DETAILED STRATIGRAPHY OF KANSAS COALS.

A REVIEW OF ERASMUS HAWORTH'S REPORT ON KANSAS COALS, 1898.

FREDERIC W. CHRISTENSEN.

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GENERAL OUTLINE OF THE STRATIGRAPHY.

The Coal Measures.

The Kansas coals occur in various shales and all positions, from the Cherokee shales at the base to the Osage shales, 2000 feet above. The order and position of the strata is shown in the generalized section figure.

The Cherokee shales produce greater quantitites of coal than any other shale beds in the whole Coal Measures. From these shales, are obtained the coals of Cherokee and Crawford Counties and nearly all of Labette and Leavenworth Counties. Borings, as of wells, show that the Cherokee shales extend over a considerable area west, and the probability is that coal can be found anywhere under the eastern fifty or seventy five miles of the state.

The Labette shales, first in order above the Cherokee shales, contains considerable bituminous matter, but no good bed coal.

Above this, we have the Pleasanton shales, which contain large quantities of coal, especially in the lower Pleasanton shales. They probably rank next to the Cherokee shales.

The Thayer shales carry a considerable amount of coal, especially in the vicinity of Thayer.

The Lane shales, next in importance, have no coal as far as is known.

Above this are the Lawrence shales, which produce coal enough to be of commercial importance. In Atchison, Jefferson, Douglas, and Franklin counties, coal is mined from these shales.

Above the Lawrence shales, the shale beds contain little or no

coal, until the Osage shales are reached. The average thickness of this formation is about 200 feet. It extends across the state, from the north to the south. It is rich in coal, and is extensively mined at Burlingame, Osage City, Carbondale, and Scranton. The quantity and quality varies considerably in different sections.

The only coal remaining, worthy of notice is found in the Cretaceous area of the Dakota area of North Central Kansas. These beds belong to what is known as the Upper Group. The coal is in the form of lignite, and is mined chiefly to supply the local trade.

CHEROKEE SHALES.

The Cherokee shales are the most important of all the coal-bearing horizons, having produced three-fourths of all the coal thus far mined in Kansas. The surface areas are mostly in Cherokee, Crawford, Labette, and Bourbon counties. The shales extend westward under the overlying strata, to unknown distances. The coal map shows the surface covered by these shales.

From our present knowledge of geology and the Cherokee shales, it is probable that coal may be found in abundance anywhere east of the outcropping of the Cread Limestone.

For a more detailed study of the Cherokee shales we will give some extracts of well records.

Weir City Water Well.

Material	Thickness of coal.	Thickness of strata.	Depth to Bottom of Strata.
Soil and Clay		15 feet	15 feet
Sandstone		5 "	20 "
Shale		10 "	30 "
Coal	36 inches	3 "	33 "
Fire Clay		3 "	36 "
Shale		75 "	111 "
Coal	14 inches	1 foot 2 inches	112 " 2 inches
Fire Clay		2 feet	114 " 2 "
Shale		100 "	214 " 2 "
Coal	24 inches	2 "	216 " 2 "
FireClay		2 "	218 " 2 "
Shale		62 "	280 " 2 "

McKee's Gas Well, North of Girard.

Material Beginning at 148 ft.	Thickness of coal	Thickness of strata	Depth to Bottom of Strata.
Black Shale		5 feet	153 feet.
Brown Limestone		2 "	155 "
Oil Sand		5 "	160 "
Sand Shale		55 "	215 "
White Shale		33 "	248 "
Brown Shale		10 "	258 "
Brown Limestone		4 "	262 "
Shale		2 "	264 "
Limestone		3 "	267 "
Shale		2 "	269 "
Limestone		3 "	272 "
Shale		52 "	325 "
Sandstone		7 "	332 "
Shale		26 "	358 "
Black Shale		2 "	360 "
Lime Shale		3 "	363 "
White Shale		17 "	380 "
Brown Shale		30 "	410 "
Alternate Light and Dark Shale		79 "	489 "
Sand and Little Gas		3 "	492 "
Shale		4 "	496 "
Alternate Sandstone and Shale		13 "	509 "
Sandstone		6 "	515 "
Black Shale, Little Coal		3 "	518 "
Dark Shale		32 "	550 "
Total		402 "	

La Harpe Well.

Reported by L. C. Beattie, Manager Palmer Oil Company.

Material Beginning at 637 ft.	Thickness of Coal	Thickness of Strata	Depth to Bottom of Strata
Gray Shale		5 feet	642 feet
Gray Sandstone		8 "	650 "
Gray Shale		8 "	658 "
Dark Shale		6 "	664 "
Red Flint and Limestone		3 "	667 "
Black Shelly Sandstone		10 "	677 "
Dark Shale		26 "	703 "
Changeable Shale; Light, Dark, Green, Black		192 "	895 "
Sand Shale, with some clear Sand		12 "	907 "
Black Shale		6 "	913 "
Dark Sand Shale		8 "	921 "
Black Shale		61 "	982 "
Total		345 feet.	

Coal Beds in the Cherokee Shales.

The coal of the Cherokee shales is found in different positions, varying both horizontally and vertically. In some localities, coal is found near the base of the shales, but this coal has never proved of commerical importance.

About 150 feet above the base of the shales, we have another bed of coal, covered by a thin layer of shale capped with the Columbus sandstone. According to well records, the coal does not extend far westward. It is of no great importance commercially, altho it is mined to some extent for local markets.

The Weir-Pittsburg Beds: The Weir-Pittsburg beds lie above the Columbus, and are the heaviest known in the state. They are divided into two layers, the Upper and the Lower, averaging 30 and 40 inches

respectively. The outcroppings from an irregular line passing thru Stippville, Scammon, Weir City, and Pittsburg.

Development of Weir-Pittsburg Coals: In 1868, Professor Wilbur of Chicago was sent out by a Chicago company to examine the "Cherokee neutral lands" for coal. He reported that coal existed in large quantities, in some places reaching a thickness of four feet.

Previous to this, coal had been mined by early settlers in Kansas and Missouri. The coal could be obtained easily, but was used for nothing but blacksmithing purposes.

A coal company was formed at Fort Scott, shortly after the completion of the Missouri River, Fort Scott and Gulf Railroad, now the Kansas City, Fort Scott, and Memphis Railroad. Most of the mining was done along the outcropping of the coals. The stripping process was employed almost entirely. The coal was mostly sold to the railroad company at that place.

In 1874, the Scammon Brothers began a new process of mining in that district by sinking a shaft at a place which now bears their name; the town of Scammon. They met with great success, and soon developed a mine with a capacity of 50 cars a day.

In 1871, the firm of Keith & Rawlings of Kansas City began to deal in coal, and their business did much to develop the coal industries of Kansas. In 1872, the successors to this firm began extensive mining operations, using the strip pit process. Large quantities of coal were sent to Kansas City and other markets.

In 1878 and 1879 the Joplin and Girard Railroad was built, primarily for the purpose of reaching the Kansas coal fields. Pittsburg, at the terminus of the road, developed into a great coal center, and

has chiefly been such until the recent establishment of the zinc smelters. The Kansas, Texas Coal Company began operations in 1878. The Mont Carmel Coal Mining Company did not gain a foot hold until 1886, and the Missouri, Kansas, & Texas Railway Company started its mines at Mineral, in 1895.

Cherokee and Crawford counties produced 2,652,029 tons of coal in 1897, furnishing employment for 5,540 men part of the year. These figures include the area of Arcadia.

