GEOLOGY OF WAPELLO COUNTY

BY

A. G. LEONARD.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Wapello county forms one of the second tier of counties north of the Missouri line and is fourth in order of succession from the Mississippi river. It is thus situated well toward the southeastern part of the state. Its northern boundary is formed by Mahaska and Keokuk counties. Jefferson borders it on the east, Davis on the south and Monroe on the west.

Included within these boundaries are twelve congressional townships with a total area of 432 square miles. The Des Moines river crosses the county diagonally from northwest to southeast.

Wapello is one of the leading coal counties of the state and in 1901 it ranked seventh in the production of that mineral. It also holds an important place as a producer of clay products and stone. The importance of the mineral resources of the county is shown by the fact that in 1901 the total value of its coal, clay and stone amounted to $404,503.

PREVIOUS GEOLOGICAL WORK.

The first geologist to visit this region was D. D. Owen, who in the summer of 1849 made a trip up the Des Moines as far as Fort Dodge. In his report* he mentions the heavy beds of Coal Measure sandstone occurring along the river between Eldon and Ottumwa and the ledges of limestone outcropping at and above the latter town. Several beds of coal were noted on Sugar creek and along the river below the mouth of that stream.

In 1856 A. H. Worthen made an examination of the valley of the Des Moines and gives in his report several sections occurring along that river in Wapello county.† During the following year the same geologist again visited the region and published a brief general account of the geology of the county.‡ At that time the principal coal banks were in the neighborhood of Dahlonega and Kirkville, and in the river bluffs, four miles be-

* Geol. Surv. of Wis., Iowa and Minn., pp. 113-114, Philadelphia, 1852.
† Geol. of Iowa, Vol. I, pt. i, pp. 162-166. 1858.
‡ Geol. of Iowa, Vol. I, pt. i, pp. 248-258, 1858.

low Eddyville. In 1867 C. A. White visited the coal mines which were then in operation in the county and in his report* gives their location, together with the thickness and number of veins.

The record of one of the artesian wells put down at Ottumwa was published in 1889 by C. H. Gordon† and the record of this and another well is given and discussed by W. H. Norton in his report on the Artesian Wells of Iowa ‡ In 1893 the coal mines of the district were visited by members of the present Survey and a brief account of them is contained in the report on the Coal Deposits of Iowa, by C. R. Keyes §

From the above it will be seen that little work had been done on the geology of Wapello county except that of a fragmentary and very general nature, which was all it was possible to do in the time which had been devoted to the study of the area.

PHYSIOGRAPHY.

TOPOGRAPHY.

The topography of this region is due entirely to erosion and the valleys and ridges have been formed by the action of running water on the soft drift materials and the underlying indurated rocks. The region was once a level or nearly level drift plain, from which the inequalities of the present surface have been carved by the streams. The greater portion of this plain has been thoroughly dissected and deep valleys eroded in it. In the northeastern part of the county the surface has been much less affected by erosion than the rest of the area, the land is gently rolling and the creeks have cut comparatively shallow valleys. In strong contrast with this are the southwestern townships and those crossed by the Des Moines river. In these the surface has been deeply cut by valleys which branch and rebranch in all directions and produce a rough and rugged topography. But all the divides are seen to rise to the same height, and if the valleys were filled up to the same level the original plain would be restored. This thoroughly and deeply dissected area includes

* Second Ann. Rep. of State Geologist, pp. 108-112, 1868.
Geol. of Iowa, Vol. II, pp 263-270 Des Moines, 1870.
† Am Geol., Vol. IV, pp. 237-239, 1889.
‡ Iowa Geol. Surv., Vol. VI, pp. 3 7-320, Des Moines, 1896.
§ Iowa Geol. Surv., Vol. II, pp. 383-393, Des Moines, 1894.

Green, Keokuk and Polk townships, with parts of Adams, Center, Cass, Columbia and Richland. The upland plain includes Highland, Competine and Pleasant townships, together with parts of Dahlonega, Agency and Washington townships. A northwest-southeast line passing through Kirkville, Dahlonega, Agency City and Ashland would separate this rolling plain from the deeply eroded and rough country bordering the Des Moines river and lying south and west of it.

The most marked topographic feature of the region is the broad valley of the Des Moines. That stream crosses the county diagonally from northwest to southeast and has cut its broad valley to a depth of from 150 to 200 feet. The flood plain varies in width from one-half to two miles, the average being about one mile. From Eddyville to Ottumwa the valley is noticeably narrower than it is below the latter town. Above Ottumwa the average width is less than three-quarters of a mile, while from Ottumwa to Eldon it is one and one-quarter miles. A large part of Ottumwa is built on the broad bottom land of the Des Moines, whose valley here broadens out until just below the town it has a width of two miles.

This difference in the width of the valley is probably due to a

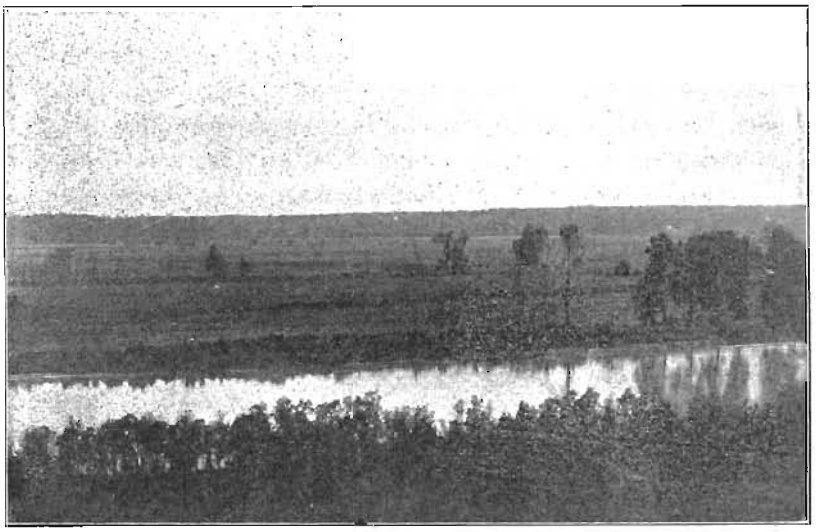

FIG. 64. The broad valley of the Des Moines, two and one-half miles below Cliffland station; looking southwest across the flood plain, which is here one and a half miles wide.

difference in the rock in which it has been carved. Below Eddyville as far as the county seat the river has cut its channel through the soft Coal Measure shales and into the harder and more resistant Saint Louis limestone. Below Ottumwa the limestone lies beneath the bed of the river and the stream, in forming its valley, has had to erode only the easily washed shales and soft sandstones. The recession of the sides by lateral cutting of the river and by atmospheric agencies would progress rapidly in these readily affected materials. On the other hand, where the channel is in limestone, the widening process goes on less rapidly owing to the greater resistance offered by the latter rock.

In the broader portion of its valley between Ottumwa and Eldon the Des Moines meanders back and forth across its flood plain, striking first one bluff and then the other. At the former place the river makes several broad loops and its course has changed in recent times, as is shown by an old abandoned channel. Another excellent example of stream meanders is furnished by Soap creek as it flows across the flood plain of the Des Moines river, in the southeastern corner of the county.

The behavior of Village creek when it enters the valley of the Des Moines, in section 8 of Keokuk township, is so peculiar as to deserve notice. As soon as the flood plain of the latter stream is reached, instead of keeping on in the same direction as before, it turns abruptly and, taking a course at right angles to its former one, it follows along close to the side of the valley and enters the river a mile or more below. The cause of the creek taking this course and following the bluff is probably found in the slight outward slope of the flood plain. It is well known that there is a tendency for a flood plain to be highest next the river, where the deposition of silt goes on most rapidly, and from this point it slopes gently toward the sides of the valley. On this account when a tributary stream enters a valley it may be compelled to follow down along one side, where the land is lowest, until a favorable opportunity is afforded for joining the larger stream. In the present instance this is when the river makes a bend and comes over to its west bluff. North Avery creek at one time followed the edge of the flood plain in the same way as Village creek and entered the Des Moines at Chillicothe, one

mile below its present mouth. The old channel still remains and is occupied by the river during ordinary stages of the water. The formation of a new mouth and the abandonment of its old channel were caused by lateral cutting. At the bend where the creek abruptly changed its course the current was swiftest on the outer side, the cutting of the bank was most rapid at that point and the creek thus gradually shifted its channel until it entered the main stream by its present mouth. On the map of the county made six or seven years ago, North Avery is represented as emptying into the river by way of its old channel and its new mouth has probably been formed within a few years.

The Des Moines and its tributaries have eroded their valleys through the drift and have cut down deep into the Coal Measure strata, while in the northwestern part of the county they have worn their channels into the underlying Saint Louis limestone. At Ottumwa, where the Des Moines flows over the ledges of this limestone, the Coal Measures rise from 100 to 150 feet above the river and at Eldon to a height of 135 feet above the same stream.

The chief drainage lines of the county appear to be preglacial. The valleys of the Des Moines and its larger tributaries were probably formed, at least in part, before the advent of the ice sheet. During glacial times they were filled with drift and the entire region was covered with a mantle of that material which obliterated the topographic features previously existing. Upon the retreat of the ice a nearly level drift plain was left where before there had been a surface deeply cut by the stream into valleys and ridges. But in the old preglacial valleys where the drift was thickest it would settle more than upon the uplands over which it was thinner. Slight depressions would thus come to occupy the place of the former valleys and these sags would be taken possession of by the streams which established themselves on the surface upon the withdrawal of the ice. These streams would quite readily carry away the loose materials of the drift until they had cut their way down to the bed rock, clearing out and deepening the former waterways.

That the valleys are preglacial is shown by the fact that in places the drift is seen to follow down the sides, covering up the strata which once formed the walls. This is what would be ex-

pected if the valleys were already formed when the mantle of drift was laid down.

The following table gives the elevations above tide of the principal towns of the county and several just outside the area. The figures are taken from Gannett's Dictionary of Altitudes in the United States:

LOCALITIES.	ELEVATION.
Agency	807
Batavia	727
Bidwell	720
Blakesburg	912
Chillicothe	660
Dudley	674
Eddyville	676
Eldon	630
Hedrick	827
Highland	780
Ottumwa	650

Batavia is just over the east line of the county and Hedrick is a mile from the north line. Agency, Blakesburg, Hedrick and Highland are located on the upland plain, while the other towns are located in the valleys. The highest part of the area is in Adams township, in the vicinity of Blakesburg, and the lowest point is in the Des Moines valley at Eldon.

DRAINAGE.

The drainage of Wapello county has reached its maturity. The streams, with their numerous tributaries, reach out to all parts of the land and carry off the water as rapidly as it falls upon the surface. The Des Moines and its tributaries drain about two-thirds of the area, and the affluents of the Skunk river, Competine and Cedar creeks, with their branches, drain the other third. The former drainage system, as already stated, has cut valleys which are much deeper than those formed by the latter system. The major stream and its chief tributaries flow in valleys from 150 to 200 feet in depth, while Competine and Cedar creeks, which drain the northeastern townships, have valleys with a depth of not more than forty to sixty feet. They are broad, with gently sloping sides, and in no place do they extend through the drift to the underlying Coal Measures. Though the drainage

lines of the northeastern townships ramify over the surface until they reach all portions of the area, the channels are shallow and the land is not deeply dissected as in other portions of the county. The reason the tributaries of the Skunk river have not eroded their valleys to the same depth as those of the Des Moines system is found in the fact that the former streams flow long distances before entering the Skunk river, and the latter in turn enters the Mississippi over thirty-five miles above the mouth of the Des Moines. Cedar and Competine creeks, therefore, have much less of a fall and erode their channels more slowly than the Des Moines drainage system. The Des Moines, being a large stream, has been able to cut its valley at a comparatively rapid rate and its tributaries have carved their valleys down to the same base level.

The chief tributaries of the Des Moines river are North Avery, South Avery, Bear, Village and Soap creeks, all of which enter it from the west or southwest. The streams flowing in from the north are smaller, the majority of them being only a few miles in length. They have narrow, steep-sided valleys and their courses are approximately at right angles to the major stream.

In traversing the county from the northwest corner to the opposite one, a distance of twenty-eight miles, the Des Moines has a fall of forty-eight feet. But the gradient below Ottumwa is twice as great as it is above. From Eddyville to Ottumwa the river has a fall of one and one-eighth feet to the mile, but from the latter town to Eldon the fall is two and one half feet to the mile.

STRATIGRAPHY.

The geological formations which are present in Wapello county are few in number, but of much importance economically. They belong to the Carboniferous and Pleistocene systems. The oldest strata which appear at the surface are the limestones of the Lower Carboniferous. Overlying these, but separated from them by an unconformity representing a long time interval, are the more recent shales and sandstones of the Upper Carboniferous. It is when these upper beds, which once covered the entire county, have been cut through by the larger streams that the Lower Carboniferous limestones are exposed. As will be seen

by a reference to the map, they are found in the valley of the Des Moines and along some of its chief tributaries.

Overlying these indurated rocks, which are of marine origin, is a formation of entirely different character and of very much younger age. It is made up of the loose and heterogenous deposits of the Pleistocene, including the drift and loess. These were formed at the time the great ice sheets from the north invaded Iowa and left behind the mixture of clay, sand, gravel and bowlders which forms the drift. The drift is covered by a thin layer of silt-like material, the loess. Belonging to the same period is the alluvium of the river valleys, formed by the streams during periods of overflow. The taxonomic relations of these formations are shown in the following table:

SYNOPTIC TABLE OF THE GEOLOGICAL FORMATIONS OF WAPELLO COUNTY.

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB STAGE.
Cenozoic.	Pleistocene.	Recent.	Alluvial deposits.	
		Glacial.	Loess.	
			Kansan drift.	
Paleozoic.	Carboniferous.	Upper Carboniferous or Pennsylvanian.	Des Moines (Coal Measures)	
		Lower Carboniferous or Mississippian.	Saint Louis.	Pella.
				Verdi.

