GEOLOGY OF MONROE COUNTY.

BY

S. W. BEYER AND L. E. YOUNG.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Monroe is one of the smaller counties of the state and is a regular rectangle containing twelve Congressional townships or about 432 square miles. It lies in the southern tier of counties but one and numbers seventh and fifth from the Missouri and Mississippi rivers respectively. Three lines of railway extend entirely across the county while two other systems enter and give outlets to important coal fields. Monroe county is in the center of the great bituminous coal industry of the state and in 1901 became the banner county both in total output and the number of

men employed, surpassing Mahaska county, which had for many years consistently held first place. In 1902 Monroe more firmly established her supremacy as the ranking mining community in the state, mining being second only to agriculture.

PREVIOUS GEOLOGICAL WORK.

Monroe county is traversed by none of the larger streams of the state and the reports of early reconnaissance surveys in the Mississippi valley fail to make specific mention of the physical or geological features of the county. The area was within the general territory mapped by Nicollet as early as 1841, but none of the features within its confines were sufficiently prominent to receive individual mention.

Owen* in 1846 and 1847 traversed the Des Moines river and ascended Cedar and Bluff creeks, but no mention is made of any of the points of interest in Monroe county. Numerous sections are described in the southern tier of townships in Marion and Mahaska counties within a few miles of the Monroe county border. In many of these the conditions are not unlike those farther up the creeks in the north tier of townships of Monroe county. On section 30, township 74 N., range XVIII W., an outcrop on the southern branch of Cedar creek is described in which the author states that a seam of coal varying from four to six feet in thickness and of pure quality may be found. He also makes mention of a laminated sandstone containing the remains of *Lepidodendron sternbergii* outcropping on section 15 of the same township. The sandstone formation is overlain by a selenite-bearing shale, immediately under which was a bed containing cone-in-cone structure, or the *Tuten-mergel* of the Germans. Several other sections are described in detail.

Hall,† in his work on the Coal Measure of Iowa, mentions the section exposed on the south side of the Des Moines river at Eddyville, and indicates the relations between the Coal Measures and the underlying limestone.

A decade later White‡ gives a brief summary of the geology of the county. Incidentally he mentions the presence of the Lower

*Geological Survey of Wisconsin, Iowa and Minnesota, pp. 114 *et seq.* Philadelphia, 1852.
†Geology of Iowa, Vol. I, pp. 165–166, 253-254. Des Moines, 1858.
‡Geology of Iowa, Vol. II, pp. 267–8. Des Moines, 1870.

Coal Measures over almost the entire county and states that they are overlain by the Middle Coal Measures. In the same volume Professor Rush Emery gives the results of analyses made of several samples of coal obtained from the mines then in operation.

McGee* makes reference in his "Pleistocene Iowa" of a complex drift section exposed along the railroad south of Albia. Several references are made to the geology of the county in the reports of the present Survey, and due credit will be given where such references are used in this paper.

The reports of the State Mine Inspector, especially the early numbers, contain considerable information regarding the coal and Coal Measures stratigraphy. Some of the drill sections will be found in a later portion of this report.

PHYSIOGRAPHY.

TOPOGRAPHY.

Monroe county belongs to the dissected plain type of topography. It is typically erosional in character, the surface features conforming to the drainage lines. The ridge crests rise to about the same level and when produced roughly approximate the original plain before it was acted upon by the streams. A marked divide mapped out by the Wabash railway bisects the county into almost equal east and west halves. The streams on either side have worked headwards completely draining the area and producing very gentle undulations in the watershed even when viewed longitudinally. Albia is located on this watershed at a point where its direction changes from northwest-southeast to west of south and from which point the streams radiate in practically every direction. The divide when viewed broadly inclines gently to the north as indicated in the table of elevations; Moravia showing an altitude of 1002 feet, Albia 959, and Lovilia 932. The stream valleys and hill slopes are generally well wooded while the divides are prevailingly prairie. This is the general rule even in the case of the minor drainage lines. The maximum general inequalities vary from 677 feet, low water level of the Des Moines river at Eddyville, to about 1000 feet on the Albia-Moravia divide

*Sixth Ann. Rep. U. S. Geol. Surv., Vol. 493-4. Washington, 1891.

near the south county line. The local inequalities do not as a rule exceed 100 feet, although occasionally reaching about 150 feet. The entire surface is fairly well drained and may be designated as topographically mature. All of the topographic features may be ascribed directly to stream work and can best be understood when studied in conjunction with the drainage lines.

The elevations of the principal representative points in the county are given in the table herewith appended:

TABLE OF ELEVATIONS.

PLACE.	Altitude above tide water.	AUTHORITY.
Albia	959	Chicago, Burlington & Quincy Railway.
Brompton	950	Chicago, Milwaukee & St. Paul Railway.
Buxton	799.7	Chicago & Northwestern Railway.
Coalfield	727	Iowa Central Railway.
Consolidation Coal Company, Shaft No. 10	844.3	Chicago & Northwestern Railway.
Consolidation Coal Company, Shaft No. 11	948.7	Chicago & Northwestern Railway.
Des Moines River, Eddyville	677	Iowa Central Railway.
Dudley	697	Chicago, Burlington & Quincy Railway.
Eddyville	685	Iowa Central Railway.
Foster	904	Chicago, Milwaukee & St. Paul Railway.
Frederick	737	Chicago, Burlington & Quincy Railway.
Hagerty	946.2	Chicago, Burlington & Quincy Railway.
Hamilton	905.5	Chicago, Burlington & Quincy Railway.
Lovilia	932.3	Chicago, Burlington & Quincy Railway.
Melrose	891	Chicago, Burlington & Quincy Railway.
Moravia	1001.6	Wabash Railway.
Selection	973.3	Wabash Railway.
Tower	815	Chicago, Burlington & Quincy Railway.
Tyrone	839	Chicago, Burlington & Quincy Railway.

DRAINAGE.

The streams which have to do directly with the drainage of the county are unimportant individually with the exception of the Des Moines river, which barely truncates the northeast corner of the county. With this exception none of the streams are persistent through their entire courses during seasons of protracted drouth. During the exceptionally dry year of 1901 the majority of the streams which are shown on the map were entirely dry or reduced to a series of disconnected ponds and pools. In many instances, however, the isolated ponds gave no evidence of stagnan-

cy but indicated rather a sub-surface drainage connection through the stream gravels. Most of the streams have done considerable cutting even to the tributaries of the second order, fully draining the divides and giving the country a broken appearance

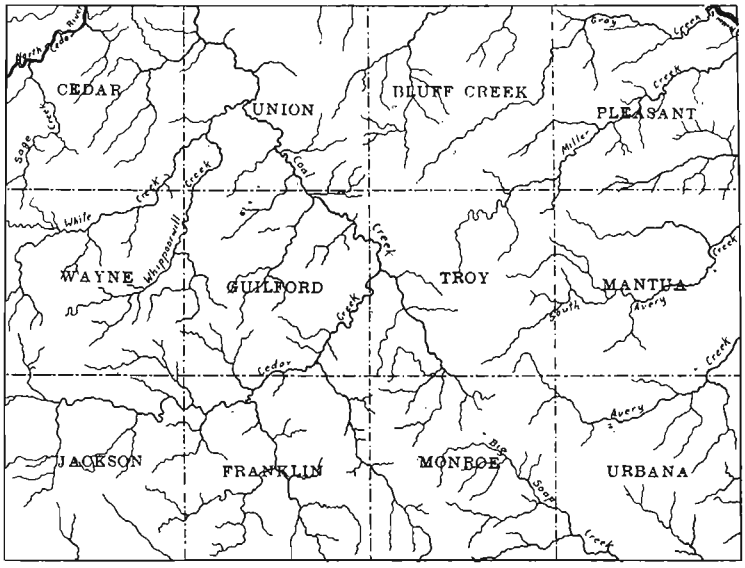

FIG. 51. Sketch map showing the drainage of Monroe county.

characteristic of south-central Iowa. While the work of degradation accomplished by the streams is great in the aggregate, their energies have been devoted chiefly to channeling and but little has been done toward the production of broad valleys and the upbuilding of flood plains. In fact but few of the drainage lines have mapable flood plains according to the scale used in these reports. While the distance from bluff to bluff may attain several hundreds of yards the steep slopes render obvious the instability of the materials and greatly limit the true flood plain deposits. The materials in many of the stream channels tell the same story by their coarseness in texture, evidencing the carrying power of the streams. This is notably true of all those directly tributary to the Des Moines river.

The Des Moines River System.—The Des Moines river, with its numerous tributaries, drains about thirty-nine fortieths of the county, the remaining fortieth finds outlet through the Chariton system. The most important tributaries of the Des Moines are Cedar river, Coal, Bluff, Gray, Miller, Avery and Soap creeks. A marked divide sought out by the Des Moines branch of the Chicago, Burlington and Quincy railroad and the Wabash and the Iowa Central below Albia, separates the tributaries of Cedar river, Coal creek and the Chariton river system from the easterly flowing feeders of the Des Moines. From the town of Albia the streams flow towards all points of the compass save northwest.

The Cedar river, whose confluence with the Des Moines is in Marion county, with its leading tributary Coal creek, drains more than half the county. Both streams flow almost due north as they leave the confines of the county and their most important branches flow in the same direction, paralleling the Albia-Lovilia divide. Cedar river proper drains scarcely half a township while Coal creek, with its sinuous bifurcating branches collects the run-off from half the county. Cedar river has a low gradient and presents a narrow flood plain. The indurated rocks are exposed only near the Marion county line.

Coal creek does not depart materially from the usual type of Iowa stream, being asymmetric and receiving the larger tributaries from the west, in fact, receiving none worthy a name from the east. From north to south the branches are White, Whippoorwill, Bee and Cedar; the last being the most important and draining all of Franklin and portions of Wayne, Guilford, Troy and Monroe townships. The main line of the Chicago, Burlington and Quincy railroad follows Cedar creek from the west border of the county to its junction with Coal creek. The old right-of-way closely paralleled the water grade while the new road cuts numerous headlands and is more or less independent of the immediate stream valley. Both Cedar and Coal creeks and their northern tributaries have cut completely through the drift at numerous points and expose limited sections of the Coal Measures. South of Cedar creek stream cutting is confined wholly to the drift. All of the streams have comparatively narrow valleys and alluvial deposits are of scarcely mapable dimensions. Terraces

are not prominent, but certain poorly defined gravel benches may be viewed along White and Whipporwill creeks in Wayne township forty to fifty feet above the present channel. A fairly prominent terrace may be seen along Cedar creek in Union township. Fragmentary terraces may be noted at other points but are so greatly obscured by the loess and recent wash that it is almost impossible to trace them with any degree of confidence.

East of the Albia-Lovilia divide the creeks which drain into the Des Moines, listing them from north to south, are Bluff, Gray, Miller, the Averys and Soap creeks; all flowing approximately at right angles to the divide. Here, as is the case with streams west of the divide, those draining the northern portion of the county have completely incised the drift and expose the indurated rocks at numerous points. All of the streams possess high gradients and all are yet in the down cutting stage a few miles away from the Des Moines river. Miller and Gray creeks show numerous escarpments and give a very rugged character to the adjoining topography.

The Des Moines river cuts off from the northeast corner of the county an isoceles triangle whose base is scarcely more than half a mile in length. The river flows through a broad valley bounded by low bluffs which rise gradually for some distance inland until the level of the general upland is reached some two miles back. The belt flooded by ordinary high water is small as compared with the width of the valley. At Eddyville and vicinity the valley varies from a mile to one and a half miles in width, while the actual belt subject to inundation does not exceed from one-fourth to one-half that width. A well marked terrace appears some twenty feet above low water level and can be traced more or less continuously on one or both sides of the river. Near Eddyville this terrace is often rock supported in part. Terraces at a higher level cannot be recognized.

The Chariton System.—The tributaries representing the Chariton system are unimportant. None have cut through the drift and none persist through dry seasons.

Age of the Streams.—All of the tributary streams appear to be post-Kansan. The Des Moines river alone occupies a preglacial valley.

STRATIGRAPHY.

GENERAL RELATIONS OF STRATA.

Monroe county lies well within the accepted limits of the Western Coal Field. The Des Moines river and a few of its tributaries near the northeastern corner of the county have cut entirely through the drift and Coal Measures and uncover the Saint Louis limestone. The Lower Carboniferous constitutes the country rock for less than two square miles in the county. The Coal Measures while universally present are quite generally concealed by the drift and only fragmentary exposures may be observed along the drainage lines. The most important sections occur in the northern half of the county.

The Pleistocene series is represented by an older drift sheet everywhere covered by the loess save where removed by erosion. The physiographic features in general are but little influenced by the older rocks.

The taxonomic relations of the formations represented in the county are shown in the following synoptical table:

GROUP.	SYSTEM.	SERIES.	STAGE.	FORMATION.
Cenozoic.	Pleistocene.	Recent.		Wind Deposits. Alluvium.
		Glacial.	Iowan. Kansan. Aftonian?	Loess. Drift. Grave's?
Paleozoic.	Carboniferous.	Upper Carboniferous or Pennsylvanian.	Des Moines.	Chariton Conglomerate. Appanoose Beds. Monroe Beds.
		Lower Carboniferous or Mississippian.	Saint Louis.	Limestone. Sandstone.

The two great systems of rock represented in the county are separated by an unconformity of the first magnitude. This un-

conformity means an enormous time interval during which the surface was subjected to erosion, a large proportion of the Coal Measures doubtless being removed. The entire Mesozoic and most of the Cenozoic rock systems are wholly unrepresented. The oldest rocks appear in the northeastern corner of the county, but pass out of sight almost immediately away from the valley of the Des Moines river. The general dip of the strata is to the southwest at a very low angle, scarcely more than an average of five feet per mile, while local undulations, as evidenced by coal seams, have dips which are much greater, often exceeding five degrees.

Mississippian Series.

SAINT LOUIS STAGE.

Only the uppermost member known to occur in Iowa is represented and comprises a very limited area in the immediate vicinity of the Des Moines river at Eddyville. Outcrops are confined to Gray and Miller creeks and the Des Moines river. On Miller creek south of Eddyville the following section may be observed:

		FEET.
7.	Drift and surface wash	5
6.	Shale, arenaceous, with calcareous cement	7
5.	Limestone, compact, brittle, containing pyrite balls	3
4.	Limestone, öolitic, evenly bedded and shows much shell breccia	3½
3.	Marl, containing Rhynchonella casts	½
2.	Limestone, compact, lithographic, becoming softer below	4
1.	Sandstone, in heavy beds, often exhibiting cross bedding planes, exposed above creek bed	25

All of the beds mentioned above save number 7 are supposed to belong to the Saint Louis and the sequence is believed to be fairly representative for the district. Outcrops may be noted on either side of the Des Moines river both above and below Eddyville, but none of them show any new members or any decided variations from the type section. The low terrace along the Des Moines, mentioned in an earlier portion of this paper, is supported by numbers 4 and 5 of the standard section.

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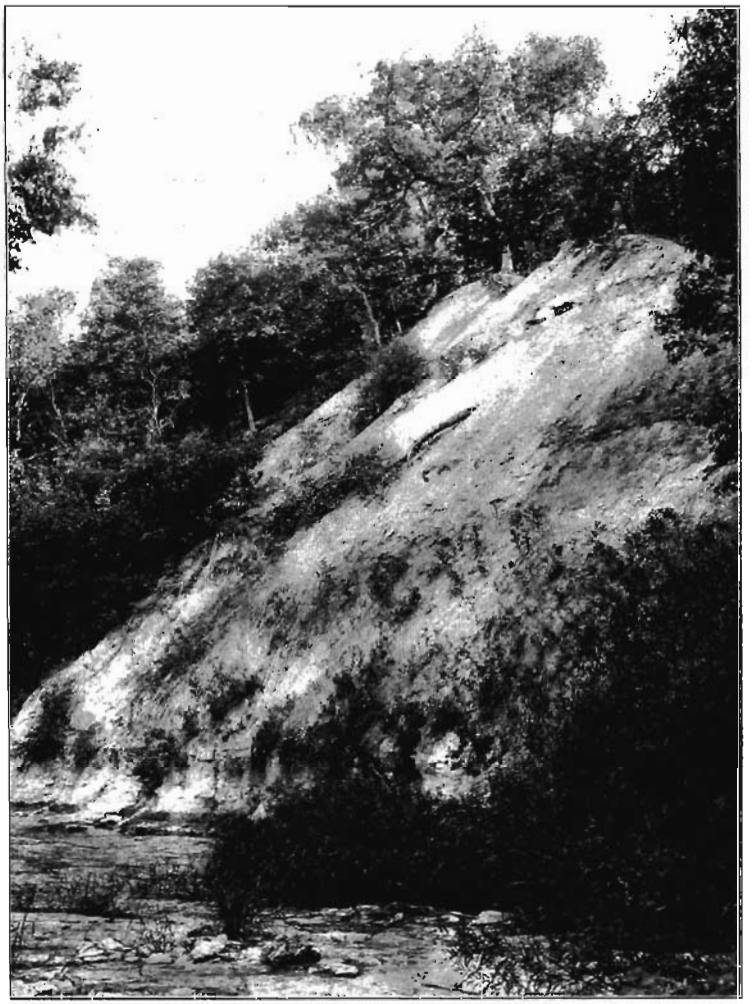

Truncated headland along Gray creek, showing the Coal Measures resting unconformably upon the Saint Louis limestone. A thin seam of coal appears near the middle of the section.