These coal beds diminish in importance as we go southwest, until they end in a point opposite to Columbus. They do not extend as far as Girard to the North-west. The southern and western limits are not yet fully determined.

Coal above the Weir-Pittsburg: There are several lesser beds above the Weir-Pittsburg coals, but there are only two of any great importance.

What is known as the Fort Scott red coal is found near the top of the Cherokee shales. The red color of the coal is due to the oxidation of the iron pyrites which it contains. Large quantities of coal are produced from this bed, the stripping process being used entirely.

The Leavenworth coal is found in the Cherokee shales, but its connection with the beds in the southern part of the state has not been thoroly established. It occurs in three horizons at depths of 988, 748, and 720 feet below the surface, each bed being 24 inches thick. The lower bed, in its position, corresponds to the Columbus shales but any further connection has not been established.

Weir-Pittsburg Area.

Returning to Cherokee and Crawford counties, we will examine

the mining districts more in detail.

The lower stratum is the thickest and the one most worked. It is reached at depths varying from 25, 80, 90, to 230 feet from the surface. The upper stratum is reached at distances of 15 to 96 feet. Th The outcropping cannot be traced continuously thruout the country, due to the weathering of the overlying shales.

Mineral City and Vicinity:

A.-- Record of Drill Hole Five Miles North of Mineral City.

Material	Thickness of Coal	Thickness of Strata	Depth to Bottom of Strata
Soil and clay		12 feet	12 feet
Clay and Gravel		27 " 4 inches	39 " 4 inches
Gray Shale		5 " 4 inches	44 " 8 "
Coal	16 inches	1 " 4 "	46 "
Fire Clay		2 "	48 "
Gray Shale		5 "	53 "
Black Shale		14 " 6 "	67 " 6 "
Coal	34 inches	2 " 10 "	70 " 4" "
Fire Clay		2 " 2 "	72 " 6 "
Drab Shale		9 " 1 "	81 " 7 "
Coal	15 inches	1 " 3 "	82 " 10 "
Fire Clay		4 " 2 "	87 "
Sandstone		4 "	91 "
Gray Shale		5 " 7 "	96 " 7 "
Coal	25 inches	2 " 1 "	98 " 8 "
Fire Clay, soft		2 " 8 "	101 " 4 "
Drab Shale		16 " 8 "	118 " 9 "
Coal	9 inches	9 "	118 " 9 "
(?)		2 " 9 "	121 " 6 "
Gray Shale		33 " 6 "	155 "
Black Jack		4 " 6 "	159 " 6 "
Coal	11 inches	11 "	160 " 5 "
Gray Shale		17 " 7 "	178 "
Coal	41 inches	3 " 5 "	181 " 5 "
Black Shale		1 " 5 "	182 " 10 "
Coal	4 inches	4 "	183 " 2 "
Fire Clay		1 " 7 "	184 " 9 "
Gray Shale		8 " 3 "	193 "
Black Shale		8 " 2 "	201 " 2 "
Coal	12 inc hes	1 "	202 " 2 "
Gray Shale		7 " 10 "	210 "
Black Shale		19 " 6 "	229 " 6 "
Coal	32 inches	2 " 8 "	232 " 2 "
Fire Clay			

B.-- Record of a Prospect Hole near Mineral City.

Material	Thickness of coal	Thickness of strata	Depth to Bottom of Strata.
Clay and Shale		7 feet 7 inches	7 feet 7 inches
Coal	11 inches	11 "	8 " 6 "
Gray Shale		10 "	9 " 4 "
Sandstone		6 " 3 "	15 " 7 "
Black Shale		14 " 7 "	30 " 2 "
Coal	24 inches	2 "	32 " 2 "
Fire Clay, sort		5 " 5 "	37 " 7 "
Drab Shale		6 " 5 "	44 "
Gray Shale		6 " 10 "	50 " 10 "
Drab Shale		10 "	60 " 10 "
Coal	8 inches	8 "	61 " 6 "
Fire Clay		2 " 6 "	64 "
Gray Shale		4 " 10 "	68 " 10 "
Sandstone		4 " 6 "	73 " 4 "
Gray Shale		5 " 2 "	78 " 6 "
Drab Shale		21 " 4 "	99 " 10 "
Gray Shale, hard		22 " 4 "	122 " 2 "
Coal	47 inches	3 " 11 ""	126 " 1 "
Black bituminous clay		2 "	126 " 3 "

These tables will show more in detail the nature of the strata in this vicinity. A comparison of the tables shows that the black shale roof in A is changed to a gray shale in B, the latter making a better roof. These holes were drilled only a few hundred feet apart, so we see there is considerable variation in the same vicinity. "Horse-backs" are quite numerous in this locality, making mining unprofitable in some places.

The Upper strata is reached at 96 feet 7 inches in A, and the Lower at 229 feet 6 inches. In B, the Upper strata is reached at 122 feet 2 inches, and the Lower at 250 feet.

Chicopee:

K.--Record of a Prospect Well near Chicopee.

Material	Thickness of Coal	Thickness of Strata	Depth to Bottom of Strata
Soil		13 feet	13 feet
Gray Shale		4 " 6 inches	17 " 6 inches
Dark Shale		4 " 6 "	22 "
Gray Shale		10 "	22 " 10 "
Coal	10 1/2 inches	10 1/2	23 " 8 1/2
Gray Shale		7 "	30 " 8 1/2
Black Shale, hard		5 " 1 "	35 " 9 1/2
Coal	7 inches	7 "	36 " 4 1/2
Gray Shale		10 "	37 " 2 1/2
Black Shale		5 " 1 "	42 " 3 1/2
Coal	6 1/2 "	6 1/2	42 " 10
Gray Shale, hard		22 "	64 " 10 inches
Gray Sandstone, hard		9 " 7 "	74 " 5 "
Coal	32 inches	2 " 8 "	7 7 " 1 "
Black Shale		1 "	78 " 1 "
Gray Shale, soft		6 " 4 "	84 " 5 "

Total depth of well, 95 feet 7 inches.

L.--Record of a Prospect Well near Chicopee.

Material	Thickness of Coal	Thickness of Strata	Depth to Bottom of Strata
Clay and Gumbo		17 feet 3 inches	17 feet 3 inches
Black Shale, hard		5 " 5 "	22 " 8 "
Coal	32 inches	2 " 8 "	25 " 4 "
Gray argillaceous Shale		6 "	31 " 4 "
Limestone Blue, fossiliferous		8 "	32 "
Gray argillaceous Shale		8 " 6 "	40 " 6 "
Black Shale		3 " 8 "	44 " 2 "
Coal	14 inches	1 " 2 "	45 " 4 "
Gray argillaceous Shale		4 "	49 " 4 "
Gray Shale		22 " 2 "	71 " 6 "
Black Shale		6 "	77 " 6 "
Coal	6 inches	6 "	78 "
Gray arenaceous Shale		12 " 6 "	90 " 6 "
" " "		2 "	92 " 6 "
" " "		6 "	98 " 6 "
Coal	39 inches	3 " 3 "	101 " 9 "
Black Shale		1 " 1 "	102 " 10 "

M.--Record of a Prospect Well near Chicopee.

