GEOLOGY OF MARION COUNTY.

BY

B. L. MILLER.

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INTRODUCTION.

LOCATION AND AREA.

Marion county lies slightly east of a north and south line drawn through the center of the state, and is in the third tier of counties from the southern boundary. It corners with Polk county on the northwest, is bounded by Jasper on the north, Mahaska on the east, Monroe and Lucas on the south, and Warren on the west. It is regular in outline, being a square each side of which measures twenty-four miles. It includes sixteen congressional townships with an area of 516 square miles.

PREVIOUS GEOLOGICAL WORK.

The navigation of the Des Moines river in the early history of the state led geologists to study the formations outcropping along that stream. In 1849 Dr. D. D. Owen conducted a geological survey of the Des Moines river and adjacent territory for the U. S. Treasury Department.* He described several exposures of the Coal Measure rocks at various points in the county, noting particularly those which show to such good

*Geol. Surv., Wis., Iowa and Minn., pp. 115-119, with plates. Philadelphia, 1852.

advantage at Elk Bluff and Red Rock. In 1856 A. H. Worthen, at that time an assistant on the Iowa Geological Survey and later State Geologist of Illinois, made a more detailed study of the Des Moines valley.† He included in his report several sections at different places along the river. The next geologist to publish anything concerning the geology of Marion county was Dr. C. A. White, who, in his report of 1870, briefly described the coals of the county and gave some analyses of the same.‡

In the course of the work carried on by the present geological survey, the county has been visited at various times by several of the geologists connected with it. Among these was Dr. C. R. Keyes, who, in his report on the coal deposits of Iowa, describes these deposits in Marion county§. Until the publication of this report only that part of the district lying along the Des Moines river had been studied, but in it the entire county is considered in reference to its coal mines.

PHYSIOGRAPHY.

TOPOGRAPHY.

Marion county may be considered as a broad, rolling plateau into which the Des Moines and South Skunk rivers, with their tributaries, have cut their valleys. This plateau gradually rises to the southwest, as is indicated by a difference of over thirty feet between Pella and Knoxville. Beyond the latter place the rise continues, though it has not been accurately measured. The Des Moines and Skunk rivers, which are approximately parallel to each other, cut across the northern part of the county, flowing in a southeasterly direction, while their tributaries join them at a slightly acute angle. The main tributaries run parallel to each other and in a northeasterly direction. Thus, there are two systems of divides, the main divide between the two rivers running northwest

†Geology of Iowa, Hall, vol. I, pt. I, pp. 167-170, Albany, 1858.
‡Geology of Iowa, White vol. II, pp. 263-264, 364-365. Des Moines, 1870.
§Iowa Geol. Surv., vol. II, pp 317-340. Des Moines, 1894.

and southeast, and those between the tributaries running southwest and northeast. These divides rise to almost the same altitude in every part of the county, about 900 feet, and are very similar in appearance. They are followed entirely across the county by diagonal roads which encounter few hills. The uplands display no prominent topographic features but everywhere present gentle rolling surfaces with just enough slope to secure good drainage. The well improved farms occupying the uplands present a most pleasing appearance and are good evidence of the fertility of the soil. In the northern part of the county the plateau-like character is better preserved than in the southern, on account of the smaller number of streams.

The present surface features of Marion county are due almost entirely to stream erosion, most of which is post-glacial. The whole county having been covered with Kansan drift and loess, the erosion topography is essentially different from that of a driftless area. Steep hills and bluffs are seldom found except in immediate proximity to the streams.

In the eastern part of the county the underlying rocks are mainly limestones, while in the middle and western portion they are shales, with occasional beds of sandstone. In the limestone and shale regions the streams have eroded valleys to about the same extent, the flood-plains of the larger streams being well developed and the slopes gentle, especially on the northern side of eastward flowing streams. Where the streams have cut through sandstone, the valleys are much narrower and the sides steeper; this results from the cementing material of the sandstone being almost insoluble in river water. Where the Des Moines river cuts through the Red Rock sandstone the valley is narrower than in any other part of its course in Marion county; it is less than a quarter of a mile wide, while usually it is from half a mile to two miles in width. The rocks which have been cut through by the streams in eroding their valleys are so homogeneous in character that the slopes of the hills are the same from top to bottom. In

no place can terraces, due to the alternation of harder and softer layers of rock, be traced for more than a few rods and seldom are they present at all. Thus, the entire region presents a smooth, rolling, featureless surface, although considerably rougher than some of the prairie counties of the state.

All of the five principal streams of the county have developed flood plains throughout nearly their entire courses. Of these Cedar and English creeks have narrow flood plains in comparison with South Skunk and Des Moines rivers and White Breast creek. As is true of all the rivers in this part of the state, where the streams have an easterly direction, they flow near the south side of the valleys, thus permitting the development of flood plains on the north side with very gentle slopes connecting them with the uplands. On the south the bluffs are much steeper. In places the stream may not flow near this side of the valley, but even in such instances the south bluff is much steeper than the north one.

Two explanations have been offered to account for these features. The first is that they are due to the deflection of streams to the right banks, caused by the rotation of the earth. G. K. Gilbert, in a paper* read before the National Academy of Sciences in 1884, shows that "all streams in the northern hemisphere are by terrestrial rotation pressed against their right banks and all in the southern are pressed against their left banks, the degree of pressure being independent of the direction of the flow." He considers this force to be sufficient for the deflection of the water to the right bank of the stream, and consequently the formation of cliffs on that side, with gentle slopes on the left. Deflections of this kind are certainly partly accountable for the steep bluffs on the right of the streams of this district, but not primarily, since, if this were the only cause, the steepest bluffs would be found on the right side of those streams flowing nearly straight north or south. On the contrary, it is found that the most

*Memoirs of the Nat. Acad. Sciences, vol. III, First Memoir, Washington, 1884

noticeable differences in the steepness of the bluffs on the two sides occur where the streams flow southeast.

The second explanation accounts for this phenomenon by the different rates of decomposition of the rocks on the two sides of the streams. Where all the rock strata yield to weathering influences with equal readiness, the more rapid the decomposition the more gentle will be the slopes. In this state frost is one of the greatest destructive agents of rocks. With each successive freezing the cohesion of the particles is overcome and they are forced farther apart. On those slopes facing northward the rocks remain frozen during the entire winter, while on the opposite side there may be many alternate thawings and freezings during the same space of time. Thus, in the spring, far more material is found ready to be removed by erosion on the north side of the streams than on the south. This latter cause is the most effective in this region. Were the streams very swift the former might be more effective. Where the streams flow southeast, as in the case of all the larger ones of this part of the state, we have the combined action of the two causes and there is the greatest variation in the steepness of the bluffs on the two sides.

Table of Elevations.

LOCALITY.	Elevation above sea level.	Authority.
Bussey	876.2	C. B. & Q.
Cedar creek bridge at crossing C., B. & Q., north of Bussey.	704.7	C, B. & Q.
Cedar creek, bed of stream at crossing C., B. & Q., north of Bussey	673.2	C. B. & Q.
Cordova	745.5	Wabash.
Donley	759.6	C. B & Q.
Dunreath	747	Wabash.
Dunham	744.7	C. B. & Q.
English creek bridge at crossing C. B. & Q., about one mile east of Flagler	728 8	C. B. & Q.
English creek, bed of stream at crossing C., B. & Q., about one mile east of Flagler	704.7	C. B. & Q.
Fifield	732 3	*Wabash.
Flagler	745 5	C. B. & Q.
Hamilton	905 5	C B. & Q.
Harvey	718	C., R. I. & P.
Howell	724.5	Wabash.
Knoxville	910	C., R. I. & P.
Knoxville	911.7	C. B. & Q.
Lovilla (Monroe county)	932.3	C B. & Q.
Marysville, at bridge	760.5	Survey.
Monroe (Jasper county)	924	C., R I. & P.
Morgan Valley	759 5	Wabash.
Otley	893	C., R I. & P.
Pella	878	C., R I. & P.
Percy	759	Wabash
Pleasantville	925.7	C. B. & Q.
South river bridge at crossing C., B. & Q. west of Swan, (Warren county)	763.24	C. B. & B.
South river. bed of stream at crossing west of Swan, (Warren county)	735.7	C. B. & Q.
Summit of divide, north of Pleasantville	936 7	C. B. & Q.
Swan	761.7	C. B & Q.
Tracy	716 7	C. B. & Q.
Walnut creek bridge at crossing C., B. & Q., south of Tracy.	703.7	C. B. & Q.
Walnut creek, bed of stream at crossing C , B. & Q., south of Tracy	680.7	C. B. & Q.
White Breast creek bridge, crossing C., B. & Q., northwest of Knoxville	761.7	C. B. & Q.
White Breast creek, bed of stream at crossing C., B. & Q., northwest of Knoxville	723.7	C. B. & Q.

DRAINAGE.

Marion county is drained by the Des Moines and South Skunk rivers and their tributaries. The South Skunk river flows across the northeastern corner and drains an area of

about forty square miles. The remainder of the county is drained by the Des Moines river, which enters the northwestern corner and flows southeast, leaving the county along the eastern border a little south of the center. The two rivers flow approximately parallel to each other. They are marked by broad ox-bow loops and wind about considerably in their flood plains, showing that they have cut nearly to grade and have ceased to erode their channels. The South Skunk river has a length within the county, measured with the stream, of somewhat more than eight miles, while a straight line from where it enters to where it leaves is only five miles in length. In the same manner the Des Moines river flows thirty-four miles within the county, while it is only twenty-four miles from the point it enters to where it leaves. This river has frequently changed its course over the flood plain, leaving cut-offs, and at present is much straighter than it was a few years ago.

The drainage systems are completely developed and hence there are no lakes on the uplands. The only bodies of standing water are on the flood plains, and these are usually the remnants of former cut-offs.

The glacial material of the Kansan ice sheet was apparently spread quite evenly over the surface, leaving no depressions of any considerable size, into which the surface water might be drained to form lakes. Neither are there any terminal moraines which serve as dams to interfere with the drainage. No evidence has been found indicating the former existence of such lakes. Yet it is probable that at the close of the glacial period the surface water was not drained off as quickly as it is at the present time, since the valleys of nearly all the tributaries of the main streams are post-glacial in their origin.

The three chief tributaries of the Des Moines river, White Breast, English and Cedar creeks, all have northeasterly courses. They rise in adjoining counties lying to the west and south, and flow within the county approximately parallel to each other. Besides these, the lower course of South river

lies within Swan township, emptying into the Des Moines river less than a mile from the western border. This latter river drains directly only a very limited region, but through Coal creek a considerable area is drained in Franklin and Pleasant Grove townships. Besides the streams just mentioned the Des Moines river receives several small tributaries, such as Sugar, Ballard and Teter creeks from the south and Walnut, Prairie, Calhoun and Brush creeks from the north.

The only tributary of any importance emptying into the South Skunk river is Thunder creek, which has its source on the Pella divide.

Knoxville is located on the divide between White Breast and English creeks. These streams are from two to six miles apart, with an average distance of about four miles. Because of the narrowness of the divide there are no large tributaries flowing from it into either stream.

History of the Drainage.—There is evidence to show that the Des Moines and Skunk rivers, through part of their courses in the county, if not the entire distance, flow in preglacial valleys. The best evidence of this is the fact that the loess and drift cover the sides of the valley in the same manner that they do the uplands. If the streams were post-glacial, these sheets would have been cut through as the valley deepened. The same evidence would show that the streams had about reached their base-level before the ice age, as there has been no appreciable deepening of either valley since. Further, it indicates that there have been no elevations or depressions or general warping of the earth's crust in this region within comparatively recent times. Another evidence of the preglacial origin of these two river valleys is found in their width and in the character of the limiting bluffs. Along these bluffs there are few outcrops of rock and the slopes are very gentle. This is probably due to the great amount of weathering which has taken place, together with

the smoothing of the rougher rock contours by the later filling in of drift and loess.

All of the other streams of the county seem to be post-glacial, unless perhaps it be the lower part of White Breast creek, but there is no conclusive evidence of this. However, the streams do not all seem to be of the same age. White Breast and English creeks flow about the same distance through similar material and carry about equal amounts of water. Notwithstanding these points of similarity, White Breast creek throughout the greater part of its course has a well developed flood plain, a feature which is almost altogether lacking along English creek. The former stream also has a meandering course, and in several places has formed cut-offs, most of which are of small size. Thus it would seem that White Breast creek is much older than English. It has the best developed flood plain of any of the secondary streams. Cedar creek, in the southeastern part of the county, is the only other stream that has one worthy of mention. The two principal rivers of the county do not now carry as much water as they did a few decades ago, when it was possible for small steamboats to pass up the larger stream as far as Des Moines. This is now out of the question, since at places there are bars extending entirely across the river where the water is only a few inches in depth, except during times of high water. This decrease in the size of the streams is due not so much to the decrease in the amount of rainfall as to the cultivation of their drainage basins, thus causing a larger amount of the water which falls upon the land to penetrate the soil instead of being drained off the surface.

It is the popular opinion that in former geological times those streams which now have flood plains were so much larger than at present that they filled their valleys from bluff to bluff. Because of the prevalence of this idea it seems best to offer a few words in refutation. When the ice melted, the streams were probably very much swollen in size and may perhaps have entirely filled their valleys, but this was

only temporary, the conditions not lasting long enough to accomplish much in valley erosion. Instead of this the valleys have reached their great width by the process of lateral corrosion, meandering from side to side after having ceased to cut at the bottom. The result seems to have been accomplished in part, also, by tributary streams and the weathering agents wearing back the bluff lines.