Along Avery creek at Dudley, some two miles from the Monroe county line, the Saint Louis is being developed on a considerable scale. Number 6 is more perfectly indurated and with numbers 4 and 5 constitute the chief quarry rock. The Saint Louis appears farthest inland along Gray creek in the northeast quarter of sec-

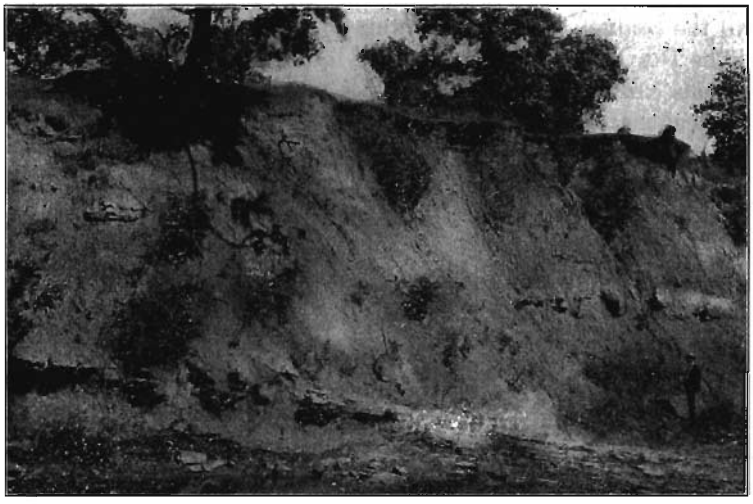

FIG. 55. Saint Louis limestone in Miller creek near Eddyville. The beds dip to the southwest at an angle of five degrees.

tion 10, in Pleasant township. Here some four feet of the indurated beds of the Saint Louis may be viewed, overlain unconformably by some forty feet of Coal Measures. Beyond this point the gradual rise of the surface toward the divide with the gentle dip of the beds to the southwest effectually conceals the Saint Louis.

Pennsylvanian Series.

DES MOINES STAGE.

The Coal Measures cover practically the entire county save where removed by the Des Moines river, Gray and Miller creeks, and rest unconformably upon the Lower Carboniferous. Good exposures showing the contact between the Upper and Lower Car-

boniferous are comparatively rare and are confined to those truncated headlands which appear along Gray creek in Pleasant township. At these points the Saint Louis limestone presents a somewhat uneven surface and exhibits evidence of weathering and erosion. These observations support those made in other districts that the Coal Measures overlap unconformably the Saint Louis and the contact plane is very uneven.

The Des Moines may be divided into three sub-stages; the lowest beds consisting chiefly of shales and sandstones with several coal seams and constituting the major portion of the Coal Measure section may be designated the Monroe beds, as they are typically represented in Monroe county; a middle series typically developed in Appanoose and consisting of limestones and shales, with thin but persistent seams of coal, the Appanoose beds; and an upper conglomeratic deposit exposed at but few points and known as the Chariton conglomerate.

THE MONROE BEDS.

Standard Sections.—The best natural sections of beds referable to the Monroe sub-stage appear along Gray, Bluff, Coal, White and Whippoorwill creeks. Near the center of the northwest quarter of section 8, Pleasant township, the following strata are exposed:

		FEET	IN.
7.	Drift, exposed	5	
6.	Shale, clayey	10	
5.	Coal	1	
4.	Clay	2	6
3.	Sandstone	3	
2.	Shale	35	
1.	Coal	4	

The base of the coal seam is just above the bed of the stream.

A second section worthy of mention occurs along Gray creek in Bluff Creek township in the southwest quarter of section 23. The sequence is as follows:

		FEET.
6.	Drift	10
5.	Sandstone, shattered	4
4.	Sandstone	3
3.	Shale, blue	4
2.	Sandstone, gray	8
1.	Shale, blue, exposed	6

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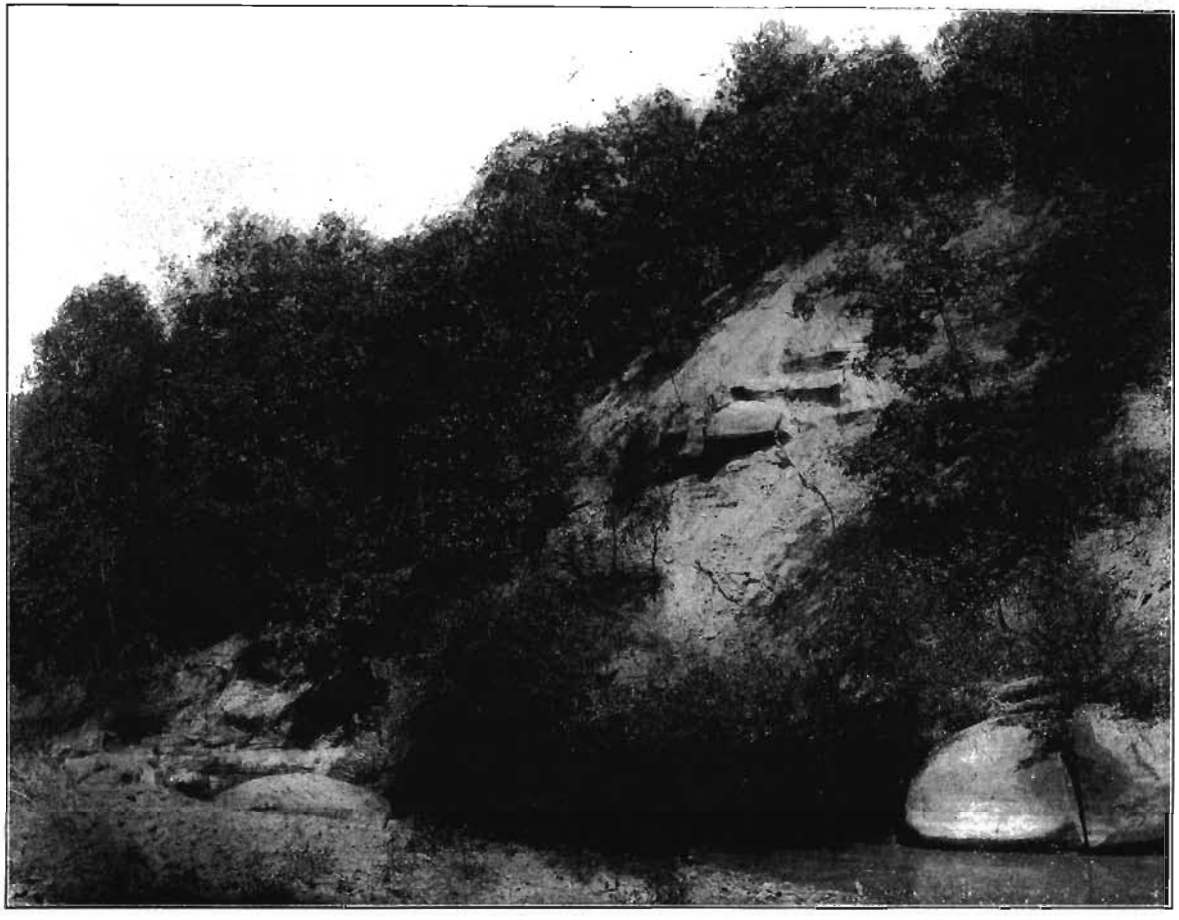


Section along Coal creek which shows spheroidal weathering of the sandstone.

Up the stream a short distance the shaly layers present a calcareous facies and a thin seam of coal may be viewed. Plant remains weather out of the shales, and consist chiefly of Lepidodendrons. Coal also appears lower on the stream. On the northeast quarter of the same section a seam two feet in thickness is exposed.

But few exposures of any consequence appear along Bluff creek. At the point where the Chicago and Northwestern railroad crosses the creek in section 5, Bluff Creek township, Coal Measure beds may be viewed as follows:

		FEET.
3.	Shale	4
2.	Coal	5
1.	Shale	10

All of the beds are covered by the drift, which attains a considerable thickness back from the stream.

On Coal creek near the east line of section 20 in Union township an abrupt escarpment faces the creek on the east side. Ten feet of sandstone underlain by twenty-five feet of sandy shale represent the bedded rocks. The sandstone shows a marked tendency to weather out into spheroidal bowlders. Plate X is a photograph of the section. Lower on the stream trunks of Lepidodendrons of gigantic size are strewn along the cliff face. Some of the trunks are more than two feet in diameter. The sandstone is bedded very irregularly and carries pyritic balls, fragments of Lepidodendrons and coal.

No important exposures of stratified rocks occur in Cedar township. On the east bank of White creek, in the southeast quarter of section 25 an irregularly bedded, conglomeratic sandstone outcrops some twenty feet above the creek level. The sandstone contains pyritic concretions weathered to a brownish black limonite whose fresh fractures show unaltered iron pyrites. Chert concretions varying from a fraction of an inch up to a foot across are abundant. A thin pockety seam of coal appears below the sandstone about ten feet above the creek and is underlain with a pyritiferous shale extending down to water level.

Guilford township represents a rugged topography near Coal and Cedar creeks, but exposures of the Coal Measures are unim-

portant because of the greater thickness of the drift. Near the west line of section 35 a series of thin beds aggregating a thickness of thirty feet occur in the following order from top downward: Drift, coarse sandstone, gray shale, blue shale, clay shale, coal and fire-clay. The coal is considerably iron stained. The overlying shale is highly carbonaceous and contains numerous

FIG. 56. Gigantic Lepidodendrons weathered out of the shales and sandstones along Coal creek.

clay ironstones. Down the stream in section 26 the coal rises gradually until it has an elevation of about twenty-five feet above the stream.

The Coal Measure strata may be viewed along the principal drainage lines in nearly all of the other townships, but none of the exposures are of sufficient importance to deserve individual mention.

While natural sections are not extensive and generally somewhat obscured by the drift and talus slopes, nearly all of the coal companies operating in the county have put down many drill holes of which careful records were kept and these records the coal companies have generously permitted the Survey to use freely.

The Central Coal Company has done considerable prospecting in the middle of Pleasant township and the following section may be taken as an average for the district:

		FEET.	IN.
17.	Drift ending in water bearing sand and gravel below	50	
16.	Shale, dark	12	
15.	Shale, gray	21	
14.	Shale, blue, hard and calcareous	2	
13.	Shale, gray	10	
12.	Coal		3
11.	Shale, black	13	
10.	Shale, light in color	3	
9.	Shale, black	14	
8.	Hard rock	2	
7.	Sandstone	5	
6.	Fire clay	2	
5.	Shale, blue	46	
4.	Sandstone, hard	1	
3.	Coal, bony	4	6
2.	Shale, black	3	
1.	Fire clay	3	

In Bluff Creek township the Consolidation Coal Company has put down many drill holes and the upper portion of the Coal Measures has been very thoroughly explored. A drill hole put down in the southeast quarter of the southeast quarter of section 16 may be considered to be fairly representative:

		FEET.	IN.
20.	Drift	25	
19.	Sandstone, gray	29	6
18.	Clay, shale	3	6
17.	Shale, dark	3	1
16.	Coal	1	9
15.	Shale, light	10	2
14.	Coal	2	
13.	Shale, dark	3	6
12.	Coal	1	3
11.	Shale, light	32	
10.	Coal		10
9.	Shale, light	21	
8.	Shale, dark	2	4
7.	Coal		6
6.	Shale	15	10
5.	Sandstone	3	

		FEET.	IN.
4.	Shale, gray	13	11
3.	Coal	2	
2.	Shale, dark	49	
1.	Coal	5	
		225	2

The above section is of especial interest on account of the large number of coal seams penetrated. No other drill sections in the state show so many repetitions of coal producing conditions. In Mantua township the streams have cut well into the Coal Measures and drill sections are not so common. The Smokey Hollow Coal Company has done considerable prospecting in the vicinity of the Averys and the following section may be taken as an average.

Section in southwest quarter of the southeast quarter of section 14, Tp. 76 N., R. XVI W.:

		FEET.	IN.
16.	Drift and alluvium	20	
15.	Sand and gravel	60	
14.	Clay mixture	20	
13.	Shale, black	14	
12.	Coal		8
11.	Shale, light	13	
10.	Shale, dark	5	
9.	Shale light	6	
8.	Shale, dark	6	
7.	Coal	1	
6.	Fire clay	3	
5.	Shale, dark	8	
4.	Coal	5	6
3.	Shale, sandy	4	
2.	Sandstone	21	
1.	Shale, gray	2	
		189	4

In Guilford township the Wapello Coal and Mining Company has thoroughly explored a large area along Coal creek. The drillers' log for a hole put down on the southwest quarter of the northwest quarter of section 3 gives the following sequence:

		FEET.	IN.
17.	Drift ending in sand and gravel	68	
16.	Clay shale	20	
15.	Shale, dark	4	
14.	Coal		9
13	Clay shale	21	3
12.	Shale		9
11.	Clay shale	7	3
10.	Sandstone	4	
9	Clay shale	14	
8.	Sandstone	3	
7.	Shale	5	
6	Slate	3	
5	Coal	1	6
4.	Sandstone	3	
3.	Shale	6	6
2.	Shale, dark	72	
1.	Coal	5	10
		239	10

In Troy township the Hocking Coal Company has prospected extensively along Coal creek and the adjoining territory. One of the deepest holes in the district was put down in northwest quarter of the southeast quarter of section 4 and the following beds were reported to have been penetrated:

		FEET.	IN.
19.	Drift	25	
18.	Shale, light	10	
17.	Sandstone	25	
16.	Shale, light	25	
15.	Sandstone	10	
14.	Shale, light	15	
13.	Hard rock	2	
12.	Shale, dark	43	
11.	Hard rock	5	
10.	Shale, light	11	
9.	Sandstone	10	
8.	Shale, light	8	
7.	Coal	1	
6.	Hard rock	1	
5.	Shale, light	11	
4.	Hard rock	2	
3.	Shale, dark	92	8
2.	Coal	4	4
1.	Fire clay	1	
		302	

The several ledges of "hard rock" reported by the driller should be interpreted as more or less indurated sandstone ledges. Only two seams of coal are reported, while shales and sandstones repeat themselves many times.

Monroe township is the headquarters for the Whitebreast Fuel Company of Illinois and numerous drill records are on file in their office. A hole sunk near the northwest corner of the northeast quarter of section 10 may be taken as fairly typical for the township. The record is as follows:

		FEET.	IN.
35.	Drift	71	
34.	Shale, yellow	10	
33.	Shale, gray and clayey	9	5
32.	Coal	1	9
31.	Shale, blue	1	4
30.	Coal	1	1
29.	Shale, blue	25	5
28.	Shale, black	4	
27.	Sandstone, gray	2	
26.	Shale, black	7	
25.	Coal	1	6
24.	Clay shale, light	9	6
23.	Sandstone, hard	6	
22.	Shale, dark	3	
21.	Shale, sandy light	10	
20.	Shale, dark	6	8
19.	Coal		9
18.	Shale, dark	4	7
17.	Clay shale, light	3	
16.	Shale, dark banded	7	
15.	Shale, gray	5	
14.	Coal		4
13.	Shale, dark and light below	17	8
12.	Sandstone	3	
11.	Shale, mixed	7	
10.	Sandstone	2	
9.	Shale, dark	4	10
8.	Coal	1	4
7.	Sandstone, hard	2	10
6.	Shale, dark	36	6
5.	Coal	4	2
4.	Coal, shaly		7
3.	Shale, dark above and light below	5	9
2.	Sandstone	3	
1.	Shale, dark	4	
		230	

On the upland near Foster the Coal Measures run fairly uniform and the following may be taken as an average drill section:

		FEET.	IN.
22.	Drift	90	
21.	Sand and gravel	2	
20.	Fire clay	6	
19.	Shale, gray	8	
18.	Clay shale, light colored	14	
17.	Shale, black	11	
16.	Coal	1	
15.	Fire clay	2	
14.	Shale, gray and arenaceous	22	
13.	Shale, dark	6	
12.	Coal	1	6
11.	Shale, dark	2	
10.	Sandstone, shaly	4	
9.	Fire clay	3	
8.	Shale, clayey	15	
7.	Sandstone, shaly	19	
6.	Hard ledge	1	6
5.	Sandstone	10	
4.	Shale, black	5	
3.	Sandstone, shaly	31	
2.	Hard ledge	2	
1.	Sandstone	14	
		270	

While but two seams of coal appear in the section, the drillers' record shows a number of beds of fire clay which suggest the presence of additional coal horizons. Such seams are found to occur when other drill records are examined.

From the foregoing sections it is apparent that in the order of their importance shales and sandstones constitute the bulk of the Monroe beds as developed in the county, and show all gradations from typical sandstones through shaly sandstone and sandy shales to typical shales. The sandstones present oftentimes unusual facies. At several points, notably large bowlders appear in the cliff walls and the weathering agencies bring out the bowlder character to good advantage as the matrix breaks down readily and the bowlders stand out prominently. Along Coal creek, southwest of Lovilia the sandstone presents a decidely conglomeratic appearance which on closer inspection is seen to be due to the presence of chert and pyrite balls in the form of concre-

tions. The concretions vary from a fraction of an inch to several inches across and here again weathering brings out the structure in a very striking manner. Figure 57 shows two detached blocks at close range. The sandstones often show false bedding planes on a small scale which is quite a characteristic feature of Coal Measure deposits in general. The shales vary considerably in fineness of grain and fissility. As before stated all gradations are found from shaly sandstone to almost gritless shales and they vary in color from light gray, nearly white, fire-clays through the various shades of gray and blue to the black carbonaceous

FIG. 57. Concretionary sandstone which appears conglomeratic on casual inspection, Coal creek.

shales which are generally closely associated with the coal seams. In fissility they vary from the almost structureless fire clays through the clay shales to highly fissile shale. As a rule the shales carry but a small percentage of the carbonates of lime, magnesia and iron.

In addition to the shales and sandstones occasional ledges of calcareous rock are present and usually occur as argillaceous limestone, commonly known as "cap-rock," when near a coal seam. Such ledges rarely reach a thickness greater than two feet. Last and most important from an economic standpoint are the

seams of coal, which vary in number from one to seven and possibly more when the entire assemblage of beds is taken into account. In the vicinity of both Buxton and Hilton seven seams were penetrated in sinking the prospect holes, although the entire Coal Measure series were not penetrated. In thickness the individual seams vary from a thin film or "blossom" to a maximum of seven or eight feet. The Buxton section previously mentioned shows seven seams with an aggregate thickness of thirteen feet and four inches of coal, while but one seam is of sufficient thickness to be of commercial importance. The seams also vary greatly in character; some are "bony," others contain numerous bowlders and are known as stony, while still others run high in sulphur, chiefly in the form of the iron sulphides represented by the minerals pyrite and marcasite. The latter seams when exposed to the air disintegrate rapidly and show a greenish white coating of green vitriol or iron sulphate. The greenish white coating dissolves readily and in case of continued exposure is removed or changed to limonite, which makes itself manifest by the red and yellow brown stains, characteristic of the staining done by most of the waters issuing from coal mines when they come in contact with foreign substances.