Material	Thickness of Coal	Thickness of Strata	Depth to Bottom of Strata
Clay and Gumbo		12 feet 8 inches	12 feet 8 inches
Black Clay		2 "	14 " 8 "
Coal	28 inches	2 " 4 "	17 "
Argillaceous Shale, gray		11 "	28 "
Blue Limestone		6 "	28 " 6 "
Argillaceous Shale, gray		4 " 6 "	33 " [illegible] "
Dark Shale		10 "	33 " 10 "
Gray Limestone		1 " 2 "	35 " [illegible] "
Dark Shale		4 "	35 " 4 "
Coal	9 inches	9 "	36 " 1 "
Argillaceous Shale, gray		5 " 7 "	41 " 8 "
Gray Shale		19 " 9 "	61 " 5 "
Black Shale		2 "	63 " 5 "
Blue Limestone		4 "	63 " 9 "
Black Shale		4 " 4 "	68 " 1 "
Coal	5 inches	5 "	68 " 6 "
Gray Shale		9 "	77 " 6 "
Gray Sandstone		1 " 6 "	79 "
Shale, hard		1 " 6 "	80 " 6 "
Blue Limestone		7 "	81 " 1 "
Gray Shale, hard		10 "	91 " 1 "
Gray Sandstone		3 " 4 "	94 " 5 "
Gray Shale, hard		1 " 8 "	96 " 1 "
Coal	25 1/2 inches	2 " 1 1/2	98 " 2 1/2
Dark Argillaceous Shale		1 "	99 " 2 1/2

A comparison of these tables shows that the Upper stratum is reached in K, L, & M at 21, 22, and 14 feet respectively. The coal roof is argillaceous, and in general makes a good safe roof for the mines. The Lower stratum is reached at a depth of 83 feet 7 inches, 93 feet 6 inches, and 96 feet 1 inch, in K, L, and M respectively. One of the characteristics of these shale beds is the large amount of bituminous (black) shales and clays found in them.

Area north of Pittsburg and Chicopee: We have only a small number of well records in this area, but there is an indication of a gradual dip of the Lower stratum, to the northwest. The line of out-

outcrop passes in anortheasterly direction from Pittsburg to the state line.

Inclination of Coal Beds: The Weir-Pittsburg Lower bed, from the ourcrop east of Weir, west to Mineral City shows a dip below the surface of 20 feet to the mile. Traced north from Columbus it shows a dip of 4 feet to the mile below the surface. The Weir-Pittsburg Upper dips at the rate of 3 feet to the mile in passing northward. To the west from Weir to Mineral there is an average dip of 12 feet to the mile.

A comparison of the dip of these two beds shows a thickening of the shales separating the beds at the rate of eight feet to the mile as we go westward, indicating that there must ha ve been a more rapid formation of shales in the west. The dip of the Cherokee shales is quite marked, and it soon carries them below the higher formations.

Arcadia Area.

There are three strata found at Arcadia. The upper is mined at Bunker Hill and Coal Mound. The second stratum is stripped just east of Arcadia. Coal is mined from the third at Coalvale, a few miles south of Arcadia. The coal strata here average 20 inches. See Fig. 4.

Fort Scott Area.

The Fort Scott coal is found in two beds near the top of the Cherokee Shales. The upper bed lies from 6 to 10 feet below the lower Oswego limestone, and the lower bed lies 60 feet or more lower still.

Mining was first begun at Fort Scott about 1865. As the coal is so near the surface, it is subject to the various weathering agents which have oxidized the iron sulphide, giving the coal a red appearance.

When the Kansas City, Fort Scott and Memphis Railroad in 1869 entered Fort Scott a great demand for coal was created; but later when the road was extended further south, it was found more profitable to get coal in the south, where the beds were thicker. This led to a decline in the coal trade, which is now confined principally to supplying the local demand. Considerable quantities of coal are mined and carted into Fort Scott by people working at odd times.

Leavenworth Area.

There has been no coal mined from the Cherokee shales north of Fort Scott, until we reach Leavenworth. The coal is here obtained from the upper part of the Cherokee shales, and averages 2 feet in thickness. About 25 feet below this bed is another bed of coal of about the same thickness and quality. Still further below this, is another bed about equal to the others. The lining area lies southeast of the Oread escarpment, so that the Lawrence shales must be passed thru in order to reach the coal. The same horizon extends into Missouri, where coal has been mined from it for many years.

History and Development of the Leavenworth Area: In 1859, the Leavenworth Coal Mining Company was organized, thru the persistent efforts of Major Hawn. Major Hawn had studied the strata of Missouri, and was convinced that coal was to be found at Leavenworth. The other members of the firm, not having faith in Major Hawn's convictions, abandoned the enterprise, and transferred all their rights to Major Hawn, who continued the work as fast as his limited means would allow.

In 1865, a 2 foot bed of coal was reached. The right to mine under the streets and alleys of Leavenworth was obtained from the city, and a new company was formed. The shaft reached coal at 713 feet, in

1870. At first, the mine did not prove a very paying investment, but after two years, a skillful engineer was employed, and under his direction the mine soon became profitable.

Since then, a number of companies have been formed, and the industry has greatly increased. The following table will show the production and the number of men employed by the Leavenworth mines.

Leavenworth Company --------	112,261 tons,	301 men
Home-Riverside Company- ----	190,000 "	435 "
Penitentiary mine----------	64,880 "	336 "
Total of Leavenworth Co. -	367,141 "	1,072 men

Coal Production from the Cherokee Shales.

The foregoing discussion shows that the Cherokee shales are a rich coal producing formation. The table showing the output by counties shows for the year 1897 that the Cherokee shales produced 93.32 per cent of the output of coal in the state.

As to the future production of coal from the Cherokee shales, it is difficult to make any definite statements. At the present rate of mining, the now available coal near the surface will be exhausted in a few generations. How far westward coal may be found cannot yet be stated, but from present indications the coal supply gradually diminishes as we go westward; so the prospects of more coal in the west are not very encouraging. However, time may still reveal some beds that have not yet been discovered.

LABETTE AND PLEASANTON SHALES.

The Labette shales, as far as known, carry but little coal.

The Pleasanton shales, however, are rich in coal, particularly in the lower parts. Considerable quantities are mined in Linn and

Bourbon counties, both the strip and the pit methods being used. In thickness, the coal varies from 16 to 30 inches, and is of good quality.

In the vicinity of Pleasanton, Boicourt, and La Cygne the shafting method of mining has been extensively used. Coal is reached here at a depth of 60 to 100 feet. Farther to the west, it is mined to some extent by stripping.

LAWRENCE SHALES

The Lawrence shales form the first coal-bearing horizon above the Pleasanton shales. This shale bed extends entirely across the state, from north to south, with a maximum thickness of 600 feet.

There are two distinct beds of coal in the Lawrence shales. The Lower one, in the vicinity of Lawrence, is 150 feet below the Oread limestones, and the Upper one, in the vicinity of Atchison, is about 30 or 50 feet below the Oread limestones.

Formerly coal was mined in Douglas County, at various places; but of late these mines have been entirely abandoned. In Franklin County, there are still some mines in operation. The strip pit process is principally used. The coal beds here are about 16 inches in thickness.

At Atchison, the mines were opened in 1893, and have been in operation since that time. The Atchison coal is of a better quality than the coal found elsewhere in the Lawrence shales. The bed reaches a thickness of 16 inches or more at Atchison.

It is impossible to give accurate statistics in regard to the production of coal from these shales; but up to the present time,

according to estimation, at least a hundred thousand tons have been produced from these shales.

OSAGE SHALES.

The only shales within the Shawnee formation that bears coal is the upper one, the Osage shales. This is the strongest rival of the Cherokee shales. It is situated 2000 feet vertically above the Cherokee shales, corresponding to terranes generally considered barren in other parts of America.

History of the Development of the Osage Coal.