The Deeper Strata.—Our knowledge of the deep strata of the region is gained from the deep wells sunk at Ottumwa in search of water. The record of the well of the Artesian Well Company, as given in W. H. Norton's report on the Artesian Wells of Iowa,* is as follows:

* Iowa Geol. Surv., Vol. VI, p. 319, Des Moines, 1896

		THICKNESS.	DEPTH.	A. T.
18.	Loam, Pleistocene	21	21	†639
17.	Limestone, Mississippian	21	42	608
16.	Shale, Mississippian	14	56	594
15.	Sandstone, Mississippian	30	86	564
14.	Limestone, Mississippian	60	146	504
13.	Shale, Mississippian	20	165	484
12.	Sandstone, flinty, Mississippian	40	206	444
11.	Sandstone, Mississippian	30	236	414
10.	Limestone, Mississippian	195	431	219
9.	Shale, Mississippian Kinderhook	160	591	59
8.	Limestone	200	791	−141
7	Limestone	180	971	−321
6.	Limestone mixed with sand, Devonian, Silurian and Ordovician	96	1,067	−417
5.	Sandstone, white, Saint Peter	110	1,177	−527
4.	Shale and limestone, Oneota	200	1,377	−727
3.	Slate, Oneota	19	1,396	−746
2.	Limestone, Oneota	320	1,715	−1,065
1.	Limestone, water bearing Oneota	332	2,047	−1,397

† Approximately.

No Upper Carboniferous strata were passed through in this well since it was sunk in the Des Moines valley where those beds have been removed by erosion. No. 17 is the upper portion of the Saint Louis formation, which everywhere in the county underlies the shales and sandstones of the Upper Carboniferous series. It is seen outcropping in the bed of the river at Ottumwa.

The Carboniferous System.

SAINT LOUIS STAGE.

The rocks belonging to this stage are the oldest which appear at the surface in Wapello county. They consist of limestones, marly shales and sandstones. The limestone, which is quite uniform in character and appearance, is very compact, fine-grained and light gray or blue in color. It frequently contains small particles or crystals of iron pyrites and careful examination will usually show minute fragments of fossils, especially on a weathered surface. Some of the rock, however, resembles lithographic stone in appearance and bears no evidence of organic remains. The beds vary in thickness from two or three inches to two feet. Interstratified with the limestones are gray, marly shales which are commonly quite rich in fossils. These marls, on long con-

tinued exposure to the weather, become soft and earthy, and, wearing away more rapidly than the limestone, leave the latter in projecting ledges. The marly layers often attain a thickness of two or three feet and range from that down to an inch or less. They are very characteristic of the upper portion of the Saint Louis. At several points sandstone was observed underlying the calcareous beds, and these arenaceous deposits are also reported from a number of wells in different parts of the county. Where seen in its outcrops the sandstone is soft and white or yellow in color.

Where studied in adjoining regions it has been found possible to divide the Saint Louis into three members. The Springvale beds, which form the lowest of these divisions, are not exposed anywhere in the county. They are composed of magnesian limestones, marly shales and some sandstone. The Verdi beds constitute the middle member and are made up of alternating layers of limestone and sandstone. The latter rock occasionally reaches considerable thickness, and in southeastern Mahaska county single beds are found twenty-five to thirty feet thick.* The limestones are sometimes hard and very compact, sometimes brecciated. This middle member also is but poorly represented in Wapello county, but the soft sandstone which is found beneath the limestone and marls is believed to belong to the Verdi beds.

The upper division of the Saint Louis is the Pella beds, and the limestones and marls described above belong to this member. It is this portion which furnishes the excellent building stone quarried at many points in this and neighboring counties. The Pella beds, and especially the marly layers, are rich in fossils, the following being some of the more common:

Zaphrentis pallaensis, Worthen.
Productus ovatus, Hall.
Athyris (Seminula) subquadrata, Hall.
Allorisma marionensis, White.
Spirifer keokuk, Hall.
Orthothetes, has been described as *Orthis keokuk.*
Pugnax ottumwa, White.
Astartella sp?
Bellerophon sp?

* Bain; Iowa Geol. Surv., Vol. V, p. 150, Des Moines, 1896.

The thickness of this upper division is from fifteen to twenty feet.

The Saint Louis limestone is confined to the northwestern part of the county, where it outcrops in the valleys of the streams which have cut their channels through the overlying Coal Measure shales and sandstones and exposed the beds beneath. Though the strata of the formation underlie the entire area, as shown by deep wells, they are in most places buried beneath the deposits of the Upper Carboniferous. It will be seen from the map accompanying this report that the limestones occur in the valley of the Des Moines from Ottumwa to Eddyville, and also south of Eldon, just north of the Davis county line, along the South Avery and North Avery creeks and along the lower courses of many of the smaller streams entering the river from the north and west. The Saint Louis also probably occurs beneath the drift in several sections in the northern part of Competine and Highland townships, as shown from outcrops across the line in Keokuk county.

The rock is extensively quarried at Dudley, Ottumwa, and Eddyville.

The character of the upper portion of the Saint Louis formation is well shown in the following sections.

I. SECTION IN THE CAWLEY QUARRY, ONE MILE SOUTH OF EDDYVILLE, IN NW. ¼ OF SEC. 7, TP. 73 N., R. 15 W.

		FEET.
5.	Drift	3
4.	Residual clay, deep red	1
3.	Limestone, thin bedded	1
2.	Limestone, compact, light blue or gray, in ledges 6 to 15 inches thick; marly partings between some of the ledges. In places the limestone contains nodules of limonite	8
1.	Unexposed to river	37

The limestone here rises about fifty feet above the Des Moines river. A short distance south of here in another quarry on Miller creek the following section is shown:

II. MILLER CREEK SECTION.

		FEET.
6.	Drift	3
5.	Residual clay	1
4.	Limestone in thin beds	1
3.	Marly shales with 6 inch band of limestone	3
2.	Limestone in distinct layers separated by marly partings	8
1.	Unexposed to creek	25

About one-quarter of a mile below the mouth of Miller creek several feet of black, fissile, Coal Measure shales appear overlying the limestone, and one and a half mile above the same point in Monroe county there is a four and a half foot seam of coal twenty feet above the Saint Louis, separated from it by shale and fire clay. Eight to ten feet of this black shale outcrop at the wagon bridge in the Ne. ¼ of Sec. 18, Columbia township. The limestone appears along Palestine creek, five feet of it being exposed below the bridge in section 21 of the same township.

Sections on North Avery Creek. The Saint Louis limestone is exposed at many points along North Avery Creek between Chillicothe and Dudley. In the southwest quarter of section 26 the following section is shown:

III.

		FEET.
7.	Drift, with ferruginous gravel at base	6 to 15
6.	Sandstone	2
5.	Shale, gray, sandy	8
4.	Sandstone	2
3.	Shale, sandy	3
2.	Limestone, thin bedded below	5
1.	Unexposed to creek	4

The limestone (No. 2) is oolitic in part. Nos. 3 to 6 probably belong to the Upper Carboniferous (Coal Measures). The following section is exposed in the old railroad quarry, just west of the station at Dudley:

IV.

		FEET.
6.	Drift	10
5.	Limestone	1
4.	Marly shale, gray	2
3.	Limestone	½
2.	Marly shale, gray	3
1.	Limestone, light gray, very compact	6

One-half mile east of Dudley the Chicago, Burlington & Quincy railroad has opened a new channel for the North Avery creek in order to straighten out its course. In this artificial cut the Saint Louis limestone is well exposed and the following strata appear at the west end of the opening:

V.

		FEET.
7.	Drift	10
6.	Limestone	2
5.	Marly shales, gray	2
4.	Limestone	½
3.	Marly shales, gray	3
2.	Limestone, very fine-grained, compact, light gray, thin-bedded above	10
1.	Sandstone, soft, exposed in bottom of cut	1

The ledges of No. 2 are the quarry beds which are worked so extensively at Dudley and elsewhere. The sandstone (No. 1) probably belongs to the Verdi beds, the rest of the section to

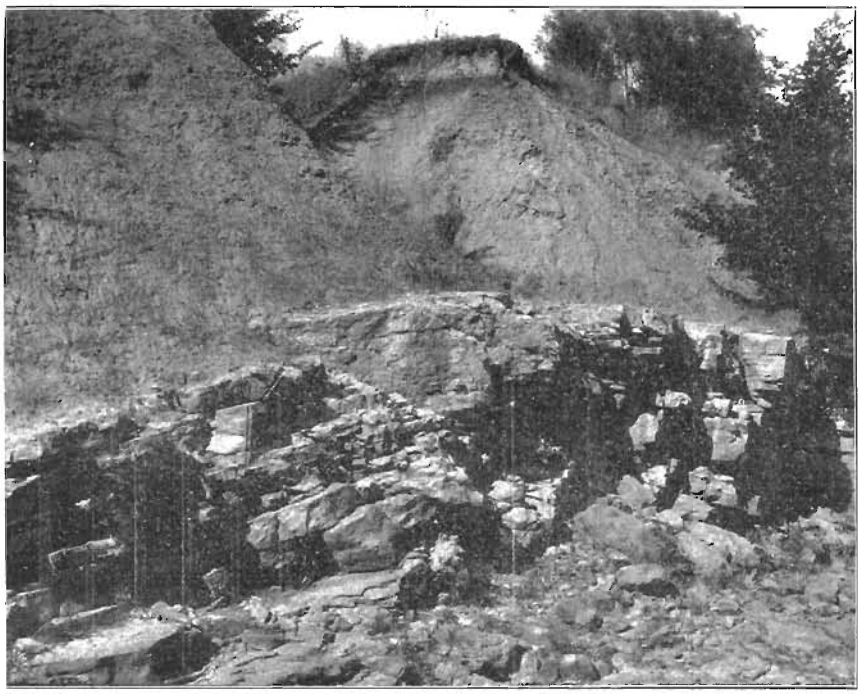

FIG. 65. Monoclinal fold in the Saint Louis limestone, one-half mile east of Dudley.

the Pella. As these strata are followed toward the east they are carried up by a gentle monoclinal fold with a dip of 20°. At the east end of the cut they are overlain by Coal Measure strata. From six to eight feet of the limestone beds exposed at the west end of the cut have been eroded and are replaced by black shale. The section is as follows:

VI.

		FEET.
4.	Drift	10
3.	Shale, black, fissile, contains much pyrites....	8
2.	Limestone, much decomposed and covered with iron oxide (limonite) .....2 to 3	
1.	Sandstone, soft, white on inside, stained brown on outer surface, exposed ....4 to 6	

The above is of especial interest since it shows the unconformable contact between the Upper and Lower Carboniferous or between the Saint Louis and Coal Measure strata. The lime-

FIG. 66. Contact between the Saint Louis limestone and Coal Measure shales. The limestone ledges of the Pella division overhang the Verdi sandstone, and are overlain by black shales.

stone and sandstone are both stained brown by limonite, formed by the decomposition of the original iron pyrites, and are much decomposed and rotted. The limestone has been dissolved in many places and is badly pitted. The underlying sandstone, being soft, has been worn away by the water of the creek, leaving the limestone ledges overhanging. An effective agent in the decomposition of the limestone has been the sulphuric acid derived from the iron pyrites of the shales. The Saint Louis outcrops at many points along South Avery creek, and below the limestone of the Pella beds the sandstone of the Verdi beds often appears. At the sharp bend of the creek to the south, in the Sw. ¼ of the Se. ¼ of Sec. 35, Tp. 73 N., R. XV. W., twenty feet of limestone strata are exposed and have been quite extensively quarried. Only a short distance south of here a soft, yellow, micaceous sandstone (Verdi) appears beneath the calcareous beds. In the Ne. ¼ of Sec. 10, Polk township, the contact between the Saint Louis and Coal Measures is again seen. Overlying the limestone is a very irregularly bedded, light gray, soft sandstone which contains streaks of coal. Below the sandstone at one end of the outcrop

FIG. 67. Unconformity between the Saint Louis limestone, 1, and the Coal Measure shales, 2. The shales rest on the uneven and weathered surface of the limestone. At the old quarry on the Des Moines river, three miles above Ottumwa.

there is a black shale and some clay. The most southern exposure of the Saint Louis along South Avery occurs in the bed

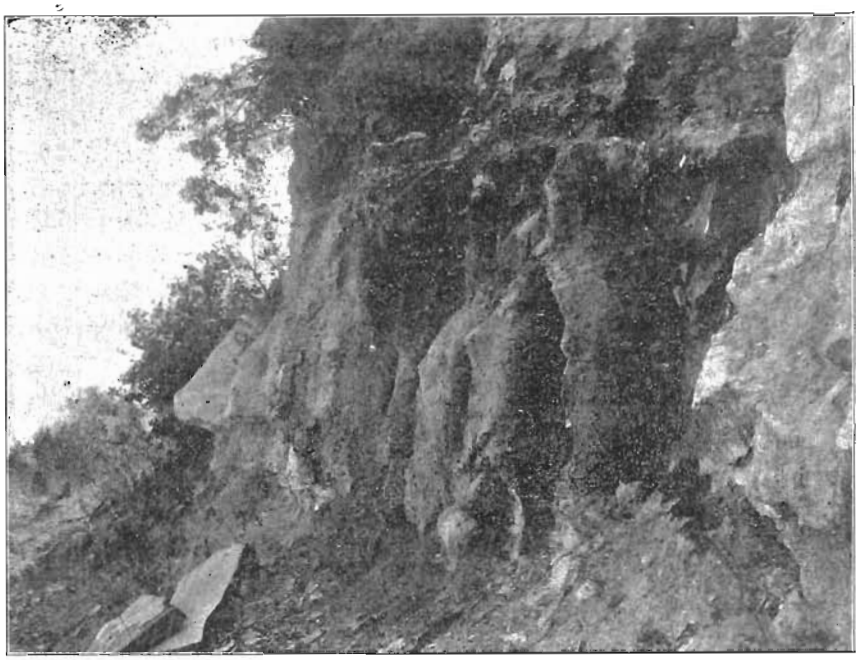

FIG. 68. Contact between the Saint Louis limestone, 1, and Coal Measures, 2. Three miles above Ottumwa.

of the stream in the Ne. ¼ of Se. ¼ of Sec. 10, Polk township. Just below the Chicago, Burlington & Quincy railroad bridge over the Des Moines river there is an excellent exposure at the old stone quarry.