The Coal Measures thicken gradually from northeast to southwest. Away from the outcrops along the streams near the east boundary of the county the prospects rarely or never penetrate the entire series so that it is impossible to assign a definite figure for the maximum thickness of the beds.

The deepest prospects whose records are available were put down by the Hocking Coal Company and the Whitebreast Fuel Company and these scarcely exceed three hundred feet from the surface. A drill hole put down by the former company to a depth of 317 feet near the center of the northwest quarter of the southwest quarter of section 34, Tp. 72 N., R. XVII W., shows at least 272 feet of Coal Measures while the drill hole of the latter company recorded on a preceding page penetrated the Coal Measures to a depth of 212 feet. From the drill records available it is reasonable to infer that the Coal Measures attain a thickness of about 300 feet for the central portion of the county and probably exceed 400 feet for the southwest portion of the county.

Structurally the Coal Measures lie almost flat when viewed broadly, dipping to the southwest at a low angle. Local undulations are quite the rule, the wave-like undulations possessing an amplitude of from a few feet to thirty or even forty feet or more. The general trend of the waves is somewhat variable, but more commonly approximate east and west. Faults of sufficient magnitude to cut out a coal seam are unknown in the county, although there are evidences of minor movements in the sheared and "slickened" surfaces of some of the roof shales. Erosional cut-outs or unconformities are encountered occasionally, especially near the thin edge of the Coal Measures. The Chariton conglomerate is reported to fill an erosional trough, deep enough to cut out the productive measures in Appanoose county. The conglomerate extends well into Monroe county, but little is known of its relation to the workable coal, though it is believed to lie too high in the series to in any way influence mining operations in the county.

THE APPANOOSE BEDS.

According to Bain* the Appanoose beds consist essentially of limestone beds which bear a certain definite position with reference to the Centerville (Mystic) coal seam, separated by shales. The normal sequence is the "fifty foot limestone," "seventeen foot limestone," the "cap rock" and the "bottom rock." The records for southern and especially for southwestern Monroe, where the Appanoose beds would naturally be expected to occur, are very meager and it is impossible to assign limits with any degree of confidence. The beds cannot be recognized definitely within the confines of the county, but on the map were continued across the Monroe county line from Appanoose county.

THE CHARITON CONGLOMERATE.

Conglomeratic beds referable to the Chariton are known to be exposed in but a single locality in the county. A limited outcrop may be viewed along one of the tributaries of Coal creek on section 3 in Monroe township, about three miles south of Albia. The beds here exposed form projecting ledges on account of their more

* Iowa Geol. Surv., Vol. V, p. 378, *et seq.*, Des Moines. 1895.

resistant character than the underlying shales. The conglomerate consists essentially of rounded limestone pebbles, fragments of coal, crinoid stems and brachiopod remains imbedded in a more or less ferruginous sandy matrix. The pebbles vary considerably in size up to two or three inches in length. Some yellowish brown magnesian limestone is present. More extensive outcrops

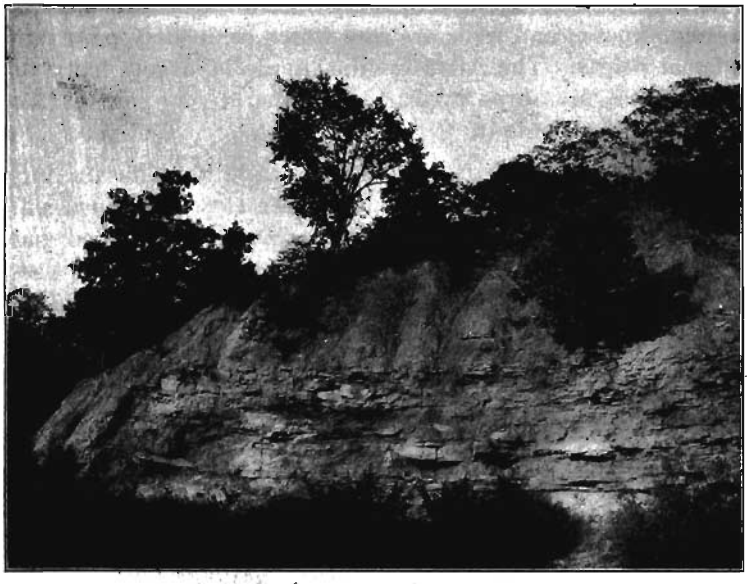


FIG. 53. Exposure of Carboniferous sandstone on Coal creek, in the southeast quarter of the southwest quarter of section 16, Union township, showing a local undulation.

of the conglomerate occur in Appanoose county, the nearest exposure to the above occurring in section 1, Tp. 70 N., R. XVII W. A line connecting these two points would pass about one-half mile east of the mine of the Whitebreast Fuel Company at Hilton. Although much prospecting has been done in that vicinity no trace of the conglomerate is recorded.

The Pleistocene.

The Upper Carboniferous beds present evidence of profound erosion wherever they can be viewed, which indicates an unconformity between the Coal Measures and the overlying drift. The

Pleistocene may readily be separated into the drift below, the loess which forms a top dressing everywhere unless it has been removed by the streams, and recent deposits which consist chiefly of alluvium and wind blown materials. The drift constitutes by far the larger portion, varying from a few feet to about 100 feet in thickness, perhaps averaging seventy feet for the entire county. It is thinner in the eastern portion, especially the northeastern section, and thickens to the southwest, where the stratified rocks are rarely exposed and wells are rare which completely penetrate the glacial debris. The Albia-Lovilia divide is largely made of drift, the Coal Measures appearing comparatively low in the ravines which head into it.

The bowlder clay or drift may be referred to the Kansan. Although numerous natural sections have been closely scanned and drill records closely examined there appears to be no good and sufficient reason for subdividing the drift, which has been possible in other places. Certain sections display a heavy sand or

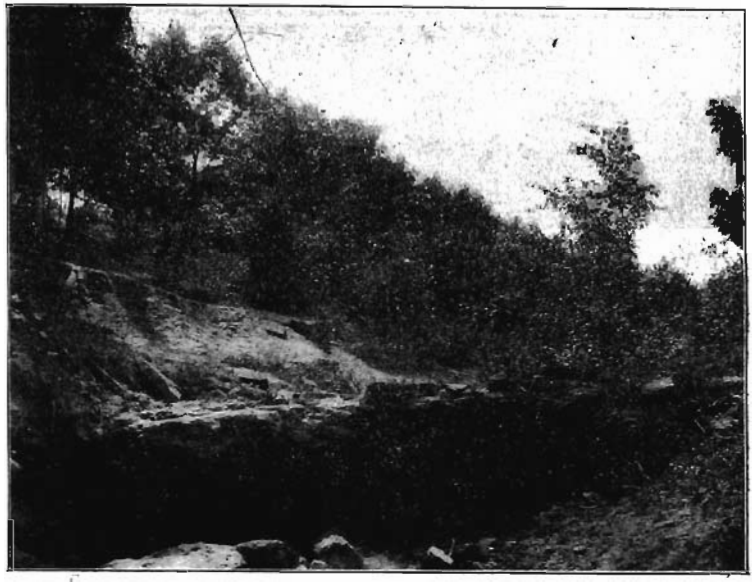


FIG. 69. Pleistocene conglomerate underlain with Coal Measure shales forming an escarpment across a branch of Gray creek, near Eddyville.

gravel deposit below the till sheet, but a second till sheet cannot be identified with certainty. In other places the gravels are quite completely cemented and form a conglomerate as may be well seen in figure 59 where these conglomeratic beds form a considerable fall in one of the branches of Gray creek.

PRE-KANSAN GRAVELS?

Drillers in prospecting for coal rarely keep a detailed record of the surface materials. From conversation with drillers and from natural sections and the few records giving the details of the surface formations it is obvious that the Kansan drift is pretty generally underlain with from five to twenty feet of sand and gravels which rest directly upon the bed rock. The bowlders and pebbles include many rocks foreign to the district and argue the presence of an older drift-sheet at no great distance.

THE KANSAN DRIFT.

The Kansan drift usually exhibits a lower blue bowlder clay, often very compact and hard and an upper more or less loosely aggregated portion stained yellowish to a reddish brown through the oxidation of the iron and is known as the "ferretto zone." The upper stained material is quite thoroughly leached, while the blue clay effervesces freely when treated with dilute hydrochloric acid. Pebbles and bowlders occur throughout the deposit, but large bowlders are comparatively rare. The rocks present often show facetted and striated surfaces and the granite bowlders are quite generally in an advanced stage of decay, falling to pieces when removed from their matrices. Fragments of coal and pieces of wood are not infrequent, especially in the lower blue till.

THE LOESS.

A clayey silt known as the loess veneers the drift and Coal Measures over the entire county, save where removed by erosive agencies. Where present it is fairly uniform in thickness, varying from total absence along the streams and ravines to twenty or thirty feet near the crests of the adjoining bluffs. From the face of the bluff the loess thins slightly toward the divides. In

texture the loess is sandiest near the streams and is highest in clay substance near the divides; it also increases in the sand constituent from surface to base in vertical section. These facts are well shown at many points along roadways and in railroad cuts. The clay ballast plants formerly at Maxon and Selection developed the loess high in clay characteristic of the divides.

RECENT.

The streams of the county have done comparatively little in the way of building alluvial deposits. The Des Moines river has done considerable filling and presents an alluvial belt varying from one to two miles in width. Narrow belts may be noted along Coal and Cedar creeks and the Avery. The bounding bluffs along all of the last mentioned streams retain their convex profiles and the deposits of the streams are commingled with the hillside wash.

West of the Des Moines river along the Buxton extension of the Chicago and Northwestern railway, several wave-like ridges may be observed. Similar ridges occur in the adjoining counties. The railway cuts across the end of one of these ridges and exposes some fifty feet of assorted sands and silts. While there is some evidence of sorting, no persistent stratification planes are apparent. These ridges have been ascribed to wind work because of their wave-like form and imperfectly stratified character and are fairly representative dunes. Examples are more numerous north of Eddyville, in Mahaska county.

ECONOMIC GEOLOGY.

Coal.

The coal industry in Monroe county dates from the early sixties. White in his brief sketch of the geology of the county published in 1870* states that small mines had already been opened along Bluff, Miller and Avery creeks and that the Cedar mines west of Albia were producing coal. None of the mines at that time were scarcely more than country banks and operated chiefly during the winter season to supply the local demand. The first biennial report of the state mine inspector covering the years 1880

* Geology of Iowa, Part II, pp. 267-268. Des Moines, 1870.

and 1881 contains some interesting statistics. Herein it is asserted that some thirty mines are in operation in Monroe county employing 638 men. The deepest shaft is reported to be 150 feet and was located near Albia. The total production and average price per ton are not given in the report. The number of men employed is doubtless an exaggeration.

In 1883 the laws governing the inspection of mines were so amended as to require the collection and compilation of the statistics of coal production each year and beginning with 1883 the records are fairly complete. The records available showing the progress of the industry and the remarkable prosperity at the present time are tabulated in the table below. For the years 1883 to 1889 inclusive the records are compiled from the reports of the state mine inspector, for the years 1890 to date the data are obtained from the Mineral Resources of the United States Geological Survey. Total production, total value, average price per ton, average number of men employed, and average number of days worked, are compiled for Monroe county, while total production, average number of men employed, and average number of days piled for the entire state:

MONROE COUNTY.

YEAR.	Total production in short tons.	Total value.	Average price per ton.	Average No of men employed.	Average No. of days worked.	Total production for entire state in short tons.	Average price per ton for state.	Total No. of men employed for entire state.
1883	104,607					$ 4,457,540		
1884	110,288					4,370,566		
1885	113,699					4,012,575		
1886	181,824					4,315,779	$ 1.25	
1887	205,525					4,478,528	1.34	
1888	261,164					4,952,440	1.30	
1889	238,401	$ 299,745	$ 1.16			4,995,358	1.33	9,247
1890	324,031	892,078	1.21	735	197	4,021,739	1.24	8,130
1891	393,227	475,805	1.21	806	208	3,745,496	1.27	8,124
1892	507,106	638,954	1.26	1,112	233	3,918,491	1.32	8,170
1893	570,905	638,085	1.12	1,103	214	3,972,229	1.30	8,868
1894	505,164	559,017	1.09	1,212	172	3,467,253	1.26	9,995
1895	559,982	570,879	1.02	1,037	216	4,153,074	1.20	10,066
1896	483,520	497,490	1.01	840	188	3,954,028	1.17	9,672
1897	497,881	498,757	1.00	986	229	4,611,865	1.13	10,703
1898	584,578	594,980	1.02	1,086	232	4,618,842	1.14	10,262
1899	689,004	725,052	1.05	1,218	221	5,177,479	1.24	10,971
1900	765,286	859,720	1.14	1,592	254	5,202,969	1.33	11,608
1901	1,038,332	1,292,503	1.24	2,319	295	5,617,499	1.39	12,653
1902								

With the exception of the period of great business depression ending in 1896 Monroe county has shown a fairly uniform in-

crease in the production of coal. The average price per ton reached its lowest point in 1897, when coal sold for an even dollar per ton at the mines. Since 1898 the tonnage, price, number of men employed, and number of days worked have increased rapidly. The production for 1901 exceeds that for 1900 by more than twenty-five per cent. This unusual increase resulted very largely from the opening of mines along Bluff creek by the Consolidation Coal Company. In 1883 it may be noted that Monroe produced less than two and a half per cent of the total production, while in 1901 her output exceeded eighteen per cent of the production of the entire state.

COAL BASINS.

Miller Creek District.—In the northeastern part of the county where the coal outcrops along the streams there have been many small mines, so-called country banks. Slopes are driven either in the coal where it outcrops or, when the coal seams lie a few feet below the surface, at a small angle through the measures. In the latter case the opening is called a "rock drift." Nearly all of the mines of the Miller creek district are slopes and drifts. The coal is hauled to the surface by ropes and thus the expense of hoisting is eliminated. In the southwest quarter of the southwest quarter of section 1, Pleasant township, is a local mine known as the Bridgeport or Davis mine. This mine works the lowest seam in Monroe county. For some years it has furnished considerable coal to Eddyville. The coal is obtained by a slope, but no machinery is employed in haulage. The seam worked varies from two to four feet in thickness and has a fair roof.

The Little-Hoover Company of Oskaloosa has opened a slope west of Coalfield. The Mary Jane Coal Company has a prospect east of the Little-Hoover Company, but no large operation is contemplated.

The Central Coal Company has opened a slope on the west bank of Miller creek and considerable coal is being shipped from this mine over the Iowa Central railroad. The seam worked lies thirty-five feet below the tipple and dips at a low angle to the southwest. It is rather irregular and averages about four feet in thickness. Drill records in this locality show a great number of

coal seams, some sections penetrating as many as seven, the majority of which are not of sufficient thickness to be worked. The main entry of the Central company is driven northwest and encounters numerous irregularities. Basins of sandstone extend in a northeasterly direction and in some places are 300 feet wide. The sandstone contains many fragments of coal, pyrite balls and plant remains. The coal gradually runs out and sandstone comes in, there being no signs of cutting out by water. The roof is good and the mine is increasing its output rapidly. The coal is of good quality and is known as the Miller Creek Steam coal.

Avery Creek District.—The Smoky Hollow Coal Company has been for some years one of the largest producers of this district. Thus far the work has been carried on east and south of Avery in

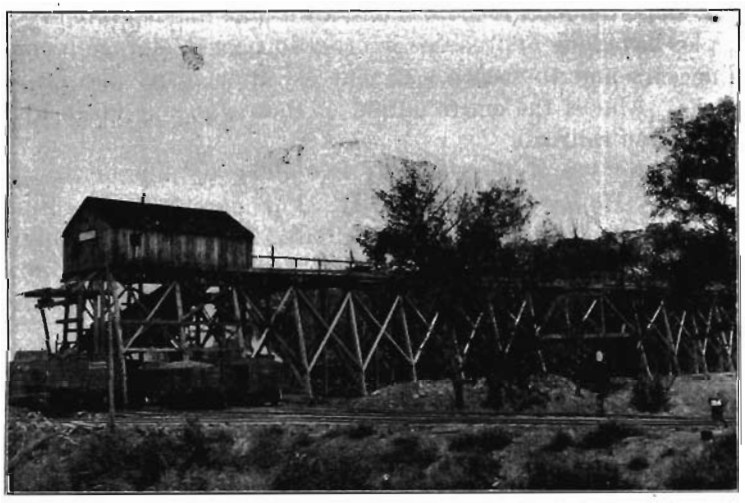


FIG. 60. Approach and tipple of one of the mines of the Smoky Hollow Coal Company.

the valley of South Avery creek. The coal either outcrops in the hillsides or is covered only lightly by the drift. For six miles abandoned workings mark the outcrop and from time to time the railroad stub has been extended as new mines have been opened. The company has operated principally in sections 9, 10, 11, 13, 23, and 24 in Mantua township. At present the bulk of the coal produced is mined at slopes 4 and 6, number 5 having been recently

abandoned. Slope number 4 is located in the southwest quarter of the northwest quarter of section 11; slope number 5, in the northwest quarter of the northwest quarter of section 13, and slope number 6, in the southeast quarter of the northeast quarter of section 23. It is probable that the railroad will be extended westward up the valley and that a new slope will be opened in the southwest quarter of the northwest quarter of section 23. The company has done considerable prospecting over this township and operates a diamond drill almost continuously. The sections reported show considerable irregularity in the coal seam. The coal varies in thickness from three and one-half to five feet and is mined by the pillar and room system. All the slopes are equipped with tail rope haulage systems as the length of haul makes it inadvisable to use other than mechanical haulage. At each slope the haul is more than half a mile under ground. The tipples have long approaches in order to furnish storage room for mine cars and to secure sufficient elevation above the railroad tracks. Almost the entire output of these mines is taken by the Burlington railroad.