Coal was first discovered in the Os age shales in 1869, by Mr. John F. Dodds, who began mining at Carbon Hill, near Carbondale in the northern part of Osage County. In the fall of the same year, mines were opened at Osage City, and five years later, mining was begun at Peterton.

At Burlingame, coal was reached at 90 or 100 feet, and mining was begun in 1878 or 1879.

Since 1880, most of the mining has been done by the Sante Fe Railroad Company; but at present the Mont Carmel Company does over 45 per cent of the whole business.

Geologic Position of the Osage Coal.

The Osage shales have an average thickness of 200 feet. The coal is found about midway in the shales. In Osage County, the coal averages from 20 to 22 inches in thickness.

There is a general inclination of the strata to the northwest and west. At Burlingame, there is a synclinal trough which makes the coal lower than elsewhere. At Carbon Hill, the coal is 1100 feet

above sea level, while at Scranton, five miles southwest, it is only 1000 feet above sea level; and at Burlingame, it is 950 feet above sea level. From here to the south, it gradually rises, being 1025 at Osage City, and 1125 at Lebo. It now gradually declines, reaching a height of 1050 above sea level at Eureka. From Carbon Hill to Topeka it declines but from here it gradually rises to the northeast.

Coal has been mined from these shales both north and south of Osage County, but not on such an extensive scale, as the thickness of the coal is reduced to from 14 to 18 inches as we go north or south from Osage County.

A large amount of coal has been produced from these shales, but there is still plenty left, which may be obtained whenever the price of coal rises a little so as to make the mining profitable.

HORSEBACKS OF THE KANSAS COAL MEASURES.

Horsebacks are certain peculiar formations found in the Kansas Coal Measures. From an economic point of view, they are of considerable importance in coal mining. Various names have been applied to these formations such as: "horse," "want," "trouble," "nip," and probably best of all "clay veins."

Localities.

"Horsebacks" are found in nearly all the coal fields of America, but the size and frequency of their occurrence varies greatly in different places. In Kansas, the "horsebacks" are most numerous in the Cherokee shales, in the southeastern part of the state; but they are entirely absent in the Leavenworth beds. Here, however, we find another kind of formation known as "bells," which will be considered later.

Nomenclature: In Kansas, the term "horseback" is applied to almost vertical fissures, filled with clay; but in Pennsylvania such formations are known as "clay veins." A bulging up or dipping down of the strata from above or below the coal is called a "roll in the slate." This is what they mean by a "horseback", "nip," "want," etc., and these terms will be used in this paper.

Characteristics of Horsebacks.

Forms of the Fissures: The "horsebacks" of Kansas seem to be fissures filled with clay formed after the consolidation of the coal. From all appearances, there is no regularity in the direction of these fissures. The average width is less than 5 feet. In general, the "horsebacks" pass from below up, as shown in figures 6 and 7, but in some cases they pass from above down.

Nature of the Walls. The walls of the fissures are usually rough and ragged; but in some cases, they are smooth and polished. Sometimes, fragments of coal are found in the fissures, as if they had fallen into them at the time of formation. Again, there seems to have been a lateral compression after the fissure has been formed and filled. These different conditions are illustrated by the figures showing the "horsebacks."

Extent of the Fissures. No accurate or definite statement can be made in regard to the extent of the fissures since it is so difficult to trace them underground. Instances are known where they have extended over half a mile.

Contents of Fissures. In general, the fissures are filled with fire clay, and in a few instances, fragments of coal and sandstone are mixed with it. As a rule, the clay is finely divided, and has no

regular structure; altho in a few cases a lenticular structure is found.

Crossing of Veins. "Horsebacks" are seldom found alone, but are frequently crossed by other similar veins. Sometimes a given vein is crossed and recrossed by another vein. In some cases, one vein cuts another, just as the "horsebacks" cut the coal, indicating a difference in the time of formation of the two fissures. See figure 10.

Origin of "Horsebacks."

Theories of Formation. Various theories have been advanced to account for the formation of "horsebacks," "clay veins," etc; but as they fail to correspond with observed facts, we need not consider them here.

Observed Phenomena. The statement of a few observed facts may help us arrive at a probable theory of their origin.

1. The walls of the fissures are broken and ragged, as if torn or broken apart.

2. "There is always an upward displacement of the shale at the upper extremities of the clay veins." Figure 30.

3. The fire clay in the fissures is generally homogeneous.

4. Fragments of coal are frequently found in the clay, and sometimes their former place in the wall can be determined. Figures 9 and 11.

Probable Origin. From a study of observed facts, Mr. Haworth arrives at the following conclusions as to the origin of "horsebacks:" Long after the coal had been consolidated, vibratory movements of some sort fissured the strata. When the fissures were formed, the pressure

on the fire clay under the coal beds would be relieved in places, causing the clay to move upward and fill the fissure. The fragments of coal in the fissures can be accounted for by pieces breaking off, and falling into the fissure.

Since there are no violent vertical displacements, the vibratory movements must have been comparatively gentle. At the same time that the vibratory motion took place there seems to have been a stretching of the strata; and in this way the fissures were formed.

It is not possible to give the age in which these fissures were formed; but from observed facts, it seems probable that the greater number of them were formed during the period known as the Ozark uplift.

"BELLS" IN THE KANSAS COAL MEASURES.

These are pot or bell shaped structures found in mines, and probably receive their name from ther form.

They are found abundantly in the Cherokee shales, in the vicinity of Leavenworth, but are rarely found to the south.

Characteristics of Bells.

Form of Bells. Perhaps the best way to get an idea of the forms of bells is to examine figures 14 and 15. The bells do not vary greatly in size or shape. The average diameter of the bells is about 4 feet. The bells generally pass from above downward into the coal, several inches, and in some cases, passing entirely thru the bed. In a few cases, the bells are inverted as shown in figure 15.

Nature of Lateral Portions. As a rule, the sides of the bell and the adjacent coal are very smooth. There are no signs of any

fractures or displacements, and as yet no coal fragments have been found in the matrix of the bell.

At the junction of the bell and the coal, there is a seam which contains a small layer of smooth anthracite coal, as shown in figures 14 and 15.

Contents of Bells. The matrix of the bell is shale just like that around it, except that it differs a little in lamination and contains a greater number of fossil invertebrates.

Origin of Bells.

Observed Phenomena. 1. "The lateral parts of the projecting body are smooth and even, often being marked with creases, which always extend in a vertical direction. These creases are similar to those observed when two pieces of wood or rock masses are caused to slip one upon the other when under high pressure."

2. "The laminae of the coal have not been disturbed."

3. "The character of the contents does not differ from the adjacent shales of the roof."

4. "The laminae of the contents of the bells are in the form of concentric circles or elipses -- that is, always parallel to the outside of the bell."

5. "There is a larger number of invertebrate fossils in the matrix of a bell than in a corresponding portion of the adjacent shales."

6. "The seam produced by the junction of the coal with the bell often extends upward into the overlying shale strata. When this occurs, the fissure is always filled with coal which has been changed to anthracite."

7. "No coal or rock has yet been found in the matrix of the bell."

Probable Origin. After a careful study of the observed facts, Mr. Haworth thinks that the bells have been formed in a manner something like the following: During the accumulation of coal forming, there were slight irregularities of various sorts in the amount of accumulated material, due, perhaps, to water currents, burrowing animals and the like. As the overlying strata were formed, their weight would tend to depress the roof strata down into the depressions of the coal.

The laminations, the larger number of fossils, the fissures in the overlying shales, and the presence of thin laminae of coal within these fissures can all be accounted for by this theory.