VII. DES MOINES RIVER SECTION, NW. ¼ OF SW. ¼ OF SEC. 9, TP. 72 N., R. 14 W.

		FEET.	INCHES.
11.	Drift	20	
10.	Shale, black	15	
9.	Sandstone, with many carbonized stems of plants, thin-bedded and shaly above	4 to 5	
8.	Coaly seam, composed of laminæ of coal separated by thin, sandy layers, and containing much iron pyrites in nodules	½ to 2	
7.	Fire clay	2 to 8	
6.	Limestone, argillaceous, greatly decomposed on upper surface and containing much limonite, the carbonate of lime having been		

		FEET.	INCHES.
	removed ....5 to 6		
5.	Marly shale, gray	2	
4.	Limestone		8
3.	Marly shale, gray	3	
2.	Limestone	5	
1.	Unexposed to river	6	

This section, like the previous one, shows the contact between the Saint Louis and Coal Measures. Nos. 1 to 6 belong to the former and Nos. 7 to 10 to the latter. The upper surface of the limestone (No. 6) is uneven and undulating and is decomposed to a depth of from six inches to two feet. So much of the lime carbonate has been dissolved out that the residue is composed largely of limonite.

VIII. SECTION IN QUARRY ON ROCK RUN, SW. ¼ OF NW ¼ OF SEC. 15, TP. 72 N., R. 14 W.

		FEET.
4.	Drift, sandy and gravely, contains much iron..	3
3.	Limestone	2
2.	Marly shale, gray	2
1.	Limestone, gray, compact, contains cubes of iron pyrites, thin-bedded above	8

IX. SECTION IN QUARRY ON BEAR CREEK. NE. ¼ OF SW. ¼, SEC 23, TP. 72 N., R. 14 W.

		FEET.
6.	Soil	2
4.	Marly shale, gray	1½
5.	Limestone, in thin beds	1⅓
3.	Limestone, in two ledges separated by marly parting	1
2.	Marly shale, gray	3
1.	Limestone, light blue, very compact	7

The Saint Louis limestone is exposed along Harrow's branch, in the city of Ottumwa, and in the bed of the Des Moines river at the same place. The most southern point at which the limestone outcrops at the surface, with the exception of the small area in the bed of the river about one mile below Eldon, is on Sugar creek, near where it empties into the river.

X. SECTION ON SUGAR CREEK IN SW ¼ OF SW ¼ OF SEC 28, TP 72 N., R 13 W.

		FEET.	INCHES.
5.	Alluvial clay	5	
4.	Limestone, argillaceous, thin bedded	3	
3.	Limestone ledge	½	
2.	Marly shale, gray	2	8
1.	Limestone, in two ledges, exposed to bed of creek	2½	

The Saint Louis strata appear along Fudge creek as far north as Se. ¼ of Ne. ¼ of section 14, Columbia township, where it is seen in the bed of the stream. It also appears two miles south of Kirkville, along the stream with the east-west course, near the center of Ne. ¼ of section 20, Richland township. At this point the beds rise eight to ten feet above the creek and are composed of gray, marly shales with limestone ledges six inches to one foot thick. Overlying the calcareous beds are gray and black shales and thin-bedded sandstone.

A comparison of the above sections shows that in several of them the succession of strata is the same, namely, there are three limestones separated by marly shales. The thickness of the beds is also quite uniform over a considerable area. Thus the sections at Dudley (IV and V), on the Des Moines river (VII), and on Bear creek (IX), correspond very closely and from them can be made the following general section of the upper beds of the Saint Louis.

		FEET.
5.	Limestone	1 to 6
4.	Marly shale	2
3.	Limestone	½ to 1
2.	Marly shale	3
1.	Limestone, exposed	5 to 10

This gives a maximum thickness of about twenty feet for the upper division of the Saint Louis. The Verdi beds are represented by the soft, micaceous sandstone seen below the limestone in the artificial cut east of Dudley and on South Avery creek.

DES MOINES STAGE (COAL MEASURES.)

The rocks of this stage in the order of their aggregate thickness are clay shales, sandstones, limestones and beds of coal. The shales, which make up the great bulk of the Coal Measure strata, are of two varieties. One is carbonaceous, fissile and black in

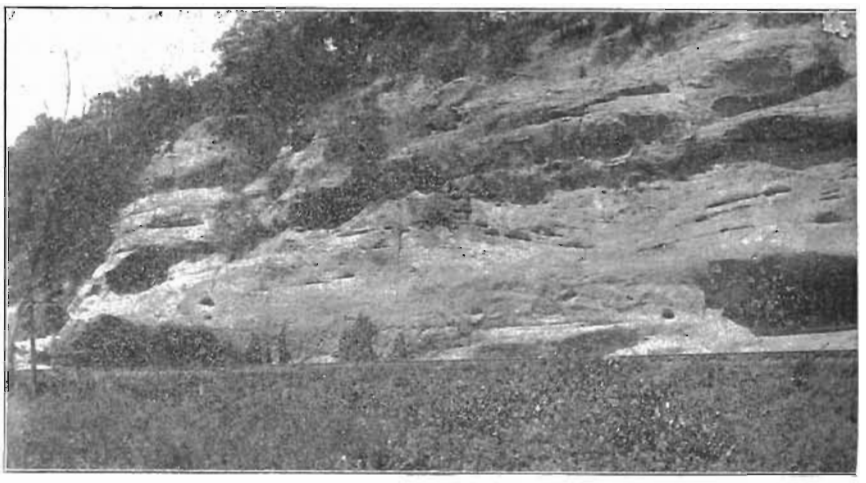

FIG. 69. Bluff of Coal Measure sandstone at Cliffland station, showing the massive character of the rock and the irregular way it weathers.

color; the other is argillaceous, is not so fissile and is found in a variety of colors, of which gray predominates. By an increase in the carbonaceous material the black shale passes into bony coal and so into true coal. The argillaceous variety frequently becomes sandy and with the increase of this constituent it graduates into sandy shales and sandstone.

A thick bed of massive sandstone occurs along the Des Moines river about two miles below Ottumwa, and for nearly six miles it forms the bluffs on either side of the valley. It is well exposed at Cliffland station, on the Chicago, Rock Island and Pacific railroad. In places it rises as a steep escarpment 100 feet above the river. This massive bed of compacted sand is known to have covered an area of some eighteen square miles and probably more. The Des Moines has cut its valley through it and has carried away a large part of the bed. Such thick Coal Measure sandstones are known to occur at other localities in southeastern Iowa. The well known Red Rock sandstone in northern Marion county is a mass of this kind with a maximum thickness of over 100 feet. It has a length of at least eleven miles and a width of three miles. Another occurrence is at Raven Cliff (Tp. 75 N., R. XVII W., sections 32 and 33) in southwestern Mahaska county. Here for a distance of two miles along an old channel of the Des Moines

river there is a sandstone which is nearly 137 feet thick. In Wapello county, as well as at the other localities, the sandstone occurs near the base of the Coal Measures and rests unconformably upon the shales. At no place in this county was it seen to lie directly on the Saint Louis limestone, being separated from the latter by thirty feet or more of argillaceous strata.

The sandstone is composed of irregular grains of quartz which are somewhat loosely cemented together. It contains considerable iron in the form of limonite, which is either scattered uniformly through the mass or is gathered in concretions or nodules. The rock is soft, micaceous and gray or yellow in color. One of the most noticeable characteristics of this sandstone is its cross-bedding. This structure, which is exhibited in great perfection, is seen in almost every outcrop and is very seldom absent. Another noticeable feature is the presence of large numbers of iron

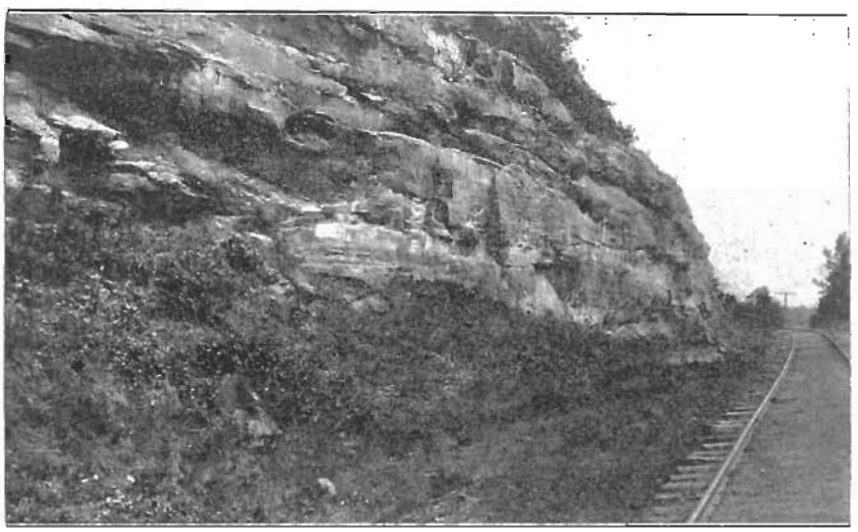

FIG. 70. Escarpment of Coal Measure sandstone along the Des Moines river, three miles above Eldon.

concretions. These are especially well shown in the bluff at Cliffland where the rock is filled with them. They are scattered irregularly through the sandstone but are arranged with their longest diameters in a horizontal direction. Their length is usually two or three times greater than their thickness. Measured along

the greatest diameter they vary in size from an inch to more than a foot. They are composed of a hard crust of limonite from one-eighth to one-quarter of an inch thick, the interior being empty or filled with an ocherous material, or an impure limonite. The hard, ferruginous crust of these concretions often projects beyond the rest of the rock, since they weather less rapidly than the soft sandstone.

Besides the thick bed of massive sandstone just described there are other sandy strata only a few feet in thickness alternating with the shales.

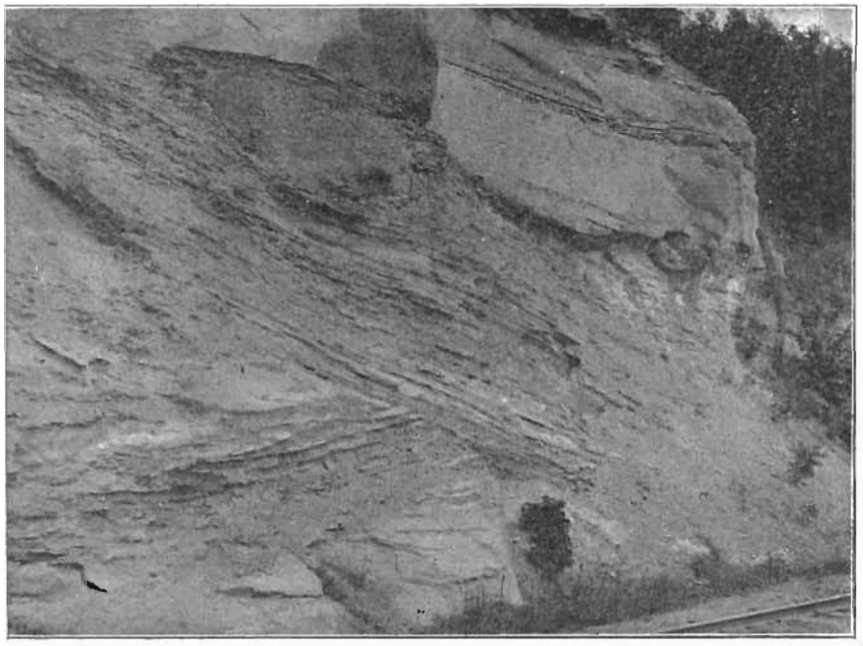

FIG. 71. Cross-bedding in Coal Measure sandstone, one-half mile below Cliffland station.

Occasional bands of limestone occur in the Coal Measures. One of these is seen in the bed of the river about one-half mile above the wagon bridge at Eldon. Near by, at the mouth of Big branch, two ledges of limestone appear, and others are seen along Sugar creek, less than a mile east of Ottumwa. The beds have a thickness of from eight inches to four feet. They are not continuous over large areas but thin out and disappear within a

short space. This rock is darker in color than that of the Saint Louis, is compact and usually very fossiliferous. In places it is concretionary and contains septaria, the cracks of which are

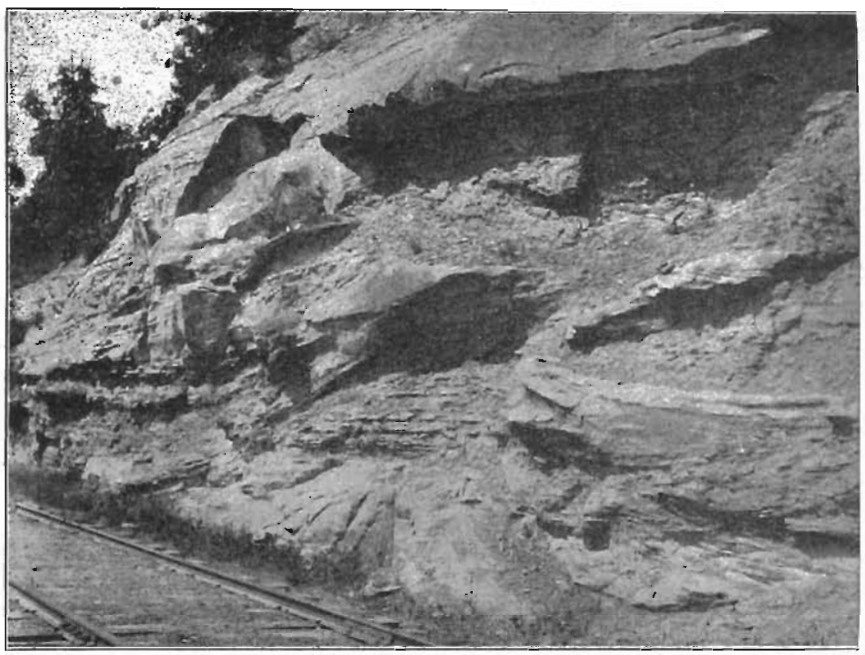

FIG. 72. Cross-bedding in the Coal Measure sandstone, along the Des Moines river, one-half mile below Cliffland station.

filled with calcite and sphalerite. The following fossils occur in these calcareous beds:

Productus muricatus, Norwood & Pratten.
Productus cora, d'Orbigny.
Productus punctatus, Martin.
Athyris (Seminula) subtilita, Hall.
Spirifer rockymountana, Marcou.
Nucula ventricosa, Hall.
Soleniscus brevis, White.
Orthonema conica, Meek & Worthen.
Loxonema, sp. ?