The employes of the company live along the line of the spur, in Smoky Hollow and Hynes City. For many years the Smoky Hollow district has been a large producer. There are many old openings on both sides of the hollow. As the coal has been worked out operations have been extended to the south and now the largest producers are several miles from the old town.

The Frederick Coal Company north of Smoky Hollow has located a shaft on the northeast quarter of the southeast quarter of section 3, in Mantua township. For a number of years this mine has been producing some coal, but recently the management has been changed. A railroad track has been built from the Burlington, new buildings have been erected and a much larger output is to be expected in the near future. Considerable coal is hauled by teams from this mine to Avery and the surrounding country. The seam worked averages over three feet in thickness and is mined longwall.

The Foster District.—The Deep Vein Coal Company at Foster operates a mine through shaft number 1. The shaft reaches a coal seam at a depth of 208 feet which averages four and a half feet in

thickness. The mine is a very old one and at present is producing but little coal. The underground haulage is by mules. The hoisting drum is seven feet in diameter and is driven through a 1-4 gearing by a 12x16 inch Ottumwa engine. Air is supplied to the mine by two fans; one fan six feet in diameter is located about 300 yards from the shaft. A five horse power gas engine drives the fan and gives satisfaction. A steam line from the boiler house to the fan would require considerable attention and would not be efficient.

A short distance east of shaft number 1, a new shaft has been sunk on the upper vein. This seam runs from one to three feet in thickness and lies about thirty feet above the lower vein. The

FIG. 61. Horse gin used in sinking a shaft near Foster.

output from shaft number 2 is small and only a gin hoist is used. At present but ten men are employed.

There are no other mines of importance in this district.

Hiteman Basin.—The Wapello Coal Company operates three mines in the vicinity of Hiteman. For some years this company has been one of the leading shipping mines of the state and its entire output is handled by the Burlington. All of the mines belonging to the company are operated through shafts. Shaft number 1 is located on the northeast quarter of the southwest quarter

of section 11, of Guilford township. This mine has been in operation about ten years and a considerable area has been worked out. The coal is hauled almost a mile under ground by a tail rope system. Trips of from thirty-five to forty cars are hauled every twenty minutes when the mine is in full operation. Shaft number 2 is located in the center of section 2. This mine is about worked out and some of the machinery is being removed to the other plants. The engine and boilers are of the Ottumwa pattern. The hoisting engine is direct connected, cylinders 14x20 inches; the hoisting rope one and one-fourth inches in diameter is wound on a six foot drum. A twelve foot fan driven by a 12x18 inch engine furnishes air to the mine.

As in mine number 1, the coal is hauled underground by a tail rope system. This consists of a three-fourths and a five-eighths inch rope wound on four foot drums driven by a 10x16 inch en-

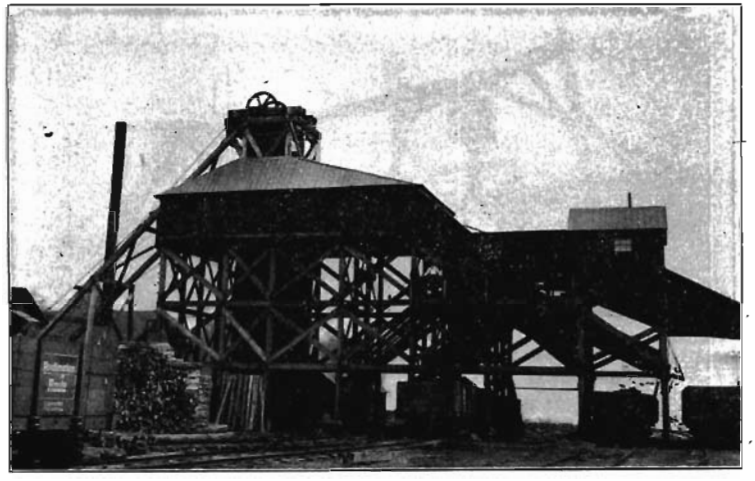


FIG. 62. Tipple at shaft No. 3, Wapello Coal Company, Hiteman.

gine. The real strain in this system comes on the tail rope for there is a heavy grade in favor of the loaded trip. The tail rope is carried about 400 yards on the surface by means of pulleys and then enters the mine through a four inch pipe sunk through the covering.

Shaft number 3 is located in a basin running east and west on the southeast quarter of the southeast quarter of section 3. For several reasons it was sunk so as to penetrate the lowest point in the basin, although the coal here is very poor, containing much rock. At present all of the rock must be hoisted. The thickness of the coal in this tract is well known through the many drill holes sunk by the company. The coal runs no thicker in the basins than on the rises. The company has a Sullivan diamond drill in operation and has made a careful study of the adjacent coal lands. All of the drill records are preserved and sections are constructed showing the exact position and the thickness of the workable coal seams.

Cedar Creek Mines.—For many years there have been a number of mines operating within a few miles of Albia both north and west. The Cedar mines have produced much coal, but have been abandoned for some years because all of the coal that could be mined profitably had been removed. But two mines are operating in this field at present.

A new mine is being opened on the main line of the Burlington just west of Tower. At present no coal is being produced.

The Star Coal Company has for some years been producing coal from a shaft about two and a half miles northwest of Albia. The coal is hauled by team to Albia and to a side track on the Des Moines branch of the Burlington, where it is loaded for shipment.

The Hocking Basin.—The town of Hocking is located on a spur of the Iowa Central railway about two miles southwest of Albia. The Hocking Coal Company with central offices in Oskaloosa is the only company operating in this district. Shaft number 1 was put down and operations begun in 1899 while shaft number 2 was sunk during 1900. Both shafts are located on a low terrace along Coal creek, and are 180 and 208 feet in depth respectively. The company did a large amount of preliminary drilling so that the character and limits of the coal basin were pretty well understood.

In mine number 1 the coal seam varies from four to six and one-half feet in thickness and furnishes a good grade of steam coal. The coal floor is quite irregular on account of the numerous rolls which trend about 30° east of south. The maximum variation amounts to about twenty-five feet. Some of the rolls almost

completely cut out the coal, the floor rising apparently and the roof descending. Sometimes the seam cuts out quite abruptly, the coal wedging out within a distance of twenty feet. In such cases there is no appreciable change in the character of the fire clay below nor in the roof covering above. Bowlders of clay ironstone and pyrite concretions are not uncommon. In certain instances banded beds occur in the coal seams composed of alternate layers of bony coal and pyrite, probably the variety marcasite. Occasionally "black jack" cuts into the upper portion of the seam and must be separated before the coal is loaded. The roof shale

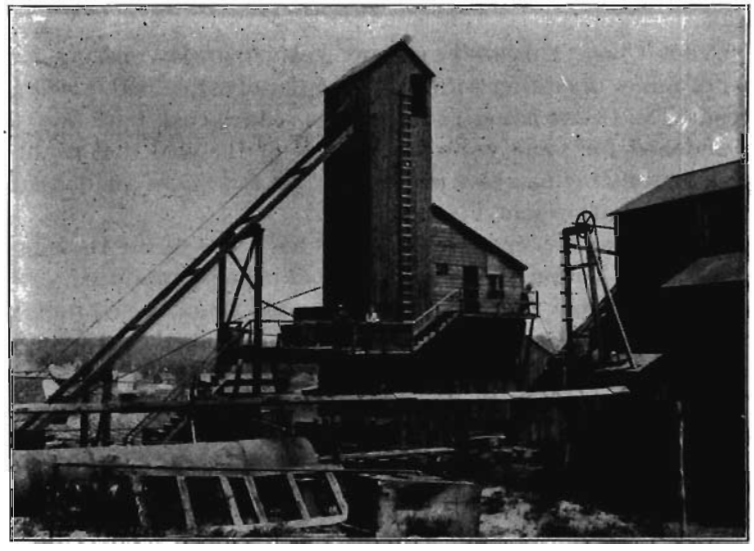


FIG. 63. Tipple and screening plant at shaft No. 1, Hocking Coal Company, Hocking.

is pyritic and during the summer months causes considerable difficulty in supporting the roof in both entries and rooms. In certain portions of the mine "creep" gives a great deal of trouble. This is brought about by leaving too small pillars to support the roof load. In places the heave of the bottom amounts to nearly the thickness of the seam, requiring much attention and involving great expense. The bottom clay varies from four to five feet in thickness and is quite soft. Occasional slips may be noted in the

roof shale and where the settling is not carefully provided for the roof shears along the entries.

The mine is worked pillar and room system. The room centers are forty feet apart and a fifteen foot pillar is left. The side entries are run 400 feet apart.

The surface plant consists of a 12x24 inch hoisting engine and five foot drum. Haulage on the main entries is by tail rope, using five-eighths and three-fourths inch cable, driven by a 12x18 inch engine and wound on a five and a half foot drum. Air is supplied by a ten foot fan driven by a 10x16 inch engine.

An automatic dumping cage is in use. The coal is dumped directly over a standard screen or "grizzly." The screenings are elevated and graded into nut, pea and slack. Considerable rock is hoisted and must be taken off at a lower level, an arrangement which involves a loss of time.

FIG. 64. Tipple of shaft No. 2, Hocking Coal Company, Hocking.

Mine No. 2 is very similar in general character to No. 1. A conical drum, a larger fan and hand dump are the chief differences in surface equipment. Rolls and floor irregularities are of

less importance than in mine No. 1 and no trouble is experienced from "creep."

Hilton Basin.—The Whitebreast Fuel Company is operating but one mine in the county at present, the mine being located at Hilton. The hoisting shaft is located near the center of section 10, Monroe township. The mine was opened late in 1900 and has already become one of the large producers of the state. The seam is four feet thick and furnishes a good grade of steam coal. The equipment and management of the mine both surface and underground are excellent. The buildings on the surface are very substantial, steel alone being used in the framing and corrugated iron for the sheathing. The steel tipple forty by sixty feet is well

FIG. 65. Steel tipple and surface plant of the Whitebreast Fuel Company, Hilton.

planned for the work that it must do. One thousand two hundred tons of coal can be handled daily. The boiler house is forty-two by forty-five feet and contains at present two tubular Ottumwa boilers which furnish steam at eighty pounds pressure to the hoisting engine, the fan engine and the loader. The fuel used is what passes through the screen from the chute that supplies the country trade. A larry brings the coal into the boiler room on an elevated track from which it can be dumped at either boiler. Sufficient space has been reserved for a third boiler similar to the two in place in case an increasing output demands greater boiler capacity. The main

hoisting engine is a Litchfield pattern and has cylinders sixteen by thirty-four inches. The one and one-fourth inch hoisting ropes are wound on direct connected six foot drums. The air shaft is situated about 300 feet east of the main shaft and has two compartments, one for air, the other for hoisting in case the main engine be disabled. The auxiliary engine for this purpose has eight by twelve inch cylinders with a three foot drum and three-fourths inch rope. The fan is fourteen feet in diameter and is run by an engine with fourteen by twenty-four inch cylinders. All are enclosed in a fireproof house sheathed with corrugated iron. The machine shop is a well equipped building thirty-six by sixty

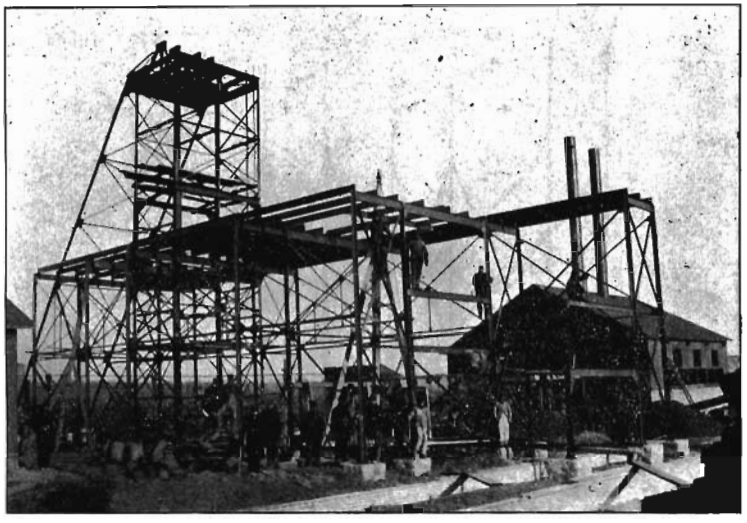


FIG. 66. Steel tipple of Whitebreast Fuel Company in course of construction.

feet and the tools and facilities for repairing mine equipment can be increased readily with increased tonnage. At present an eight by ten inch Ottumwa engine supplies power to a Champion blower and an upright post drill. All of the blacksmith work is done in this building, mine cars can be run in and repaired and tools unloaded easily.

Steel cars weighing 1100 pounds and having a capacity of 45 cubic feet are used under ground. The gauge of the mine track

is three feet two inches and the wheel base two feet. The hinged gate of the car is fastened by two latches of inch iron, which must be raised when the car is dumped.

Ventilation is very expensive in the larger Iowa mines on account of the number of trappers required to facilitate haulage. Unless undercasts or overcasts are to be built the only solution for the trapper problem is the automatic door. Such doors are in use in the Whitebreast mine. As haulage is in both directions the

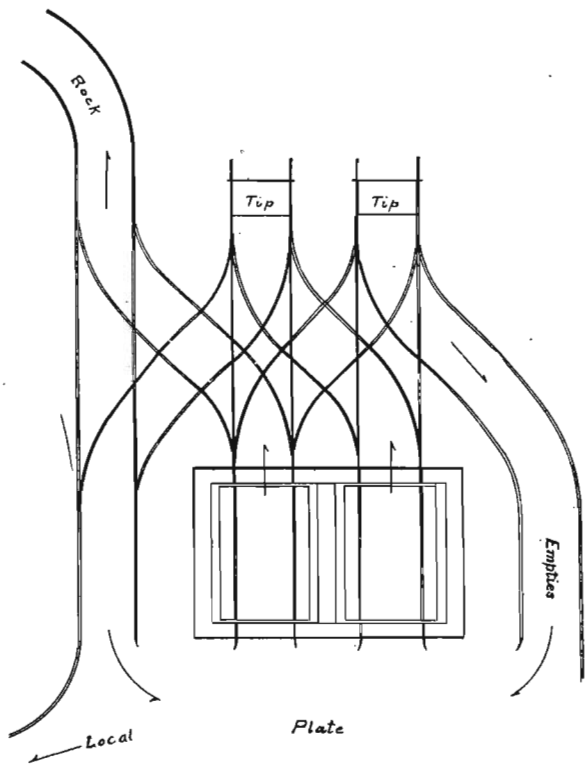


FIG. 67. Diagram showing arrangement of tracks and switches in the Whitebreast tipple.

doors must swing either way, open easily when the mule pushes against them with his head and shut promptly and tightly after the trip has passed. On each side of the door, weights are sus-

pended over pulleys along the side of the entry. These weights are sufficient to close the door and there is always an excess of weight on the side against which the ventilating pressure is the greater. In order to preserve the door a two by four carrying a strip of sheet iron is fastened to the door at the height of the axles of cars. By means of this device the cars do not cut the door nor is the coal thrown to the floor. The costs of fitting up such a door is low and its maintenance is no higher than for the common door. The saving effected is over $200 a year per door.

The bottom plan is good, only one man being required to cage. Loaded cars are caged from one side while the empties run off the other. The drivers drop their trips at the head of the grade and pass directly to the empties on the other side of the shaft. Loads are caught by the cager by means of a brake consisting of a strip of oak on a rail at such a height above one rail of the track that by means of a lever it can by lowered sufficient to bear on the wheels of the cars. The car wheels can thus be held firmly between the track and the brake rail. The cager can hold twenty cars on the grade and the brake-rail is so inclined that he can drop the cars one by one to the cage. The entire bottom is laid out on a sufficient grade to cause an empty car to run easily from the point at which loaded cars are received to the storage track for empties on the opposite side of the shaft. When a loaded car is released by the cager it runs slowly down the grade to the shaft, strikes a lever which depresses the dogs, holding the empty car on the cage and bumps the empty off the cage. It is caught on the cage by the dogs, while the empty car runs to the track from which the trips of empties are made up. Crossover switches permit cars to be caged in either compartment of the shaft. Car after car is caged automatically, the loaded cars are always at hand and the empties take care of themselves.

The steel cages are equipped with the best devices, lifting track, lever catches, etc. Fifty pound steel rails are used as guides in the hoisting shaft. The patent detaching safety hook and the safety catches on the cage prevent the cage from falling to the bottom if the rope breaks or from being pulled over the sheave when there is an overwind.

In the tipple three men are employed in handling the cars; two remove the loaded car from the cage, dump it and switch it around the shaft to the cager. A steel plate is used instead of switches on the empty car side of the shaft. The arrangement of the switches in the tipple permits all possible combination in the handling of cars, except that rock, and coal for local trade must be hoisted in one shaft.

The output of the mine is lump and steam coal. The lump coal is loaded largely into box cars, which necessitates considerable labor if machinery is not used. The coal must be moved from the middle of the car to the ends in order that the car may be loaded to its full capacity and that the load may be placed over the trucks. The box car loader in use here was manufactured at the mine. The sweep is not solid to the shaft, but consists of a steel blade eight inches wide and one and three-fourths inches thick. The loader has a sweep of three feet and is operated by an eight by fourteen inch engine.

Bluff Creek Basin.—The first biennial report of the state mine inspector, printed in 1881, states that unimportant openings had been made along Bluff creek and that a local supply was obtained during the winter months from these country banks. It was not until 1901 that the district became a real factor in the coal production of the county and in 1902 the basin became a most important mining community in the state. In 1900 and 1901 the

FIG. 68. View of Buxton from the west.