The amount of fall of the Skunk and Des Moines rivers has been determined by Mr. Dwight Porter, whose results were published in the Tenth Census Report on Water Power of the United States.* The following tables are taken from his report:

ELEVATION AND SLOPES OF THE SOUTH SKUNK AND DES MOINES RIVERS.

LOCALITY.	Elevation above sea—Feet.	Fall between points—Feet	Distance between points—Miles.	Fall between points—Feet per mile.
South Skunk River—				
Vowell's, Jasper county	759	.....	.....	.....
Rome, Henry county	550	209	108	1.94
Des Moines River—				
Des Moines, Polk county	786	150	111	1.35
Ottumwa, Wapello county	636	.....	.....	.....

ESTIMATED VOLUME AND HORSE POWER OF THE SKUNK AND DES MOINES RIVERS.

LOCALITY.	DRAINAGE AREA—SQUARE MILES.	LOW WATER ORDINARY DRY YEAR.		LOW WATER AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume cubic feet per second.	Theoretical horse power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse power, 10 feet head.	Volume cubic feet per second.	Theoretical horse power, 10 feet head.
Skunk River—							
Vowell's (Jasper Co)	1,275	80	91	100	114	150	170
Farmersville (Mahaska Co.)	1,654	100	114	130	148	200	227
Des Moines River							
Bennington.	11,822	900	1,022	1,050	1,193	1,580	1,795
Ottumwa (Wapello Co)	13,465	1,040	1,181	1,210	1,375	1,820	2,068

*Tenth Census of the United States Water Power, pt. II., pp. 381-389

Since the towns of Vowell's and Farmersvills are no longer given on the maps it is necessary to locate them. Vowell's was on the South Skunk river in Tp. 79 N., R. 20 W., Nw. ¼ of Sec. 11, while Farmersville was in Tp. 76 N., R. 16 W., Ne. ¼ of Sec. 23.

From the above table it seems that the two main streams might well be made to yield considerable power if suitable dams were erected.

STRATIGRAPHY.

Geological Formations.

The surface geological formations represented in the county are very widely separated in age, since they belong to the Carboniferous and Pleistocene systems. The absence of rocks of intervening periods indicates either that the region has been land from the close of the Carboniferous to the present time; or else, if under water since, the deposits have been removed by erosion. If the latter supposition were true, it is highly probable that there would be occasional fragments of the rocks of intervening periods, as the strata are seldom removed entirely by erosion over any considerable area. But no such evidence has, as yet, been reported.

The Carboniferous has been divided into the Lower and Upper, or the Subcarboniferous and the Coal Measures. The upper part of the Lower Carboniferous, known as the Saint Louis, and the lower part of the Coal Measures, known as the Des Moines, are the sole representatives of the system in Marion county. The Pleistocene deposits consist of the Kansan drift, the loess, which was probably contemporaneous in origin with the Iowan ice sheet, and the more recent alluvium of the river valleys.

Unconformability between the formations of the different epochs is plainly indicated in various places. The Coal Measures lie unconformably upon the Saint Louis, and the loess is in turn unconformable with the drift. Furthermore, within the Des Moines formation there are several local unconform-

abilities. One of the most interesting occurs in Red Rock bluff, shown in the geological section along the Des Moines river. Here a bed of coal and shale occupies a depression cut in the massive sandstone.

The Saint Louis strata appear at the surface only in the eastern part of the county and there only along the streams. The Des Moines and South Skunk rivers, with a few of their tributaries, such as Cedar, English and Thunder creeks, by the erosion of their valleys, have exposed these beds to view. Westward they dip under the Coal Measures, but their presence has been determined by deep drilling. The surface of the Saint Louis formation is quite irregular, there being numerous anticlines and synclines, most of them, however, of very limited extent. These are plainly seen at several places along the Des Moines river. That the bending preceded the deposition of the Coal Measure rocks is shown by the unconformability existing between the two formations. Pella is situated upon the crest of one of the largest of these anticlines, since the Pella beds rise very close to the surface and have an elevation of slightly less than 900 feet, while the same strata are found along the Skunk and Des Moines rivers at an altitude of 100 feet less.

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

GROUP.	SYSTEM.	SERIES	STAGE.	FORMATION.
Cenozoic.	Pleistocene.	Recent.		Alluvium.
		Glacial.	Iowan.	Loess.
			Kansan.	Drift.
Paleozoic.	Carboniferous.	Upper Carboniferous or Pennsylvian.	Des Moines.	Red Rock Sandstone.
		Lower Carboniferous or Mississippian.	Saint Louis.	

Underlying Formations—Rocks older than the Carboniferous are not exposed within the county but were encountered in sinking a deep well at Pella. The detailed record of this well is published in the report on the artesian wells of the state* but the following summary of Professor Norton's study of it may be of interest here.

SUMMARY OF THE DEEP WELL AT PELLA.†

Nos.	Formation.	Thickness—feet.	Depth—feet.	A. T—feet.
59–62	Pleistocene	135	135	733
53–58	Des Moines	195	330	538
42–52	Mississippian	270	600	268
40–41	Kinderhook	125	725	143
32–39	Devonian	165	890	– 22
28–31	Silurian	255	1,145	–277
16–17	Maquoketa	190	1,335	–467
4–15	Trenton	350	1,685	–817
3	St. Peter	15	1,700	–832
1–2	Oneota (penetrated)	60	1,760	–892

Carboniferous System

SAINT LOUIS.

The strata of this period consist so largely of limestones that the formation is frequently known as the Saint Louis limestone. These are the oldest surface rocks found within the county. Besides limestone, they consist of marl, sandstone and shale.

The following section from Tp. 75 N., R. 18 W., Ne. ¼ of Se. ¼ of Sec. 35, gives a fairly good idea of the lithology of the formation. All below the first three members belong to the Saint Louis, the upper two being Pleistocene, while the third belongs to the Coal Measures. The upper members are exposed in a quarry, while the lower ones have been reached by drilling.

*Iowa Geol. Surv., vol. VI, pp. 310-315.

†It is suggested by Mr. Bain that the local stratigraphy favors the reference of Nos. 56-58 to the Pleistocene. It is possible that the Coal Measure material of the sample belongs to a till usually rich in such fragments. The glacial materials of the samples, which we have taken to have fallen in from above, may belong to till at the horizons stated.

		FEET.	INCHES.
15.	Loess	2	
14.	Drift	2	
13.	Black carbonaceous shale	3	6
12.	Fossiliferous marl	8	
11.	Limestone	1	4
10.	Limestone, thin bedded	5	
9.	Thick ledge of limestone	1	7
8.	Compact limestone	1	5
7.	Flagging stone, fine grained		4
6.	White limestone	1	
5.	Shale, carbonaceous, black, friable		1
4.	"Soapstone," drab		7
3.	Limestone, hard, cherty	1	
2.	Shale	5	
1.	Sandstone	20	

Nos. 6 to 12, inclusive, have been called the Pella beds while 1 to 5 are known as the Verdi.

Since other sections of the Pella beds are given under the head of stone quarries it does not seem advisable to give more here. The following are characteristic sections of the Verdi beds in the northeastern part of the county.

Tp. 77 N., R. XVIII W., Se. ¼ OF Sw. ¼ SEC. 24.

		FEET.
4.	Sandstone, buff, cross-bedded, lower part very soft	5
3.	Limestone, massive, cherty, breaks irregularly, has been quarried for foundation purposes.	4
2.	Sandstone, gray, soft	3
1.	Limestone, cherty (exposed)	2

The above section is exposed in the bluff of Thunder creek. The bluff is here much higher than indicated above, but the lower portions are concealed by talus.

Tp. 77 N., R. XVIII W., Se. ¼ OF Ne. ¼ SEC. 26.

		FEET.
4.	Drift and loess at edge of bluff (thicker farther back)	3
3.	Limestone, cherty	2
2.	Shale, argillaceous, buff	5

1. Sandstone massive, yellow, with arenaceous interbedded limestone bands one-half inch to four inches in thickness. These bands are very hard, compact, fine grained, and resist weathering to greater extent than sandstone so that layers stand out from sandstone on weathered surface. Occasional irregular fragments of this limestone 1 to 2 inches in diameter are found in the sandstone (exposed)..... 20

This section occurs on the south bank of Thunder creek, rising from the water's edge.

Tp. 77 N., R. XVIII W., Ne. ¼ OF SEC. 23.

		FEET.	INCHES
5.	Loess and drift, gradually thickening back in hill..	10	
4.	Sandstone thinly laminated, quartzitic.....	1	
3	Shale, bluish gray, argillaceous.....		6–8
2	Limestone, hard, cherty.....	2	4
1.	Sandstone, soft, variable in color, yellow, buff....	6	

Exposed on south side of Skunk river at bridge.

The Saint Louis limestone is of fairly good quality and consequently is used very extensively for building purposes throughout the region in which it is found. The individual ledges vary little in thickness, and, because of the regularity of the fissures, can be quarried to good advantage. The stone is usually very white in appearance and fine grained. Some of it when first exposed to the air is blue, but soon turns white. The limestone is comparatively free from impurities and was formerly used for the production of lime. Most of the rock is very fossiliferous, the principal fossils being brachiopods.

The marl is highly calcareous, effervescing freely when treated with acid. Several layers of this marl are found intercalated between the limestone ledges in the upper part of the formation, sometimes forming the upper member as in the section given. On an unweathered surface the marl is very compact so that in quarrying it is removed in large blocks which, when exposed to the atmosphere, soon fall to

pieces. The weathered marl resembles the clay resulting from the decomposition of drab argillaceous shale. The marl is highly argillaceous and possesses little or no grit. This deposit is the most fruitful source of fossils of all the Saint Louis beds. Scarcely a cubic inch can be found that does not contain one or more fossils, most of which are in an excellent state of preservation. Many different species occur, including brachiopods, corals, crinoids, pentremites, etc. On the weathered surface of a heap of this material thrown out from a quarry near Pella, hundreds of fossils were picked up in a very short time. Thus far no use has been made of the marl, but it seems not improbable that it may prove valuable as one of the ingredients in the manufacture of cement.

The shale of the Saint Louis is principally argillaceous and is commonly called "soapstone." It is gray, drab, or blue in color and is very soft. Occasionally the cleavage planes are not well developed, so that it appears not unlike mere beds of clay. The shale is found principally in the lower part of the Pella beds or in the upper part of the Verdi.

There is within this county usually a thin layer of black, friable, carbonaceous shale, found immediately under one of the thick layers of limestone of the Pella beds. This shale varies in thickness from one to four inches. It is the nearest representative of coal thus far found within the lower carboniferous of the state, and its presense seems quite unusual. It is prominently exposed in four different places in the county near the Des Moines river.

The sandstones of the Saint Louis differ markedly from the sandstones of the Coal Measures in that they are always intercalated with thin layers of limestone or sandstone possessing a calcareous cement. All the layers are massed together, appearing as a single massive ledge. Frequently these intercalated layers of limestone are somewhat cherty in appearance, so that on a weathered surface they stand out prominently. The limestone layers are usually from one to three inches in thickness, and are found from six to twelve inches

apart. Occasionally they attain a thickness of from one to three feet, but even then there is no marked bedding plane between the limestone and the sandstone. In a few places the sandstone of the Saint Louis, together with the intercalated limestone ledges, has been quarried for foundation purposes. Its characters, however, are such as to make it quite undesirable because of the irregularity with which it breaks. In these respects it is quite unlike the indurated rocks of the Pella beds.

While no attempt was made to secure a complete list of the fossils found in the Saint Louis of the county, the following were frequently observed. Most of them occur in the marl of the Pella beds, previously noted.

Allorisma marionensis, White.
Spirifer keokuk, Hall. (*S. litttori*, Swallow).
Rhynchonella (*pugnax*) *ottumwa*, White.
Athyris (*seminula*) *subquadrata*, Hall.
Productus marginicinctus, Prout.
Terebratula (*dielasma*) *turgida*, Hall.
Orthis keokuk, Hall.
Zaphrentis pellaensis, Worthen.
Pentremites koninekana, Hall.
Trilobite, (fragments undetermined.)
Chaetetes, sp. undescribed.
Crinoid stems.
Bryozoa, (specimens not identified.)

DES MOINES.

The Coal Measures form the surface rocks of the entire county, except where they have been removed in the eastern part in the valleys of the streams. On the uplands they are concealed by the drift and loess but every large stream cuts down into them. The Coal Measures generally have a slight dip to the southwest and gradually increase in thickness as one proceeds from the northeastern to the southwestern part of the county.

The rocks of the Coal Measures consist of shale, coal, sandstone, limestone and conglomerate. The maximum thickness is probably about 600 feet. These beds have been deposited upon the eroded surface of the Saint Louis and are consequently everywhere unconformable with them. At one place a short distance south of Pella, a block of Saint Louis limestone was found included in the Coal Measure shales. Beds of coal frequently occur at a lower level than the Saint Louis limestone at neighboring outcrops. In these respects the Coal Measures of Iowa agree with those of Kansas. At the close of the Lower Carboniforous the rocks just formed were uplifted to form land, and a period of active erosion prevailed. Strange to say the Pella beds, consisting largely of marl which is so easily worn away, were in some places left at the surface. The base of the Coal Measures frequently rests upon this marl. At other points it has been worn away and they rest immediately upon the lower limestone layers of the Pella beds, while in one place along the South Skunk river the latter are entirely wanting, so that the Coal Measures are found immediately overlying the Verdi beds. These facts seem to indicate a considerable period of erosion between the deposition of the Lower Carboniferous and the Des Moines rocks. In this county the maximum erosion was about thirty feet; in an adjoining county it was very much greater.