A brecciated limestone is also found in the Coal Measures of this area. It is seen in the northeast part of Ottumwa, 100 feet above the river. The ledge is two or three feet thick, dark gray

in color and composed of angular fragments from one quarter to one inch in length. Fragments of a similar rock were observed along Big branch, in Washington township, which had doubtless come from a ledge well up toward the top of the Coal Measures, though none of the limestone was here observed in place.

All the beds, whether they be shales, sandstones or limestone, are found to change rapidly when followed horizontally. No one of them is continuous over a very large area but they thin out and disappear and are replaced by other strata. Thus the shales which occur at one point will, within only a short distance, give way to sandstones or sandstone will pass into shales. The limestones likewise disappear and their place is taken by beds of different character. These lateral changes in the strata are often quite abrupt, the transition from one kind of rock to another being made within a small space. It is this changeableness of the beds which makes the correlation of the Coal Measure strata very difficult and often quite impossible. Two outcrops separated from each other by only a few yards or different parts of the same outcrop will frequently show marked differences in the succession, thickness and character of the beds. Examples of this are given under the description of typical sections. Not only do the inclosing strata vary rapidly but the coal seams themselves are not continuous for any great distance. They are more or less lenticular in shape, being thickest in the central portion and thinning out toward the edges.

As will be seen from the map, the strata of the Des Moines stage cover the entire county underneath the drift except where they have been cut through by the streams. Where the latter have eroded their valleys into and through the Coal Measures they have removed these younger beds and exposed the underlying Saint Louis limestone.

The thickness of the Coal Measures in Wapello county varies widely in different parts of the area. In a few places they are entirely absent, in others they are more than 200 feet thick. In the bluff at Ottumwa they are 150 to 175 feet thick, at Eldon they are about the same and in section 12 of Pleasant township they reach a thickness of 222 feet. It is probable that the maximum thickness of these strata in the county is not over 250 feet, and the average may be given as between 150 and 200 feet.

The following sections show the general character of the beds of the Des Moines stage.

I.—BEAR CREEK SECTION.

One of the best outcrops is on Bear creek, two miles west of Ottumwa, in Se. ¼ of Ne. ¼ of section 28, Center township.

		FEET.
15.	Drift	20
14.	Shale, argillaceous, gray, sandy in upper part.	20
13.	Shale, black, carbonaceous, fissile	3
12	Sandstone	3
11.	Shale, gray, argillaceous	2
10.	Shale, black, fissile, carbonaceous	5
9.	Coal, impure and bony, contains iron pyrites..	½
8.	Fire clay, filled with plant remains	1
7.	Shale, gray, argillaceous	5
6.	Shale, black	6
5.	Sandstone	⅓
4.	Shale, black	4
3.	Coal, bony and impure	1 ⅓
2.	Shale, black, carbonaceous, fissile, rich in plant remains	½
1.	Shale, gray, argillaceous, exposed to creek....	20

It is probable that No. 3 is the same coal seam that is mined one mile and three-quarters northwest of here, on the opposite side of the creek. The vein there has a thickness of four and one-half feet and lies twenty-five feet above the Saint Louis limestone, as determined by test borings. The base of the above section cannot be far from the limestone, for the latter outcrops along the creek less than two miles below and rises fourteen feet above the stream.

II.—SECTION IN CLAY PIT OF OTTUMWA PAVING BRICK AND CONSTRUCTION COMPANY.

The plant of this company is located in the northwest part of town, just beyond the city limits. The Coal Measure shales are finely exposed in the clay pit.

		FEET.	INCHES.
12.	Drift	3	
11.	Shale, argillaceous, gray	20	
10.	Shale, black	4 to 10	
9.	Coal	1	1
8.	Fire clay		10
7.	Sandstone, argillaceous, massive	5 to 7	
6.	Shale, black, fissile	2	
5.	Sandstone, argillaceous, gray in single ledge	4	
4.	Shale, gray, argillaceous	4	
3.	Shale, black	1	
2.	Coal	3 to 4	
1.	Fire clay	6 to 8	

The rapid change in the strata is well shown here. At the north end of the pit Nos. 4 and 5 are replaced by eight feet of black shale. No. 10 grows much thicker in the same direction, increasing from four feet to ten. No. 7 becomes thinner and

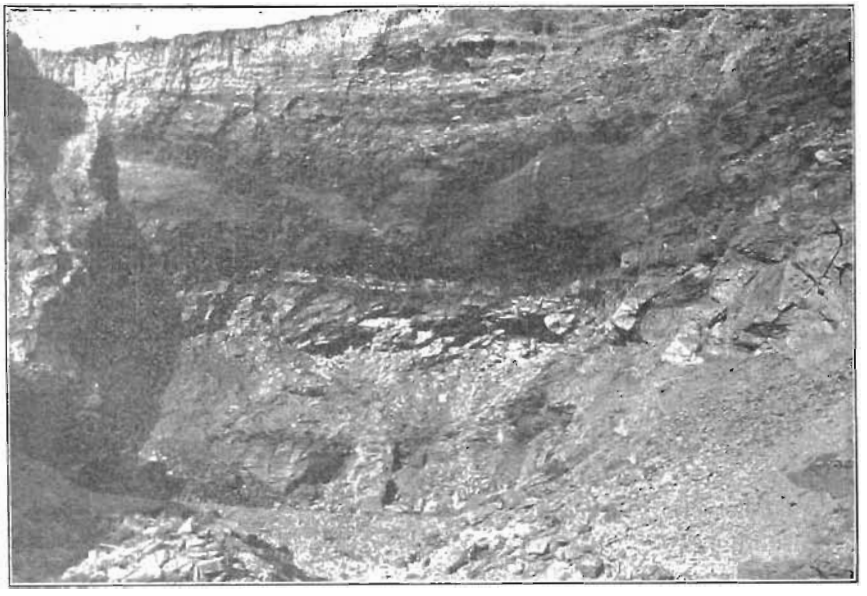

FIG. 73 The clay pit of the Ottumwa Paving Brick and Construction Company.

more shaly toward the north. All the beds in the section are used in making brick except the coal, No. 2, which has served for fuel.

III.—SECTION ON SUGAR CREEK AT THE CHICAGO, BURLINGTON AND QUINCY RAILROAD BRIDGE.

		FEET.
9.	Sandstone	10
8.	Shale, black, fissile	12
7.	Coal	2
6.	Fire clay	3
5.	Coal	2 to 4
4.	Fire clay and agillaceous shale	10 to 12
3.	Shale, black	15 to 20
2.	Unexposed	8 to 10
1.	Limestone, Saint Louis, exposed near by on creek	4

The sandstone, No. 9, increases in thickness as it is followed back into the hill.

Along the creek a short distance above the railroad bridge a four foot bed of blue, concretionary, Coal Measure limestone rich in fossils outcrops. It is not continuous over a large area, but is absent in places. Immediately below the ledge is a seam of coal from one to four feet thick which has been worked in the bed of the stream.

IV.—SECTION ON EAST BRANCH OF SUGAR CREEK, IN NW. ¼ OF SECTION 54, AGENCY TOWNSHIP.

		FEET.
5.	Sandstone, yellow, micaceous, soft, cross-bedded, contains concretions of iron	25
4.	Coal, impure, bony	2
3.	Fire clay	2
2.	Shale, argillaceous, gray	3
1.	Shale, black, carbonaceous, exposed	6

No. 5 is the same massive bed of sandstone that outcrops along the Des Moines river one mile and a half south of here. Nos. 1, 4 and 5 appear at a number of points along the east branch of Sugar creek.

V.—SECTION AT OLD COLGAN MINE, NE. ¼ OF SECTION 4, KEOKUK TOWNSHIP.

		FEET	INCHES.
7.	Sandstone, massive, soft, cross-bedded	50 to 60	
6.	Shale, black		½
5.	Coal	1	2
4.	Fire clay and argillaceous shale	15	
3.	Coal	2 to 3	
2.	Fire clay and black shale	1 to 10	
1.	Coal	4½ to 5½	

The rapid transitions which occur in the Coal Measure strata are well shown two and one-half miles below Cliffland station, along the Chicago, Rock Island and Pacific railroad (Ne. ¼ of Sw. ¼, Sec. 18, Tp. 71 N., R. XII. W.) Just below a narrow and steep sided ravine entering the river at this point the following section is exposed:

VI.

		FEET.
4.	Sandstone and sandy shale	37
3.	Shale, black, carbonaceous	3
2.	Coal	1½
1.	Shale, black, carbonaceous, fissile, exposed	45

Less than 250 feet northwest of here and across the ravine the entire outcrop above the railroad track is composed of a massive sandstone which rises 100 feet above the river. The lower twenty-five feet is not exposed. The shale rises gradually above the level of the track and a one foot vein of coal lies just beneath the sandstone. The latter also contains near the bottom bands and streaks of coaly material. Less than a quarter of a mile above this section the thick bed of sandstone disappears and is replaced by shales in which are two veins of coal. The upper is eighteen inches thick, the lower is from two to three feet thick, and they are separated by four to six feet of fire clay and argillaceous shale.

VII.—BIG BRANCH SECTION.

Near the mouth of Big branch in the Ne. ¼ of Sec. 28, Washington township, was seen the following:

		FEET.	INCHES.
6.	Drift	10	
5.	Shale, argillaceous, dark blue	2	
4.	Limestone, not continuous, concretionary		8 to 10
3.	Shale, black, carbonaceous	10	
2.	Limestone, with several systems of joints	1	
1.	Shale, black, carbonaceous	6	

No. 4 does not form a continuous bed but is absent in places. It forms, however, a well marked limestone horizon. No. 2 is doubtless the same stratum that appears in the bed of the river just below the mouth of Big branch.

Several years ago a number of prospect holes were put down

in the southern part of the county near Laddsdale, in sections 31 and 32 of Washington township. The holes were bored at distances of from 150 to 200 feet apart and their records are interesting as showing the character of the Coal Measure strata, especially the rapid changes in the beds, and the irregularity of the coal.

LADDSDALE SECTIONS.

A.

		THICKNESS IN FEET.	DEPTH.
24.	Drift	12	12
23.	Clay shale, gray and blue	13	12
22.	Shale, black	3	28
21.	Shale, sandy, gray	6	34
20.	Clay shale, blue	10	44
19.	Coal	1	45
18.	Clay shale, gray and blue	24	69
17.	Sandstone	1	70
16.	Shale, black, carbonaceous	3½	73½
15.	Coal	3	76½
14.	"Rock"	1½	78
13.	Clay shale, gray and blue	14½	92½
12.	Coal	1½	94
11.	Clay shale, gray and blue	6½	100½
10.	Shale, sandy, blue	2	102½
9.	"Rock", soft, blue	1½	104
8.	Coal	1⅓	105⅓
7.	Fire clay	2⅔	108
6.	"Rock" (limestone ?)	5	113
5.	Shale, sandy, blue	6	119
4.	Clay shale, blue and gray	16½	135½
3.	Coal	2½	138
2.	Fire clay	2	140
1.	Clay shale, light blue	12	152

B.

29.	Drift	25	25
28.	Shale, black	1	26
27.	Shale, sandy, black	4	30
26.	Clay shale, gray	2	32
25.	"Rock"	½	33½
24.	Clay shale, gray and blue	27½	60
23.	"Rock," black	1	61
22.	Shale, blue	13	74
21.	Coal	1½	75½
20.	Clay shale, gray	11	86½
19.	Coal	1½	88
18.	Shale, gray	10	98

		THICKNESS IN FEET.	DEPTH.
17.	"Rock"	1	99
16.	Shale	4	103
15.	Coal, with rock band	3¼	06¼
14.	Fire clay	8	114¼
13.	Clay shale, blue	2¼	116½
12.	Coal	½	117
11.	Fire clay	½	117½
10.	Coal	½	118
9.	Clay shale, gray and blue	14	132
8.	Coal	1⅔	133⅔
7.	"Slate stone," black	⅓	134
6.	Shale, gray	1	135
5.	Sandstone	5..	140..
4.	Shale, sandy, blue	12	152
3.	Clay shale	6	158
2.	Coal	2½	160½
1.	Clay shale, blue and gray	16½	177

C.

15.	Drift	25	25
14.	Clay shale, blue	2	27
13.	Coal	½	27½
12.	Sandstone	4	31½
11.	"Clay rock", gray	6	37½
10.	Clay shale, gray and blue	32	69½
9.	Shale, black	2	71½
8.	Coal	1	72½
7.	Clay shale, gray and blue	28	100½
6.	Clay shale, black	2	102½
5.	"Rock"	1	103½
4.	Coal	1½	105
3.	Clay shale, blue	29	134
2.	Shale, sandy, gray	7	141
1.	Clay shale	35	176

D.