NOTES AND DRAWINGS.

Figure 1 is a generalized vertical section of the Coal Measures of Kansas showing the order, position, and average thickness of the various strata from the Sub-carboniferous limestone up to the Burlingame limestone. The Coal Measures of Kansas are divided into the Upper and Lower as shown in the section.

GENERALIZED SECTION OF COAL MEASURES.

Fig. I.

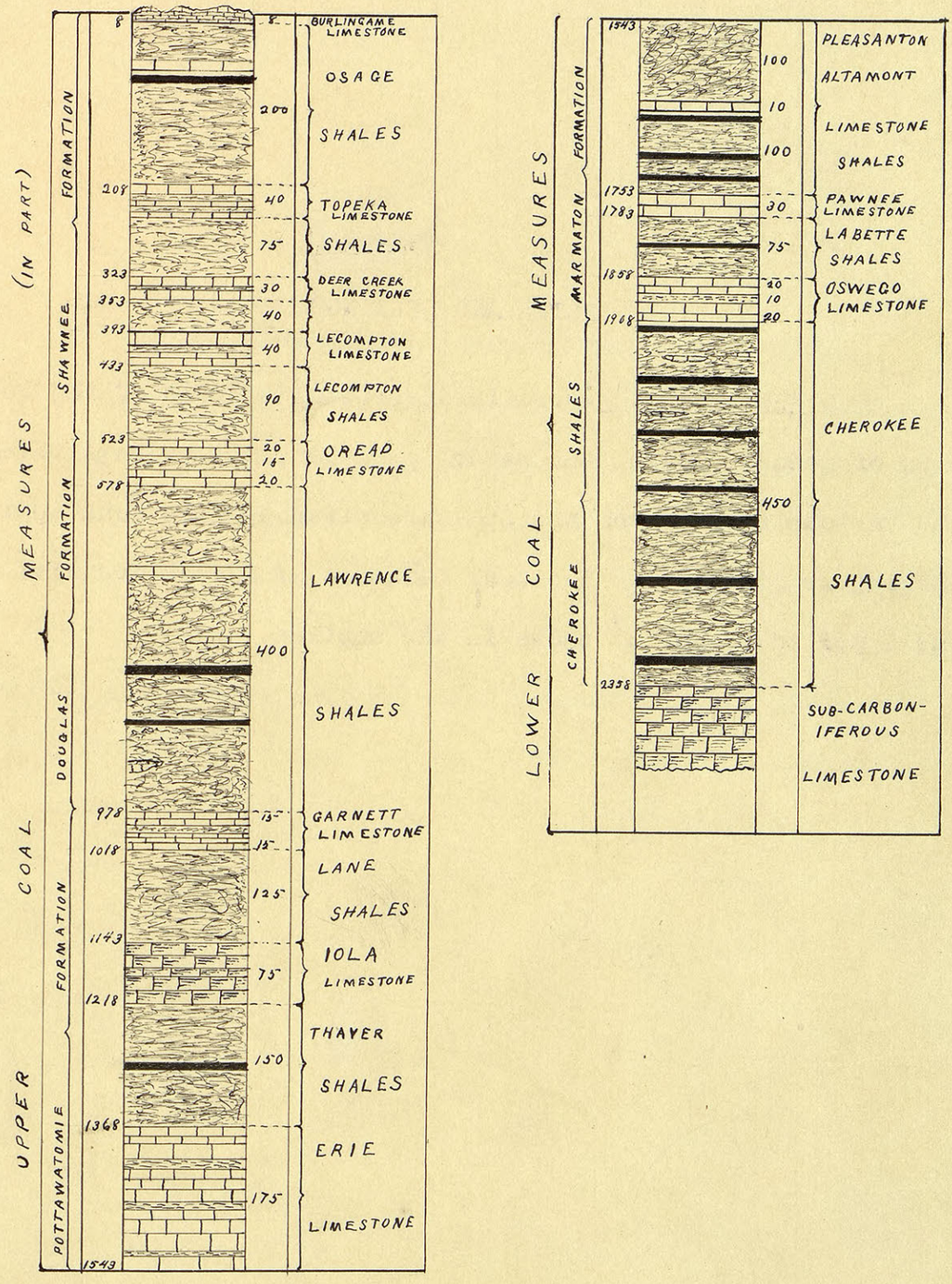


Figure 2 is a section along the Kansas River from Wilder to Sugar Works. This section shows where the various strata crop out along this line and also shows the general dip of the strata.

Figure 3 is a section along the Osage River from Ottawa to Burlingame showing the succession of the strata and where they crop out.

Figure 4 is a section thru Arcadia showing the position of the coal and the succession of the strata.

SECTIONS.

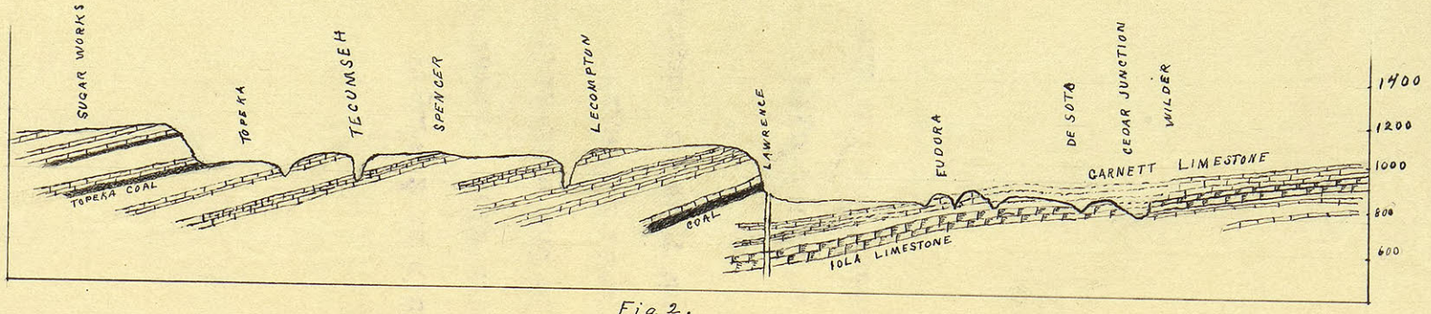


Fig. 2.

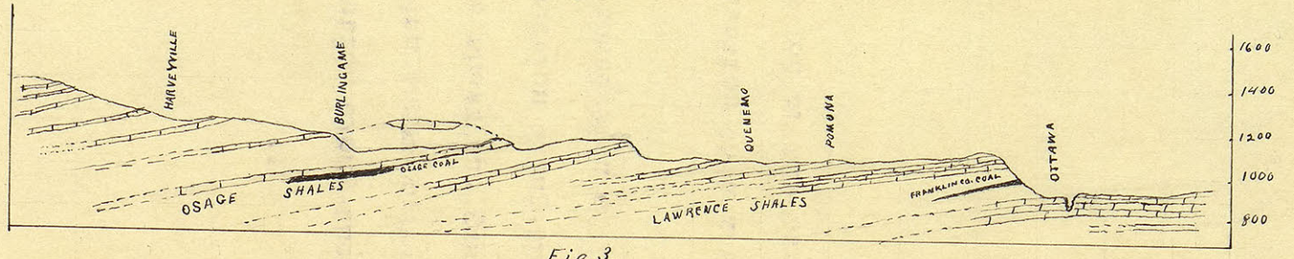


Fig. 3.