The rocks of the Coal Measures vary rapidly in longitudinal as well as in vertical extent, thus making it exceedingly difficult to definitely correlate the different horizons. Very few strata can be traced more than two or three miles. Sandstones gradually pass into arenaceous shale, from that into bituminous shale, and then into coal. When changes such as these occur, if the intermediate steps cannot be seen, it becomes exceedingly difficult to make general sections with any degree of accuracy. Wells sunk in the Coal Measures, sometimes only a few rods apart, pass through quite different materials. At times this is due to contemporaneous erosion, which will be discussed later in connection with the Red Rock

sandstone, but more frequently is due to the different kinds of deposits formed contemporaneously in adjoining regions.

The following sections taken from various parts of the county are characteristic of the Coal Measures.

ENGLISH CREEK, Tp., 75 N., R. 19 W., Sw. ¼ OF Ne. ¼ OF SEC. 2.

		FEET	INCHES
10.	Loess	1	
9.	Drift	3	
8.	Shale, gray, argillaceous	2	
7	Sandstone massive, yellow, and buff	10	
6.	Shale, arenaceous, light yellow	2	1
5.	Shale, black, containing large concretions	18	
4.	Limestone, extremely hard, black, containing iron pyrites	1	6
3.	Shale, arenaceous	10	6
2.	Limestone, hard, black, called hydraulic rock	1	6
1.	Shale, black to water's edge (exposed)	13	

This section is near the base of the Coal Measures, the Saint Louis appearing a very short distance down the stream. Presumably the black shale rests upon the upper member of the Saint Louis.

CEDAR CREEK Tp. 74 N. R., XVIII W., Sw. ¼ OF Se. ¼ OF SEC. 2.

		FEET.
6.	Shale, white, argillaceous	8
5.	Sandstone, yellowish brown, variable hardness, formerly quarried	8
4.	Shale, yellow	*
3.	Shale, bituminous	*
2.	Shale, arenaceous, gray, at times sandstone proper; numerous plant fossils	*
1.	Sandstone, in bed of creek, extremely hard, brown, containing some $CaCO_3$, exposed	2

WHITE BREAST CREEK Tp. 75 N., R. XX W., Se. ¼ OF Se. ¼ OF SEC. 19.

		FEET.	INCHES.
10.	Clay, yellow, derived from decayed shale	5	
9.	Shale, bituminous	5	
8.	Coal, very soft	1	6
7.	Fireclay, arenaceous, extremely hard, much fractured, filled with lepidodendron roots	2	
6.	Sandstone, gray, thinly laminated, soft	4	
5.	Sandstone, gray, massive, has been quarried	8	

*Numbers 2, 3 and 4 are poorly exposed and thickness could not be determined.

		FEET.	INCHES.
4.	Shale, arenaceous	1	4
3.	Sandstone, gray, soft	2	6
2.	Shale, arenaceous	5	9
1.	Sandstone, massive, buff to gray, displays very irregular cross-bedding, exposed to water's edge	25	

The coal mentioned in the above section has been mined near here for home use. In one mine it is almost two feet in thickness but on account of its poor quality is of little value.

WHITE BREAST CREEK Tp. 74 N., R. XXI W., Ne. ¼ OF Ne. ¼ OF SEC. 4.

		FEET.	INCHES.
11.	Drift and loess	10	
10.	Shale, yellow, argillaceous	5	
9.	Shale, bituminous	3	
8.	Coal, very soft	1	2
7.	Fire clay	2	3
6.	Coal, soft		4
5.	Fire clay	2	6
4.	Sandstone, thinly laminated, white	1	
3.	Sandstone, massive, buff, yellow; is quarried	4	
2.	Shale, gray, arenaceous	3	
1.	Shale, bituminous (exposed)	10	

A third bed of coal which averages about three feet in thickness is said to be reached a short distance below this section.

Over most of the county the Coal Measures are represented by thick beds of shale with intercalated coals. The shales are principally bituminous, although the argillaceous and arenaceous varieties are not infrequent. They are of such a motley character that no general statements can be given which will apply to all of them. In color they vary from white to black with the gray, drab, red and blue well represented. Nearly all the Coal Measure shales seem to have been deposited in small basins and hence have very little lateral extent and vary greatly in thickness. The only positive characters which might distinguish the Coal Measures from the Lower Carboniferous shales are the greater abundance in the former

of bituminous matter and of fire clay filled with the roots of the coal plants underlying the beds of coal. Selenite crystals of a diamond shape are frequently found in the argillaceous variety in considerable abundance.

The limestones of the Coal Measures are limited in amount and are usually of very poor quality. They are quite impure owing to the considerable percentage of silica present, but yet at one time lime was burned from a ledge of this rock. This lime was used in building the foundation of the old court house and, notwithstanding the impurities, seems to have been very durable. The limestones are heterogeneous in character and consequently break irregularly. For the same reason the weathered surfaces are very rough. Fossils of marine invertebrates are frequently present, but not in such large quantities as in the Saint Louis limestones. Still, the weathered surface of almost every ledge of this limestone will show some crinoid stems standing out from the matrix. The rock is either white or yellow, except in those cases where it is found in contact with the coal. It then belongs to another class which has been described by Mr. Bain in his report on Polk county.* It is called clay-ironstone, which is merely an impure form of limestone. In one of the mines near Flagler a ledge varying in thickness from eight to twelve inches is found near the upper part of the coal vein. The stone when removed from the mine is of an intense black color and usually very hard. When exposed to the weather the surface becomes whitened until it does not appear unlike ordinary limestone. Besides calcium carbonate and the calcareous material whose presence can be easily detected by the color of the weathered and unweathered stone, analyses show the presence of both iron and sulphur. The following analyses of specimens of this stone from Mahaska county illustrate this:

*Iowa Geol. Surv., vol. VII, p. 297. Des Moines, 1897.

ANALYSIS OF IRONSTONE BOWLDERS FROM COAL SEAM IN MINE OF AMERICAN COAL CO., EVANS, MAHASKA COUNTY, IOWA.

Hygroscopic water (loss at 100 degrees C)	.25
Carbonic acid, CO_2	39.67
Other volatile and combustible matter	7.78
Silica and insoluble	.10
Sulphur (in FeS_2)	.64
Iron (in FeS_2)	.56
Iron protoxide, FeO	.38
Alumina, Al_2O_3	.34
Manganese oxide, calculated as MnO	.38
Lime, Ca O	49.62
	99.32
Loss and undetermined	.68
	100.00

PROBABLE COMBINATIONS.

Hygroscopic water	.25
Organic matter and combined water	7.78
Pyrite. FeS_2	1.20
Calcium carbonate, $CaCO_3$	87.89
Silica and silicates of alumina	2.88
Carbonates and oxides of Fe.Mn., etc	....
	100.00

ANALYSIS OF ROCK FROM TOP OF ROOM, COREY'S MINE, ROSE HILL, MAHASKA COUNTY.

Water expelled at 100°C	.25
Carbonic acid, CO_2	25.10
Silica and insoluble matter	.30
Sulphur (as FeS_2)	18.30
Iron (as FeS_2)	16.00
Sulphuric acid, SO_3	1.27
Sulphur, free or otherwise combined*	1.30
Lime, CaO	32.94
Alumina, Al_2O_3	.54
Organic matter and water expelled by ignition (mostly organic matter) by difference*	4.00
	100.00

APPROXIMATE COMBINATIONS.

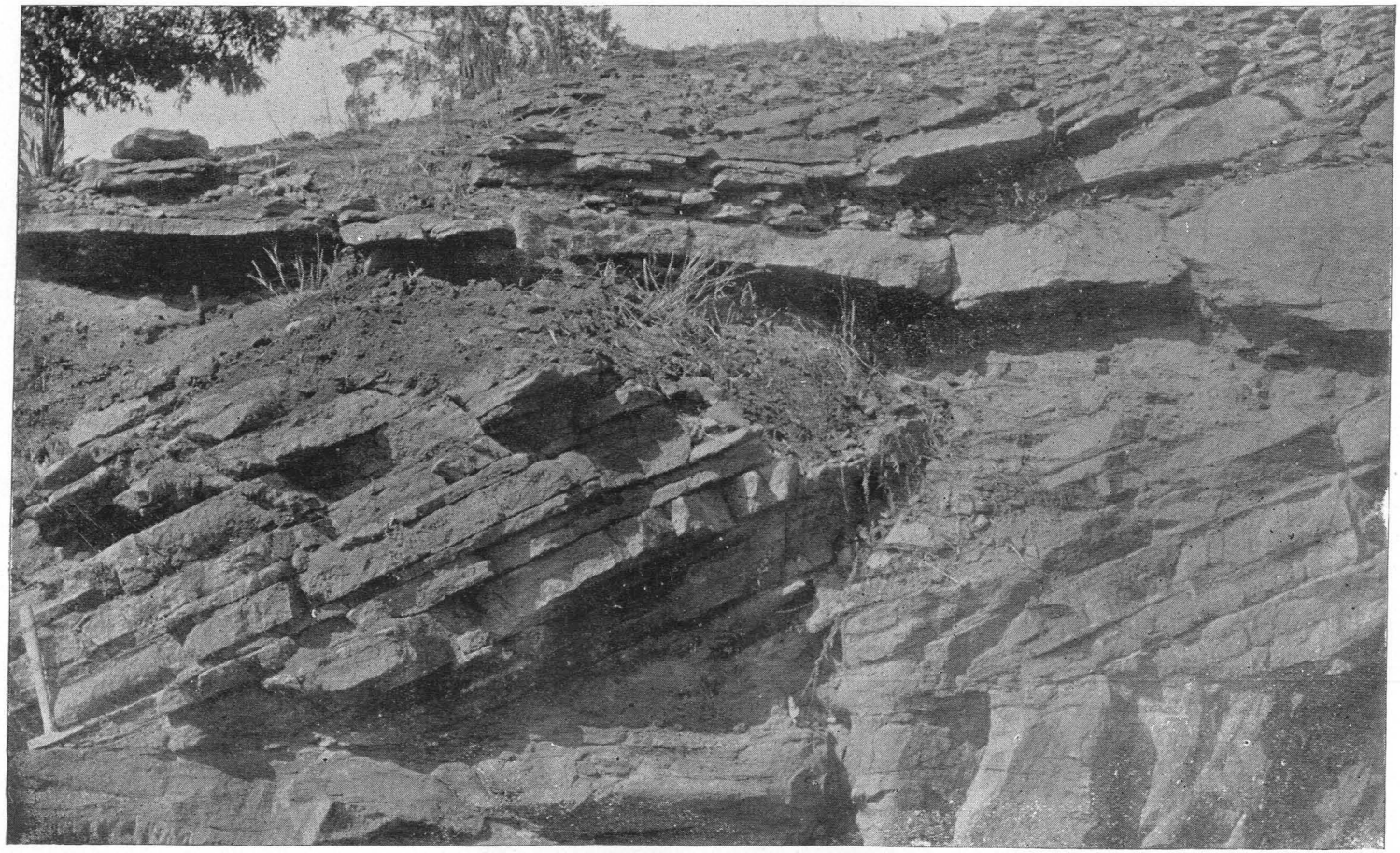
Hygroscopic water	.25
Calcium carbonate, $CaCo_3$	57.04
Pyrite, FeS_2	34.30

*Uncertainty here. Needs further investigation.

Silicates, sulphates and sulphur in some form ?.....	4.41
Organic matter, water and loss by difference	4.00
	100.00

It is very seldom in this region that these impure limestones are found in the form of a continuous stratum; they usually occur as loose bowlders lenticular in shape and of various sizes. The long diameter of the bowlders is always parallel to the planes of stratification. At times these bowlders occur in such large numbers that they seriously interfere with the process of mining and some mines have been abandoned merely because of their presence. They occur in largest numbers in the overlying black shale or in the upper part of the coal bed although occasionally some are found near the base. In a few places bowlders of such large size have been encountered lying within the seam that the coal was almost entirely cut out. At one place a shaft was sunk upon one of these bowlders and no coal at all was struck, but it was found by drifting off to either side.

The conglomerates of the Coal Measures of this county are not well developed, there being only two places where they are prominently exposed. These are in Moose's quarry, a few miles northwest of Knoxville. and Feight's quarry, in the southwestern part of the county, near Newbern. Both of these conglomerates are calcareous. While they are of considerable thickness they seem to have but small lateral extension and to occupy small basins in earlier Coal Measure deposits. Neither one can be traced far, either by exposures or by well records. They do not seem to be contemporaneous and the former is much the older. In the first mentioned outcrop fossils of calamites are abundant, while in the latter fragments of marine organisms are present in large numbers. In Moose's quarry the limestone conglomerate alternates with sandstone. The following section is taken from this locality:



Cross Bedding in Coal Measure Sandstone, Red Rock Quarry.

MOOSE QUARRY SECTION

		FEET.	INCHES.
14.	Sandstone		6
13.	Limestone conglomerate, marked cross bedding	2	6
12.	Sandstone		8
11.	Shale, white, argillaceous		6-24
10.	Limestone conglomerate		22-32
9.	Sandstone, thin bedded		20
8.	Limestone conglomerate, breaks into pieces eight to ten inches in thickness	2	6
7.	Sandstone, hard, coarse, brown	1	
6.	Sandstone, brown, soft	3	6
5.	Sandstone, gray, hard	2	
4.	No exposure	50	
3.	Coal		28
2.	Fire clay	1	
1.	Coal		24

The quarry is located near the top of a hill while the coal outcrops in the ravine at its base. The limestone conglomerate spoken of in the above section is by the quarrymen usually known as "bastard" limestone.