Consolidation Coal Company founded the town of Buxton on the extension of the Muchakinock branch of the Chicago & Northwestern railway and opened mine number 10 about two miles south of the town. In 1901 and 1902 the company put down shaft

No. 11, which is located about a mile south of number 10. Both shafts are in full operation at the present time, while shafts 12 and 13 are being sunk. Buxton is an ideal mining town. It was laid out on a rolling hillside facing north and west. Houses are better built and larger than those usually provided in mining camps. They average one full story and a half and are well kept. The streets are regularly laid out and the town as a whole presents a thrifty appearance. Mine number 10 is located on the second bottom land along Bluff creek and prospects usually show three seams of coal, while mine number 11 is located on the prairie upland and prospects in the vicinity show as many as seven distinct seams. The veins vary from six inches to above six feet in thickness. Only the lowest vein in each case is considered of sufficient thickness to warrant development under present conditions. The following section may be considered to be fairly representative of the bottom land prospects:

		FEET.	INCHES.
9.	Surface wash and drift	12	
8.	Sandstone	1	6
7.	Clay shale	3	
6.	Shale, dark	6	
5.	Clay, shale	10	6
4.	Shale, dark	9	7
3.	Coal	1	8
2.	Shale, dark	62	7
1.	Coal	6	2
		113	.....

Of the upland prospects the following is about an average:

		FEET.	INCHES.
20.	Drift and loess	25	
19.	Sandstone, gray	29	6
18.	Clay shale	3	6
17.	Shale, dark	3	1
16.	Coal	1	9
15.	Shale, light	10	2
14.	Coal	2	
13.	Shale, dark	3	6
12.	Coal	1	3
11.	Shale, light	32	
10.	Coal		10
9.	Shale, light	21	
8.	Shale, dark	2	4
7.	Coal		6

			FEET	IN.
6.	Shale		15	10
5.	Sandstone		3	
4.	Shale, gray		13	11
3.	Coal		2	
2.	Shale, dark		49	
1.	Coal		5	
			225	3

The records of the entire district show the presence of dark shale just above the lower coal seam which varies from forty to about sixty feet in thickness. This shale appears to be always present and furnishes a good safe roof.

Mines numbers 10 and 11 are thoroughly modern and up to date on every way. The tower of number 10 is of steel construction and is believed to be the highest tipple in the state, measuring sixty-nine feet to the top. Power is supplied by a battery of the three 150 horse power boilers manufactured by the National Machinery Company of Chicago. A direct connected hoisting engine of the Ottumwa Iron Works pattern with 18 by 32 inch cylinders is used. The hoisting rope is one and a fourth inch steel wire and is wound on a six foot drum. The mine cars weigh 900 pounds and will hold from 2000 to 3000 pounds of lump coal and when the mine is running full capacity an average of four cars per minute is hoisted. Cages dump automatically and one man is required at the tip to take up checks. The weigh room is on the ground level, the coal is run over a standard grizzly and arrangements are made for the separation of the screening into nut and slack, although fancy steam coal is the usual product. The plant is equipped with an Eagle Iron Works box car loader.

The arrangements at the bottom are such that all of the loaded cars are caged from one side and the empties are removed from the other. Only one man is required to cage. A double track with a one and a half per cent grade leads to the shaft, each track holding sixteen cars, the cars being controlled by sprags. The empty cars run from the cages by gravity and pass an automatic switch, after which they are shunted right and left. On the empty car side the track is lowered so that the entire entry is below the coal seam, the coal serving as the roof.

In a number of places the main entries are roofed by leaving in a portion of the vein; the shaft is protected by forty foot coal pillars; the coal runs from five to seven feet in thickness and is fairly uniform in character. Pyritic concretions and clay ironstone bowlders are not as common as in the other districts of the county. Black jack comes in as usual, but rarely exceeds six inches in thickness. The roof is uniformly good and shows but

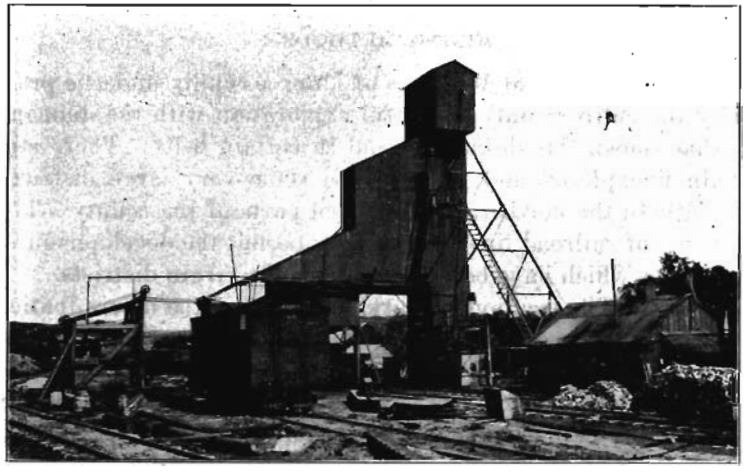


FIG. 69. Steel tipple, showing box car loader, shaft No. 10, Consolidation Coal Company, Buxton.

few slips and cuts. It consists of a blue gray to black shale and is but slightly affected by the weather. A thin seam of false shale or draw shale varying from two to twelve inches in thickness is often present, but gives comparatively little trouble. The rock away from the bottom is wholly gobbed in the vacant rooms. Irregularities in the way of thickening and thinnings and rolls and swamps are not unlike those in other mining camps of the region. The floor inequalities rarely exceed ten or fifteen feet. The only water encountered was in the drift, principally at the air shaft. All of the water which gathers in the mine is used in wetting down the entries, although formerly a pump was operated.

The room and pillar system of mining is used, the rooms being turned forty feet from center to center and driven 210 feet

Widening out begins after twenty feet. No undercutting or mining is done. The coal is produced wholly by shooting from the solid.

The Consolidation Coal Company has five churn drills prospecting on lands adjacent to those now being worked by the company. These drills are operated very economically by three horse power Clingman gasoline engines. The engines at 400 revolutions per minute drive the drills at 90 strokes per minute.

MINING METHODS.

The productive Coal Measures of Monroe county underlie practically the entire county. Careful exploration with the diamond drill has shown the absence of coal in certain belts. There still remain unexplored and undeveloped some very large districts, especially in the northern and western parts of the county. The extension of railroad lines will at once permit the development of large areas which have been located in these virgin districts.

Drilling.—The location of workable coal and the determination of the acreage are difficult and expensive in such a county as this. The outcrops of the Coal Measures are few, the drift is thick and erosion has cut out considerable coal. In the northeastern part of the county exploration is simpler than in the south and west. The streams of Pleasant township show coal smudge and a few outcrops. Prospecting can be done by means of drifts and pits. As the till sheet thickens it becomes necessary to use the churn drill or the diamond drill. Large areas about Coalfield and Smoky Hollow, Hilton, Foster, Hiteman and Buxton have been examined. For many years the common churn drill alone was used, but today most of the companies prefer and use the diamond drill. A notable exception is the Consolidation Coal Company, which employs only the churn drill. The value of drill sections depends upon the accuracy with which the various strata intersected are recorded and the number of drill holes per acre. An intelligent and skillful drill runner can obtain remarkably accurate results with the churn drill, but the average drill man returns reports which fail to check with subsequent records obtained by sinking a shaft. The average driller regards only the fact that he is looking for coal and considers the accurate observation and

record of other than carboniferous strata a waste of time and energy. For the driller who tries to record what he actually cuts there are many difficulties. Sludge from intersected argillaceous beds mixing with that from the bottom of the hole often causes a stratum to be recorded with an exaggerated thickness. Changes from sandstone to shale, shale to sandstone, shale to coal and coal to fire clay are easily noted and are generally accurately recorded. But the changes in the character of shales are very seldom given correctly. If the drill hole is to tell nothing more than the pres-

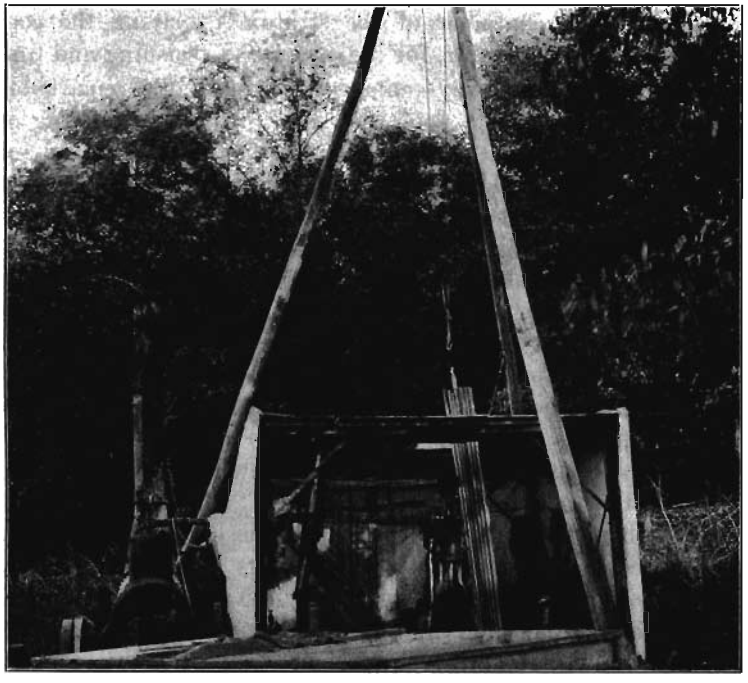


FIG. 70. Diamond drill of the Wapello Coal Company.

ence or absence, and the thickness of the coal seam, the churn drill can be satisfactorily employed. By the use of the diamond drill several other important observations may be made. Principal among these are the examination of the coal as to physical character and calorific value, and the examination of the rocks of

the adjacent strata. Today much of the fuel put upon the market is sold on its heating value. The careful investor and operator should know just what he is going to mine and put on the market before beginning to sink a shaft. A diamond drill hole is cheaper than a shaft and gives a fair sample for calorific tests. The friability of coal can be observed from the diamond drill core and its ability to stand shipment noted. Too much emphasis cannot be placed upon these examinations of the coal prior to the opening up of the seam. Sometimes the inability of the coal to stand shipment is not discovered until it is found that the coal is not marketable. The character of the stratum overlying the coal means much to the operator, for the expense of brushing and timbering air and haulage ways cuts down profits at a remarkable rate. In extreme cases a poor roof may prevent the mining of good coal. A shale that is very brittle or has many slips or one that carries considerable pyrite or clay ironstone bowlders causes no end of trouble, especially on entries which must be kept open for a considerable length of time. Something of the character of the shale as regards ability to withstand pressure and exposure to air currents can be learned from a diamond drill core. The amount of covering and the integrity and position of the strata with regard to water-bearing horizons must be noted with care and the shaft be located where the most favorable conditions are shown. A single drill hole means little or nothing in this district. One hole may show no coal while a few rods away a second hole may show a seam of good thickness. Many cases are on record to show how frequent have been the errors in assuming the presence of good coal over large tracts when several holes seem to show uniformity and regularity. Numerous holes must be drilled at regular intervals in order to prove the integrity of the coal seam. One operator in this field says: "We are never sure of the presence of coal until we have our entries driven and the things opened up in good shape." This fact has been appreciated by all of the companies and the numerous drill crews at work almost continuously are determining very carefully the exact boundaries of the several coal basins.

The cost of drill holes per foot varies considerably, depending principally upon the character of the materials penetrated, depth

of hole and cost of fuel and water. When the drift carries bowlders much time is lost in getting through or around them and quite often the hole is lost. The more regular the material the more easily is the drill operated and the expense is proportionately less. The depth of the hole means considerable to the drill crew. Both the shallow and the deep holes are expensive. In the former case it is necessary to move often and much time is lost in

FIG. 71. Churn drill of the Consolidation Coal Company, operated by a gasoline engine.

setting up the outfit. When the hole is very deep progress is impeded considerably by the additional friction of rope and rods. Fuel and water charges become large when either or both must be hauled some distance. Coal itself is cheap, but teaming charges add a large figure for drills operating at a distance from mines

and railroads. Gasoline has been adopted as a fuel for the churn drills operated by the Consolidation Coal Company and is giving excellent satisfaction. Three horse power Clingman gasoline engines furnish power for their drills. The cost of teaming is thus reduced to a minimum as water is required only for cooling the cylinder and for removing the broken material from the drill hole. In developing a large tract of coal land it is quite important to mark and record the exact location of the drill holes. The most accurate and only reliable way to preserve drill records is to connect all drill holes with section corners by actual surveys with the transit and to determine the elevation of the surface at each hole.

Opening the Mine.—Having the exact location and elevation of each hole and the depth of the coal seam beneath the surface, the actual elevations of the coal seams and the dips and rises can be plotted. Having made such an exploration of the coal field the location of the shaft, the planning of the bottom, the driving of entries and the actual underground layout in order to produce the maximum percentage of coal with the least expense in the haulage and drainage columns are not blind guesses. Several of the large companies are developing mines on this plan and it is the only economical method of developing coal properties where there are so many irregularities.

The coal seam may be opened by a drift, slope or shaft. When the seam crops out at a point easy of access and sometimes even when the outcrop is not easily approached by railroads the entrance may be made by a drift. When the seam does not outcrop or when the approach for tracks is not advantageous or suitable to opening by a drift, a slope is driven across the barren measures to intersect the coal seam and then follow along it. When the coal seam lies at a considerable depth and when a slope is not considered advisable a highly inclined or vertical opening called a shaft is made through the covering to the coal.

The dimensions of these openings will depend upon their uses and the quality of the material through which they are driven. Thus a very large opening cannot be easily maintained in heavy material. In such a case it must of necessity be as small as possible. An air shaft or air way will have to be driven with such an

area that it can easily furnish the required amount of air to the working places. A haulage way in which mules are used has at once its minimum height determined. A hoisting shaft may comprise one, two or three compartments. As a rule there are at least two compartments and a third is sometimes added for pipes, air or ladders. Drifts and slopes vary from five by seven feet to six by fourteen feet in cross section. Shafts vary from six by ten feet to seven by fourteen feet.

The Iowa mining laws require that there be for every seam of coal worked in the mine "two separate outlets, separated by natural strata of not less than 100 feet in breadth by which shafts or outlets distinct means of ingress and egress are always available to persons employed in the mine. * * * and if the mine is a slope or drift opening the escape shall be separated from the other openings by not less than fifty feet of natural strata. * *" *

After one of the main openings to the mine is determined the second opening is located within the limits of the law. The hoisting shaft should be located so that it will cut the lowest point of the coal basin and at the same time pass through material which is dry and can be supported easily. The requirements as to surface facilities are also important and must be considered. The grades on the railroad approaches should be light and the spur that must be built as short as possible. There should be space available for tracks, for empty and loaded cars. When the coal is hauled out through a drift or slope, tracks of sufficient length to accommodate two trips should be provided. Sometimes long trestles must be built for such tracks when underground conditions do not warrant the openings being driven at points offering greater facilities, for the simpler and cheaper installation of the top works.

Shaft sinking through the Coal Measures presents no serious difficulties, but when there is a heavy drift sheet carrying numerous bowlders many precautions must be taken. The work of sinking is all done by hand. Horse whims or gins are used to hoist the buckets, into which the broken ground is loaded. In order to sink large shafts quickly and when small shafts exceed seventy-five feet in depth steam hoists are generally installed.

*Chapter 21, Laws of 1884, Section 8.

Water is often bailed out in buckets, but sinking pumps must be hung in the shaft if there is any large inflow of water.

It pays to timber a shaft well. According to the character of the material passed through the timbering may be either heavy or light. Through the heaviest ground two by twelve inch plank laid horizontally give good support. Through very loose materials the shaft timber may be hung in sets from the top by a wire rope or each set hung from the next one above by rods. This practice is not common in the district. Slopes must be well timbered near the outcrop because from season to season there is considerable disintegration of the surface materials and where the slopes are steep there may be more or less "creeping" in the spring.

Systems of Mining.—Practically all of the coal of this county is mined by the pillar and room system; but one mine is operating longwall at the present time. The well known pillar and room system is named from the practice of first removing alternate blocks of coal, and leaving the remainder to temporarily support the roof. The rooms or openings from which the coal is removed are rectangular in shape and vary in width in this county from twenty to thirty-five feet and are driven as much as 200 feet in length. he pillars or blocks of coal remaining to support the roof vary in width from fifteen to twenty-five feet. After the rooms have been driven the length planned the coal in the pillars is mined retreating along an entry, "robbing the pillars."

The double entry system is used throughout the district. Two entries are driven parallel and from fifteen to forty feet apart. In order to allow the air to be carried as near as possible to the working face the entries are connected about every hundred feet by break-throughs. Secondary pairs of entries are driven off the main entries and are usually from 200 to 400 feet apart. Rooms may be turned from one or both of these entries. If possible the entries and rooms are driven so that the grade is in favor of the loaded car. If the grade will be against the load in either the entry or the room, the room is turned on the rise.

The rooms are driven narrow for about ten feet, that is the neck or room turning, or room door-way is only seven to nine feet wide. The work is then widened by bearing in forty-five degrees

on one or both sides until the room has the desired width. The work is then carried along straight until it holes with the room driven toward it from the next entry. Adjacent rooms are connected at frequent intervals by break-throughs in order that the ventilating current may be carried close to the working face.

The actual work of the miner consists in breaking down the coal, removing waste material, loading the coal into mine cars and the timbering of the working place. The coal may be broken down either by undercutting and shooting or "shooting off the solid." Coal may be undercut by hand or by machine. In this district there are no mining machines in operation. In undercutting coal the miner lies on his side and cuts out the bottom coal with a pick to a depth of from two and one-half to three and a half feet. He works across his room until he has removed across the entire face a triangular section about twelve inches high and two and a half to three and a half feet long or deep. He then either wedges down the coal which is undercut or bores several holes and shoots it down.

The general practice of the district is to "shoot off the solid." This simply means that the miner does no undercutting or mining, but puts in holes and shoots the coal out or off the face. The first system is the more laborious, but produces the larger percentage of lump coal and requires less shooting. It is adapted rather to thin veins than to thick ones.