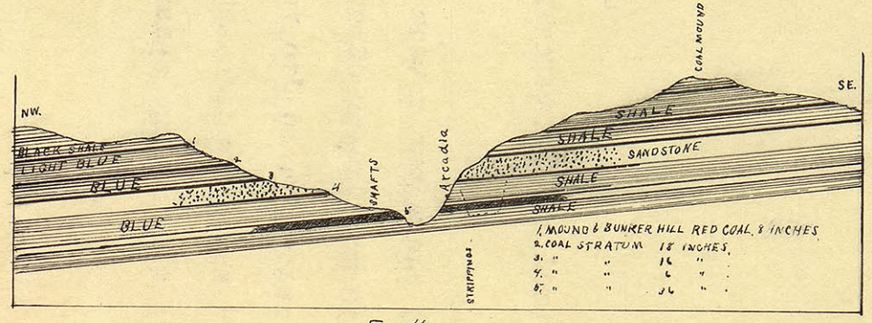


Fig. 4.

III

Figure 5 is a map of Eastern Kansas showing the surface areas of the Cherokee shales and the most important limestonesiin Eastern Kansas. These surface areas are shown on the map by means of different colors. A, B, C, D, E, and F represent the Cherokee shales, and the Oswego and Pawnee, the Erie, the Iola and Garnett, the Oread, and the Burlingame Limestones respectively; and the lines a', b', c', d', and e' mark the place where each stratum dips below the one to the west of it. The lines a', b', c', d', and e', also mark the eastern limits of the various limestones as shown by the different colors on the map.

A COAL MAP OF EASTERN KANSAS.

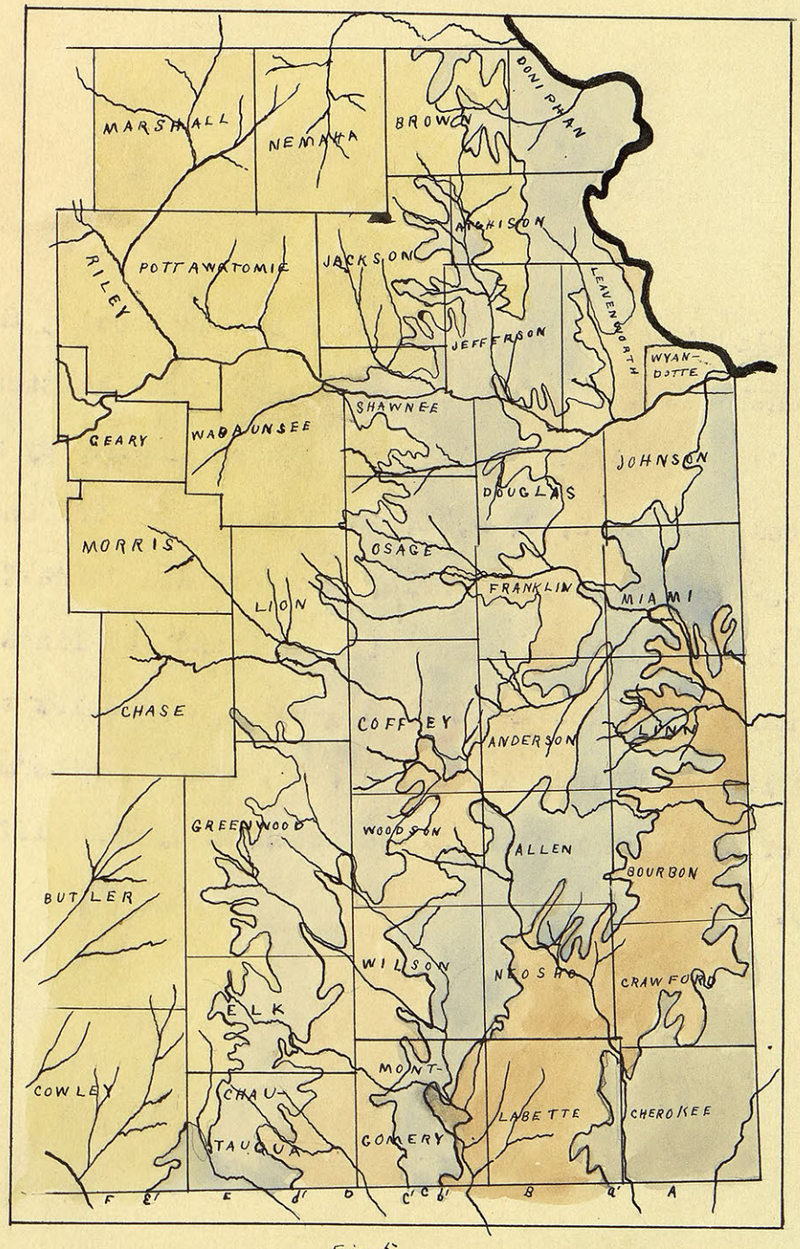
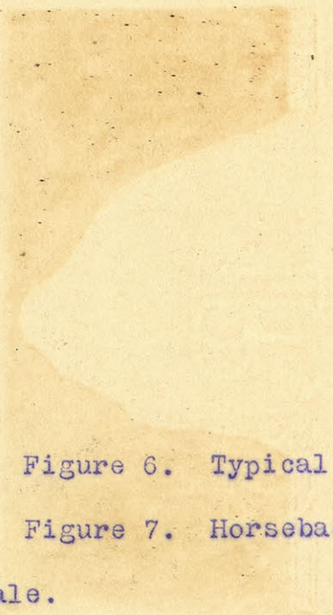


Fig. 5.



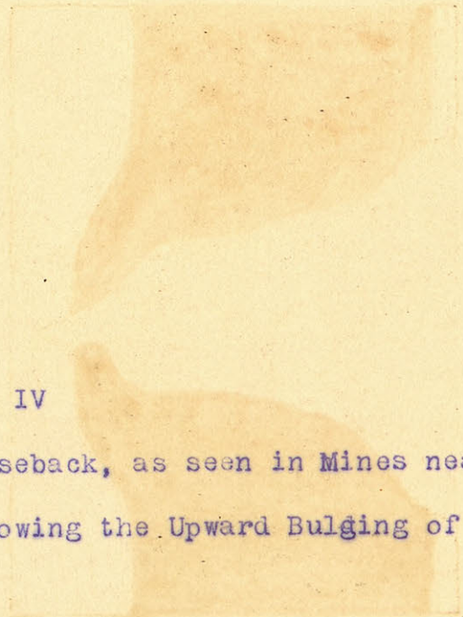
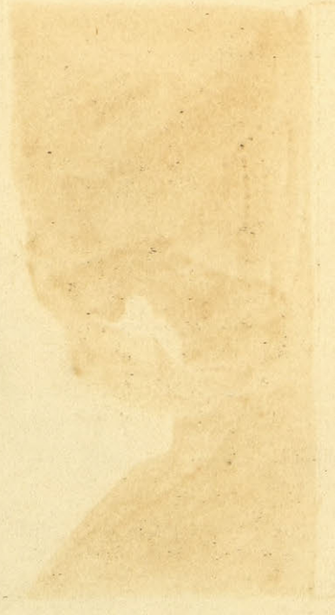


Figure 6. Typical Horseback, as seen in Mines near Pittsburg.

Figure 7. Horseback showing the Upward Bulging of the Coal and shale.

Figure 8. Horseback showing the Fragments of Coal scattered thru the Fire Clay, as seen in Mines near Pittsburg.

Figure 9. Horseback protruding into Coal Stratum from above, as seen in Mines north of Pittsburg.



HORSEBACKS.