The sandstones of the Coal Measures are very well represented in the northern part of the county and are found in other parts also. They contain considerable iron, and, at times, are very highly colored. They differ from the Verdi sandstones in these respects and also in being more highly micaceous. (See plate V.)

RED ROCK SANDSTONE.

This sandstone, belonging to the Des Moines formation, is in many respects the most interesting deposit of the county. It has been noted and described by every one who has done any geological work in this region. It outcrops along the Des Moines river a short distance below and above the town of Red Rock. Its greatest thickness at these places is slightly over 100 feet. It is interesting because of its great thickness and the very small area over which it is found. On either side, to the east and the west, it ends abruptly and no further traces are found of it in either direction. Owen, who passed

up the Des Moines river in 1849, supposed that its disappearance was due to great faults on either side with a vertical displacement of at least 100 feet. It seems, however, on closer study that this disappearance is due, not to faulting, but to contemporaneous erosion. Since this term may not be generally understood I quote from Scott* in explanation of it. Contemporaneous erosion "is produced when a current of water excavates channels for itself in the still soft and submerged mass of sediment. After the current has ceased to flow renewed deposition fills up the hollow with the same or a different kind of material than was thrown down before. This structure requires only a short pause in deposition, not a long unrecorded break, and does not necessarily involve movements of elevation and depression. Furthermore, contemporaneous erosion is a local phenomenon, and though in a limited section it may not always be easy to distinguish it from an unconformity, the difference becomes apparent when a wider area is examined. If the structure be one of contemporaneous erosion the two series of strata will be conformable except along the line of the channel or channels."

The reason for believing that contemporaneous erosion is the correct explanation rather than faulting is that the sandstone occurs in a region where faults are infrequent and, when present, have a very small vertical displacement. Furthermore, Coal Measure shales are found lying against the sandstone and unconformable with it. Thus it seems that the area now occupied by the Red Rock sandstone was originally a place of great deposition of sand which certainly had a much greater lateral extent than at present, but streams during the Coal Measure period eroded it on either side and left this small isolated mass. It is probable that this mass was once also thicker than at present and was considerably reduced in thickness during the erosion of its borders. During the Coal Measure period the sediments had not yet become so thoroughly consolidated as at the present time so that the removal itself

*Scott, Introduction to Geology, pp. 272-273, Macmillans, 1897.

was much easier. Possibly the erosion took place while it was a mere loose mass of sand.

While detailed study has not been made to connect this area with the massive sandstones along the Des Moines river in Mahaska county, from their position near the base of the Des Moines formation it seems probable that they were at least contemporaneous in origin if not actually connected at one time, the intervening area having been removed by stream erosion. The rock of the two outcrops is quite different in character, but sandstone is so variable that it would be unusual to find the same characters at the two places, especially as regards composition and color, separated as they are by a distance of about fifteen miles.

This sandstone has its greatest extent in a south-west-northeast direction, the southernmost point being Eagle Rock, located directly south of the most eastern outcrop along the river. Northward it was traced by well records to connect with the large sandstone quarries located about four miles northeast of Monroe, in Jasper county. Here it again comes to the surface along the south bluff of the South Skunk river and is extensively quarried.

It is not improbable that it extends even farther northward as there are outcrops of similar stone at Lynnville and Kellogg in Jasper county, though these may belong to an entirely distinct formation. The sandstone has an extent north and south of at least eleven miles with a maximum width of about three miles. But within this area it has been removed in several places. Eagle Rock is an isolated portion separated from the larger area on the north by a small ravine; northward one deep well record was obtained which did not pass through any thick layer of sandstone at all comparable to the Red Rock sandstone, while wells in the immediate neighborhood were sunk into this sandstone a great distance, but failed to penetrate it. The isolation of Eagle Rock illustrates recent stream erosion while the absence of the sandstone in the well is due to erosion during the Coal Measure period.

Eagle Rock is a small hill extending east and west for a distance of about one quarter of a mile with a width slightly less. It forms a part of the north bluff line of White Breast creek, and where it has recently been washed by the waters of this stream it presents a vertical face of fifty-three feet of massive sandstone. The ridge rises fifty feet above this, but the rock is not exposed. No trace of this ledge is found south of the creek but instead, at the same level, thick beds of Coal Measure shale occur. Its former westward extent from Eagle Rock is indicated by the sand ridge occurring between the Des Moines river and Teter creek, the sand of which has undoubtedly been derived from this sandstone which itself has been removed by the latter stream.

The color, composition and hardness of this rock varies considerably in the area described. That of Eagle Rock is gray or buff in color and firmly consolidated throughout the greater part. In places, however, the cementing material seems to have been very insufficient, thus leaving pockets, as it were, of loose sand. In the exposed face of the rock these appear as holes of variable size. Within one of these it is said that an eagle formerly built its nest for several seasons, thus giving the name to the rock.

As it outcrops along the Des Moines river the sandstone resembles that of Eagle Rock in that the sand grains are chiefly quartz with the principal cementing material iron oxide. It also varies in hardness in the same way. Unlike the Eagle Rock sandstone, however, the predominant color is brick red, although large masses are gray or buff in color. The two most notable exposures are Elk Cliff in Tp. 76 N., R. XIX W., Ne. $\frac{1}{4}$ of Ne. $\frac{1}{4}$ of Sec. 7, and Sw. $\frac{1}{4}$ of Sw. $\frac{1}{4}$ of Sec. 5 and the Red Rock stone quarry in Tp. 77 N., R. XX W., Sw. $\frac{1}{4}$ of Ne. $\frac{1}{4}$ of Sec. 35. In the quarry the distribution of the red coloring matter is not in layers but occurs in irregular blotches throughout the mass. In places the color of the stone changes very rapidly so that a deep red may be next to a white mass.

The line of contact is usually a sinuous one although at times nearly straight. The color is due to the presence of iron oxides, since analyses shows that the buff rock carries .94 per cent of these while the red contains 2.65 per cent. The question arises whether the coloring of the stone was contemporaneous with its deposition or not. That it has not been caused by exposure to the atmosphere, thus allowing the oxidation

FIG. 9. View on the Des Moines river at Elk Cliff.

of the exposed layers, is quite apparent from its very irregular distribution. The porosity of the rock would indicate that the color had not been caused by percolating water, containing iron in solution, subsequent to the cementation, since the buff possesses the greater absorptive power of the two. The percent of increase of the buff is 10.82 and of red 8.64.* The hardness of the stone seems, in general, to correspond

*Bain. Iowa Geol. Surv., vol. viii, pp. 410-412

to the color, the darker colored stone being harder than the buff. Thus we may say with a considerable degree of certainty that the color is contemporaneous with the cementation process. The irregular distribution is similar to the segregation of nodules of iron pyrites in shale and coal beds, and to the collection of the calcareous matter of the loess in the formation of the loess-kindchen.

In this same quarry large spherical concretions are occasionally found composed of material not unlike quartzite in

FIG. 10. Red Rock Quarry, showing quartzitic concretions in the Red Rock Sandstone at the top.

appearance. They vary in size from a diameter of six inches to three feet. A slight flattening in the vertical direction is quite noticeable. They are extremely hard and so interfere seriously with the sawing of the stone. In color they vary from a white to a gray, never being highly colored. At first thought it might seem that they were deposited as bowlders at the time the enclosing mass of sandstone was formed. But careful observations disprove this, since a very gradual transition from the quartzitic mass to the softer sand-

stone can be noticed. Microscopic studies show that these masses have been rendered quartzitic through the secondary enlargement of the sand grains by additions of silica.

Northward from the Des Moines river no outcrop of the Red Rock sandstone is found until the quarry near Monroe is reached. Here the stone is of a much more compact nature and the cementing materials, especially at the base, seem to have been much greater in amount. It is also somewhat coarser grained, while the coloring matter is more evenly distributed. The lower layers are very dark red while the upper ones are gray. The sandstone at this point shows a vertical exposure of thirty-five feet.

The Red Rock sandstone is unconformable with the underlying Coal Measures and also with the Saint Louis. Although not the basal member of the Coal Measures this sandstone immediately overlies the Saint Louis a short distance above Elk Cliff. Here the upper members of the Pella beds rise in a low anticline about fifteen feet above the river with a lateral extent of a few rods. Elsewhere shale beds including coal are found between the Saint Louis and the Red Rock sandstone. Keyes* estimates that these shales are at least seventy-five feet in thickness as exposed along the Des Moines river. Where the sandstone is the thickest no well records have been obtained in which this stone has been penetrated to the underlying formations because very few wells, if any, go through it, sufficient water being obtained within the sandstone.

In Missouri a sandstone deposit, nearly 200 feet in thickness, is found in the Coal Measures which is similar to the Red Rock sandstone in occupying only a small area. It is, however, more recent in origin. It is known as the Warrensburg sandstone.†

The lower part of the Coal Measures of Iowa seems to be equivalent to the Cherokee shales of Kansas, described by

* Iowa Geol. Surv., vol. II. p. 146, Des Moines, 1894.

† Winslow: Mo. Geol. Surv., vol. IX, pp. 45-54, Jefferson City, 1896.

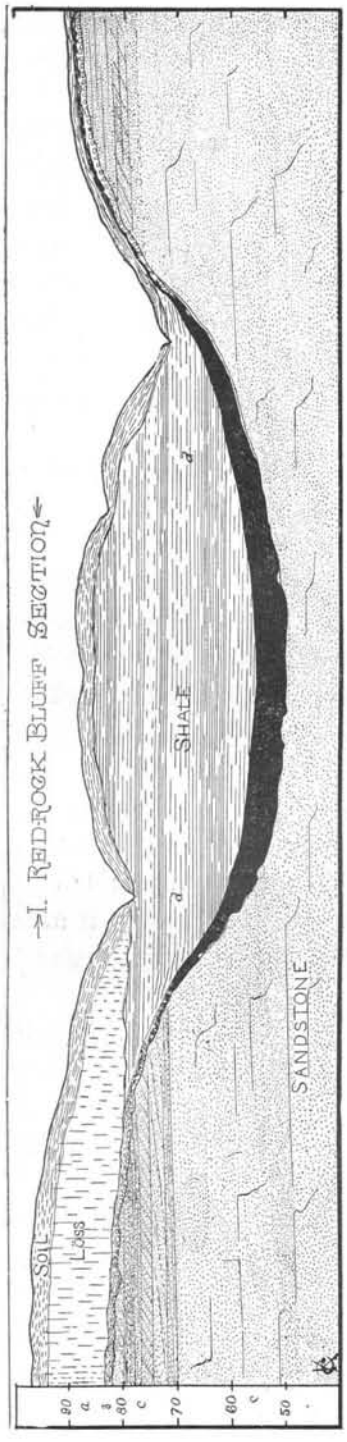


FIG. 11. Unconformability shown in Red Rock quarry.

Haworth.* There are naturally many minor differences, there being no development of sandstone in Kansas comparable to the Red Rock formation. The conglomerate previously spoken of as occuring a short distance north of Knoxville seems to be of later origin than the Red Rock sandstone. It is, perhaps, best correlated with the conglomerate described by Shepherd in his account of the Coal Measures of Greene county, Missouri.† This rock occupies depressions in a basal sandstone known as the Graydon sandstone. These can be compared with each other only in their position and not from any characters possessed by the strata themselves.

In the Red Rock quarry a very good example of local unconformity occurs. This is a small basin formed in the upper part of the sandstone which has been filled by Coal Measure shales and a bed of soft coal. This has been described by Keyes in former reports of the survey‡ and is shown in the section along the Des Moines.

From the different kinds of deposits found within the Coal Measures of this county and their comparatively local extent it would seem that the conditions existing during their formation were un-

* Univ. Geol. Surv. Kansas, vol. I, pp. 150-151, 221-224, Topeka, 1896.

† Mo. Geol. Surv , vol. XII, pp. 123-138. Jefferson City, 1898.

‡ Iowa Geol. Surv., vol. I, pp. 100, 108; vol. II, p. 52.

favorable for any extended deposit. While the Red Rock sandstone was being formed in the northern part of the area, shales of various kinds were being deposited in the southern; it is not unlikely that during the time the coal was being deposited in the basin above the sandstone, thin ledges of sandstone were being formed in other parts of the county. Indeed it is highly probable that other sandstones found within the county owe their origin to the deposition of sand removed by streams from the former extensions of the Red Rock formation. Some of the arenaceous shales may have had a similar origin.

Fossils of the Coal Measures.—The fossils of the strata of this period include the remains of both animals and plants, but more particularly the latter. Fossil plants in great numbers and almost perfectly preserved are found in many places in the shales and sandstones. On White Breast creek, directly north of Knoxville, and on the Des Moines river south of Pella, literally wagon loads of plant remains could be obtained with very little effort. They occur either in arenaceous shales or fire clay. These fossils are the remains of coal plants, lepidodendrons, sigillaria, calamites, and ferns. The fire clay underlying the coal beds is usually well filled with the fossilized roots of the coal plants, while the shales above contain many leaf impressions.

The fossil plants above mentioned occur in layers and so are unlike the ones described by A. C. Spencer* in the following article quoted in its entirety: "The wide celebrity of the fern-bearing concretions from the Carboniferous beds of Mazon creek, Illinois, attaches more than passing interest to the occurrence of similar structures in the Coal Measures of Iowa.