In mines in which there is a parting in the coal seam the miner must give special care to the removal of all bone or shale from the coal. Bony layers often occur in the coal seam, perhaps more often occurring directly above it. In either case the bone must be removed and put in the gob. The coal is then loaded into mine cars. Tracks extend from the entry into each room and as near to the working face as possible. Very often these tracks are made of timber instead of rails. Props are supplied the men by the company, but the miner himself is responsible for the timbering of the working place. The timbers are placed regularly in order that the roof pressure may be evenly distributed, and whenever the miner notices a break in the roof he places timber so that he can support the pieces until he has removed the adjacent coal. The timbers are about long enough to extend from the floor to

within an inch or two of the roof. By means of a cap piece they may be wedged and securely held in the line of greatest pressure.

The irregularity of the coal seams and the varying conditions of the roof cause some difficulty in supporting the top and make considerable gob in the poor places. The percentage of coal removed varies widely with the mine. In some entries eighty per cent of the coal is removed, while in others not over sixty-five. The estimates of coal per acre made before the mine is opened up are very seldom equalled by actual records as given by the shipping returns.

Longwall is adapted to coal seams over which the roof is rather heavy but not poor. The practice is to leave a good shaft pillar, after which a continuous face is opened and the work directed away from the shaft. Along this face all the coal is removed. The face thus advances from the shaft to the boundaries and increases in length as it advances. The coal is undercut and broken down, preferably by roof pressure, but often by shooting. Main roadways are kept open to the working face by building pack walls to prevent the roof from settling. These roadways are maintained so that for about every forty or fifty feet of face there is roadway extending to a diagonal road which leads to one of the main haulage ways. There are generally eight main road ways and from these diagonals extend to the working face and with those already mentioned form a complete system by which there is easy access to any point on the face.

Ventilation.—Ventilation is one of the most important problems in mining. Various laws have been enacted by the State Legislature in order to secure for the workmen sufficient air to permit them to do their work with comfort. The principal one of these commands that not less than 100 cubic feet of air for each person and not less than 500 cubic feet for each mule shall be provided every minute.*

Ventilation has to do not only with the supply of fresh air, but also with the removal of the noxious gases escaping from the coal and resulting from shooting. There are no explosive gases found in the coal mines of Iowa, so there is no danger save from CO_2 escaping from the old workings resulting from the exhalation of

*Chapter 21, Laws 1884, Section 10.

men and animals in the mine and the various harmful products resulting from the combustion of black powder or dynamite.

The circulation of air in a mine is due to the difference in pressure at different points. Such difference is developed in this district by furnaces and exhaust and force fans. A furnace at the bottom of a shaft will heat the air in that shaft to a temperature considerably above that of the mine and the atmosphere. This difference in temperature means a difference in weight of the air in the two shafts and hence a difference in pressure. The cooler air being denser, is heavier and causes greater pressure than the warm air in the furnace shaft. So the furnace shaft becomes an upcast.

The mechanical ventilators are more common and they alone can furnish sufficient air for a large mine. Most of the new fans in the county are steel and vary in diameter from ten to sixteen feet. They are generally operated by direct connection to a horizontal reciprocating steam engine. In several cases they are belt driven from steam engines. When the fan house is located over the air shaft, at some distance from the main shaft, steam must be piped to the fan engine. Owing to the loss by radiation and leaky joints there are generally many difficulties in supplying steam to the fan engine. Several gas or gasoline engines have been installed for driving fans and these give complete satisfaction. The troublesome steam line is eliminated and the gas engine can get along with less care during actual operation than a poor steam engine.

In order to properly distribute the air to the various working places underground, it is necessary that the air current be conducted in as direct a path as possible to the sections to be ventilated. When the mine is very large and there are several sections it is advisable to split the air current and ventilate each section on a separate split rather than to conduct the air through all the working places in sucession. The proper distribution of the air requires canvas, brattices, doors and overcasts and undercasts.

When air is carried along a haulage way which intersects another pasage not carrying air it is necessary that the carrying be enclosed through the intersection; this may be done by the erec-

tion of doors or stoppings. Doors are necessary when any travel is maintained along the second opening. When two airways intersect, one air current may be conducted over the other by the building of an overcast, or beneath by an undercast. An undercast or overcast is the most economical method of getting air across a haulage way. In case one of these plans is not used, it is necessary to put two doors in the haulage way. To open these doors when a trip is passing through and to close them immediately afterwards requires a trapper. He is paid by the day, generally one dollar per day. In large mines from ten to twenty trappers are employed when no overcasts or undercasts are built. It can be easily shown that an overcast can be paid for by the sum paid out to trappers in a year. Automatic doors are used in the Whitebreast mine at Hilton and have been described in the report on that mine. The fuel charges against ventilation are low; the principal expense is for labor and by good timbering and the construction of overcasts this can be reduced to a minimum.

Drainage.—Drainage of coal mines is effected by the collection of the mine water in the lowest points in various sections of the mine and then by a number of air or electric pumps this water may be lifted to the sump at the bottom of the shaft. Such a sump should be large enough to hold all the water produced in the mine for two days. In case of accident to the main pumps unless the sump is large, the bottom is very frequently flooded. Ditches should be dug on all wet haulage ways in order to keep the track as dry as possible. Whenever feasible, ditches for conducting water to the shaft should be made in the air ways rather than the main haulage ways. When entries are being driven in the dip, small pumps or water cars will have to be put in. Electric pumps may be economically operated when electric power is already used underground. Portable pumps driven by either air or electricity are to be recommended for the opening up of the mine.

Haulage.—Haulage underground is effected either by mules or horses or by mechanical power. Mules are preferred for short hauls, for pulling loaded cars from the working places to the switches and for distributing empty cars. But when the length

of haul is considerable and the grade against the loads high, some mechanical equipment is usually installed. In Monroe county the tail-rope is used in almost all of the large mines. Such equipment consists of an engine, either on the surface or underground, driving the main shaft on which are two drums, both of which may be loose on the shaft or be fastened by clutches. Two ropes, the main and the tail-rope, are used in drawing out the loaded cars and pulling the empties back to the inside switch. The main rope is generally the heavier rope. In case there is a loaded trip inside to be pulled out the main rope extends from the drum to the trip. The trip is fastened to the rope by a catch, the simpler the catch, the better; the tail-rope drum is loose on the shaft and the tail-rope passes the whole length of the line around the bull-wheel at the end of the line and back to the rear end of the trip. The tail-rope acts as a break and holds the loaded trip on grades while the main rope pulls. On returning empties to the mine the tail-rope pulls and the main rope acts as a brake. The tail-rope must be twice as long as the main rope. The rope is kept off the ground by wooden or iron rollers placed every twenty to thirty feet. On the curves guide sheaves are placed so as to keep the strain on the rope uniform and to keep the rope in the center or at the side of the track. Rope haulage can be used on almost any grades and by means of branch ropes coal can be hauled from side entries.

The endless rope system is used in several mines in the state outside of Monroe county and is adapted to a very large and uniform output. As named, the rope in this system is endless or continuous. It passes around the drums on the surface or at the shaft bottom at one end of the line and around a bull-wheel at the other. There is always some device for taking up the slack in the system. Cars may be picked up individually and fastened to the rope by chains or grips or a number of cars may be hauled in trips by grip cars. Compared with the tail-rope system the endless rope system has only two-thirds as much rope, but requires two tracks,—one for empties going in and the other for loads coming out. The endless rope travels at a uniform rate of about three miles per hour, while the tail-rope runs as high as eight miles per hour. No engineer is required or attendance at the engine

while the tail-rope requires one man. The tail-rope system is better adapted to hauling from side entries and to the extension of the haulage tracks. Rope haulage can be used on almost any grade and under a great variety of conditions. Locomotive haulage requires special conditions of track, generally increased size of haulage ways and the installation of an expensive power plant and a power line of some kind. Electric haulage has given satisfaction at Pekay, where two locomotives have been in use for several years. At present there is no compressed air haulage plant in the state.

Track and Shaft Bottom.—The track underground should be kept in as good condition as possible. Poor and ill kept roads increase the friction of mine cars at a remarkable rate. On main haulage ways nothing less than a thirty pound rail should be used and where there is a very heavy haul it is safer to put in fifty pound rails. Lyes and switches should be located at convenient points wherever there are long hauls. Considerable track room should be provided at the bottom of the shaft.

The general plans for a shaft bottom may be, first, caging from one side, and, second, caging from both sides. The former plan is more economical of operation, but demands that there be such an arrangement of tracks that all of the loaded cars can be conveniently collected on one side and the empties be handled either from the opposite side or be switched easily around the shaft to the track for empties. The bottom plan of the Hilton mine already discussed is a good example of caging from one side and shows what can be done when the bottom is well designed. When the loaded cars are caged from both sides of the shaft the loaded car is supplied from one side and the empty is taken off on the other. The next loaded car is then taken from the opposite side and so on. Switches may be used at the shaft bottom, but plates of iron are commonly used for light weight cars.

Cages.—The cars are held on the cages by latches or dogs and are easily released when the car is to be removed. Quite a number of improvements have been added to the old style cage. The lifting track and the automatic dump are giving satisfaction wherever used. Self dumping cages are used by the Consolidation and Hocking companies. The details of such cages differ

considerably, but the general principle is the same. The mine car is held on the cage so that when the floor is tipped forward it will not run off. The door of the car is caught by a hook and when the car tips, the door is held up and the coal falls out upon the grizzly. The operation of the dump is very simple. The floor of the cage is mounted pivotally so that it can turn easily on a horizontal axis about three feet below the floor. Auxiliary guides run the full depth of the shaft, parallel to the main guides which direct the wheels on the extremity of the lever arm, extending to the axis about which the floor dumps. When this wheel is deflected by the guides from a vertical path the cage is deflected in the same direction. The auxiliary guides are so curved at the top of the shaft that the cage platform and the car on it are turned to an angle of about forty degrees, while the cage frame work on the main guides retains its vertical position. When the cage frame is lowered, the car on the platform returns to a vertical position as the guide wheel before mentioned following along the auxiliary guide leaves the curve and follows down the section parallel to the main guide. Such cages for automatic dumping have various patent details as to guides, levers and platforms, the general principles being the same.

In order to protect the workmen at the top and the miners who descend into the mine, safety gates, safety catches and detaching hooks are necessary. Several of the mines in this district have done much to protect their men and one company has put in safety hooks.

Top Works.—The top works and shaft house or tipple should be so planned and equipped that the maximum output of the mine can be easily and economically handled. The coal must be dumped upon the screen at such an elevation above the tracks that it can be thoroughly and quickly screened and yet at not so great a height that the lump coal in dropping through to the railroad cars is unduly shattered after leaving the screens.

Power Plant.—Hoisting engines and boilers should be simple, durable and able to stand hard usage. The boilers used in this district are generally two flue boilers or tubular boilers especially adapted to the grade of fuel used. As the quality of water varies considerably during the year and generally contains a high per-

centage of solid matter the boiler must be able to stand rougher usage than those commonly used by manufacturing establishments. The fuel used is generally slack or bony coal which is unmarketable.

The hoisting engine must be able to give rapid hoisting, a quick start and must be easily controlled. The engines of this district are of both the common types, the direct connected and the geared. When direct connected the engines must be very powerful and give high speed hoisting. They must be controlled easily and have powerful brakes in order that they can be stopped quickly and at the desired point. The geared drums permit a smaller engine to be used. In order to hoist rapidly when the gear is from one to four to one to eight the engine must be run at a high speed; such engines are easily controlled and the cage can be stopped at the top more easily than when the engine is direct connected.

Various styles of indicators are used in engine rooms to show the position of the cages in the shaft. The finger moving in the vertical line and the disk on which points are marked by the finger moving like the hands of the clock are the most common.

Transportation and Markets.—Practically all of the mines operating in the county are railway mines and produce but little coal for local consumption. In 1901 out of a total production of over a million tons less than one and a half per cent was sold to the local trade and employes. The average percentage for the entire state sold to the local trade and employes during the same year approximated twelve per cent. The railways are the chief customers and all of the large mines usually have large railway contracts which tend to steady the price and equalize the production throughout the year. In 1901 Monroe county mines were in operation the largest number of days of any of the great coal producing counties. Her record for the year was 265 days active, while the records for the whole state show an average of only 218 days active.

The general movement of the coal is to the west and north. An apparent exception is in the case of the mines at Hilton and Foster, where most of the coal goes northeast over the Kansas City division of the Chicago, Milwaukee and Saint Paul railway.

The Miller creek and Hocking mines are tributary to the Iowa Central and the total output is carried north. Smoky Hollow district, Hiteman and the Cedar creek mines are directly connected by spurs to the Burlington and the bulk of their output is carried west and distributed by the various branches of the system. The mines of the Bluff creek basin contribute their entire product to the Chicago and Northwestern railway system. The coal produced by the Consolidation Coal Company is carried to Belle Plaine and from there distributed north and west by the various branches of the system.

COAL TESTS

Samples of coal representative of the leading mines of the county were tested both chemically and calorimetrically. The chemical work was done by Mr. F. M. Weakley and the results appeared in the "Iowa Engineer."* The calorimetric work was under the direction of G. W. Bissell, professor of Mechanical Engineering, Iowa State College, and the results are published in the Iowa Engineer.† A Parr Standard Calorimeter, the invention of Professor S. W. Parr of the University of Illinois, was used. In the table below the calorimetric tests of a number of coals from other parts of Iowa and standard fuels from other parts of the country are added for comparison:

*Volume II, pp. 13-18. Ames, 1892.
†Loc cit. pp. 1-12.

COMPANY AND LOCALITY.	No. sample.	Volatile combustible.	Fixed combustible.	Total combustible.	Ash.	Sulphur.	Calorimetry B. T. U.
Consolidated Coal Co.—							
Buxton, Iowa, No. 11	1	37.00	50.83	89.92	12.08	2 27	10,585
No. 10	2	48.60	45.02	93.71	6 29	3.58	12,030
Hocking Coal Co.—							
Hocking, Iowa, No 1	3	40.02	44.86	84.88	15.12	7.41	12,087
No. 2	4	45.18	45 34	90.52	9.48	8.98	12,560
Whitebreast Fuel Co.—							
Hilton, Iowa	5	40 61	48.21	88.82	11.18	3.28	12,396
Average for five Monroe county coals	6	42.32	46.81	89.18	10.83	4.10	11,922
Centerville Block Coal Co.—							
Appanoose county	7	37.79	54.85	92.64	7 36	3.29	12,681
Corey Coal Co.—							
Webster county	8	37.98	47.98	85.96	14.04	5.90	12,431
Crawe Coal Co.—							
Boone county	9	41.46	50.33	91.79	8.21	4.16	12,729
Des Moines Coal and Mining Co.—							
Polk county	10	45.62	50.29	95.91	4.09	2 74	12,041
Eldon Coal and Mining Co.—							
Wapello county	11	42.72	47.78	90.50	9.50	4.96	18,141
Jasper County Coal and Mining Co.—							
Jasper county	12	42 24	50.27	92.51	7.49	3.08	12,134
Lodwick Bros.' Mystic.—							
Appanoose county	13	39.07	54.91	93.93	6.02	3.15	12,780
Lumsden Coal Co.—							
Davis county	14	39.06	53.46	92.52	7.48	2.38	12,097
Platt Coal Co.—							
Van Meter, Dallas county	15	40.54	51.04	91.53	8.42	3.68	11,941
Whitebreast Fuel Co —							
Pekay, Mahaska county	16	46.06	46.89	92.95	7.05	2.81	13,050
Carbon Coal Co.—							
Willard, Wapello county	17	38.94	54.20	91.14	8.86	2.86	12,245
Indiana coal, Brazil	....	37.89	55.21	93.10	6.90	1.49	.....
Average four samples, Hocking Valley, O.	....	38.14	53.03	91.17	8.83	1.68	.....
Pocahontas coal, West Virginia	....	18.23	75.08	93.31	6.69	0.60	.....
Average of twenty-two Illinois coals	..	35.11	51.91	87.02	12.77	3.02	.....
Anthracite coal	....	.....	.....	.....	....	.....	12,532
Foundry coke	....	.....	.....	.....	....	.....	12,133
Lampblack	....	.....	.....	.....	....	.....	14,467
Crude petroleum, Chanute, Kansas	....	.....	.....	.....	.....	.....	19,488
Crude petroleum, Beaumont, Texas	....	.....	.....	.....	....	....	19,000

The desirable qualities of a coal are a high percentage of fixed carbon and total combustibles, and low percentage of ash and sulphur. The sulphur is present usually in the form of iron sulphide or marcasite and the hydrous calcium sulphate or gypsum. In the first instance the sulphur is combustible while in the second it is not. The iron of the sulphide remains with the ash. The gypsum is dehydrated and remains with the ash. In the Monroe county coals the sulphur is mainly in the form of the sulphide. The coal of the Centerville seam or the "Mystic seam" of Bain, contains thin white partings of gypsum. Coke is the sum

of the fixed carbon and ash. None of the Monroe county coals are suitable for foundry coke, unless washed, on account of the comparatively high percentage of sulphur.

It is obvious from the above table that the actual heat value of the coal cannot be accurately determined from its chemical analysis. Nor is it possible to determine more than approximately from both chemical analysis and calorimeter tests the coal which would yield the best results when used in actual boiler tests. In a general way it may be observed, other things being equal, that the coal highest in fixed carbon gives the highest results calorimetrically, but when consumed under a boiler may be beaten by a really inferior coal. The percentage of volatile carbon affects the length of flame and coals possessing a high percentage of volatile carbon may possess a distinct advantage over better coals when used with certain types of furnaces or boilers. These are facts which should be kept in mind in the selection of a fuel for a given purpose or in the design and selection of grates and boilers when a certain fuel is to be used.

Clays.