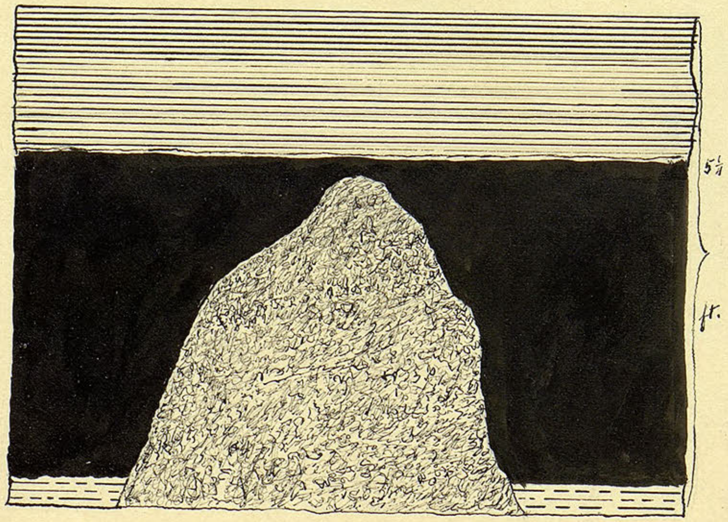


Fig. 6.

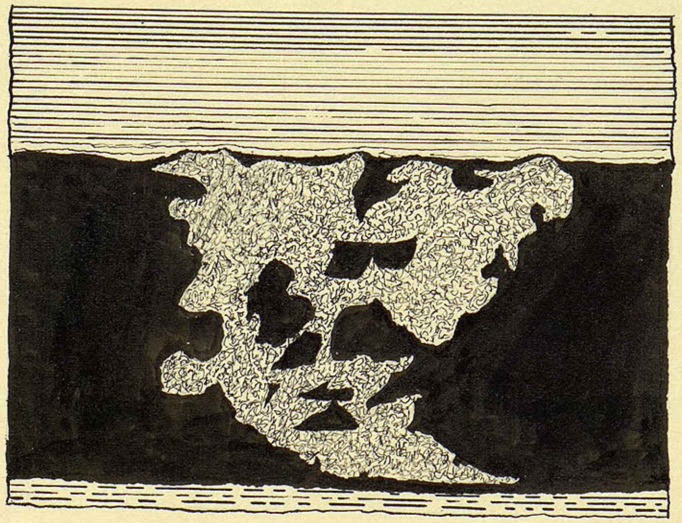


Fig. 8.

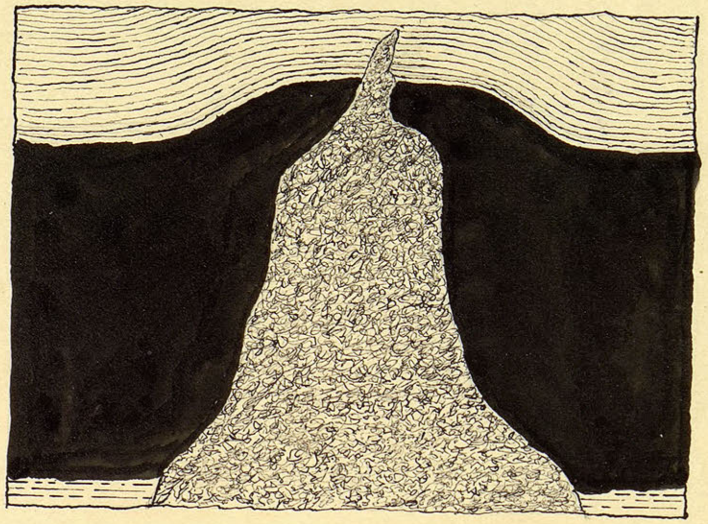


Fig. 7.

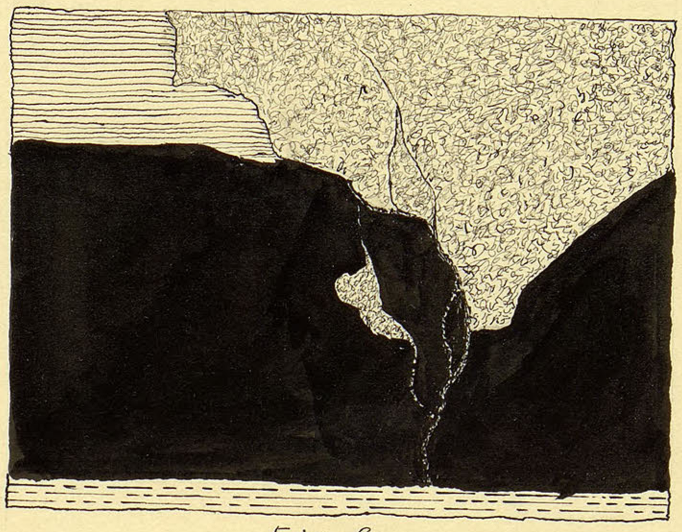


Fig. 9.

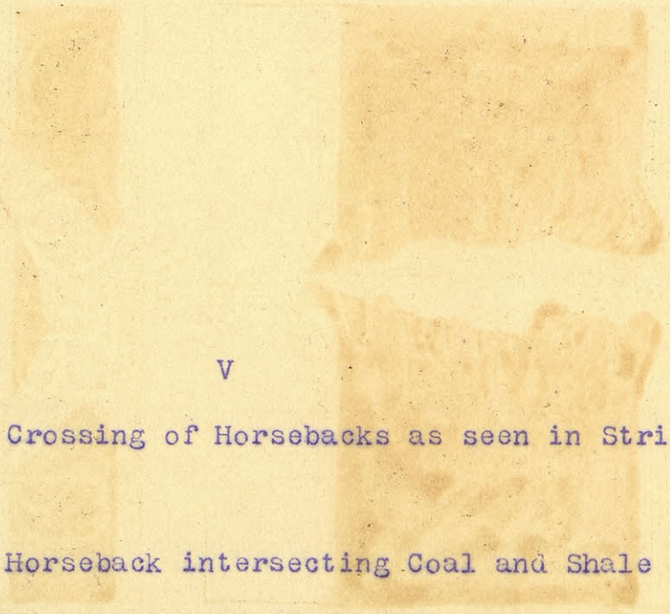
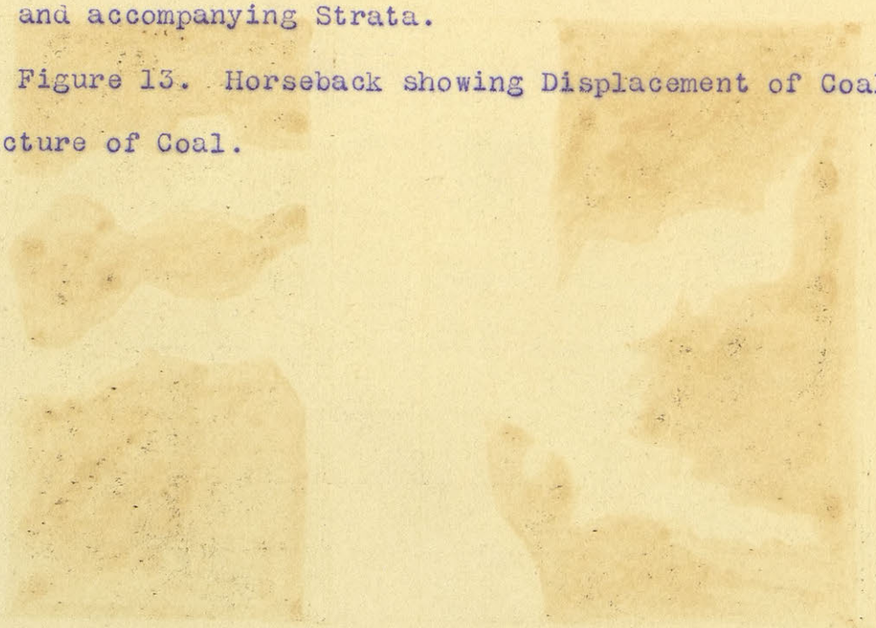


Figure 10. Crossing of Horsebacks as seen in Strip Pits near Weir City.