"These concretions are found in a small ravine near the Des Moines river north of Dunreath, in Marion county. Careful search for similar concretions in the gullies of the neighboring streams has not been successful, from which it seems that

*Proc. Ia. Acad. Sci. Vol. 1, pt. IV p 55, Des Moines, 1894.

the strata, which are cut by the streams in question, lie above their general level on a slight anticline. The other alternative is that the concretions are limited to a very small area, but from the relations of the overlying beds the first explanation seems to be correct.

"The plant remains are found in nodules or concretions, scattered through beds of drab shale. These, when broken open, often display very perfect forms. Plant remains are not, however, present in all the concretions. Others are like small septarial masses and are filled with zinc blende.*

"The nodule-bearing shale is from three to perhaps ten feet in thickness, and of a light drab color. It rests upon an irregular layer of large septarial masses, which, exposed in the dry bed of the stream, resemble roches-moutonnees of a small scale. Above are shales, in part bituminous and in part arenaceous. Four inches of compact gray limestone, bearing fern impressions, follow, above which is more sandy shale and a thin seam of coal which has been mined near by. The coal is about fifteen feet above the concretionary bed.

"Many of the concretions have been washed out and are found already opened, but the best specimens are those recently exposed, which afford very perfect leaflets of several ferns. Among the forms identified were *Neuropteris hirsuta*, *N. augustifolia* and *Annularia longifolia*. Others will undoubtedly be found when more material is examined."

The animal remains of the Coal Measure rocks of the county, while not so abundant as the plants, are much more varied. Two localities deserve especial mention: These are Ruckman's coal mine, Tp. 75 N., R. XIX W., Sec. 20, and Feight's stone quarry, Tp. 74 N., R. XXI W., Nw. ¼ of Nw. ¼ of Sec. 28. At the former place, in the roof material of the mine, so plentiful are the fossils, and so perfectly preserved, that not even the Pella beds marl of the Saint Louis surpasses it as a collecting ground.

*Mr. Spencer here seems to have made the error, so common in this region, of mistaking siderite for zinc blende.

The stone in which they occur is an impure limestone, containing so much bituminous matter that it is as black as coal when taken out. On exposure, however, it whitens similar to the clay ironstone previously described. The other place mentioned is of interest because of the presence of an unusually large number of crinoid stems and scutes of the fish known as *Petrodus*. The stone containing them is a massive

Fig. 12. Fossil fish found in old coal mine in the south part of Knoxville.

ledge of limestone conglomerate, varying in thickness from eight to twelve feet. The fossils appear very prominently on the weathered surface.

Pleistocene.

THE KANSAN DRIFT.

The drift of Marion county is that formed by the Kansan ice invasion. None of the other ice sheets, with the possible exception of the pre-Kansan, are represented here. This mantle of drift originally covered the entire county and was probably quite evenly distributed. Since the glacial period, stream erosion has been very active and all of the streams of any importance have cut down through it. The drift is prominently exposed on almost all hillsides, but is covered on the

bottoms by alluvium and on the uplands by the loess. Its thickness varies considerably, being seldom less than five or more than one hundred feet.

The drift consists chiefly of bowlder clay of a blue or yellowish color, containing many glaciated pebbles. Large bowlders are frequently met with in the bottom of the ravines and streams, but are seldom seen in other localities. Occasionally a ravine will be fairly filled with these bowlders as is notably the case with one in Tp. 75 N., R. XX W.,Se. ¼ of Se. ¼ of Sec. 20. Here one of considerable size was found which measured three feet two inches by two feet four inches by two feet six inches. This was the largest one observed, most of them being little more than a foot in diameter. These glacial bowlders represent various kinds of igneous and sedimentary rocks and are of many different colors. The most common variety is red granite. Many of them are greatly striated and polished, sometimes only on one side, but frequently on two sides almost parallel to each other.

That the ice had great force as it moved over the country is evidenced by the position of the rocks in a stone quarry located a few rods south of Marion county, in Lucas. Here in a ravine a great thickness of Coal Measure limestone outcrops, the rock being quarried in several places. By action of the ice this stone was broken into large and small masses which were shifted about somewhat, but not removed. The rocks appear as they might had they been fractured and disturbed by a great earthquake. Most of these blocks have later been loosely joined together by deposits of calcareous matter from percolating water. Some of the fragments are many feet in diameter, while others are only a few inches.

That a considerable length of time elapsed between the periods of deposition of the drift and the overlying loess is indicated by the color of the upper portion of the drift sheet. In that part exposed to air previous to the deposition of the loess the iron has been oxidized to a red color. This zone of weathered drift has recently been designated by the term ferretto.*

*Proc. Iowa Acad. Sci., Vol. V, 1897, pp. 90.

It varies in thickness from six to twenty inches, but has perhaps an average of about fourteen. The porosity of the till seems to have been an important factor in determining the extent of the oxidation.

In the Saint Louis limestone quarry near Durham, Tp 75. N., R. XVIII W., Nw. ¼ of Sw. ¼ of Sec. 4, an old forest bed is found.

The section here is as follows:

		FEET.
5.	Black soil	2
4.	Loess	10
3.	Black soil, with numerous small stems and roots	2
2.	Water worn gravels and fine sand	8
1.	Saint Louis limestone	6

This section is briefly described and figured by McGee in his report on the geology of northeastern Iowa*

The forest bed seems to be post-Kansan and probably is of the same general age as the Buchanan gravels. The color of the old soil indicates the presence of a large quantity of vegetable material. It also shows vertical jointing, with the joints very numerous. The deposit seems to be quite local as it appears only in the east end of the quarry.

The bowlder clay is quite homogeneous in character, considering the number of different kinds of material entering into its composition. This material has been derived from many sources, picked up as the ice advanced, and finely pulverized and intimately mixed together. Some grit can usually be detected even in the most finely divided clay.

LOESS.

The loess of this district possesses no character to distinguish it from that of the other counties of the state. It is a fine, dull gray, homogeneous deposit found everywhere over the uplands and occasionally extending down the slopes of the valleys and connecting with the alluvium. This is always true in the preglacial valleys, and may be found in post-glacial

*Eleventh Ann. Report U. S. Geol. Surv.. pp. 494, 511.

valleys, where it has been washed down over the drift. In passing down a steep hillside from the uplands, one passes successively over exposed layers of loess, drift, country rock, and alluvium. The loess deposits range in thickness from a few feet to seventeen feet. Small, irregular concretions of lime, sometimes two inches in the longest diameter, are very abundant in certain localities. These are known as loess-kindchen. While no special effort was made to collect fossils from the loess a few were found. In the main, however, the loess deposits of this county are sparingly fossiliferous. The loess displays the characteristic vertical jointing. It contains small quantities of sand, the individual grains being so fine as to be invisible to the naked eye.

ALLUVIUM.

The alluvial deposits are the most recent ones and are represented by the black alluvial soils of the river valleys. They have been derived principally from the loess of the uplands. A large amount of vegetable material is present, thus rendering these soils very productive. The alluvium, as a general rule, is evenly distributed over the flood plains of the larger streams, and the bottom lands are so level that they are drained with difficulty. White Breast creek, in Tp. 76 N., R. XIX. W., Sec. 19, has built up one bank slightly higher than the surrounding flood plain so that there is a noticeable slope from the bank of the creek back to the bluff line, similar to the Mississippi in its lower course. This is produced in times of flood when the creek overflows. The greatest deposit of sediment is made just at the bank, where the first loss of velocity of the overflow water occurs, and the carrying power is correspondingly decreased.

The alluvium that is continually being carried down into these river valleys in time fills up the lakes or ponds which represent former cut offs. Thus, these bodies of water are only temporary.

Sand Ridges.--At three localities, as shown on the map, sand covered areas of considerable extent are found. These ridges could scarcely be called sand dunes, since they do not possess the dune-like form, neither are they composed entirely of sand. The term ridge is also a misnomer, since they are not true ridges, but common usage is followed in designating them thus. They are sand covered uplands of limited area and topographically scarcely unlike other uplands. The largest area is about one and one-half miles in length with a maximum width of one mile. They are all located near streams, the distance from the latter seldom being over three-fourths of a mile.

The Coal Measures of this county include several thick, though local, deposits of sandstone of which the Red Rock deposit previously described is the most remarkable. In some places the cementation process has consolidated them into firm, resisting rock; in others, the cementing material has been insufficient, so that the stone readily crumbles into loose sand. Near each of the three ridges, sandstone ledges of loosely cemented sand have been cut through by streams when just about at their base level. In each case the sandstone is now seen outcropping on either side of the valley immediately above the level of the flood plain. Furthermore, in each instance, the valley has attained a considerable width, showing that a large amount of sandstone has been removed by erosion. It is thus evident that the sandstone has been worn away by streams meandering through their valleys from bluff to bluff. The streams had about the same slope and velocity as at the present time, and so were not able to transport the sand resulting from the disintegration of the strata. It was deposited on the flood plain near the place from which it was obtained.

The next step in the process of formation of the ridges occurred when the sand was taken up by the wind and blown to the uplands, where it was spread out as a mantle over the loess. A casual observer could scarcely fail to see that the sand has been brought to these places from the valleys and

that the wind has been the motive force. That this action took place very recently, geologically, is evidenced by the fact that, though the surface may be very level, the thickness of the sand will vary greatly, showing that there was considerable erosion between the time of the deposition of the loess and that of the sand. It is apparent that this action is not in progress at the present time, since there is no sand connection between the flood plains of the streams and the sand ridges. Yet conditions may again become such that sand will be blown from the flood plains upon the uplands.

The three ridges of Marion county resemble each other in their location, all of them being northeast of the place where the sandstone ledges have been cut through. This is to be accounted for in the prevalence of southwest winds during the summer, the season when the sand is blown. Where it is not held firmly by vegetation the sand is being slowly, though gradually, moved toward the northeast. Were it not for the frozen condition of the ground in the winter the strong northwest winds then common might cause a shifting of the sand toward the southeast.

Since only the finest materials are taken up by the wind and carried in this way the sand is usually too fine to be of any use, particularly as it is seldom pure, but is mixed with considerable loess. The color is a dull gray, instead of white or buff, as is that of the sandstone. In one place, however, an excavation by the roadside revealed a thickness of several feet of almost pure sand and from this place the material had been removed for plastering purposes.

The character of these sand ridges can perhaps be made clearer by selecting a single one for description. The largest one lies in the extreme northeastern corner of the county, just north of the Skunk river. The sand covering this area is of unequal depth, ranging from three to eighteen feet. The area is very irregular in outline on account of the streams heading in this divide having cut through it in many places.

The water supply is interesting and somewhat unusual. Although the difference in elevation of any two points on the divide is not more than ten feet, yet a spring is found in the head of a ravine just at the divide which never fails entirely, even in droughts. In other places, also, a good supply of water is reached at a depth of ten to sixteen feet or just at the base of the sand. These wells can be used only for a short time on account of the sand gradually filling them up, even when cased. The sand is evidently a very good water bearing stratum, but the supply from this source is limited in amount and varies from season to season; nevertheless, it is greater and less variable than one might expect.

The roads in this area are very poor since the sand is readily ground up by vehicles into a loose mass, at times six to eight inches in depth. It is sometimes almost impossible to haul heavy loads over these roads.

On account of the large amount of loess mixed with the sand, the soils of this ridge support some kinds of vegetation nearly as well as those of the surrounding country. The entire ridge is under cultivation. Those plants which thrive in sandy soils, such as watermelons and potatoes, grow luxuriantly here, while other crops, such as corn, do poorly. In some places there is so much sand that the corn will scarcely mature.

ECONOMIC PRODUCTS.

Coal.

Mr. Park C. Wilson, who was state mine inspector from 1880 to 1886, speaks of Marion county coal as follows:* "In regard to Marion county as a coal county I will say that while visiting the different coal counties in the state for almost four years in the capacity of mine inspector, I have made a careful study, so far as possible, of their deposits to determine their extent and I am now firmly of the opinion that Marion county has the largest deposits of coal of any county in the state.

*Marion County Coal Company, its Property and Prospects, 1889.

"In my opinion the greatest difference there is in Iowa coal is in the hardness of the coal, as the softer it is the more it is damaged by being handled, and in a practical point of view I consider that the most important question in regard to the condition of the Iowa coal in different localities, and one which can be readily answered by those who are shipping. The harder the coal, the better condition it is in when delivered to the consumer, and the better price it will bring in the market, and the hardness of the coal does not add to the cost of production, but on the contrary, lessens the cost of mining, does not require the care in handling, stands exposure better, and is better for steam purposes than softer coal, and, in the above particulars, Marion county stands second to none in the state."

As previously described, the Coal Measures extend over nearly the entire county, only small areas in the eastern part having the Lower Carboniferous as the surface rocks, immediately underlying the Pleistocene deposits. The Coal Measures contain numerous beds of coal so that it may be said that almost the entire county is underlain by coal.

Notwithstanding these abundant deposits mining has not been carried on nearly so extensively as in some of the adjoining counties, particularly Mahaska. The reason for this non-development of the mining industry in this region has been neither the character of the coal nor the thickness of the seams, but the lack of railway facilities for the transportation of the product. Mahaska county, while not possessing any better coal or thicker beds has had the advantage in a larger number of railroads. Without the latter it is impossible for large mines to be operated. For many years the chief fuel of this region has been coal, practically all of which, with the exception of small quantities of anthracite, has been mined at home. Marion county is not very well supplied with railroads and they are not located where they will best serve the coal interests. The three which do cross it are located in the northern and eastern parts. These roads, however, have been

very serviceable and several extensive mines have been opened near them from which considerable coal has been shipped. But in other parts of the county only country mines have been opened. Recent drillings seem to indicate the presence of numerous workable beds in the southern and southwestern portion of this area which rival if not surpass those already being worked.