20.	Drift	20	20
19.	Clay shale, blue	5	25
18.	Sandstone	5	30
17.	Clay shale, blue and gray	33½	63½
16.	"Stone" (limestone ?)	2	65½
15.	Clay shale, gray and blue	6½	72
14.	Coal	1	73
13.	Clay shale, gray	12½	85½
12.	Coal	1½	87
11.	Clay shale, gray and blue	18	105
10.	Coal	2	107
9.	Clay shale, blue	26	133

		THICKNESS IN FEET.	DEPTH.
8.	Shale, sandy, gray	5½	138½
7.	Clay shale, blue and gray	19½	158
6.	"Cap rock"	½	158½
5.	Coal	2¼	160¾
4.	Clay shale, gray and blue	8	168¾
3.	Shale, sandy, blue	8	176¾
2.	Sandstone	5½	182¼
1.	Limestone (Saint Louis ?)	1½	183¾

A comparison of these records shows that two beds of coal were encountered in all four of the holes at approximately the same depth, namely at seventy-two and 103 feet, but that the veins varied considerably in thickness. At about 135 feet another seam was encountered in two of the holes (A and B) and at 158 feet still another was found in two of the borings (B and D) but was absent from the others. Besides the four just mentioned, other veins were struck at different depths in the various holes, no less than seven being penetrated in one boring (B) and only three in the one next to it (C) and less than 200 feet distant. These sections show that the coal beds are not persistent for any great distance and that their thickness varies quite widely.

A well sunk on the land of Norman Reno, in section 12 of Pleasant township, went through 222 feet of Coal Measures, these strata consisting of shales, without any limestones or sandstones, so far as reported. The lower 100 feet, before striking the Saint Louis limestone, was composed of black carbonaceous shale. The record of this well is given below:

		FEET.
13.	Drift clay	60
12.	Sand	3
11.	"Soapstone"	15
10.	Shale, gray	30
9.	"Soapstone"	20
8.	Shale, black, carbonaceous	7
7.	Coal	3½
6.	Shale, blue	15
5.	"Soapstone"	10 to 15
4.	Shale	8
3.	"Soapstone"	10 to 14
2.	Shale, black	100
1.	Limestone (Saint Louis) alternating with thin layers of blue "sandstone"	182

The Pleistocene System.

Separated from the Carboniferous by a long interval of time and resting unconformably upon the strata of that system are the loose, unconsolidated deposits of the Pleistocene system. These include the drift, loess and alluvium. The latter is confined to the valleys of the Des Moines and its chief tributaries and the bottom lands along Cedar and Competine creeks. With the exception of these strips along the streams the surface is covered to a greater or less depth by drift and loess.

KANSAN DRIFT.

In common with the rest of southern Iowa Wapello county is covered by the Kansan drift sheet. This is not the oldest of the glacial deposits, since at a number of localities in the state a still older drift is found beneath the Kansan and usually separated from it by a forest bed or deposit of gravel. While no evidence was found that such a pre-Kansan drift sheet is present in Wapello county it probably occurs below the Kansan, as evidence of its presence has been found in the counties lying to the east.

The drift varies widely in thickness over different parts of the area. In Center and Polk townships it is not very heavy and will probably not average much over twenty-five feet, while in Highland and Competine townships, as shown by well records, the thickness is from 120 to 130 feet. The greatest thickness reported as having been encountered in drilling wells was in section 3 of Cass township, where the drift was 170 feet. While the maximum may reach 200 feet in some places, it is likely that the average thickness is not more than 100 feet.

The materials composing the Kansan drift are clay, sand, gravel and bowlders, but the proportions in which these are found vary considerably at different points. Bowlders of any considerable size are not at all common. The largest one observed, which was beside the road in the Sw. ¼ of the Se. ¼ of section 32, Center township, measured six by twelve by five feet. The striations were at right angles to the surface of the ground, so that the longest diameter was doubtless buried, the striæ usually being parallel to the greatest diameter. The rock was a fine-grained

granite. Good sized diabase and greenstone bowlders were also observed.

The best place to study the drift is in the deep cuts along the new line of the Chicago, Burlington & Quincy Railroad between Ottumwa and Agency City. While these cuts were not completed when visited by the writer in June, 1902, several of them showed from forty to fifty feet of drift. In the river bluff just east of Ottumwa, at Franklin Park, the following section is exposed:

	FEET.
3. Loess, gray, quite argillaceous, filled with plant roots	.8
2. Till, sandy, leached, reddish brown, ferruginous	10
1. Till, blue or gray, contains but little sand and is a stiff clay (exposed)	4

The line of separation between numbers 1 and 2 is here quite distinct owing to the marked change of color. The iron has accumulated at the base of number 2, where it has been deposited in the form of limonite by descending water. It occurs in thin crusts about one-quarter of an inch thick. This middle number is also very sandy; in places it is almost a pure sand, the particles frequently being cemented together by iron. Another section which is seen in the cut one-half mile east of Sugar creek is given below:

	FEET.
3. Loess	6 to 8
2. Till, reddish brown, leached, oxidized	12
1. Till, blue or gray	30

Granite, greenstone and limestone pebbles are common in the lower part of the drift and many of them have one or two sides flattened, ground and striated, through being carried along beneath the ice sheet. The loess appears to increase in thickness toward the higher ground and on the upland near Agency City is ten to fifteen feet thick.

In all of these cuts the upper leached and oxidized zone of the Kansan drift is well shown. It indicates that before the deposition of the loess the surface of the drift was for a long period subjected to weathering agencies. The calcareous materials have been dissolved out and carried away by the water and the iron constituents have been completely oxidized, giving the upper part of the till its deep red color. The depth to which this weath-

ered zone extends, from eight to ten feet or more, indicates that a long interval of time elapsed between the deposition of the Kansan drift and the laying down upon it of the loess. The fact that the later drift sheets have undergone comparatively little change by weathering, though they were formed thousands or tens of thousands of years ago, gives some idea of what that interval must have been.

At several points a ferruginous gravel or conglomerate occurs at the base of the drift, resting directly on the Coal Measure shale. This is well shown in the Nw. ¼ of the Nw. ¼ of section 6, Cass township, along a tributary of South Avery creek. Here the black shales are overlain by a very ferruginous gravel and coarse, cross-bedded sand. In places the iron is so abundant as to form a cementing material for the constituent particles and a firm conglomerate or coarse sandstone is formed. The pebbles are mostly quartz and sandstone, but some are composed of igneous rock, such as diabase and granite. The presence of these foreign materials would seem to indicate that the conglomerate is to be placed with the drift rather than with the Coal Measures on which it rests, since if it belonged to the latter the constituent pebbles would undoubtedly be composed of local materials and would contain no igneous rocks brought from any considerable distance. If the conglomerate belongs with the drift series, however, these foreign pebbles are to be expected. On North Avery creek, in the Sw. ¼ of section 26, the ferruginous gravel is again exposed at the base of the drift, which here has a thickness of six to fifteen feet. Still another locality where this deposit occurs is on the Des Moines river just above Eldon. The gravel and sand here have a thickness of ten feet; they rest on the shales of the Coal Measures and are overlain by fifty feet of drift.

The age of these gravels may be either Aftonian or Kansan. Their presence at the base of the Kansan drift, from which they are not separated by any dividing line, makes it seem quite probable that they belong with that drift sheet, though this could not be determined with certainty. It is possible that the gravels are interglacial and are to be correlated with the Aftonian gravels seen at Afton Junction and elsewhere in the state.

THE LOESS.

The loess is found overlying the Kansan drift over most of the county, though its thickness does not seem to be great. Where exposed along wagon roads and in railroad cuts it rarely exceeds five or six feet in depth, though in some places, as near Agency City, it reaches a thickness of ten to fifteen feet. The loess is light gray in color, is of fine, uniform texture and is less compact than the Kansan till. No fossils were observed in the deposit and lime concretions (loess-kindchen) are rare.

ALLUVIUM AND TERRACES.

The flood plain of the Des Moines and its larger tributaries and of Cedar and Competine creeks are composed of alluvium. This deposit is composed of materials derived chiefly from the drift and loess which have been carried down the slopes by the rains and redeposited by the streams in their valley bottoms. The alluvial plain of the Des Moines reaches a width of more than two miles for some distance below Ottumwa. The limits of the flood-plain of this river are indicated by a broken line on the map accompanying this report. Its surface lies at a level of about twelve feet above low water. The remnants of an older flood plain show at a number of places in the Des Moines valley as a terrace lying eight feet above the "first bottom," or at an elevation of twenty feet above low water. The river has cut into and carried away most of this higher plain which once formed the bottom of the valley and all that is left of it is this terrace. It appears on the west side of the river just below Ottumwa, south of Eldon, and at various points between these two towns. Eddyville is built on a terrace twenty-five feet above low water and near Kirkville station there is what appears to be the remnants of a fifty foot terrace. The road between the station and Chillicothe traverses it for some distance before descending to the present flood plain.

Deformations.

The strata have undergone but slight disturbance since they were laid down under water and for the most part are nearly

horizontal. The beds, however, have a slight dip to the south, the average being about three feet to the mile. At a few points the Saint Louis strata are seen to be thrown into gentle folds. These are well exhibited one mile northwest of Chillicothe in the artificial channel cut by the Chicago, Burlington & Quincy railroad for Avery creek. In this cut the limestone beds form five or six gentle anticlines. The monoclinal fold with a dip of 20° occuring in the same beds near Dudley, has already been mentioned.

Few faults occur in this region and when found they are of small extent. In the mine of the Illinois and Iowa Fuel Company at Keb there is a fault which has a northwest-southeast direction and a displacement of between four and five feet. A fault is also reported as occurring in the Appanoose mine at Willard.

Unconformities.

Unconformities exist between the Saint Louis limestone and Coal Measure shales and between the latter and the Pleistocene deposits. The unconformity between the strata of the Upper and Lower Carboniferous is excellently shown in the artificial cut one-half mile east of Dudley, already mentioned on a previous page, where the black shales of the Des Moines stage are seen resting on the eroded and uneven surface of the Saint Louis limestone. The calcareous beds had suffered considerable erosion and a thickness of many feet had been carried away before the shales

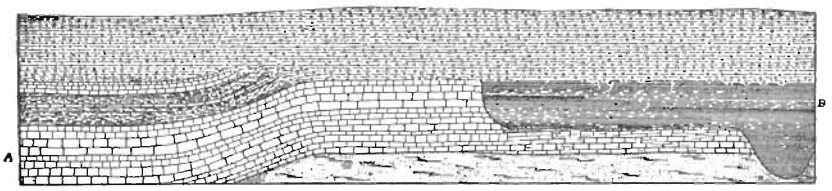

FIG. 74. Sketch showing the unconformity between the Saint Louis (A) and Coal Measures (B) as exposed in the artificial cut one-half mile east of Dudley.

were laid down on top of them. A shallow valley was cut in the limestone at this point and was subsequently filled by the argillaceous deposits of the Coal Measures (Fig. 74). The uncon-

formity is also well exhibited along the Des Moines river at the old quarry just below the Chicago, Burlington & Quincy railroad bridge.

The Pleistocene deposits everywhere rest unconformably upon the Carboniferous strata. After the latter were formed and raised above the sea there was a long erosion interval during which the land surface was carved and shaped by the streams. It is possible that there was a submergence during Cretaceous time but we have no record in this county of there being any

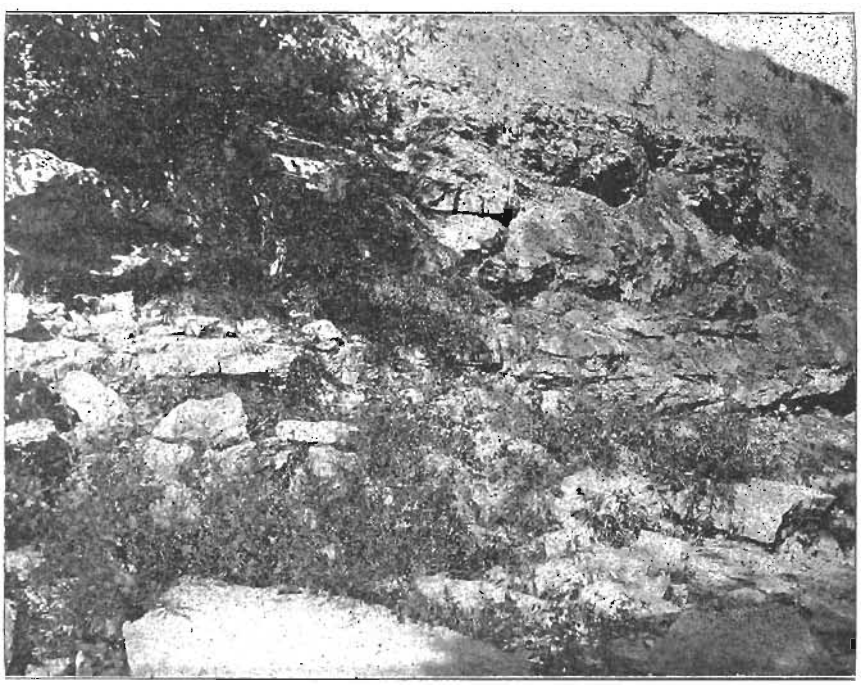

FIG. 75. Unconformity between the Saint Louis and Coal Measures. The limestone ledges of the former show on the left and the shales on the right. Cut near Dudley.

encroachment of the sea over this area during that period. For a long lapse of time therefore the rivers acted upon the land mass and eroded deep and broad valleys. Upon this old land surface the loose and heterogenous deposits of the Pleistocene were left by the ice sheets that invaded the region from the north.