Figure 11. Horseback intersecting Coal and Shale Strata, showing Stretching Effects of Earth Movements, as seen in Mines near Pittsburg.

Figure 12. Horseback showing upward and downward displacement of Coal and accompanying Strata.

Figure 13. Horseback showing Displacement of Coal and Shale, and Fracture of Coal.



HORSEBACKS.

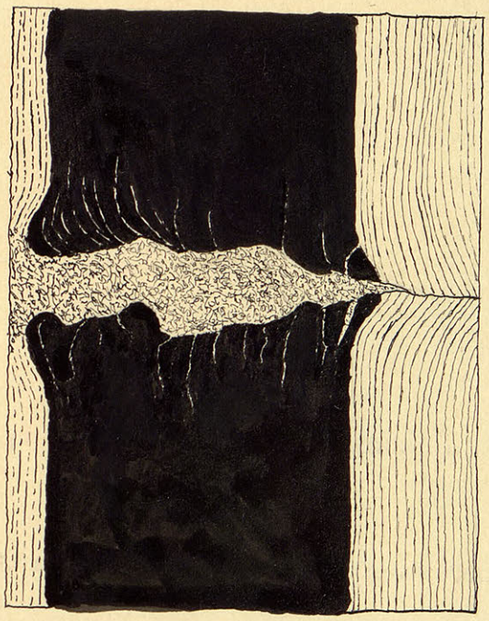


Fig. 12.

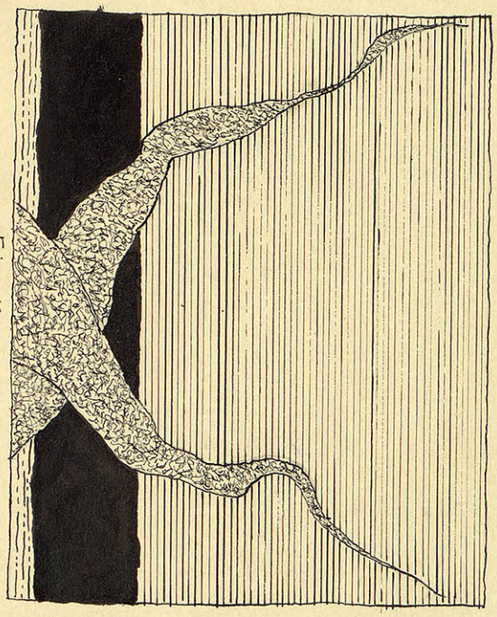


Fig. 10.

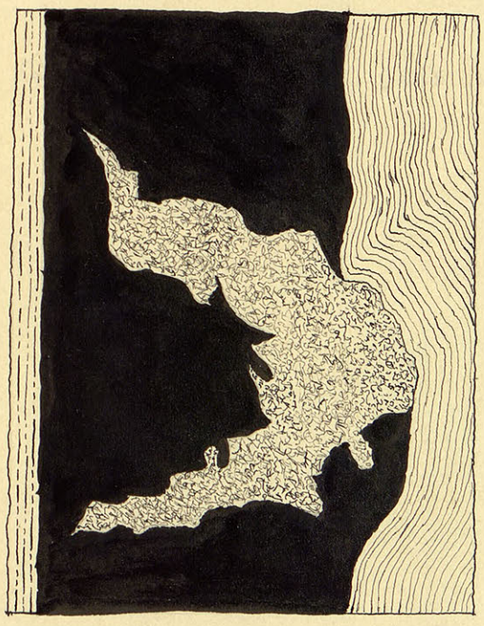


Fig. 13.

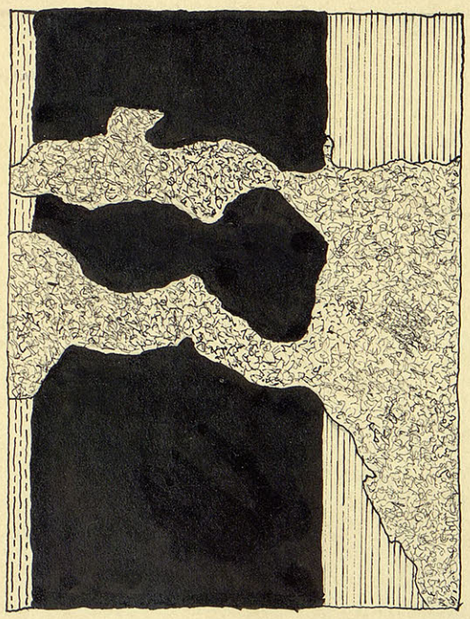


Fig. 11.

Figure 14. Typical Bell, as seen in the State Mine at Lansing.

Figure 15. Inverted Type of Bell, as seen in Mine west of Prescott.

BELLS.

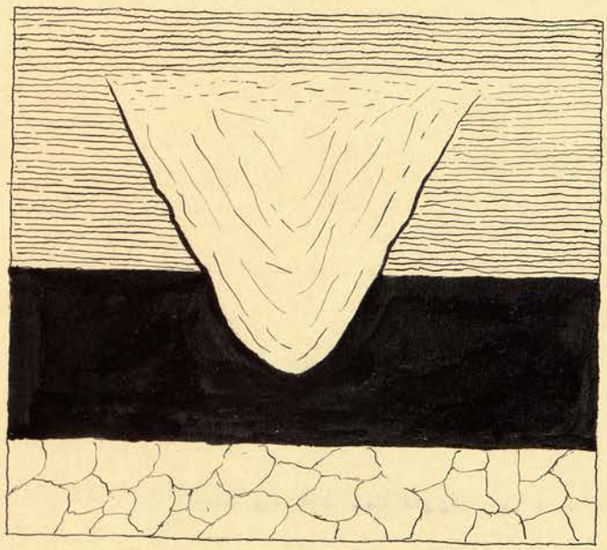


Fig. 14.

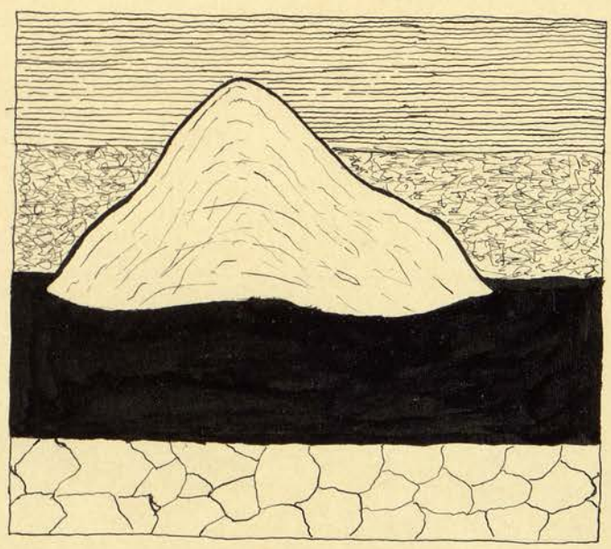


Fig. 15.