The Coal Measures dip toward the southwest, gradually increasing in thickness from the surface contact with the Saint Louis in the northeastern corner to a thickness of at least three hundred feet in the southwest. Near Newbern drill holes slightly over three hundred feet in depth have failed to reach the Saint Louis limestone.

Owing to their very local character it is impossible to say how many beds of coal there are within the county. Instead of the coal underlying the entire region in continuous beds, it is found in lenticular masses which seldom extend more than a few miles in their greatest diameter. As these masses are traced outward from the center the coal is found to gradually decrease in thickness and finally to pass by numerous gradations into bituminous shale or, occasionally, even into arenaceous or argillaceous shale. Numerous attempts have been made to trace coal beds from one region to another, perhaps many miles distant, and to correlate different seams but on account of the rapid changes in the strata of the Coal Measures such attempts have always been unsatisfactory. No great degree of accuracy is possible so that the results of such work are of little or no value.

So common is the presence of coal that where Coal Measure strata are present a drilling seventy-five or one hundred feet rarely fails to penetrate at least one coal bed, and frequently several. Four different seams have been passed through in a single drilling. Many of the veins are so thin that it has not been deemed expedient to work them at the present time, but not a few seams ranging in thickness from three to thirteen

feet have been located. Of these latter, some are now being operated but others have never been opened.

From the local nature of the various beds it is always advisable to drill a number of prospect holes before sinking a shaft, since the deposits may be too limited in extent to repay any great expenditure of money. Again, it must not be considered positive proof that coal is absent underneath a certain tract of land if a single drill record fails to record its presence. Another hole drilled only a few hundred yards away may disclose a good layer of workable coal.

Since the Coal Measures form the surface rocks of the county, disregarding the Pleistocene deposits, all of the mines are comparatively shallow. Indeed, most of them are worked from slopes extending in from outcrops along the sides of the hills or bluffs of the creeks. The deepest shaft thus far opened is somewhat less than 200 feet in depth. Coal is in some places found at a greater depth, so that when the supply lying near the surface is exhausted a profitable supply can be reached by going deeper.

The coal of the county is all bituminous but varies considerably in hardness, ranging from a very soft to a medium hard variety. As a general rule it is quite pure, although small quantities of iron pyrites, called sulphur balls by the miners, are not infrequent. Occasionally the mining of a thick bed of coal is interfered with by the presence of clay ironstone nodules or bowlders which are sometimes four or five feet in diameter. In a mine near Flagler, there is a layer of this stone occurring within the coal bed. A few mines have been abandoned because of the large amount of this stone encountered. Faults and rolls are seldom met with in the region. When they are present the faults have so small vertical displacement that the coal is seldom entirely cut off. Their presence is indicated by the fractured condition of the coal and the smooth, glazed surfaces known as slickensides. The presence of rolls, while more important than faults, may be said to cause very little interference in mining. In a few

exceptional cases a four or five foot vein of coal has been so narrowed by a roll as to be only one or two feet in thickness.

The coal of this county is underlain in almost every case by beds of fire clay varying in thickness from a few inches to fifteen feet. This fire clay is filled with the roots of coal plants, especially those of lepidodendrids and sigillarids. Though very little use has been made of this clay, it seems to possess the qualities which would make it of value in the manufacture of fire brick. In some places when the coal is removed the fire clay heaves, that is it rises in the entries on account of the removal of the overlying pressure, until it becomes necessary to remove it to prevent the passage way from being closed. The heaving, however, has seldom been sufficient to seriously interfere with the development of the mine.

In the great majority of mines the roof material is a black bituminous shale, or "slate" of the miners. On account of the very small number of faults throughout this region the shale forms a very substantial roof. But occasionally numerous faults, all of them slight in amount of thrust, will be found in a mine, so that the roof will be composed of much broken shale forming a very dangerous roof. In other mines the shale immediately over the vein frequently falls soon after the removal of the coal. This is known as the draw slate. Above this, firmer slate forming a very safe roof is found. In several mines sandstone occurs in immediate contact with the coal. In such cases, on account of the excellent quality of this rock as a roofing material, it is not necessary to use any timber. In a few instances an impure limestone overlies the coal and forms a stable roof.

The coal mines of the county may be divided into two classes with respect to their owners, namely, those owned and operated by corporate coal companies and those controlled by individuals, usually the owners of the land. There are several large coal companies operating in this district and others have extensive options on coal leases. In fact, almost

every piece of land is at present or has been in the past optioned or leased by coal companies. The method of procedure is to secure an option upon a certain tract for a stated length of time with the privilege of buying the coal if desired at any period within the specified limit. For such an option a small sum of money is paid. The option entitles the company to drill prospect holes at any place on the property. In this way considerable areas have been prospected and large bodies of coal have been located, which, but for this method might have long remained unknown.

The mines operated by companies are worked principally by shafts. They are located along the lines of railroad and the entire output is shipped. The mines operated by individuals are usually worked by slopes which extend into the hills only short distances. These latter, called country mines, are generally operated only during the winter and certain periods in the summer when there is little work to be done on the farm. Many are worked just enough to secure fuel for one or two families; others are worked enough to supply the neighborhood and the small towns near by.

A few mines located several miles from the railroads ship some coal, hauling it by wagon to the shipping point. This is not very profitable on account of the large supply located nearer these points and the low price of the output. Thus, because of the insufficiency of railroad lines, the coal resources of the county have not been properly developed.

At various times there have been projects for building a line across the southern part of the county but as yet the work has progressed no further than to make the survey. Such a line of railroad would cause a great impetus to the mining industry of the county sufficient to place it in the foremost ranks of the coal producers.

For convenience the coal deposits may be divided into three districts: (1) the district north of the Des Moines river; (2) the district between the Des Moines river and English creek; and (3) the district south and east of English creek.

DISTRICT NORTH OF DES MOINES RIVER.

In the first district coal is mined at several localities, the most important being near the towns of Pella, Otley, Dunreath, and Morgan Valley.

Pella Mines.--Near Pella a number of mines have been opened at various times, several of which are now in operation and supply the town with fuel. The coal is here found near the base of the Coal Measures, only a short distance above the Saint Louis limestone. The largest of these is the Buwalda mine, located in Tp. 77 N., R. XVIII W., Se. ¼ of Ne. ¼ of Sec. 32, on the divide between the Des Moines and Skunk rivers. The shaft is 115 feet in depth and the coal varies in thickness from four feet six inches to four feet nine inches. In sinking the shaft about eighty feet of sandstone was passed through, most of which was massive, with thin beds of shale intercalated in some portions. From the foot of the shaft the coal rises in every direction at the rate of about one foot in every twenty. The roof near the shaft is formed of a very hard sandstone, but only a short distance away the sandstone roof is replaced by shale, which gradually increases in thickness until about fifteen feet of shale separates the coal and sandstone. From four to fifteen men are employed here. It is estimated that this bed of coal is something more than 200 acres in extent, about twenty-five acres of which have already been worked out. The product is a good grade of bituminous coal. The upper two inches of the bed is called cannel, and has many resemblances to true cannel coal.

Otley Mines.—There are several mines now in operation in Summit township, the most important of which are located in Secs. 21, 27, and 28, Tp. 77 N., R. XIX W. The largest is the one owned by the Otley Coal company and operated by them until the shaft was destroyed by fire in December, 1898. They contemplate soon rebuilding, as they own the coal underlying a considerable area in that region. The old shaft, located in the Nw. ¼ of Nw. ¼ of Sec. 27, was 112 feet in depth. The coal varies in thickness from five to six feet. It was worked by

the room and pillar method, the rooms being driven 150 feet, with a width of twenty-five to thirty-five feet and pillars five feet in thickness. In sinking the shaft a seam of coal about eighteen inches was passed through at a depth of thirty feet. About forty men were employed in the mine. A switch connected it with the Rock Island railroad at Otley and the entire output was shipped. The mine was dry and possessed a gray shale roof.

The Roberts and McCloskey mines in Sec. 28, and the Vriezelaar and Smith mines in Sec. 21 are very similar to the one just described. They are all slope mines and employ from four to twenty men each. The coal from them supplies all the local trade, while some is hauled to Otley and shipped.

Dunreath Mines.—The most extensive mining operations of any in the county have been carried on near Dunreath, but at the present time almost no coal is being mined at that place. In the absence of a topographic sheet it is impossible to give the elevation of the different coal beds with any degree of accuracy or to correlate deposits several miles apart. As nearly as can be determined it seems that there are four beds of coal represented in this region. At no one place, however, are all four present. The upper one has a thickness of about two and one-half feet and lies about forty-five feet above the level of water in the river. This was not worked except just at the outcrop in the sides of the hill south of Dunreath. Fifteen feet lower is the seam that was extensively worked. This bed is correlated with the one that has previously been mentioned as occupying a depression in the Red Rock sandstone in the quarry near Red Rock. The Black Diamond and the Success were the principal mines operating in this bed. The first was located in Tp. 77 N., R. XX W., Nw. ¼ of Sw. ¼ of Sec. 26. The coal was from four to seven feet thick, with an average of about five and one-half feet. A large number of men were employed, and altogether the coal was removed from about seventy acres. The Success mine was located in Tp. 77 N., R. XX W., Sw. ¼ of Nw. ¼ of Sec. 27. The coal

here averaged four and one-half feet in thickness and some forty acres were worked out. About twenty feet below the seam just described is another layer twenty inches in thickness, and a short distance below this is a fourth which is sometimes seen in the bed of the river in dry seasons.

The Dunreath coal supply has certainly not been exhausted and we may expect that at some future time paying mines may again be located in this region, although probably at a greater distance from the town. The quality of the coal and the character of the roof material were both said to be good.

Morgan Valley Mines.—In this area, in the northwest corner of the county, several mines have been worked at different times, but altogether only a small amount of coal has been removed. At the present time one mine, located in Tp. 77 N., R. XXI W., Sw. ¼ of Nw. ¼ of Sec. 4, is being worked. The company operating it either owns or has options on several hundred acres of coal land at this locality. The mine is worked by means of a shaft forty-five feet deep. The coal averages four feet in thickness and contains little rock. No props are needed in the mine as there is a good sandstone roof. In sinking the shaft sandstone was passed through below the first five feet of soil and drift. The water necessitated considerable pumping. A switch of the Wabash railroad runs to this mine and all the coal is shipped.

DISTRICT BETWEEN DES MOINES RIVER AND ENGLISH CREEK.

Swan.—A large company mine was formerly operated at Swan but on account of the great amount of water it was abandoned in 1898. It was located in Tp. 77 N., R. XXI W., Nw. ¼ of Se. ¼ of Sec. 18. Much coal was removed from this place and yet the supply is far from being exhausted. The seam worked seems to be about thirty-five feet lower than the Morgan Valley coal. It is from three and one-half to five and one-half feet thick. The sandstone met with in the latter place is not present here and the roof is bituminous shale. The coal is considerably harder than that at Morgan Valley.

Coal Creek Mines.—Several small country mines are located in Pleasant Grove township, on Coal Creek, in Secs. 17, 20, and 21, Tp. 76 N., R. XXI W. All of them are shallow and worked either by slopes or short shafts. The seam is seldom more than three feet thick. The following section is taken from this locality, Tp. 76 N., R. XXI W., Nw. ¼ of Ne. ¼ of Sec. 20. The upper part is exposed on the west bank of Coal creek.

		FEET.	INCHES.
9.	Surface wash	5	
8.	Coal		6
7.	Fire clay	2	
6.	Shale, light colored, argillaceous	2	6
5.	Shale, drab, arenaceous	5	6
4.	Sandstone, gray, thinly laminated usually, although in a few places massive	3	
3.	Shale, gray, arenaceous	3	
2.	Shale, black, exposed to water's edge 13 feet, but altogether	30	
1.	Coal	2	6

It is the lowest member which is mined. At some points it is thicker than at this locality.

White Breast Creek Mines.—Along White Breast creek many small mines have been opened, but none have been worked extensively, nor have they shipped any coal. They are most numerous in Secs. 24, 26, and 35 of Tp. 75 N., R. XXI W., and in Secs. 19 and 30 of Tp. 75 N., R. XX W. The following section, seen at the Ritchie mine, Tp. 75 N., R. XXI W., Se. ¼ of Ne. ¼ of Sec. 26, is typical.

		FEET.	INCHES.
10.	Drift and loess	5 to 15	
9.	Sandstone, very hard	4	
8.	Slate, gray	8	
7.	Sandstone, yellow, soft	11	
6.	Coal	2	2
5.	Fire clay	6	
4.	Slate, gray	10	
3.	Coal, just at level of creek	3	9
2.	Fire clay and black slate	60	
1.	Coal	4 to 6	

The second bed of coal is the one usually worked in this region, although some has been taken from the outcrop of the first. The coal varies somewhat in quality in the different mines but in general is quite soft.

Coalport.—Near this town the first mines in the county were opened. When boats passed up the Des Moines river in the early history of the state, Coalport was one of the most important places between Eddyville and Des Moines. At this place they usually took coal which was mined near by. Only a few old buildings now mark the site of this once prosperous village. Its location was Tp. 76 N., R. XIX W., Ne. ¼ of Sw. ¼ of Sec. 14. When navigation on the Des Moines river ceased most of the mines that had formerly been worked with profit were abandoned. The following section is shown at one of the mines, now operated on a small scale, located in Tp. 76 N., R. XIX W., Sw. ¼ of Ne. ¼ of Sec. 23:

		FEET.
6.	Drift	30
5.	Coal	6
4.	Fire clay	10
3.	Shale, light colored	10
2.	Coal	3
1.	Fire clay, to bed of river	5

All of the mines in the vicinity were worked by slopes. The roof is good, so that little timber was needed. The coal is a very soft variety.

