GEOLOGY OF MAHASKA COUNTY.

BY

H. FOSTER BAIN.

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CONTENTS.

INTRODUCTION.

AREA AND LOCATION.

Mahaska county is located in about the middle of the southeastern portion of Iowa. It is bounded on the north by Jasper and Poweshiek, on the east by Keokuk, on the south by Wapello and the west by Monroe counties. It includes townships 74 to 77 north, ranges XIV to XVII west; an area of 576 square miles, or 386,640 acres.

PREVIOUS GEOLOGICAL WORK.

This county has long been noted as a great coal-producing county and has been visited at different times by several geologists. Owen*, in his reconnoissance up the Des Moines river in 1849, noted several outcrops of sub-carboniferous limestone within its limits, called attention to the coal of the Muchakinock valley then already mined to a slight extent, and described the sandstone at Raven Cliff. In 1856 Worthen† passed over the same ground, but added little information. In 1867 White‡ visited the county and called attention to the presence of Saint Louis strata in the beds of the Skunk river. He described the mines then in operation and emphasized the abundance of the coal present.

PHYSIOGRAPHY.

TOPOGRAPHY.

This county may be conceived as a rolling plateau sloping gently from an elevation of 915 feet in the northeast to about 750 feet in the southwest. Across this plain running approximately parallel from northwest to southeast are three main river valleys and three minor ones which have greatly affected the topography of the district. In crossing from a northeast to a southwest direction a series of four low ridges or watersheds would be encountered, the tops just touching the ideal plain.

*Geol. Sur. Wisconsin, Iowa and Minnesota. 114-116. 1852.

†Geology of Iowa, II, 165-166. 1858.

‡Second Ann. Rep. State Geologist, 91-93. 1868.
Geology of Iowa, II, 265-267. 1870.

mentioned above. The erosion of this section has been so vigorous and so widespread that over the greater portion of the county the actual aspect of a plain has been greatly obscured.

In that portion of the county northeast of the North Skunk river the plateau character is still the main feature of the landscape. In this region the land varies in elevation from 910 to 885 feet in elevation; the streams, away from the river, cutting but little below that level. The North Skunk river itself has cut below this plain from ninety to one hundred feet. Its direct tributaries here are mainly from the north so that it is on this side that the greatest amount of erosion has taken place. South of the river the bluffs are usually well marked and follow close along the river.

The strip of country lying between the North and South Skunk rivers, preserves toward the west the plateau feature; particularly over the greater part of Prairie township. Near Peoria, and over the greater part of Richland township, the plain has been badly cut up by Buckley creek and its branches. Toward the east division of this plateau becomes more and more well marked; Middle creek running down its center, or a little south of the center, leaving a ridge on either side between it and the respective branches of the Skunk. The north ridge is the greater and has an elevation varying from 876 feet at New Sharon, down to 843 at Tioga. Below this level Middle creek cuts ninety-three feet, while the second ridge, upon the crest of which the town of Lacey is built, rises fifty-eight feet above Middle creek. From Lacey south the slope is quite abrupt to the bottom lands of the Skunk river at 718 feet.

The high land between the South Skunk and the Des Moines river, which at Oskaloosa rises to 843 feet is likewise divided by the valley of the Muchakinock which flows centrally through its western part. This valley is quite deep, being at Evans cut down to 734 feet, though it is not large and has few side valleys of any extent. From Oskaloosa southeast the plainlike aspect becomes more prominent. Cedar creek does not greatly roughen the topography, and in general the southeastern part of the county may be considered a gently rolling plain varying in elevation from 850 to 880 feet.

The Des Moines valley is deep and usually broad. Harvey, just west of the county line, and built on the flood plain of the river, lies at an elevation of 718 feet. Eddyville with a similar location where the river crosses the south county line, is 677 feet above sea level.

The portion of this county lying southwest of the Des Moines river is quite broken. The uplands are 120 to 160 feet above the Des Moines. The creeks have usually broad bottom lands and numerous tributaries.

The topographic forms observed throughout the region are those common to regions covered by drift and altered by erosion. The hills are usually low with gentle rounded slopes. Where the rivers cut across the hardened indurated beds, high steep bluffs are occasionally seen. In some cases these beds, as for example the Saint Louis along South Skunk northeast of Oskaloosa and along the Des Moines opposite Eddyville, form well marked terraces skirting the river. In these cases it seems that the stream after cutting out the larger valley in the drift was unable to excavate its channel as rapidly in the harder rocks below.