The county is bountifully supplied with clays suitable for the manufacture of ordinary clay products and some of the more expensive wares. Almost nothing has been done toward their utilization. The clays available belong to two widely separated periods and differ greatly in character. The stratified clay-shales of the Coal Measures cover almost the entire county, although only exposed along the streamways. The most available sections appear in the northeast half of the county. Almost every ravine in the vicinity of Buxton and Hiteman exhibits liberal sections of argillaceous beds above the water line and not deeply covered by surface materials. Shales appear lower on the valley walls along Coal and Cedar creeks and their tributaries and the streams draining east from the divide. Many of the exposures are located directly on railway lines or within easy reach of such lines. None of the older clays have been used or are being used at the present time in the manufacture of clay goods.

The surface clays are second only in extent and thickness to the shales of the older rocks. The oxidized zone of the Kansan

drift often contains clays sufficiently free from bowlders and pebbles to be suitable for the manufacture of common brick and drain tile. The Kansan is almost everywhere buried by the loess which is especially adapted to the manufacture of common brick, dry press brick and drain tile. The upland loess is often very fine textured and highly prized in the manufacture of burnt clay ballast. The only clay works in the county use the loess. The somewhat assorted loess is worked into common soft mud brick and the upland loess has been used from time to time in the manufacture of burnt clay ballast. The latter material does not give satisfactory results when used for other clay products on account of its excessive shrinkage. Another source of raw materials is the alluvium modified by the wash from the loess and Kansan and furnishing a material which gives satisfactory results when wrought into common mud brick.

Clay Industry.—During 1902 only three small plants were in operation, turning out 200,000 common brick valued at $1,500. During the same time the county imported many times the above number of common brick in addition to face and paving brick, tile and sewer pipe. This is unwise economy and must correct itself in time. The various grades of brick can be made locally at least as cheaply as at the points from which they come. The raw materials are present in almost inexhaustible quantities and readily accessible; an abundance of cheap coal of excellent quality is at hand and labor is no dearer than in the neighboring counties. Monroe county should be an exporter instead of an importer of clay goods.

Until 1902 the county had been a large producer of burnt clay ballast. Upland loess along the main line of the Chicago, Burlington and Quincy at Maxon was utilized for this purpose for a number of years and the pits at this point furnished ballast for the road even beyond the limits of the county. The Davy Burnt Clay Ballast Company, whose home office is at Kenosha, Wisconsin, installed an extensive plant at Selection along the right of way of the Wabash. During 1901 the plant was in full operation, but did not operate during 1902.

The methods used by the Davy company in the manufacture of burnt clay were very simple and very effective. Some five or six

feet of the surface materials were used. A car mounted on trucks and equipped with a steam shovel and an extra long boom extending out at right angles constitutes the excavating or ballast machine. At the beginning the steam shovel cuts a trench as it moves ahead, depositing the removed materials on the opposite side of the trench by the scoop running out on the boom and dumping. The shovel car is followed by a coaling car which consists of a traveling scoop much on the same principle as the steam

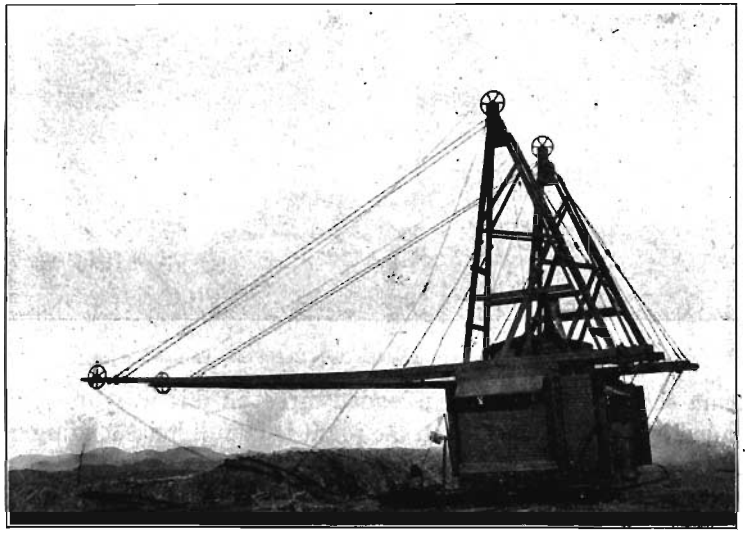


FIG. 72. Burnt clay ballast machine used by the Davy Burnt Clay Ballast Company.

shovel which brings the coal to a belt conveyer, which in turn deposits a thin layer of coal over the fresh clay ridge. The track is set back from the trench and the steam shovel cuts a new swath transferring the material across the trench and depositing it evenly over the preceding layer. This in turn is followed by the coaling machine and the process repeated over and over again. The first layers are fired and the fire passes from one layer to another, the process being continuous when once well under way. The amount of coal added is intended to be sufficient to burn all or nearly all of the

clay, but not to fuse it. The value of the ballast depends very largely upon the perfection of the burning. If underburnt the clay slakes and becomes slippery when wet. If completely fused it adds to the expense of distribution. The usual way of handling the ballast when sufficiently cooled is to lay a track on the opposite side of the pit from the ballast machine and coaler and use a

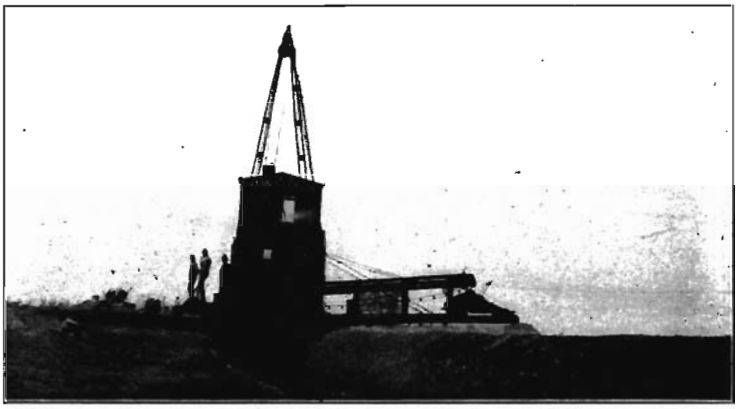


FIG. 73. Coaling machine used by the Davy Burnt Clay Ballast Company.

steam shovel. Flat cars are loaded direct in this way or may be loaded by hand. Thus when the plant is in full blast loading and removal follow closely trenching and coaling. For economical working the pit usually ranges from one-half mile to a mile in length.

Building Stone.

Outside of the limited outcrops of Saint Louis limestone in the northeast corner, the county possesses no stone suitable for building purposes. West of Eddyville some quarrying has been done, but during the years 1901 and 1902 no stone produced in the county was marketed. The beds formerly quarried, consist of about three to four feet of sub-crystalline gray limestone in fairly thick beds below and two feet of a compact, thinly bedded limestone above. The lower beds when closely inspected present a slightly oolitic facies and both beds are pyritic, the pyrite balls

sometimes attaining an inch or two in diameter. The same beds are quarried at several points along Miller creek in Wapello county and similar beds are quite extensively developed at Dudley.

Sand.

Away from the valley of the Des Moines river and its tributaries in the immediate neighborhood, building sand is a comparatively scarce article. The short stretch of the Des Moines affords sand sufficient for the entire county. Some of the larger streams in the northwest section bear gravel terraces which furnish some building sand. The loess near the more important drainage lines grades downward into clayey sands suitable for molders' purposes. The dunes along the Des Moines afford similar material.

Road Materials.

Road materials ready for use are comparatively scarce. Terrace gravels occur along some of the larger streams, but the deposits are uncertain and somewhat interrupted. The Chicago, Burlington and Quincy railway company has put down a number of test pits along Whippoorwill creek. The pits show from two to ten feet of gravel. The gravels are evidently stratified and in some of the pits fairly free from clay and silt and suitable for railway and road ballast. These gravels form a terrace some twenty to thirty feet higher than the present flood plain. As a rule the terraces at lower levels are composed of fine gravels, sands and silts and not so well suited for road work. The indurated rocks contribute nothing in the way of road materials. The Coal Measures are not sufficiently indurated and the Saint Louis not sufficiently accessible to be of importance.

For manufactured road materials the surface clay affords an inexhaustible supply of raw material suitable for the manufacture of burnt clay ballast. This topic has been discussed sufficiently under the head of the clay industry.

Soils.

As in all of the other counties of the state the soils are after all the most important asset of the county. Two fairly distinct

types may be recognized; the modified loess-Kansan of the upland and the alluvial of the bottom and "second bottom" lands. The first covers much the greater area, while the latter is the more tractable and may be the more productive. Near the divides the clay constituent may be so great in the loess-Kansan as to render it mucky and imperfectly drained. In such instances the land is cold when wet and tends to bake when it dries, qualities not favorable to the growth of cereals. Much of the county is so greatly stream dissected that there is a considerable tendency to wash under the processes of agriculture, but affords excellent pasturage. The bottom land soils are more porous an dare usually highly productive when not too sandy. In especially wet seasons they are sometimes subject to inundation.

Potable Waters.

An adequate water supply during seasons of prolonged drouth is a serious problem for a considerable portion of the county. All of the wells thus far put down are shallow, the majority drawing their supply from the gravels and sands at the base of the drift, the sub-loessial sands or from the alluvial sands and gravels. During wet seasons all of these furnish a fairly stable supply, but during the summer of 1901 all proved more or less untrustworthy. A few wells completely penetrate the superficial materials and enter the indurated rocks with indifferent results. Stock water is obtained largely by the construction of artificial ponds. Embankments are built across the sharp draws and ravines and the storm water is conserved. This is possible because of the impervious character of the surface materials. None of the cities and towns have a sufficient supply of water for domestic use and fire protection save Eddyville, and even Eddyville has done but little towards utilizing her advantages. The domestic water supply of Albia is obtained from shallow wells and the town possesses a very inadequate water supply and waterworks system for fire protection. An artificial pond affords a reserve in case of a conflagration. The mining towns of Buxton, Hiteman and Hilton have a most precarious supply of water in dry seasons. The first mentioned town was almost wholly dependent on water brought in tank cars from the Des Moines river during 1901. It is only

a question of a few years until the water problem will be more urgent than it is now. The larger towns will be obliged to provide better fire protection and to observe better sanitary practice in the disposition of sewage. To meet these requirements an increased water supply is the first essential. From the data in hand the water supply can be increased in two ways: first, by the construction of reservoirs to entrap the surface waters, and second, by the sinking of deep wells. In the construction of reservoirs to catch the storm water one precaution must be observed and that is to guard against any possible contamination over the catchment area and doubtless some system of filtering would be necessary. It would be unsafe to provide a reservoir or supply of pure water for domestic purposes and provide a reserve supply of doubtful antecedents for fire protection when one system of mains must serve for both. The impervious character of the upland surface materials renders possible the construction of surface ponds or reservoirs and perhaps affords a feasible way of augmenting the water supply. The water obtained in this way would be comparatively free from mineral matter in solution and when freed from mechanical sediments through filtration would be admirably adapted for boiler and manufacturing purposes.

The second means of water supply enlargment through deep wells is perhaps more expensive and the results are less certain. The deeper strata are practically unexplored in the county and the lower Paleozoic sandstones which afford reliable supplies of water in the north central portions of the state have not been penetrated in any of the adjoining counties. Some information may be gathered from a study of the deep wells at Ottumwa and Centerville and it is possible to estimate the probable depths at which water bearing horizons may be reasonably expected. The well put down by Morrell & Company and the one put down by the Artesian Well Company, both of Ottumwa, appear to draw their supplies from about the same horizon, the arenaceous beds in the Silurian reached at 1085 and 1015 feet below the surface respectively. Both wells give strong flows of water suitable for domestic purposes, but not adapted to boiler use until treated.

The Centerville deep wells also draw from the sandstone beds of the Silurian reached at a depth of from 1200 to 1439 feet. The

flow is not so strong as in the case of the Ottumwa wells and the water is more highly charged with solids.

For Monroe county the conditions may be expected to be about the average of Wapello and Appanoose counties and the Silurian aquifer ought to be reached at about 1200 to 1400 feet and the supply vary from 400 to 600 gallons per minute as the average supply for the two Ottumwa wells is reported to be 850 gallons per minute and for the two Centerville wells 275 gallons per minute. The water would probably be satisfactory for domestic use and fire protection, but could not be used without treatment for boiler purposes. Water from this source would probably rise to within 250 to 300 feet from the surface at Albia.

To reach the lower Paleozoic sandstone it would probably be necessary to drill to a depth of from 2600 to 3000 feet and perhaps even to a greater depth.

ACKNOWLEDGMENTS.

The writers are indebted to the mining companies operating in the county for numerous courtesies. The drill records carefully kept and secured at great expense by these companies were generously placed at the disposal of the Survey and were freely used. In fact the writers can record only courteous treatment from all those with whom they have come in contact in the progress of the work.

THE FOREST TREES AND SHRUBS OF MONROE COUNTY.

BY L. H PAMMEL.

During the month of April I made a trip to Monroe county to study the forest trees and shrubs. Stops were made at Eddyville, Albia and Moravia. The latter place is in Appanoose county, but it was a convenient location to study forest conditions as the county line is but a few miles distant.

The small streams were, during the early settlement of the country, well wooded along their borders. Much of the best timber has long since been removed, but there is a good second growth in many places, though this has suffered during recent years because of the dry weather and overgrazing in the woods. The lumbering methods are most wasteful in many cases. There is a good demand for native lumber made from such species as the walnut, ash, elm, cottonwood, and sycamore, especially near Eddyville, where a small saw-mill is located. Along the Des Moines river there are still a few fine groves of sycamore, many of the larger trees being 12-14 feet in circumference. The chief oak is the white and red. These are also cut for lumber and fuel. Two other oaks were observed, the Bur (*Quercus macrocarpa*) and shingle oak (*Q. imbricaria*). The former makes a good sized tree on upland clay woods. The latter is a small tree and nearly reaches its northern limit near Eddyville.

TILIACEAE.

Tilia americana L.—Basswood. The species occurs along the Des Moines and its tributaries in the vicinity of Eddyville. On the moist sandy hills a second growth tree was measured and found to be two feet in circumference breast high, and thirty-five

feet high. The old trees were apparently all removed by the early settlers.

RUTACEAE.

Xanthoxylum americanum Mill.—The Prickly Ash was observed near Eddyville on the sandy bluffs and also along the borders of timber in the vicinity of Moravia.

CELASTRACEAE.

Celastrus scandens L.—The climbing Bittersweet was found in the woods near Eddyville. This plant should commend itself to cultivation.

Euonymus atropurpureus Jacq.—The Burning Bush occurs in the timber and even comes up in abundance along roadsides in the vicinity of Eddyville. It is a most desirable shrub for cultivation.

RHAMNACEAE.

Rhamnus lanceolata Pursh.—The native Buckthorn was not observed, but since it occurs to the west in Dallas county and also in Boone county it probably also occurs in Monroe.

Ceanothus americanus L.—The New Jersey Tea is common on the sandy bluffs about Eddyville.

VITACEAE.

Vitis cinera Engelm.—The Downy grape was not observed, but it occurs in Davis county along the Chariton river in the vicinity of Diff P. O.

V. riparia Michx.—Our Wild Fox Grape is common everywhere in the county near Moravia, ffddyville and Albia. Specimens of considerable size were observed. Two specimens had the following measurements, circumference (1) 14 inches at base 30 feet high, (2) 9 inches at base, 15 feet high.

Ampelepsis quinquefolia Michx.—The Virginia Creeper is common throughout the county both in upland timber and along the large streams like the Cedar and Des Moines.

SAPINDACEAE.

Aesculus glabra Willd.—The Ohio Buckeye occurs along the Des Moines, and probably also along the other streams.

Acer nigrum.—The Hard Maple is cultivated in the county and may occur wild, but certainly not an abundant tree.

A. saccharinum.—The Silver Maple is one of the most abundant of the forest trees in the county in the alluvial bottoms along the Des Moines, Miller creek and Cedar creek. It is also extensively cultivated in the county, being one of the most common street trees.

LOCALITY.	When planted.	CIRCUMFERENCE.		HEIGHT.	REMARKS.
		Breast high.	Base.		
Albia	1870	5 ft.-2	5 ft.-7	60 ft.	Street trees.
Albia	1870	4 ft.-7	5 ft.-12	60 ft.	Street trees.
Albia	1870	5 ft.-8	7 ft.-1	65 ft.	Street trees.
Des Moines river bottom near Eddyville	1870	6 ft.-4	.....	50 ft.	Native.

Some large trees are still left in the Des Moines river bottom, but the best of the trees have long since been removed. In the saw-mill yard at Eddyville there were a few good sized logs 10-12 feet long of good timber. One log measured 34 inches in diameter. This tree was one hundred years old. It is propably fair to assume that good merchantable timber of this species may be produced in 75 years. In the city of Pella in the county to the north the writer measured a soft maple that was 12 feet in circumference and 65 feet high. This tree was set out in 1847. Owing to the condition of growth the tree was not a desirable one for lumber. It shows, however, what the tree will do under cultivation.

Negundo aceroides Moench.—The Box-elder is common throughout the county along streams. It is frequently used as a shade tree in the streets.

ANACARDIACEAE.

Rhus glabra L.—The common Summach is common throughout the county.

R. toxicodendron L.—The Poison Ivy occurs most frequently in the bottoms where it climbs some of the tallest of trees. It is also found in upland woods.

LEGUMINOSEAE.

Amorpha canescens.—The common lead plant occurs on the prairies.

A. fruticosa L.—False Indigo is common in low grounds.

Cercis canadensis L.—The Red Bud occurs along the Des Moines northwest of Eddyville and presumably also in Monroe county.

Gymnoclades canadensis Lam.—The Kentucky Coffee-tree is not infrequent near Moravia and also along the Des Moines near Eddyville.

Gledistchia triacanthos L.—The Honey Locust is not infrequent along the streams especially the Des Moines. There are few of the primitive trees left. Some measurements made gave the following results:

LOCALITY.	Age.	CIRCUMFERENCE.		Diameter.	HEIGHT.	REMARKS.
		Breast high.	Base.			
Moravia	43	.....		20 in.	40 ft.	2nd growth.
Eddyville	50	.....	.....	20 in.	.....	2nd growth

The rate of growth of the log twenty inches in diameter was as follows: First ten years, three inches; second ten years, four inches; four inches during the last ten years; and nine inches between twenty and forty years. This is a remarkably good growth for a tree having such desirable wood.