Knoxville.—Since the entire region about Knoxville is underlain with coal it might be expected that here numerous mines would be operated. Within a radius of one mile from the courthouse probably a dozen mines have been operated but all are now abandoned. They were all shallow mines and the seam was thin.

Flagler.—At this place the Whitebreast Fuel Company have carried on very extensive mining operations for a number of years. Several shafts have been sunk and about 100 acres have already been worked out. The Hawkeye mine, located

west of Flagler in Tp. 75 N., R. XIX W., Se. ¼ of Se. ¼ of Sec. 4, is the largest one now in operation. It is worked by means of a shaft fifty feet in depth. The coal varies in thickness from three to five feet, being quite irregular. There are also a few rolls which almost entirely cut out the coal for short distances. The mine has a good slate roof separated from the coal by two feet of draw slate. About thirty-five men are employed here in summer and seventy-five in winter. A short switch connects the mine with the Burlington railroad, over which the entire output is shipped. The coal in the immediate vicinity of Flagler is similar to that above, except that it averages about five feet in thickness. The drill section of the Flagler artesian well, given on a later page, shows the underlying formations. Although the drilling was distant only a few rods from the mines no coal bed was penetrated.

DISTRICT SOUTHEAST OF ENGLISH CREEK.

It seems probable that in a few years Liberty township will be producing more coal than any other in the county. In the vicinity of Bussey, Hamilton, and Marysville are several mines which have been worked for years, while several large ones are now being opened.

O. K. Coal Company's Mines.—This company has operated several mines west of Bussey, two of which are of special importance. It owns considerable land in this locality, and also the coal underlying large tracts owned by individuals. It has mined altogether about seventy acres.

The oldest mine now in operation is situated in Tp. 74 N., R. XVIII W., Nw ¼ of Nw. ¼ of Sec. 23. This is worked by a shaft sixty feet in depth, and the coal runs from four to five feet in thickness. It is overlain by about fifty feet of slate which forms an excellent roof. About seventy feet below this seam is another about three feet in thickness, which is however quite impure. On an average about 125 men are employed in this mine. It is connected with the Burlington road by a switch.

The other mine of the O. K. Coal Company has just recently been opened, and it bids fair to become the largest and most important in the county. The company owns the coal under about 600 acres. The shaft, forty-five feet in depth, is located in Tp. 74 N., R. XVIII W., Nw. ¼ of Ne. ¼ of Sec. 17. In prospecting over this area the maximum thickness of the coal was found to be thirteen feet, the minimum five feet, and the average about eight and one-half feet. There is a good slate roof about eleven feet in thickness. The coal is medium hard and very glossy. There is little water to interfere with the work. From the foot of the shaft the coal rises slightly toward the northwest and dips toward the southeast. A switch will connect this mine with the Burlington railroad.

Hamilton Mines.—Several mines are located in the vicinity of Hamilton, the most important of which is that owned and operated by the York Coal Company, and located along the Wabash railroad, about half a mile north of town, in Tp. 74 N., R. XVIII W., Se. ¼ of Sw. ¼ of Sec. 26. It has only recently been opened. The shaft is 164 feet deep, and the coal is from three to six feet in thickness. The roof is in some places sandstone, in others slate. Near the foot of the shaft are a number of rolls and bowlders which entirely shut off the coal for a considerable distance. In one direction the coal was found after passing throngh a roll for a distance of thirty-three feet, while in another direction a roll was encountered seventy-two feet in length. Drill records indicate that the rolls are less frequent a few hundred feet away from the shaft. If this proves to be true the mine can be worked with profit, but otherwise not.

Marysville Mines.—The Marysville mines are all country mines, located along Cedar creek. There seems to be an abundance of good workable coal in this vicinity, and no doubt in the near future large mines will be opened. The States coal mine, located in Tp. 74 N., R. XVIII W., Sw. ¼ of Sw ¼ of Sec. 30, is perhaps the most important, but it is not

being operated at present. It was a slope mine, with the entrance about fifteen feet above the level of the creek. The coal dips slightly toward the west, and the seam ranges in thickness from seven to eight feet, with an average of about seven and one-half feet. The coal is very glossy in appearance and of excellent quality. The roof consists of "soapstone," which is so firm that no propping is needed in any of the entries. This bed of coal does not seem to be merely a local deposit, but apparently extends for several miles.

As already stated, no attempt is made to correlate the various coal seams situated in different parts of the county, as it is impossible to trace any deposit for any considerable distance, yet something may be said in a general way concerning the deposits. It seems certain that the Dunreath coal is older than that now being mined south of the Des Moines river, and that those deposits, or other deposits of the same age, have been carried to considerable depth in the southern part of the county by the dip of the strata in that direction. It is not meant that the coal beds north of the river are continuous, for this is known not to be the case, but merely that there are beds of the same age in the southern part of the county. If this supposition be true, the coal supply of Marion county is vastly greater than is usually supposed, and when the upper beds are exhausted in the southern half of the county there will yet remain a large supply of good coal at a depth probably not exceeding 400 feet. Half a dozen accurate deep well records in this region would be sufficient to prove or disprove this supposition, but unfortunately these are altogether lacking.

Building Stone.

The building stones belong to the Saint Louis and Des Moines formations and consist of sandstones and limestones. At the present time no extensive quarrying is carried on at any place in this district. Little stone is being shipped out of the county and, on the other hand, but little is being shipped

in. Few stone buildings have been constructed within the past few years, and thus almost all the material quarried is used for foundation purposes.

Saint Louis Limestone.—As has been said before, the Saint Louis consists principally of limestone and is found outcropping along the streams in the eastern portion of the county. Stone both of the Pella and Verdi beds has been quarried, the former, however, much more extensively. This is due both to its superiority and to its greater extent. At every outcrop of the Pella beds, with few exceptions, stone has been or is at present quarried.

The largest quarry in this rock is located on Cedar creek, southwest of Tracey, in Tp. 75 N., R XVIII W., N. ½ of Se. ¼ of Sec. 35. The section exposed at this point has been given in the discussion of the Saint Louis formation. This quarry is only a short distance from the Burlington railroad, with which it has been connected by a short switch. It extends for about half a mile along the bank of the creek. Although hundreds of carloads of stone have been removed and shipped to all parts of the state, the quarry has been worked only a short distance back into the hill. It has been operated about eighteen years, and at times there have been as many as forty men employed, although at the present time there are, on an average, not more than six. A stone crusher was used here for a short period and in this way the thin bedded and fragmentary rocks, which are usually wasted, were utilized. The principal beds in this quarry are the 16, 17, and 19 inch ledges. From the latter, blocks measuring three feet three inches by five feet can be easily obtained, and occasionally even larger pieces are removed. The bed suitable for flagging stone is better developed in this quarry than in any other in this area and its quarrying would be profitable if there were more of it. It is of uniform thickness and can be removed in large blocks suitable for side walks.

Another quarry, formerly worked quite extensively but now abandoned, is located north of Durham near the Rock

Island railroad, in Tp. 75 N., R. XVIII W., Sw. ¼ of Sec. 4. Considerable stone has been shipped from here. The individual ledges differ very little from those in the above mentioned quarry. It was operated by J. H. Rees of Harvey, who has just recently opened another in the Pella beds in Tp. 75 N., R. XIX W., Sw. ¼ of Sw. ¼ of Sec. 1. The latter is situated between the Rock Island and Burlington railroads, with the former of which it will be connected by a stub switch. The section here is as follows:

	FEET.	INCHES.
Soil and loess	3	
Limestone, thinly bedded	6	
Limestone ledge		8
Limestone ledge		8
Limestone ledge, coarse grained, dark in color, weathering white, principal layer of quarry		20
Limestone, variable thickness		6—20
Limestone ledge		8
Limestone ledge		6
Limestone ledge		6
Arenaceous limestone, soft, of little value		14
Limestone, very hard, breaks irregularly	3	

Although this quarry has just been opened, considerable stone has been shipped from it to Oskaloosa and Washington and has found a ready market. The joints are from two and one-half to ten feet apart, thus making it possible to remove large blocks.

Nearly all the stone used in Pella is obtained from two limestone quarries located about one and one-half miles southwest of the town on the Pella-Knoxville road. The stone differs very little from that given in the above section except that a marl bed, varying in thickness from four to eight feet, overlies the limestone.

Another quarry deserving mention among those of special importance is that belonging to J. R. Morris, located in Tp. 75 N., R. XVIII W., Ne. ¼ of Se. ¼ of Sec. 13. The section here is as follows:

	FEET.	INCHES.
Limestone, thinly bedded, greatly fractured.....	5	
Limestone ledge, of no value on account of its inability to withstand frost.....		6
Limestone ledge, similar to above.....		6
Limestone ledge, fairly good stone.....		10
Limestone ledge, fairly good stone.....		8
Limestone ledge, granular in texture, joints 4 to 10 feet apart, principal stone of quarry.....		18—20
Limestone ledge		4
Limestone ledge, very hard, seldom worked.....		10
Shale, black.....		1—2
Shale, gray, soft.....		12
Limestone, thinly bedded, crystalline.....		12

The stone from this locality is all consumed by local trade, the annual output being about 100 perch.

The limestone of the Pella beds, as may be seen from the sections just given, varies little in the different quarries, so that it is possible to describe it in a general way. The rock is homogeneous in structure and usually fine grained; cavities are not common, only one layer containing many. In this layer they are merely the openings between the valves of brachiopods, and these are frequently almost entirely filled with calcite crystals.

As is shown from the sections already given, the layers are of convenient thickness for building purposes, and also for flagging. With the exception of the upper beds, the joint planes are not so numerous as to prevent the securing of blocks large enough for all ordinary purposes. The joints run true, so that the stone can be readily removed in blocks of convenient size; it also breaks evenly, so that the waste in dressing is very small. The rock is quarried both by drilling and blasting, no sawing machines being employed. Formerly some of the stone was crushed for street paving and for ballast.

The Saint Louis limestone, while far better than that of the Coal Measures, is not of superior quality. The layers vary greatly in durability, some being little affected by frost,

while others disintegrate in a few years when subjected to alternate thawing and freezing. Some foundations built of this stone present a fresh, almost unweathered appearance after fifteen to twenty years exposure to the weather, while in other cases the rock began to crumble in a very short time. In general, it does not resist frost well, due no doubt to the large amount of water which it is able to absorb. The stone is of good color, becoming very white when exposed to the air.

The following tests and analyses were performed upon specimens secured from the large quarry on Cedar creek, near Tracy. The tables are taken from an article by H. F. Bain, in one of the earlier reports of the Survey:*

CRUSHING TEST.

STONE.	HEIGHT—INCHES	CROSS SECTION—SQUARE INCHES.	BREAKING STRESS—POUNDS PER SQUARE INCH.	
			Spalling	Failure.
No. 31, Saint Louis limestone	1.95	4.12	7300	9500
No. 32. Saint Louis limestone	2.00	4.20	5200	9900

ABSORPTION TEST.

STONE.	PER CENT. OF INCREASE.		
	24 Hours	Week	Total.
No. 31, Saint Louis limestone	2.28	99.	3.27

CHEMICAL COMPOSITION.

$CaCo_3$	94.60
MgO	3.17
Al_2O_3	.49
$FeO+Fe_2O_3$	.17
Ins	1.57

Although the Saint Louis limestone in this county is not being quarried as extensively as formerly, there is a good demand for it, and a considerable quantity is being shipped to

*Properties and Tests of Iowa Building Stone, vol. VIII, pp. 402, 410, 412.

adjoining counties. The chief drawback to the extensive quarrying of this stone is the thickness of the overlying drift. The outcrops are confined to the valleys and ravines, and as the beds are followed back into the hills the drift becomes thicker, until the stripping is necessarily so great as to make quarrying impracticable. On this account it will be impossible for such extensive quarries to be worked in this county as in other parts of the state.

Coal Measures.—In the Coal Measures, limestone, conglomerates, and sandstones have all been quarried for building purposes. The first two scarcely deserve mention, as they occur only in limited areas and are inferior in quality. If it were not for the scarcity of good building stone over a large portion of the county, the Coal Measure limestone would perhaps nowhere be quarried. It is heterogeneous in composition, breaks irregularly, produces a rough surface when weathered, and can scarcely be dressed without great waste. It is used for foundation purposes and for walling wells.

The sandstones of the Coal Measures have been very extensively quarried throughout the county, notably at Red Rock. At this place the largest quarry in the county, and one of the largest in the state, is located. At present, however, it is not in operation. At many other places there are small sandstone quarries which supply a limited local trade.

The Red Rock sandstone was formerly shipped to many places in and out of the state, especially to Des Moines and St. Louis. The rock, while comparatively soft, does not crumble and is very resistent to weathering agencies. It was formerly blasted in quarrying, but this shattered it so badly as to render some of the material almost unfit for use and more recently it has been taken out by channeling. No joint planes are present in the rock, and since a vertical face of nearly ninety feet is exposed, it is possible to secure blocks of any size desired. Because of the difference in color of the various parts of the rock it is quite difficult to secure large blocks of a uniform color throughout. Thus to work the

quarry with profit it becomes necessary to remove large quantities of material which must be assorted, especially if it be used for the construction of entire buildings. When this is done there must necessarily be considerable waste on account of the coloring matter being distributed in irregular blotches rather than in layers. Mottled stone has been used to some extent but is not always desirable. Notwithstanding these difficulties, by judicious selection rock of uniform color varying from light gray to a deep brick red may be secured, suitable for the construction of the finest buildings. This stone possesses another desirable quality in that it can be readily carved, thus making it suitable for decorative purposes.

