a side pit the shovel digs down to the coal on about an 8 per cent grade, dumping the waste to one side of the pit. After the pit is opened the shovel moves forward, removing the overburden until the limits of that particular pit are reached. It then turns and digs a new path back to the other end of the pit depositing the waste in the cut made by the first cut.

Mining the coal:

After being uncovered by the shovel holes are bored in the coal with ordinary auger drills. These holes are squibbed with a small piece of dynamite, care being used to see that the squibbing fuse is entirely removed from the squibbed hole. Black powder is then used to "shoot" the coal. In performing this work there is always one coal-shooter and two helpers. The coal-shooter squibs the holes, loads them with black powder and fires the blasts. The helpers drill the holes and do whatever other heavy work is to be done. The coal is then
loaded into the cars and removed from the pit.

There are two general methods of performing this work. First, by shoveling the coal into the cars by hand and, second, by the use of a small steam shovel. The first of these methods is the one generally used and usually a number of shovelers, ranging from four to twenty or more. Fourteen men ought to load as a minimum 300 tons per day. The second method is yet in an experimental stage. It has one distinct advantage, namely, its ability to dig through horsebacks. The coal is next moved from the pit to the tipple.

An interesting method is to have a revolving crane with a longboom mounted on trucks which will run along the track on the ground level at the edge of the pit, as shown in Plate V. The boom of the crane reaches over into the pit, picks up a car, lifts it from the pit and deposits it on the main train track, situated on the ground level back of the crane track. Such pit cars have about four tons capacity. In some instances the crane instead of being located on the side of the pit is located on the coal back of the shovel. (Plate VI.). The tram-track is then located
on the edge of the pit. The crane again lifts the empty cars from the tram-track into the pit and hoists out the loaded cars. The coal next goes to the tipple where it is screened and emptied into cars. Mine run, nut and slack are the general grades of coal produced.

The question of water supply is one thing that causes more or less trouble. In some instances deep wells have been sunk. Where this has been done the water is not always of the best quality and often results in injury to the boilers in which it is used. When the wells are not used surface ponds are depended upon to supply the water. The surface water which collects in the pit may be used, but such water usually contains a large amount of soluble sulphate, therefore, it is unsatisfactory. During wet weather these pits are much bothered by water, so that occasionally work must be suspended. Every pit should be well equipped with drain pumps. The pumps in general use are the centrifugal and Chinese. The Chinese pumps are constructed on the ground. They have a very great capacity and entail little expense after installation.
Geographical Description of the Area.

The area is unique in that the surface on which the mining is carried on is comparatively flat. The very fact that the surface is flat where the coal beds dip westward at the rate of about 20 feet to the mile show that this area is favorable for steam shovel work. Streams are abundant due to the large amount of rainfall. Dividing line between the streams flowing north and those flowing south begins about a mile south of Mulberry and extends west by north across Crawford County.

Since the erosion has been very great over the greater part of the district, this accounts for the comparative flatness of the district. If the eastern edge of the steam shovel area were to be traced by the line of outcrop of the coal you would begin in Township 31 South, Range 44 East, SW half section and run diagonally across that section. The line then runs from the NW corner of Section 13 to middle of Section 6, Range 45, then swings to the northeast dropping to the SW corner of Section 14 and then directly east to the Missouri line. The line of coal outcrop does not define the eastern edge of the steam shovel stripping.
In Plate III which accompanies this paper it will be found there are three different sections of the mining region. These three sections are divided into mining, by horse-power, or stripping by horse-power; stripping by steam shovel method; and the usual method of mining, shafting. Due to the fact that the dip of the rock is known to be forty feet to the mile, we find that the western end of the stripping by horse-power is approximately a mile east of the line of coal outcrop, and as we go to the north the dip becomes little less, hence, the area becomes a little wider. The map is very diagrammatic and must be remembered to be such. However, to illustrate, that there is an area between the limit of horse-power stripping which is a little over 20 feet, and the area which is determined to be not less than 50 feet from the surface, because it requires that amount to make the roof of the mine solid, and prevent caving. Then we find an area between these two of horse-power stripping and of shafting which is ideal for that of the steam shovel method.
Again, we may notice the important effect of geology upon the location of a mining region due to the fact that these three districts are determined by the outcrops and by the amount of dip of the rocks. Hence, we note again the important role geology plays. As stated before this map is diagrammatic, and the purpose is that any one who may read this will not use this as a location map, but one that will give him a general idea of the country before he goes there. If he intends to invest in a mining proposition, or merely to look over the property.

Of course, topography will affect these lines if they are drawn accurately, but if a river cuts back to the westward it naturally makes a line of outcrop come back with it, as is the case of the structural contours of limestone, just so structural contours would follow this same method.

In Plate V which shows the picture of the coal shovel itself, we notice the sharp and bright bank to the left. This has been cut down by the steam shovel itself. You will notice to the left in the picture a coal tipple which is a typical example in this case. It is, as mentioned above, an affair very
flimsy in structure, compared to one that is intended for permanent use. At the bottom of the pit you will notice a number of miners shoveling the coal into the small cars which are laid on the track above the embankment by the boom of the loader which is attached to it. Plate VI shows one of the difficulties under which the steam shovel operates. The water, in this case, is about ten feet deep, has come up to the floor of the steam shovel itself. This is, of course, a rare occurrence, and one which the operator is not often troubled with.

Conclusions that may be drawn from this paper and a Discussion of the Length of Life of this field.

It will be noticed that while the coal stripping business as carried on by the steam shovel has been much developed, there is a great deal of room for further improvement. We will find, as time goes on, that there will be more shovels in this field very probably. It is hard to move a steam shovel, but an operator may feel assured that he can move from one field to another without serious loss to himself, which undoubtedly is made up from the fact that his profit is correspondingly great. Therefore, as the business
grows profitable for those who go into it, they will undoubtedly come into fields of profit making. The fact that the steam shovel method has proven so eminently successful in southeastern Kansas will undoubtedly have a big influence upon the further use of this method. There are some cases in Pennsylvania where this operation has been pursued for some years. Go into foreign countries there will very probably be a number of fields in which the operation may be used successfully also. There is much to be said for this method of mining, since the cost per ton is much less than that of shafting. While this has been an experiment in large measure since the starting of this industry, we have now reached the satisfactory conclusion that this is a practical, profitable business. Therefore, enlargement of it will follow as a matter of course.
In a discussion of the length of life of this field it will be best to quote the figures of men who are far more familiar with it than I. It seems to be a rather common opinion among operators in this field, and those who buy from this field, that the present rate of stripping and of mining, the coal will be exhausted at the end of ten or fifteen years. This is a conclusion reached with the facts at hand. Should further development take place in the new coal-producing areas, this statement would undoubtedly have to be retracted. At present this seems to be as good an estimate as can be made. They are rapidly despoiling nature from valuable resources in this area and, of course, justly too; but the rapidity of this work has been greatly enhanced by the introduction of this new phase of the business and is a fact which is important to keep in mind and one which will undoubtedly work further influences upon other fields.