ECONOMIC PRODUCTS.

Coal.

Wapello is one of the important coal producing counties of the state. Thirty years ago its output was greater than that of any other county with the possible exception of Mahaska, and during all the years since then it has held its place near the head of the list. It now ranks seventh in its production of coal, its output for the year 1901 being 249,880 tons.

Mining has been carried on here almost from the earliest settlement of the region. As long ago as 1857 there were mines in the neighborhood of Kirkville and Dahlonega, in the river bluffs four miles below Eddyville, and along Bear creek four miles west of Ottumwa. In 1862 Wapello produced 327,650 bushels of coal, or nearly three times as much as any other county in the state. In 1867 when White visited this district the following were the more important mines in operation: C. Dudley & Company's, one mile south of Dudley, on Middle Avery creek. The seam was four feet thick and lay fifty feet above the Saint Louis limestone. Henry Shock & Company's mines in Happy Hollow (Sec. 8, Tp. 72 N., R. XIV W.) which were working in a five foot seam. Messrs. Brown and Godfry operated the Union mine near Keb (Sec. 33, Tp. 73 N., R. XIV W.) where the coal was four to four and a half feet thick. The Alpine Coal Company had a large mine at Alpine station (two miles below Cliffland) on the Des Moines Valley railroad. The seam was from four to five feet thick and large quantities of the coal were shipped to Keokuk. White states that since the mine was opened it had produced about 1,000,000 bushels, which was probably more than the output up to that time (1867) of any other mine in the state.

In 1877 the largest mines in the county were the Union Coal Company mine with an output for that year of 608,977 bushels and the Postlewait mine in Happy Hollow with an output of 582,507 bushels. The latter mine was connected with the Chicago, Burlington and Quincy railroad, over one mile distant, by a tram

road. For a number of years prior to 1890 the Wapello Coal and Mining Company operated extensive mines just south of Kirkville (Sec. 17, Tp. 73 N., R. XIV W.) The Ottumwa and Kirkville railroad connected them with the Chicago, Rock Island and Pacific railroad and large quantities of coal were shipped. The vein averaged five and one-half feet thick and over 400 acres were worked out. Over 300 miners were employed and the total output of these mines was between one and two million tons.

Mining has been confined so far chiefly to the northwestern part of the county, in Richland, Center, Polk, Columbia and Cass townships. Aside from the Laddsdale mine and the old mine at Alpine very little coal has been taken out in the southern and northeastern portions of the county. Yet this is not because no coal occurs for seams are undoubtedly present in the Coal Measures of these parts of the area. Coal outcrops in the hills in the vicinity of Ormanville and there are a number of small country banks in Green township. An eighteen to twenty inch vein has been mined on a small scale about one mile east of Ormanville and near the latter town two seams outcrop, the lower eighteen inches and the upper three feet thick. There are no outcrops of Coal Measure strata in the northeastern townships, Highland, Competine and Pleasant, since the indurated rocks are concealed under the thick drift deposits in which the streams have cut only shallow channels. But prospecting would doubtless reveal the presence of coal in this part of the county. A deep well sunk on the land of Norman Reno, in section 12 of Pleasant township, is reported to have gone through a three and a half foot seam of coal at a depth of 135 feet. The record of this well is given on a previous page.

The absence of mines from the southern and northeastern portion of the county is probably due chiefly to the distance from railroads. Then too, toward the south the country is very rough and the roads hilly. Timber is here abundant so that there is little inducement to look for other fuel to supply the local demand. In the northeastern townships the thickness of the drift and the depth to which it would be necessary to go to reach coal have undoubtedly tended to discourage mining. In other portions of the district the coal is more accessible and in most in-

stances lies near the surface. But when these areas have been worked out it is not unlikely that the parts which at present produce no coal will furnish a good supply. It may be expected that systematic prospecting will show the presence of workable seams in these now neglected portions of the county.

The opinion seems to be quite prevalent that coal is more liable to be present in the valleys or depressions than under the uplands. But it is to be remembered that the existing valleys and hollows were not formed until long after the beds of coal were accumulated and there is therefore absolutely no relation between the configuration of the present surface and the underlying coal seams. The latter are just as likely to occur beneath the uplands and away from the streams as anywhere else, as has many times proved to be the case.

The coal in this county lies at no great depth below the surface. There is no mine that is over 130 feet deep and most of them are less than 100 feet. In many places the seams outcrop along the sides of the valleys, as along the Des Moines river two miles below Cliffland station and at various points along Sugar creek. The lower beds of coal occur only a little above the Saint Louis limestone. In one instance the vein lies only twenty-five feet above the limestone, in another but three feet. As has already been stated the maximum thickness of the Coal Measures in Wapello county is probably not over 250 feet and over a considerable portion of the area their thickness is less than this. Beneath the uplands, therefore, where it would be necessary to to go the deepest before reaching the lower coal seams, if they were present, it might be necessary to go over 200 feet in order to strike them. To the thickness of the Coal Measures must also be added that of the drift, which averages about 100 feet. It is not at all improbable that there are coal seams lying at considerably greater depths than those now worked and that when the latter are exhausted the deeper ones will be prospected.

While the coal beds vary greatly in thickness the large majority of those which are being worked now run from four to five and one-half feet. In a few instances seams two and three feet thick are being mined, but these are exceptional. It is reported that in the Happy Hollow mine and those just south of Kirkville

the beds reached a thickness in places of six and one-half and seven feet. The coal seams are not continuous for any great distance but are more or less lenticular in shape and thin out toward the sides. No one vein extends over the entire county nor probably even over one township but when followed for a few miles it is found to pinch out and disappear or to be replaced by another seam at the same or a different horizon. This comparatively rapid variation in the thickness of the beds and their thinning out toward the edges makes it necesary to put down the number of holes when prospecting for coal. A vein several feet in thickness may be struck at one point and in another hole only a few hundred feet distant the vein may be two or three inches thick or entirely absent. These irregularities in the coal seams are well known to the miners and are illustrated in the records of the borings near Laddsdale, given on a previous page.

The following analyses* made by Professor G. E. Patrick shows the composition of the Wapello county coal as it is put on the market. The samples were not picked but represent the average character of the coal. As shown by these analyses the coal compares very favorably with that from other parts of the state.

LOCALITIES	MOISTURE.	TOTAL COMBUSTIBLES.	ASH.	VOLATILE COMBUSTIBLE MATTER	FIXED CARBON.	COKE—FIXED CARBON PLUS ASH	SULPHUR.		
							IN SULPHIDES.	IN SULPHATES.	TOTAL.
Whitebreast No. 22, Keb.—									
Top of seam....	5.54	84.79	9.67	41.24	43.55	53.22	6.35	.11	6.46
Middle of seam.	6.82	82.03	11.15	35.29	46.74	57.89	9.53	.16	9.69
Bottom of seam.	7.55	79.09	13.36	33.43	45.66	59.02	6.05	.25	6.30
Eldon Mine, Laddsdale.—									
Top of seam....	3.81	93.39	2.80	41.69	51.70	54.50	2.57	.33	2.90
Middle of seam.	3.72	85.37	10.91	42.88	42.49	53.40	2.93	.66	3.59
Bottom of seam.	3.24	87.97	8.79	45.82	42.15	50.94	2.80	.56	3.36

In their mining equipment there is a wide difference in the mines. While the large ones are very well fitted in this respect,

* Iowa Geol. Surv , Vol. II, p. 509, Des Moines, 1894.

the smaller are provided with only the simplest contrivances. In nearly one-half the mines steam power is used for hoisting the coal and in most of the remainder the horse gin is employed. For underground haulage the tail rope system is used in the Illinois and Iowa Fuel Company's mine at Keb and in the Consolidation No. 9 while in eight other mines mules are used for this purpose. The room and pillar system of mining is the only one employed in the county and the coal is shot from the solid without any undercutting. The Eldon Coal and Mining Company for several years tried the Jeffery mining machine but its use was finally discontinued on account of the stony concretions in the coal which injured the machine and caused much trouble. The coal is now mined entirely by hand. Ventilation is secured in about one-third of the mines by the use of fans and in the rest furnaces are used for this purpose. A majority of the mines are equipped with substantial and well built tipples in which stationary screens are the only ones used.

Although the seams have been worked out over only an insignificant part of the area—it is probable that not much over 1,000 acres have been mined—yet the county has yielded large quantities of coal. The output for the last twenty years is given in the reports of the State Mine Inspectors and, since 1897, in the Annual Reports of the Geological Survey. Previous to 1881 no yearly records were kept but the production for certain years is contained in the State Census Reports. In the following table are given all the available data relating to the coal output of Wapello, the amounts being stated in short tons.

YEAR.	TONS.
1860	17,062
1862	13,106
1866	6,575
1868	27,503
1874	20,745
1877	53,559
1881	131,815
1882	207,721
1883	237,821
1884	240,720
1885	187,911
1886	237,111
1887	272,073
1888	380,395

YEAR.	TONS.
1889	273,362
1890	297,459
1891	167,290
1892	253,075
1893	279,160
1894	186,748
1895	205,900
1896	150,405
1897	239,960
1898	252,484
1899	316,460
1900	270,330

The total output for the twenty years since 1881 has been over 4,800,000 tons. If we add to this the estimated output for the previous years, which can be less acurately given but may be conservatively placed at 500,000 tons we have a total production of 5,300,000 tons. It has probably been greater than this, since no reports are received from many of the smaller mines and the aggregate output from these amounts to considerable in the course of a number of years. Perhaps it would be nearer the truth to estimate the total production at 5,500,000 tons.

It is impossible to give even approximately the amount of workable coal remaining but it can safely be stated that there is enough to last for many years to come. Prospecting in other parts of the county than those now worked will in all probability reveal the presence of good seams of coal.

Up to the present time mining has been carried on chiefly in the vicinity of Ottumwa and Kirkville and in a strip of country between those towns. The only important mines outside of this area are the ones at Willard and Laddsdale. In past years, however, mining was extensively carried on in Happy Hollow, five miles northwest of Ottumwa on the south side of the river, and along the river between Ottumwa and Eldon. Fourteen mines, or one-half of all in the county, are located within three miles of Ottumwa. The rest are in Richland township (seven), Polk township (three) and Washington township (two). In addition to these there is the large mine of the Consolidation Coal Company, No. 9, located just over the line in Mahaska, but the workings of which extend over into section 3 of Columbia township.

Of the twenty-seven mines now worked (1902) in the county seven are shipping or railroad mines and the rest supply the local trade, most of them being operated only during part of the year. Their location is shown on the map accompanying this report.

DESCRIPTION OF INDIVIDUAL MINES.

Ottumwa Mines.—Here are included all those which are within three miles of the city.

The Bear Creek Coal Company has a mine on Bear creek, three miles west of the city limits. The coal is hauled about one-half mile west to a siding on the Chicago, Milwaukee & St. Paul railroad where it is loaded on the cars. The railroad takes the entire output. The seam, which is four and one-half feet thick and outcrops on the side of the valley near by, lies only twenty-five to thirty feet above the Saint Louis limestone, being separated from the latter by fire clay and shale. The coal is reached by a slope 145 feet long and steam power is used for hoisting. The mine has been worked six years and since becoming a shipping mine is operated throughout the year.

The mine of the Star Coal Company is one and one-half miles south of Ottumwa (Sec. 2, Ne. ¼ of the Se. ¼.) A tramway runs from the mine to a point one-half mile nearer the city. The seam is from four feet six inches to four feet ten inches thick and is mined by a slope 400 feet long, the descent being one foot in five. Steam power is used in hoisting the coal and it is hauled by mules out to the end of the tramway.

The South Ottumwa Coal Company mine is close by the one last described and is undoubtedly in the same vein, though it here averages almost five and one-half feet in thickness. The shaft is ninety-three feet deep and coal is raised by a horse gin.

A short distance east of here is the mine of the Excelsior Coal Company (Sec. 1, Nw. ¼ of the Sw. ¼). The seam lies fifty-five feet below the surface and runs from four feet to four feet eight inches in thickness. Over the coal is ten feet of black shale which forms a good roof.

Still farther east, in the southwest quarter of section 6, is the John Daniels mine. This is one of the deepest in the county,

the bottom vein being 130 feet below the surface. Five feet above is another seam and the average thickness of each is four and one-half feet. The coal in this mine lies about fifty feet below the level of the Saint Louis limestone where it is exposed in the bed of the river at Ottumwa, two miles north. The limestone either has quite a strong dip to the south or the strata have here suffered considerable erosion prior to the deposition of the Coal Measures.

The four mines located south of the city find a ready market for their output in Ottumwa and are well equipped for supplying the demand.

The Fair coal mine is two and one-half miles southeast of Ottumwa, in the Ne. ¼ of the Ne. ¼ of Sec. 4, Tp. 71 N., R. XIII W. The seam is three to four feet thick and lies thirteen feet below the bed of the small stream entering the river near by. This is doubtless the same seam that has been extensively quarried in the bed of the Des Moines near the mouth of Sugar creek. The mine is worked by means of a short slope and supplies the local market.

Coal has been mined at numerous points along Sugar creek, the seam worked having a thickness of two feet. The chief mines now in operation here are the Owl Creek and Parker mines, the former being in the Se. ¼ of the Ne. ¼ of Sec. 22, Tp. 72 N., R. XIII and the latter in Se. ¼ of Nw.¼ of Sec. 21, Tp. 72 N., R. XIII W. Coal is also being mined on a small scale from the outcropping seams in the bluff near the Chicago, Burlington & Quincy bridge over Sugar creek.

The Spring Valley coal mine is located within the city limits, near the northern boundary and on a tributary of Harrow's branch. There are two seams of coal, the upper three and one half and the lower four feet thick. The lower seam, which is the one now being worked, is reached at a depth of forty feet and lies not far above the Saint Louis limestone. The latter outcrops along the creek less than three-quarters of a mile below the shaft.