The sandstone is very durable; since the cementing material is silicious and ferruginous, it is not easily dissolved and water has little effect upon it. Again, being fine grained and the grains well assorted, it is not effected to any great degree by changes in temperature. Although the concretions and pockets of loose sand, previously mentioned, are obstacles in the successful operation of the quarry, yet it seems that with proper management it might become one of the most extensive and profitable quarries in the state. The amount of necessary stripping is small, the quality of the stone is good, and the supply is practically inexhaustible.

Lithographic Stone.

Several years ago some specimens of stone were obtained from the Coal Measures in the southeastern part of the county, which were pronounced by several lithographers to be true lithographic stone of very good quality. The one making the discovery did not attempt to develop a quarry nor to learn the extent of the deposit. Should the beds prove to be extensive, lithographic stone might become one of the most valuable economic products of the county. Numerous finds of this stone from various parts of this county have been reported from time to time, but at present almost all of this

material used in the United States is imported from Germany. Since the locality where these specimens were obtained is kept secret, the writer has been unable to investigate further, and consequently this unsatisfactory reference to the reported find is all that can be given at this time.

Lime and Cement.

At present neither of these products is manufactured within the county, the supply being derived from outside sources. Formerly, however, lime was burned at various places, especially in the eastern part of the county, and in sufficient amounts to supply the local demand. This lime, while it was not of the best quality, proved to be quite durable and was used exclusively for many years. In it, manufacture limestone composed almost entirely of calcium carbonate was used. It was obtained from both the Coal Measures and the Saint Louis formation.

In recent years there is a decided preference for the gray magnesian limes obtained from dolomite, and this has led to the abandonment of the old kilns. The magnesian limes while darker in color, seems to have a decided superiority over the calcareous lime in point of durability, hardness, and adhesiveness. Cheap transportation has also aided the former lime, which is produced in large quantities in other parts of the state, to gradually drive out the poorer material. No cement has yet been produced in this part of the state, but it seems not at all improbable that some of the Saint Louis marls may be found suitable for this purpose.

Clays.

Marion county, in common with most of the adjoining counties, is well supplied with clay. There are many deposits of good clay that have not yet been utilized, but which should in time give rise to important clay industries. The clays, of which there are several different kinds, suitable for

various purposes, have thus far been used in the manufacture of brick, tile, and pottery.

Brick.—At the present time there are four brick plants in operation, viz: the Pella Brick and Tile Company, located in the eastern part of Pella; the Wright brickyard, a short distance north of Knoxville, Tp. 76 N., R. XX W., Se ¼ of Sw ¼ of Sec. 25; the King brickyard, southwest of Knoxville, Tp. 75 N., R. XIX W., N. ½ of Nw. ¼ of Sec. 17; and the Wright brick yard, north of Bussey, Tp. 74 N., R. XVIII W., Ne. ¼ of Ne. ¼ of Sec. 14. In early days small quantities of brick were burned in other places in the county, but only for the construction of a few buildings.

The clays are obtained from the loess and the Coal Measure shales, the former being used most extensively. This is owing to the fact that it is found in large quantities; is easily obtained, since it is only necessary to remove the sod and a small quantity of loam; and, in addition, it makes a very good quality of common brick. There are three different kinds of loess clay: the gray surface material, the yellow clay, and the blue clay. These are occasionally used separately, but usually better results are obtained by using a mixture of the different varieties. The chief objection to the loess in the manufacture of brick is that there is frequently considerable loss in the drying process, due to cracking. To prevent this they must be dried slowly. Steam dryers have been found impracticable for this reason.

At the King brickyard some Coal Measure shale is used, sometimes alone, sometimes mixed with loess. There is little waste in this kind of clay in the drying process, since it does not readily crack even when dried rapidly. These brick can also be burned much harder than those made from the loess. Sidewalk brick is produced at this place, but no attempt has been made to produce paving brick. Some brick taken out of the kiln next to the furnace where they had been subjected to greater heat seems to indicate that a very good quality of vitrified brick might be produced.

Tiling.—Considerable drain tile is used within the county, most of it being produced locally. A large quantity is also shipped to neighboring points. The tiling is made in connection with the brick at the various brickyards. Loess is used exclusively for its production and is well suited for the purpose, because of its burning to vitrification at the relatively low temperature of 2100 to 2300 F. It is better adapted to tile than to brick, since it is possible to dry the former without cracking under conditions where it is impossible to make brick. If the clay is thoroughly worked there is very little waste from cracking in the drying process and almost none in the burning. The larger sizes of tiling, such as used for culverts, are not made, but only those smaller ones with an internal diameter of from three to eight inches.

Pottery.—Formerly pottery was made at the King brickyard, at Coalport and at Attica. On account of the great reduction in prices of pottery in recent years, its manufacture has been abandoned at all three places. The potter's clay appears to be of good quality for the production of the common grades of pottery. It is found in the Coal Measures. It occurs in only a few localities, but where found it is frequently ten or twelve feet in thickness. The principal deposits are near Attica, and here a number of small potteries were formerly located. For many years the ware produced here, consisting of jugs, jars, churns, flower pots, etc., supplied the entire demand for a considerable area about Attica, and was shipped to various points in this state and Missouri.

Ochre.

In the vicinity of Hamilton a deposit of yellow ochre occurs, which, from outcrops and well borings seems to be quite extensive. It has been detected in well borings about two miles from where it outcrops, and it is believed to be continuous between these two points. If it should be found suitable as a pigment it would become one of the important

resources of the county. Samples of the material were sent to a paint manufacturing company for examination, with the request that they report as to the quality and value of the material. Their report is unfavorable on the whole, and yet the ochre is said to have the necessary constituents for paint, though in small quantity. Though it has a commercial value it is rather a low one. The chief objections to it are the presence of several impurities, principally calcium carbonate and small grains of sand. The samples were all collected near the same point, and it is possible that these impurities may not be present in all parts of the deposit. In one instance at least this ochre has been used with satisfactory results. A number of years ago a house in Hamilton was coated with paint made from this ochre and it has proved to be quite durable. The color, though not a decided yellow, is very good.

Copper.

From time to time there have been rumors of valuable deposits of copper within the county, caused by the discovery of small copper nuggets. These have been found of various sizes, ranging from a few ounces to four pounds in weight. In every case, so far as could be ascertained, the copper was picked up at the surface or was found in the glacial drift. It furnishes, therefore, no indication of deposits of copper within the county. Two possible hypotheses have been suggested to account for the occurrence of these isolated nuggets. One explanation is, that the copper was brought by the Indians, as it is known that they used the metal in the manufacture of their weapons and ornaments; the other is that it was carried from the Lake Superior region by glaciers in the same way that the glacial bowlders have been transported. Probably both these hypotheses are correct and the copper was brought here by the Indians and by the ice sheets.

Lead and Zinc.

In the course of the present survey frequent reports were met with of rich bodies of lead and zinc ore in the county. Whenever the exact location of these supposed deposits could be secured, the strata were carefully examined, but no evidence of the presence of either of these metals was found. With respect to the zinc, it is probable that the iron carbonate, siderite, which is found in the large septarial concretions in the black shale, has been mistaken for zinc blende. It closely resembles it in color, so that it is not surprising that such an error has been made.

Other Minerals.

Among the other mineral products, gypsum is probably the most common. This, however, is found in such small quantities as to be of no economic importance. It occurs in the usual diamond or needle-shaped crystals of small size, in certain black shales of the Coal Measures. Iron pyrites is frequently found in the Coal Measure shales and in the coal, but not in sufficient quantity to be of any value.

Oil and gas have been searched for, but have been found only in very small quantities. At times the water from certain wells has a thin film of oil on the surface, indicating the presence of small amounts of this mineral.

Water Supply.

The water supply of the county is derived from running streams and wells. At present no use is made of the water power, there being no mill or other plant run by water. This is mainly due to the fact that the average slope of the streams is small, especially so in the larger streams, as shown in the table previously given. The city water works of Knoxville obtains its supply from White Breast creek.

The wells are usually shallow, since the water is found in the drift. Owing to the heterogeneous character of this material and its irregular distribution, water is obtained from

small sand-filled pockets or from small veins. Two wells, situated only a few rods apart, may obtain water at different depths, drawing their individual supplies from different sources. The Coal Measures also contain water, but this is usually so strongly impregnated with mineral substances as to be unfit for household purposes. The water obtained from the Saint Louis formation, in the eastern part of the county, is of good quality, although in places somewhat hard on account of the large amount of calcareous material held in solution.

On the uplands in the northern part of the county, between the Des Moines and Skunk rivers, and also in the southern part, there are a number of deep wells varying from 100 to 300 feet in depth. The water in these is obtained from the Coal Measures and is usually of poor quality, except when found in sandstone, as is occasionally the case. In recent years the water supply of the shallow drift wells seems to have been decreasing, thus making it necessary for a great many of them to be deepened. While the average rainfall has not materially changed it does not seem to have been as well distributed throughout the year as formerly, and there are more frequent drouths.

Springs occur in a few places, but they never have sufficient flow to be of much importance. Water-bearing strata are seldom exposed, and where they lie near the surface the seepage is concealed by the drift or loess. Boggy places are thus formed rather than springs.

Artesian Wells.—There are several artesian wells in the northern part of the county which range from 200 to 800 feet in depth. Unfortunately no records have been kept, or else the records are so incomplete as to make it almost impossible to determine the age of the horizons from which the water is obtained. The most complete record, and the only one that can be depended upon, is that of the flowing well at Flagler, drilled by the Whitebreast Fuel Company. It is located in

Tp. 75 N., R. XIX W., Nw. ¼ of Sw. ¼ of Sec. 2. The record is as follows:

		FEET.
0–5	Clay	5
5–17	Sand	12
17–45	Limestone	28
45–51	Sandy shale	6
51–123	Sandstone	72
123–130	Limestone	7
130–143	Magnesian limestone	13
143–153	Limestone	10
153–160	Sandy shale	7
160–185	Limestone	25
185–191	Sandy shale	6
191–194	Limestone	3
194–198	Sandy shale	4
198–291	Limestone	93
291–292	Hard white rock	1
292–454	Limestone	162
454–524	Sandy shale	70
524–526	Sandy shale	2
526–590	Limestone	64
590–621½	Sandy shale	31½
621½–687	Limestone	65½
687–752	Lime rock	65

In this well a small flow of water was obtained at 320 feet, and a strong flow at 626 feet. In the latter case the water was probably in Devonian strata. Two flowing wells about 200 feet in depth, located in the Des Moines river bottoms, near Red Rock, seem to obtain their supply from the Coal Measures.

In none of these wells is there strong flow, nor is the force sufficient to throw the water any considerable distance above the surface. The water is highly mineralized, the chief minerals in solution being iron and sulphur. The water from the Flagler well was found to be unfit for boiler purposes on account of its corrosive action. That from the other artesian wells would probably act in a similar manner as the composition seems to be practically the same, if one may judge by the taste and odor. It is claimed that the water from the Flagler

well possesses as great curative properties as that of the famous Colfax well of Jasper county.

Soils.

The soils of this county may be classified as loess, drift and alluvial. This classification is based on the different kinds of material composing them, and the source from which they have been derived. The loess soil is by far the most important, since it covers the greater part of the county. Where erosion is not active enough to remove large amounts of the surface material each year, the upper foot or two of the loess becomes mixed with a large amount of vegetable material, thus rendering it much darker in color than the underlying portions. With sufficient rainfall this soil is very productive and is well adapted to the raising of almost all kinds of crops. On account of its porosity, it absorbs and holds a large amount of water instead of allowing it to pass downward freely by percolation. Nearly all of this water is available for the use of plants, since the roots are able to withdraw it from the loess as the plants require it. Moreover, because of the great porosity of the loess, when not covered by a dense mat of vegetation, such as bluegrass, it increases the relative amount of ground water compared with the surface drainage water.

The drift soils are relatively of small extent and are found chiefly on hillsides. They are less fertile than the loess or the alluvium. At times the boundaries between the loess and the drift can be determined by the appearance of the crops as well as by the color of the soil. The drift soils are usually designated as clay. Their unproductiveness is in a measure due to their position, since erosion is apt to be so active on the hillsides as to remove the soil mixed with vegetable material as rapidly as it is accumulated. This soil does not hold water well and frequently bakes on the surface after a heavy rain.

The alluvial soils are composed, as already stated, principally of the vegetable filled loess of the uplands and are the most productive of the county. The only drawback is due to

their position. In wet years they are flooded and their cultivation thus prevented.

ACKNOWLEDGEMENTS.

In the preparation of this report the author has been very kindly received by all persons from whom information was sought, and for this reason much valuable material was secured which could not otherwise have been obtained. Everyone seemed to take a personal interest in the matter, and, though they cannot all be mentioned individually in this place, the writer wishes to express to them his indebtedness.

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IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF MARION COUNTY, IOWA.

BY

B.L. MILLER

1901.

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

QUARRIES

COAL MINES

SHAFT

SLOPE

ABANDONED MINES

CLAY WORKS

ARTESIAN WELLS

DRAWN BY F.C. TATE

IOWA LITHO. CO.