ROSACEAE.

Prunus americana Marshall.—The Wild Plum comes up in thickets in many portions of the county.

P. virginiana L.—The choke cherry occurs along the Des Moines.

P. serotina Ehrh.—The wild black cherry occurs not only along the Des Moines, but along the smaller tributaries of this stream and the Chariton.

Physocarpus opulifolius Maxim.—The nine-bark has been reported to me from Wapello county in the vicinity of Ottumwa. Probably does not occur in this county, if so it is rare.

Rubus occidentalis L.—The wild red raspberry occurs in the woods in the vicinity of Eddyville.

R. strigosus.—The red raspberry is frequently cultivated.

R. villosus Ait.—The high bush blackberry occurs on the sandy hills near Eddyville.

Rosa Arkansana Porter—The common rose everywhere throughout the county.

R. rubiginosa L.—This sweetbriar is cultivated and rarely has escaped from cultivation.

R. setigera Michx.—The prairie rose is frequently cultivated, but scarcely hardy without protection.

Pyrus Iowensis Bailey.—The wild crab is widely distributed in the county, forming thickets.

Crataegus L.—It is probable that more species occur than the writer has been able to detect, since it is important to have the leaves, flowers and fruit.

C. mollis L.—This is the most common species of the bottoms and makes the largest tree of the genus in the county.

C. punctata Jacq.—This is the most handsome of the genus. The flat top, handsome foliage, make it a most desirable species for cultivation. It is found in bottoms.

C. margaretta.—This species is most abundant along the smaller streams in the southern part of the county.

Amelanchier canadensis Torr & Gray.—The service berry was not observed in the county, but it occurs along the Des Moines northwest of Eddyville.

SAXIFRAGACEAE.

Philadelphus coronaria L.—The mock orange is frequently cultivated.

Ribes gracile Michx.—The Missouri gooseberry is abundant everywhere in clearings along streams.

R. grossularia.—The cultivated gooseberry is hardy and frequently cultivated in the county.

R. rubrum L.—The currant is hardy and frequently cultivated.

R. aureum Pursh.—The Buffalo currant is frequently cultivated for ornamental purposes.

CORNACEAE.

Cornus sericea L.—The silky cornel forms thickets along roadsides and fences in the northern part of the county.

C. paniculata L. 'Her.—The white fruited dogwood is frequent in the county.

CAPRIFOLICEAE.

Sambucus canadensis L.—The common elder is common in low grounds throughout the county.

Viburnum opulus L.—The snowball is frequently cultivated.

V. prunifolium L.—The black haw was observed near Moravia.

Symphoricarpus vulgaris Michx.—The coral berry or Indian currant is common everywhere on the hills and dry sterile soil. Borders of woods.

Lonicera sempervirens Ait.—The trumpet honeysuckle is frequently cultivated.

L. tartarica L.—The Tartarian honeysuckle is frequently cultivated.

RUBIACEAE.

Cephalanthus occidentalis L.—The button bush is common in low grounds along the borders of sloughs.

OLEACEAE.

Fraxinus americana L.—The white ash is a rare tree in the county. It was observed along Miller's creek south of Eddyville.

F. viridis Michx.—The green ash is common along streams throughout the county and especially well developed along the Des Moines. Measurements made of some trees will be of interest.

LOCALITY.	When planted.	Age.	Diameter.	CIRCUMFERENCE.		HEIGHT.	REMARKS.
				Breast high.	Base.		
Eddyville	.....	64	3 ft.	.....	.....	.....	Log 10 ft. long
Eddyville		55	2 ft.	.....	.....	.....	Log 10 ft. long
Albia	1870	32		4 ft.	4 ft. 9in.	60 ft.	Cultivated prairie soil

The following rate of growth was made by decades of the tree at Eddyville: First 10 years, 5 inches; second 10 years, 6 inches; third 10 years, 6 inches; fourth 10 years, 6 inches; fifth 10 years, 6 inches; sixth 10 years, 5 inches; four years, 2 inches.

Syringa vulgaris L.—The lilac is frequently cultivated in all parts of the county.

BIGNONIACEAE.

Tecoma radicans Juss.—The trumpet creeper is cultivated, but not indigenous so far as I know.

Catalpa speciosa Warder.—The catalpa is frequently cultivated and hardy. A tree measured in Albia was 5 feet 11 inches in circumference and fifty feet high.

URTICACEAE.

Ulmus fulva Michx.—The slippery elm. Common on the hills. One of the older trees on sandy hills at Eddyville measured 3 feet in circumference and 35 feet high.

Ulmus Americana L.—American elm. Abundant throughout the region, especially in low grounds along streams. A rapid growing species. The following are some measurements taken at different points:

LOCALITY.	When planted.	Age.	Diameter.	CIRCUMFERENCE.		HEIGHT.	REMARKS.
				Breast high.	Base.		
Albia	1870	32	.....	4 ft. 10 in.	5 ft. 8 in	65 ft.	
Moravia	....	30	...	8 ft.	4 ft. 10 in.	40 ft.	Forest clay soil
Moravia	.....	85		2 ft. 5 in.	3 ft. 2 in.	75 ft.	Clay soil.
Moravia	.	....	.....	3 ft.	3 ft. 6 in.	40 ft.	Clay soil
Moravia	....	150	3 ft.	.....	.....	75 ft.	Clay soil.
Eddyville	....	.....	.....	6 ft. 10 in.	.....	50 ft.	Clay soil.
Eddyville		53	2 ft. 2	.....	.....	.....	Log.
Eddyville	.....	115	3 ft.	.....	.....	75 ft.	Bottom forest
Evans	...	....	.....	12 ft. 3 in.	....	75 ft.	
Evans	. .	...		6 ft. 4 in.	.....	60 ft.	
Evans	.....	110	.....	2 ft 8 in.	.....	.....	

A log at Eddyville made the following rate of growth, by decades: First 10 years, 4 inches; second ten years, 4½ inches; third 10 years, 4½ inches; fourth 10 years, 6 inches; fifth 10 years, 4 inches; in the last eight years, 4 inches.

Ulmus racemosa Thom.—Corky bark elm. This species is said to occur along the Des Moines, but I did not see specimens.

Celtis occidentalis L.—Hackberry. A frequent tree along the bottoms and uplands. The following measurement of a large tree growing in the bottoms was made at Evans: Circumference, 7 feet, 2 inches; height, 70 feet.

Morus rubra L.—Was not observed, but a cultivated specimen was found at Albia.

PLATANACEAE.

Platanus occidentalis L.—Sycamore. Abundant along all of the streams. Large and unique trees are found along the Des Moines near Eddyville. The bottoms are frequently cleared leaving the large trees standing, surrounded by fields of maize. A large tree between Eddyville and Harvey measured 12 feet in circumference and 75 feet high. The tops had been broken off by the winds.

JUGLANDACEAE.

Juglans cinerea L.—Butternut. The butternut occurs on the bluffs and higher valleys throughout the region. The trees do not attain great size, a single one of the older trees measured had a circumference of 4 feet 2 inches, and height of 35 feet.

J. nigra L.—Black walnut. The black walnut is much more abundant than the butternut. It occurs in the valleys, especially the alluvial bottom throughout the region. A cut log had a circumference of 3 feet 9 inches, age 38 years. A second cut log had a circumference of 4 feet, age 50 years. The log was 10 feet long.

Carya alba Nutt.—Shell-bark hickory. The shell-bark hickory is the most common of the genus in Monroe county. The following measurements were made:

LOCALITY.	Age.	Diameter.	CIRCUMFERENCE.		HEIGHT.	REMARKS.
			Breast high.	Base.		
Moravia			2 ft.	2 ft.	30 ft.	Clay soil second growth.
Moravia			2 ft. 7 in.	2 ft. 10 in.	35 ft.	Clay soil second growth.
Moravia			4 ft. 9 in.	6 ft.	65 ft.	Original forest.
Moravia	75		1 ft. 6 in.		60 ft.	Original forest.
Moravia	80		1 ft. 10 in.		69 ft.	Original forest.

Carya porcina Nutt.—Pig-nut. The pig-nut is distributed over the county in upland woods and in the higher wooded valleys. A second growth tree in Moravia measured 2 feet 6 inches in circumference and had a height of 45 feet.

CUPULIFERAE.

Betula nigra L.—River Birch. The species is common along the Des Moines. It finds considerable use for lumber.

Corylus americana Walt.—Hazlenut. Common throughout the region in upland woods.

Ostrya virginica Wild.—Ironwood. In upland woods not infrequent.

Quercus alba L.—White oak. Occurs throughout the county in upland woods.

Q. macrocarpa Michx.—Bur oak. The bur oak occurs chiefly in upland woods. It was noted at Albia, Moravia and Eddyville. At Moravia the trees are second growth. A few measurements were taken:

LOCALIYT.	When planted.	Age.	Diameter	CIRCUMFERENCE.		HEIGHT.	REMARKS.
				Breast high.	Base.		
Moravia	...	....	.....	1 ft. 8 in.	... .	35 ft.	Black soil.
Moravia	.....	..	.....	11 in.	.....	24 ft.	Black soil.
Eddyville	.	....	.....	12 ft. 8 in.	.....	50 ft.	Short tree. Sandy soil.
Eddyville	....		..	8 ft.	.....	45 ft.	Sandy soil.

Quercus rubra L.—Red oak. Found chiefly in upland woods and along smaller streams. The trees observed were all second growth. A tree at Moravia measured 3 feet 2 inches in circumference breast high, with a height of 45 feet, probably 40 years old.

Q. imbricaria Michx.—Shingle oak. The shingle oak occurs in scattered groves over the entire wooded section of the county. The trees are, however, small.

SALICACEAE.

Salix nigra Marsh.—Black willow. Along the Des Moines.

S. amygdaloides And.—Along the Des Moines.

S. alba L. var. *vitellina* Koch.—Commonly cultivated.

S. longifolia Muhl.—Common along streams.

S. rostrata Richards.—This species is rare in the county. Observed at the base of a sandy bluff in northwestern part of Monroe county, near a spring.

S. humilis Marsh.—Prairie willow. High banks along the Des Moines river.

Populus alba L.—White poplar. Frequently cultivated and occurring as an escape from cultivation. A single large cultivated tree in Albia, set out about 1869, measured 9 feet 9 inches breast high in circumference and 60 feet high.

Populus tremuloides Michx.—Aspen. Not observed in the county, but was noticed across the border in Mahaska county.

Populus monilifera Ait.—Cottonwood. The cottonwood occurs throughout the county, usually along streams. The tree grows rapidly and attains a large size. The following measurements were made:

LOCALITY.	Age.	Diameter.	HEIGHT.	REMARKS.
Moravia	200	4 ft.	90 ft.	Forest in bottom.
Eddyville	140	4 ft.	.....	Log from forest Des Moines bottom.

The following table shows the growth by decades:

YEARS.	INCHES.	YEARS.	INCHES.	YEARS.	INCHES.
10	4	10	3	10	5
10	3	10	4		
10	2½	10	4		
10	3	10	4		
10	3	10	3		
10	3½	10	4		
		10	3		

CONIFEREAE.

Pinus strobus L.—White pine. This species is occasionally cultivated, but none of the trees have attained any size. A large tree which was set out in 1872 had a circumference of 4 feet 5 inches, and a height of 50 feet.

P. sylvestris L.—Scotch pine. This species is cultivated more frequently than the preceding, but it does well only under favorable conditions. Some good trees were observed in the vicinity of Eddyville on the sandy slopes. Two of these trees were measured. Circumference, 3 feet 8 inches; height, 38 feet. A second tree on Mr. Long's place measured 5 feet 6 inches in circumference and 40 feet in height. They were set out in 1867. The trees are apparently healthy, in fact are as good as any I have

seen in the state. The ground is underlain with a fine sand with an abundance of moisture. Numerous springs occur at the base of the hill.

P. austriaca Hoss.—Austrian pine. The Austrian pine is frequently cultivated, but there are not nearly so many specimens as of the Scotch pine.

Thuya occidentalis L.—Arbor vitae. Mr. De Long set out quite a group of Arbor vitae on the northwest slope of his place in sandy soil in 1867. The trees have done remarkably well, far better than the balsam. Three trees were measured, but they show but little range. Circumference 1 foot 10 inches, 35 feet high; circumference 1 foot 8 inches, 32 feet high; circumference 1 foot 11 inches, 35 feet high.

Juniperus virginiana L.—Red Cedar. The red cedar is frequently planted. I saw no native trees, but old settlers tell me that they occurred on Cedar creek.

Picea excelsa Link.—Norway spruce. Here as elsewhere in the state the Norway spruce was one of the few conifers set out in early days. It is not a valuable tree except under favorable conditions. Mr. De Long's place is a favorable one. The sandy soil and the sheet of water below make it a good location. A few measurements show that a good growth has been made; circumference 6 feet, height 55 feet. Trees set out in 1867. A second tree had a circumference of 4 feet 4 inches, 60 feet high. Set out in 1867.

Abies balsamea Miller.—Balsam fir. Like the spruce the early settlers planted this species but it is less satisfactory than the Norway spruce. Few of the trees remain. Mr. De Long's place is favorable, but of the numerous trees set out but three remain. One was dead, one partially, and one still green. Measurements of the three trees were as follows: Circumference 3 feet; height 35 feet; circumference 2 feet; height 40 feet; circumference 3 feet; height 40 feet. These trees were set out on a sandy slope in 1867.

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF MONROE COUNTY, IOWA.

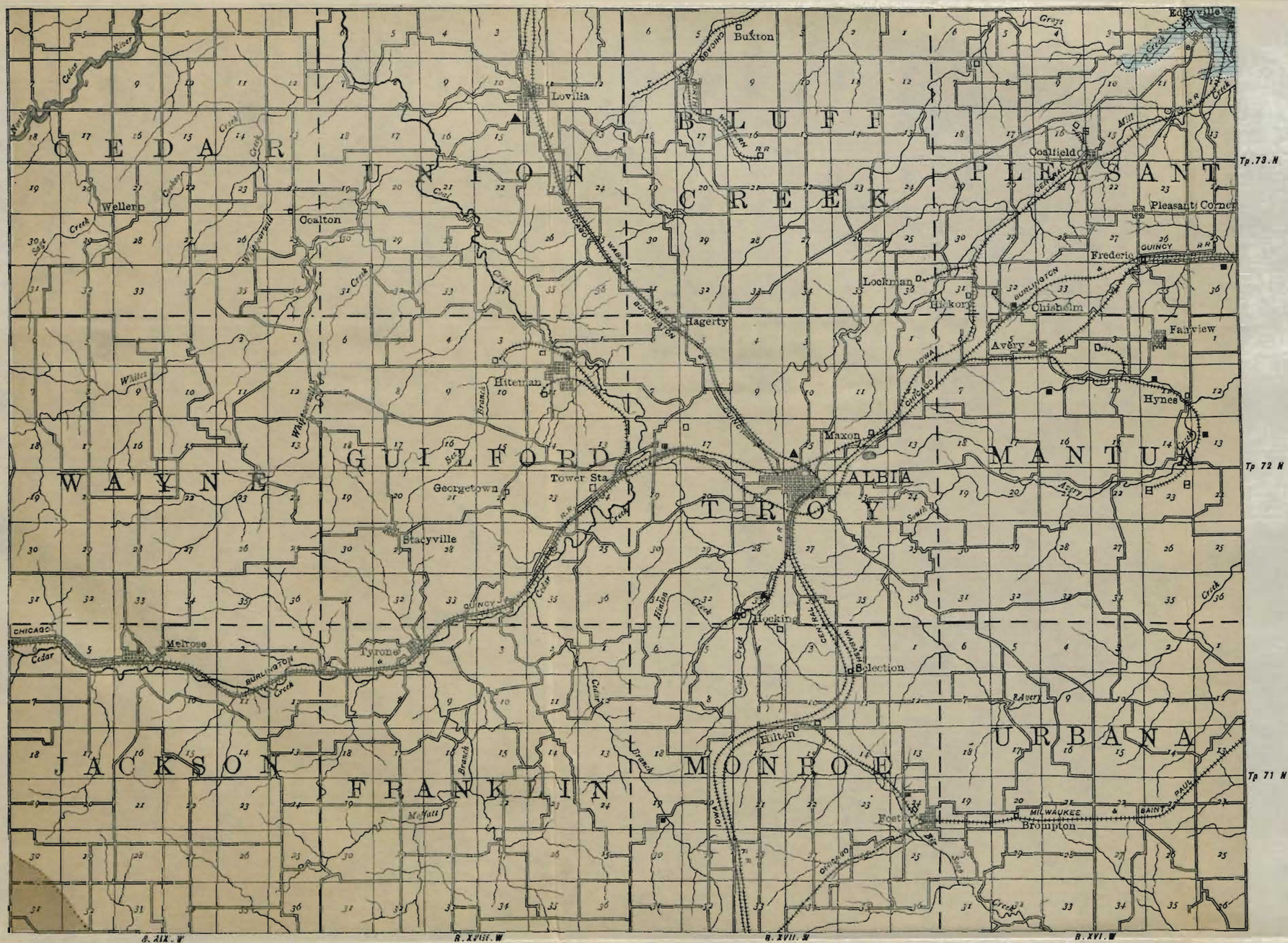
BY

S. W. BEYER

AND

L. E. YOUNG.

1902.



Scale 1/125000

1 ½ 0 1 2 3 4 5 Miles.

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

- DES MOINES (Coal Measures)
- APPANOOSE BEDS
- SAINT LOUIS

INDUSTRIES

- COAL MINE SHAFT
- ABANDONED SHAFT
- SLOPE
- BRICK YARD
- ARTESIAN WELLS
- QUARRIES

DRAWN BY F.C. TATE

IOWA LITHO. CO.