The Black Diamond mine, operated by Lumsdon Bros., is one and one-third miles northwest of the Spring Valley near the plant of the Ottumwa Paving Brick and Construction Company.

The mine is connected by a tram road with a short spur of the Chicago, Milwaukee & Saint Paul railroad running to the brick works. Two seams of coal are mined and it has been found that when one thins out the other grows thicker, so that when one seam becomes too thin to work to advantage it is customary to drift to the second one. The upper averages three and one-half feet and the lower four and one-half feet thick and the distance between them varies from four to eleven feet. This mine is well equipped, is provided with steam power and ships a large part of its output over the railroad.

The Risher Coal company mine is one of the deepest in the county, having a depth of 130 feet. It is one-half mile north of the Black Diamond and in the same section. The upper seam is here only two feet thick and twenty feet below is the lower seam with an average thickness of four and one-half feet.

One of the important shipping mines is that of the Phillips Fuel Company, No. 4, close by the last mentioned and located on the Chicago, Milwaukee & Saint Paul railroad at Phillips. Mining has been carried on in this vicinity by the above company for the past twenty years. In some places where the two seams are only eight inches apart and separated by fire clay, they have been worked together as one seam. At other points they are from four to twenty feet apart, the upper averaging three feet three inches and the bottom four feet two inches in thickness. It has been found that when one of the seams grows thin the other increases in thickness. The tipple is arranged so that three cars can be loaded at the same time, one with slack, another with nut coal and a third with lump coal, or the screens can be so arranged so as load the cars with steam coal.

One and a half miles northwest of the Phillips No. 4 and only a short distance south of Keb (Ne. ¼ of Sec. 3, Center Tp) is the Baker mine, which has been worked for nearly twenty years. The upper vein is mined, which here has an average thickness of four feet and three inches. One quarter of a mile due west is the Utterback mine, which is working the same seam of coal. Both supply local trade.

At Keb is located the important mine of the Illinois and Iowa Fuel Company, the largest in the county. It was formerly known

as the Whitebreast No. 22 but in July, 1901, came into the possession of the present company. A railroad connects the mine with the Chicago, Burlington & Quincy railroad and the entire output is sold to the Chicago, Milwaukee and Saint Paul railway. At Keb, as in all the mines between here and Ottumwa, there are two seams, the upper having a quite uniform thickness of from four feet four inches to four and one-half feet and the lower averaging from between four and one-half and five feet. The distance between the seams is about twenty feet, though it varies considerably and is in places only three or four feet. The upper seam has a clay parting one to six inches thick. Mining is now being carried on mostly in the lower seam, which is reached by a slope from the upper one. A fault with a vertical displacement of over four feet and which extends in a northwest-southeast direction occurs in this mine. The coal is hauled by a tail rope to the bottom of the sixty foot shaft and is hoisted from there by a separate engine and drum. The mine, which is eleven years old, is equipped so that it can produce large quantities of coal and in past years the daily output has been 1,000 tons and over.

In the vicinity of Kirkville there are a number of mines which supply the local trade. Just south of the town were located the extensive mines of the Wapello Coal and Mining Company, already mentioned, but these have been abandoned since 1890 although there is still much coal in this vicinity. Several of the present mines are working in the same seam that was mined by the above company.

Three miles south of Kirkville, in the Ne. ¼ of the Nw. ¼ of Sec. 28, Richland township, is the Vanderpool mine, which has been running ten years. The new shaft is fifty-five feet deep and the seam averages four feet thick. Just west of here and across the road is the Houk mine which has been opened only two years. The seam is here over five feet thick and is doubtless the same one worked at the Vanderpool mine.

One mile northwest, in the Ne. ¼ of the Sw. ¼ of Sec. 20, is the Glenn mine, a new one opened in 1890. The seam which is from four to five feet thick is reached by a short slope.

Still nearer to Kirkville, in the Nw. ¼ of Sec. 16, is the Waddell mine, 140 feet deep and the deepest in the county. The seam is quite uniform in thickness and runs about five and one half feet, with a good slate roof. Less than a mile and a half west is the Davis mine in the northeast quarter of section 18. The new shaft is forty-three feet deep and the seam averages over five feet thick. In sinking the shaft twenty-eight feet of sandstone and four feet of shale over the coal were passed through. The Fuhs mine is located one-half mile south of Kirkville and the seam mined here is about four feet thick.

Consolidation Coal Company mine, No. 9. This mine is located two and one-half miles east of Eddyville and though the shaft is half a mile north of the line, in Mahaska county, the greater part of the present workings are to the south in Wapello county, (Sec. 3 of Columbia township). A branch of the Chicago & Northwestern railroad runs to the mine and all the coal is shipped. The seam lies near the surface and outcrops close by on the west branch of Brown creek. It averages four feet and two inches in thickness, being five feet in places. The coal is hauled over a mile from the face of the workings to the shaft by two tail ropes, the seventy horse power engine which operates one of them being located under ground. The mine is provided with an electric fan and electric signals. The seam is not level but is quite undulating so that the entries are sometimes above and sometimes below it.

Eldon Coal & Mining Company's mine at Laddsdale. This is near the Davis county line and on the Chicago, Rock Island & Pacific railroad. The shaft is on the north side of the valley of Soap creek. In sinking the new air shaft, three-quarters of a mile from Laddsdale, the following strata were passed through:

	FEET.
Blue clay (drift)	75
Sandstone	50
Shale	2
Coal	1½
Shale and fire clay	3
Coal	4⅝

Several years ago an attempt was made to use the Jeffery mining machines here but they were not a success on account of

the stony character of the coal. The railroad takes the greater part of the output and the rest is shipped to various points in Iowa and Kansas. The seam has an average thickness of four feet.

A mine was recently opened by an Eldon company on the edge of the Des Moines valley one mile east of Laddsdale. An expensive tipple was built and it was connected by a switch with the Chicago, Rock Island and Pacific. Only a little coal was taken out and the mine was soon abandoned. The roof is said to have been bad and the coal of inferior quality.

William McIntosh has a mine one mile northwest of Eldon in the Ne. ¼ of the Se. ¼ of Sec. 21, Washington township. There are two seams of coal in this vicinity, the upper varies considerably in thickness but is two feet in places, and from thirty to fifty feet below is the lower seam which is three feet thick at the McIntosh mine. The limestone layer outcropping along Big branch lies between the two coal beds.

Appanoose mine at Willard. This is on the Chicago, Milwaukee and Saint Paul railroad nine miles west of Ottumwa and all the output of the mine is taken by this road. The seam is four feet thick, with a depth of 100 feet. Ten feet above there is a second seam two feet thick but the coal in this is bony and unfit for use. This mine has been running about twelve years.

About one and a half miles northwest of Willard there are two local mines which have been worked for a number of years. The Newall mine is in the Ne. ¼ of the Nw. ¼ of Sec. 29, Polk township. The shaft is fifty feet deep and the seam averages three feet thick. The equipment is unusually good for a mine of this size, there being a well built tipple and steam power being used to hoist the coal and run the fan. A. Major and Son have a mine on South Avery creek less than one-quarter of a mile north of here, and they are probably working the same seam. Where the coal outcrops in the bed of the stream it is overlain by three inches of shale. This limestone ledge is not at all persistent and is present only in places. The seam is here mined by means of a drift and the coal is three feet and ten inches thick.

Building Stone.

Wapello county is well supplied with building stone. The Saint Louis limestone is quarried at a number of points, shown on the map at the end of this report, and the sandstones of the Coal Measures are also used to some extent, though as a rule they are too soft to be suitable for building purposes. The Pella beds of the Saint Louis stage, however, furnish a good quality of stone. It occurs in ledges varying from a few inches to two feet in thickness and marly partings commonly separate the beds. The limestone is readily quarried in blocks of almost any size required for ordinary purposes and makes an excellent building material. It is of a uniform light blue or gray color pleasing to the eye, is very fine-grained and compact in texture and withstands weathering well.

The most extensive quarries are at Dudley and as they are beside the Chicago, Burlington and Quincy railroad they are well situated for shipping their products. The limestone has been quarried here for thirty years and has been extensively used by the railroad for culverts, bridges, ballast and riprap.

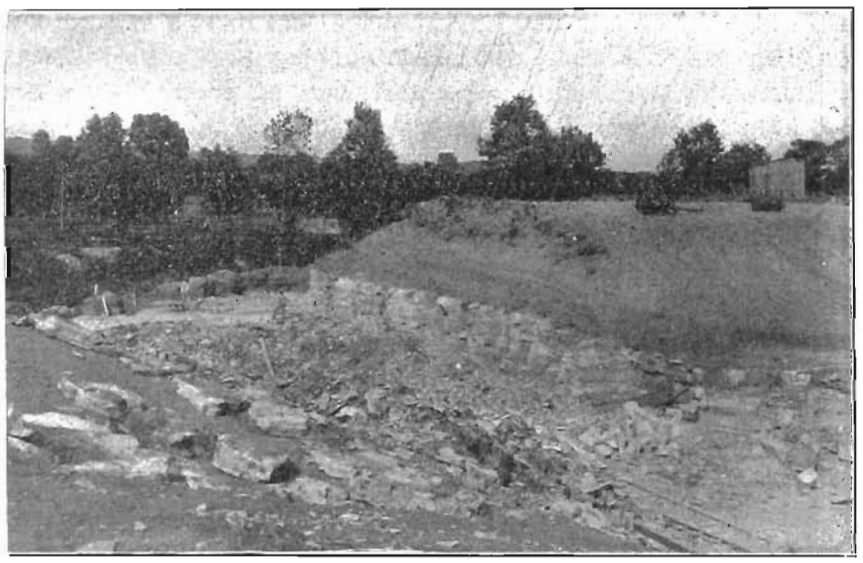

FIG. 76. Quarry of Andrew Lames at Dudley, showing the Saint Louis beds overlain by drift.

P. W. Lyon's quarry in the north bank of Turkey Creek, section 11, Lockridge township, showing the Upper and Lower Verdi beds.

(v. 12)

Large quantities have also been shipped to neighboring counties. T. H. Shields & Son operate a quarry near the station. About eighteen feet of drift are stripped off down to the rock and six to eight feet of limestone are exposed in the face of the quarry. A short distance west of the station Andrew Lames has a quarry in which the following ledges are seen from the top down: eighteen inches, four inches, nine inches, nine inches and eighteen to twenty-two inches thick. One-half mile south of Dudley on Middle Avery creek two new quarries have recently been opened up, one by John Swanson and the other by J. E. Ire, but little stone has been taken from them yet.

The Saint Louis beds have been quarried at several points in the vicinity of Chillicothe and on South Avery creek. In the Se. ¼ of Sec. 35, Tp. 73 N., R. XV W., twenty feet of limestone are exposed along the creek and considerable of it has been taken out here. There are several quarries near the mouth of Rock run in the Sw. ¼ of the Nw. ¼ of Sec. 15, Tp. 72 N., R. XIV W. The Saint Louis strata are well exposed on both sides of the stream and the section seen here has already been given on a previous page.

C. B. Castle has a quarry on Bear creek just west of the city limits of Ottumwa. It is close to the Chicago, Milwaukee and Saint Paul railroad.

Limestone has for many years been taken from the bed of the river at Ottumwa during low water. A new place is opened up and worked out each season. That portion of the bed of the stream which is to be quarried during the summer is enclosed by an embankment to keep out the water. This is constructed of barrels filled with clay against which are piled broken stone, gravel and sand until a substantial barrier is built up. About six feet of limestone is removed, the upper layers being thin-bedded and the lower in ledges three to eight inches thick. The quarry is operated by Charles Chilton and during the past year (1901) it was a short distance below the new wagon bridge.

Limestone is also quarried quite extensively on Harrow's branch, one-quarter of a mile above Second street, in the northwestern part of Ottumwa.

Across the Des Moines river from Eddyville and three-quarters

of a mile south of the town there are two quarries near the mouth of Miller creek. Thomas Cawley has one near the river and a short distance south is another belonging to John Lafferty. The

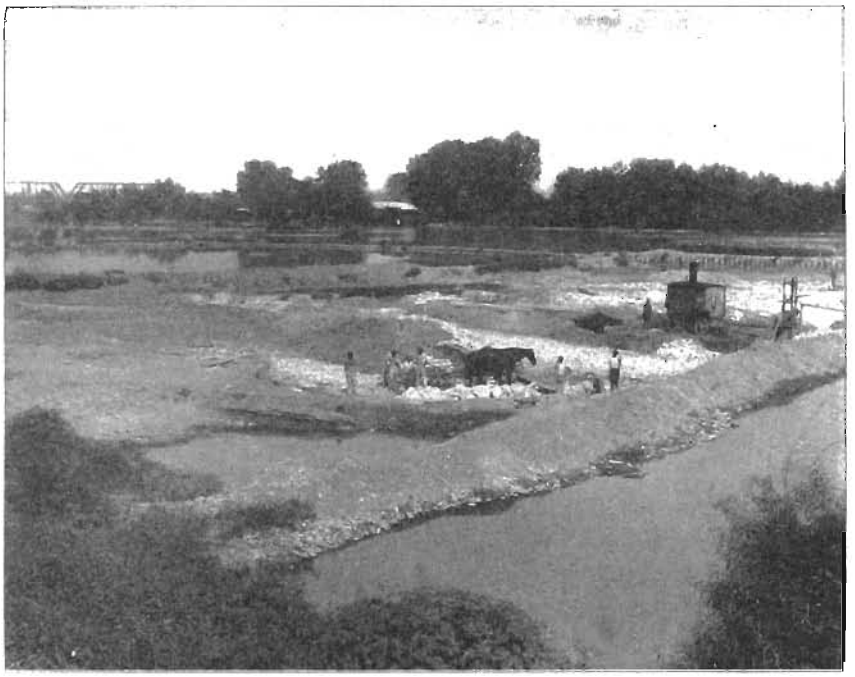

FIG. 77. Quarry in bed of the Des Moines river at Ottumwa.

Saint Louis beds here rise fifty feet above the river and are found outcropping well up in the bluff. Considerable stone has been taken out from both of these quarries and most of it used in Eddyville and vicinity, though some has been shipped. Where the Saint Louis strata outcrop on the stream two miles south of Kirkville, near the center of the northeast quarter of section 20, Richland township, the rock has been quarried for a distance along the creek. From the bed of the Des Moines river below Eldon and just north of the Davis county line quite a large quantity of limestone is annually taken out during the season of low water.

In the above list are not included all the locations where limestone has been quarried in the county, for the rock has been taken out at numerous points throughout the area covered by the

Saint Louis and it would not be possible to give all of these even if it were worth while.

The value of the limestone quarried in Wapello county during 1901 amounted to $14,757, a slight increase over the preceding year.

Clay.

The clay industry of Wapello county is an important one and within its borders is located one of the largest and best equipped brick plants in the state.

Three kinds of clay are found in the county, namely: 1, Coal Measure shale; 2, drift clay and 3, alluvium. All three of these materials are used at one or the other of the clay works. The shales outcrop at many points along the Des Moines and its tributary streams and a number of sections containing these were given under the discussion of the Coal Measures. The drift clay that is utilized is mostly the loess overlying the Kansan drift and forming the surface deposit over nearly the entire area. The alluvial clays are confined to the valleys of the principal streams, being especially abundant along the Des Moines.

Ottumwa Paving Brick and Construction Company.—The plant of this company is located just beyond the northwestern corner of the city limits of Ottumwa. It is not far from the Chicago, Milwaukee and Saint Paul railroad with which it is connected by a switch. In the clay pit, which is in the side hill just back of the works, there are exposed over fifty feet of Coal Measure shales and these are all used as they come, from the top to bottom. The section shown here is given on page 466 of this report. From that it will be seen that a variety of strata occur in the pit; clay shale, sandy shale and sandstone, black, fissile, carbonaceous shale, coal and fire clay being present. The lower coal seam has been mined and used for fuel. Most of the fuel, however, is obtained from the Black Diamond mine, only a short distance from here. This brick plant, the most important in southern Iowa, is finely equipped and no expense has been spared on buildings or machinery. The brick are burned in an immense continuous kiln 160 feet long and eighty-six feet wide, with a total capacity of 704,000 brick. It has twenty-two tunnels or arches, each with a capacity of 32,000. As

is customary in kilns of this type the firing is done from the top. The coal is ground fine in the dry pan used for the clay and is fed in a little at a time. The finer the coal the more perfect is the

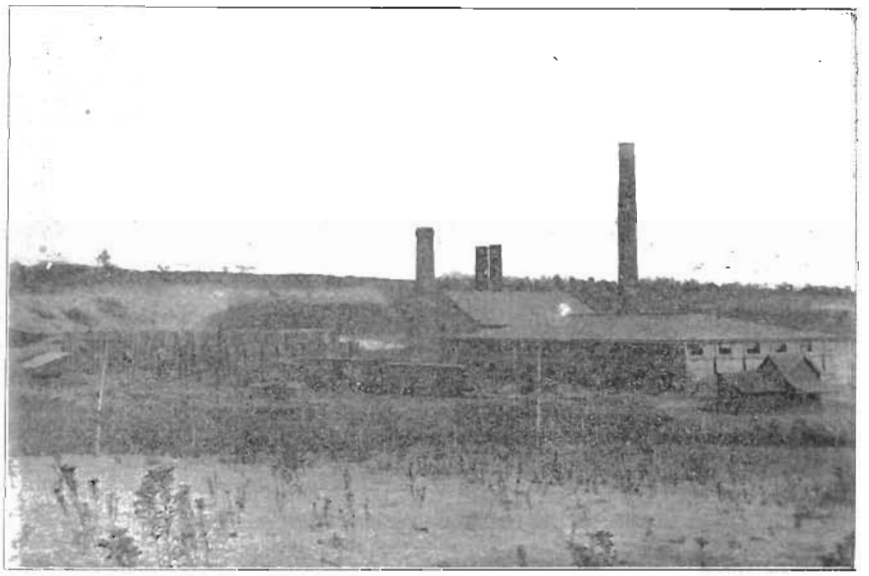

FIG. 73. Plant of the Ottumwa Paving Brick and Construction Company. The large continuous kiln is shown at the right.

combustion and the fact that the thin cloud issuing from the 100 foot smoke stack of this kiln is almost white is evidence that most of the carbon is consumed and but very little escapes. This continuous kiln is the largest in Iowa and is said to be one of the largest in the world. In addition to it there are five Endaly downdraft kilns and one open updraft kiln. Both the Penfield and the Brewer brick machines are used, and the former being employed for making end-cut brick. There is in use a nine-foot dry pan made by the Eagle Iron Works of Des Moines. In the large brick dry-shed provided with six miles of steam pipe, 50,000 brick are dried every twenty-four hours and this is about the daily production of the plant. Power is furnished by three boilers of eighty horse power each and engines of over 170 horse power.

The product of the plant is building brick of excellent quality, hollow blocks and pavers. The latter are made from the fire

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF WAPELLO COUNTY, IOWA.

BY

A. G. LEONARD

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)

SAINT LOUIS

INDUSTRIES

COAL MINES

QUARRIES

CLAY WORKS

DRAWN BY F. C. TATE

IOWA LITHO. CO.

clay which occurs in the bottom of the pit below the lower coal seam.

The Swift, Campbell Brick Company.—This company has a brickyard just east of the city limits between the tracks of the Chicago, Burlington and Quincy and the Chicago, Rock Island and Pacific railroads. The plant has been in operation two seasons. The alluvial clay which is used is obtained near by, the yard being located on the edge of the flood plain over which the alluvium has been deposited by the river. The thickness of the deposit is from ten to fourteen feet and below the clay is a layer of water-bearing sand. The clay grows sandy toward the bottom and the lower two or three feet are very arenaceous. Some of this sandy material is mixed with the clay to prevent it from shrinking too much in drying. Most of the brick are burned in a large continuous kiln with ten arches. This is provided with the Swift coking tables on which the coal is first coked and then pushed over either side on to sloping grates where it is consumed. In addition to the large kiln there are three open updraft kilns. A Brewer No. 6 brick-machine is used and the brick are dried in long sheds open at the sides.

Ostdeik Brick Plant.—This is located in the northeastern part of Ottumwa a short distance north of Pennsylvania avenue. It is the oldest brickyard in the county and has been running thirty-two years. Eighteen inches of surface clay or loess is used and in the common brick no other material is mixed with this. But in those of better quality one part of fire clay is mixed with four parts of loess. An Anderson brick machine, made in Anderson, Indiana, is in use here. The moulds are sanded and it is this sand on the surface of the bricks that gives them their red color. They are dried in sheds, partly by exhaust steam, partly by the wind and are burned in four open updraft kilns.

Mr. A. W. Melchor has a tile-yard at Phillips, just across the Chicago, Milwaukee and Saint Paul tracks from the coal mine of the Phillips Fuel Company. The plant has been in operation fourteen years. Surface clay or loess to a depth of three feet is used and with this is mixed from one-third to one-fifth of fire clay. A Brewer machine is employed and the tile are burned in one large and one small round downdraft kiln. Sizes varying

from one and one-fourth inches to ten inches in diameter are made. These tile are of superior quality, hard, tough and of uniform grade and size. They are burned two days. There was formerly a brick yard at Eldon but it is no longer in operation.

The value of the clay products of Wapello county for 1901 amounted to $64,093 or an increase over the previous year of more than $20,000.

Water Supply.

The many streams of the county furnish an abundance of water for stock and other purposes during all but very dry seasons. The summer of 1901 was such an exceptional season and the drouth continued so long that most of the streams dried up entirely. The chief source of water supply for domestic use, however, is from wells. The water is found at varying depths in sand and gravel layers in the drift. Some of these drift wells are 130 feet or more in depth while others extend down only ten or twenty feet. At a number of points in the northeastern part of the county the water is found in a bed of sand at or near the base of the drift. In sections 10 and 12 of Highland township this sand layer was struck at a depth of about 120 feet. A well one mile south of Marysville went through about 130 feet of drift and did not reach the Coal Measure shales.

Quite a number of wells have been sunk to the Saint Louis limestone and a few have penetrated to the deeper strata of the Mississippian series. One of the important water horizons of this region and one carrying an abundant supply, is a sandstone about twenty feet below the top of the Saint Louis beds. This sandstone probably belongs to the Verdi division of that stage. A well in the northwest quarter of section 27, Green township, struck the Saint Louis at 350 feet and the water-bearing sandstone at 370 feet. The water rose to within 170 feet of the surface. Near Blakesburg the limestone was struck at a depth of 365 feet. The well at the county poor farm, in section 22 of Highland township reached the sandstone at 246 feet, having encountered the Saint Louis at 226 feet. Two miles northeast of Munterville, in section 9 of Polk township water was found at a depth of 124 feet, after going through twenty-four feet of lime-

stone. Another well one and a half miles east of Munterville struck the Saint Louis at 210 feet and penetrated it twenty feet when an abundant supply was found. One of the deepest wells in the county is on the farm of Norman Reno in section 12 of Pleasant township. The record of it has already been given on a previous page. Its depth is 470 feet and the last 182 feet were through beds of the Mississippian series. In the city of Ottumwa there are three artesian wells, one belonging to Morrell & Company and two to the Artesian Well Company. The former is 1,554 feet and the latter 2,047 feet deep. The water from the wells of the Artesian Well Company is piped to about 200 store buildings and houses and is said to be used by over 2,000 persons. The following testimonial, dated September 1, 1893, is signed by fifteen of the physicians of the town:*

"We recommend the Ottumwa artesian water as absolutely pure, and coming from a depth of 2,547 feet, free from all organic matter. The exclusive use of it would do away with typhoid fever entirely, so far as danger from drinking water is concerned, and greatly reduce the amount of sickness from other diseases. It is not only of great value as drinking water, but has a remarkably beneficial effect on cases of chronic rheumatism, constipation and many forms of stomach and kidney troubles."

An analysis of the water from this well is given below, No. 1. As examples of the character of local waters from the Mississippian beds analyses of two waters from the Mineral Springs Sanitarium at Ottumwa are added. No. 2 is from a depth of 314 feet, and No. 3 from a depth of eighty-five feet.†

* Norton: Artesian Wells of Iowa; Iowa Geol. Surv., Vol. VI, p. 318, Des Moines, 1897.
† Iowa Geol. Surv., Vol. VI, p. 318, Des Moines, 1897.

COMPOUND.	GRAINS PER GALLON.		
	NO. 1.	NO. 2.	NO. 3.
Calcium carbonate	13.20	22.265	7.844
Magnesium carbonate	3.87	30.802	5.294
Iron carbonate	.....	2.940	.184
Sodium carbonate	.....	.....	10.212
Calcium sulphate	.....	38.230	.....
Magnesium sulphate	6.10	.....	.....
Sodium sulphate	33.83	200.875	13.105
Potassium sulphate	.....	2.231	Trace
Sodium chloride	11.48	51.805	2.700
Silicia	.....	7.299	1.443
Alumina	.....	Trace	Trace
Organic matter	.....	Trace	Trace
Loss	.....	.....	.662
Total	68.000	356.477	41.444

No. 1. Analyst, Professor L. W. Andrews, Iowa City; date, December 12, 1893; authority, circulars of company. (There seems to be some omission in the published analysis, as the total of the compounds is 67.88, instead of 68.)

No. 2. Analyst, D. D. Carter, Omaha; authority, circulars of company.

No. 3. Analyst, S. R. Macy; authority, circulars of company.

In South Ottumwa and elsewhere in the valley of the Des Moines an abundant supply of excellent water is reached at a depth of twenty-two to twenty-six feet. It occurs in a layer of sand which underlies the alluvial clays.

Soils.

The soils of Wapello county belong to two types and both of them have been formed from the Pleistocene deposits. As has already been stated the entire region is covered with Kansan drift over which the loess forms a thin mantle, in many places not over five feet thick. This loess differs from that found along the Mississippi and Missouri rivers in being more clay like and less porous. The particles composing it are finer than those constituting the more typical variety. The soils of the county are for the most part a modified loess. Its upper part has been more or less leached and oxidized and mingled with decayed vegeta-

tion, which carbonaceous material gives it the dark color and adds greatly to its fertility. Evidence of the richness of this soil is furnished by the prosperous farms with their large and substantial buildings which are to be seen on every hand.

In the broad valley of the Des Moines and along many of the larger streams the soil is formed of alluvial deposits and is a rich black loam. This has been derived from the uplands and from the slopes whence it has been washed by the rains and redeposited by the streams. This alluvium forms a soil of great fertility and since additions are made to it from time to time during periods of flood, it is practically inexhaustible.

Road Materials.

The question of good roads is yearly becoming a more important one as the great benefits derived from them are more clearly realized. Before many years have gone by it will be a practical question with many a community as to where it can secure cheaply good road materials. Some parts of Wapello county are well supplied with such materials. Wherever the Saint Louis limestone occurs it will furnish abundance of stone for macadamizing the roads. The sandstones of the Coal Measures are for the most part too soft and friable to be of service in road making. Deposits of gravel are not common in the county, but where they do occur they supply excellent material for this purpose. A gravel pit near Eddyville has furnished ballast for the railroad, and the Saint Louis limestone has been crushed for the same purpose. Another material which has been extensively used by the railroad for ballast is burnt clay. The stiff, gumbo-like clay, which is common in southern Iowa, is thrown into piles and burned until hard, when it forms an inexpensive and serviceable ballast.