Table of Elevations.

LOCALITY.	ELEVATION*.	AUTHORITY.
Atwood	722	C., R. I. & P. Ry.
Barnes	915	B., C. R. & N. Ry.
Beacon	736	C., R. I. & P. Ry.
Cedar	872	Survey.
Eddyville	677	Iowa Central Ry.
Evans	743	C., R. I. & P. Ry.
Fremont	888	Survey.
Given	705	Iowa Central Ry.
Harvey	718	C., R. I. & P. Ry.
Lacey	841	Iowa Central Ry.
Leighton	769	C., R. I. & P. Ry.
New Sharon	876	Iowa Central Ry.
North Skunk	780	Iowa Central Ry.
Olivet	818	C., R. I. & P. Ry.
Oskaloosa	843	C., R. I. & P. Ry.
Rose Hill	822	C., R. I. & P. Ry.
Stark	856	Survey.
Tioga	834	C. & N.-W. Ry.
South Skunk bridge	715	Iowa Central Ry.
E. Co. line 1 mile west Nassau	910	B., C. R. & N. Ry.
Stream near Barnes	895	B., C. R. & N. Ry.
River at Atwood	695	C., R. I. & P. Ry.
South Skunk west of Rose Hill	718	Survey.
North Skunk, Atwood	695	C., R. I. & P. Ry.

*Above sea level.

In this table the elevations credited to the different railways are taken from the engineer's profiles and reduced to sea level. Those credited to the Survey are based on barometric observations corrected and tied to railway levels.

DRAINAGE.

Though there is a slight general slope of the present surface from the northeast to the southwest the main drainage lines of the county run at right angles to this slope.

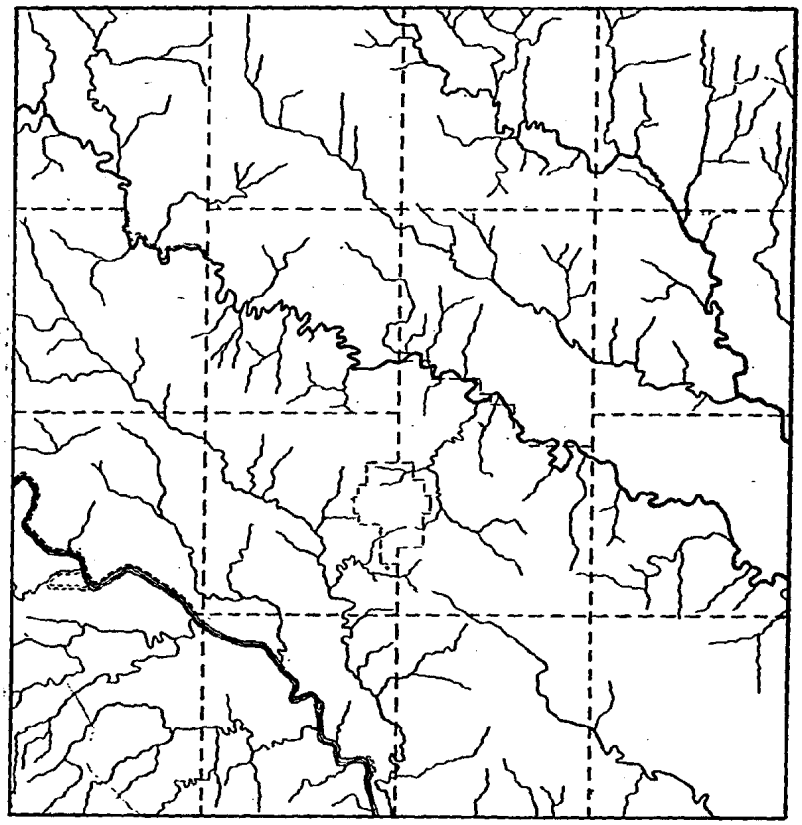


Figure 30. Drainage of Mahaska county.

In the extreme northeast corner of the county is the South English river, here an insignificant prairie stream. This region belongs to the drainage system of the Iowa river. The North Skunk river enters the county almost directly north of

New Sharon. It flows in a southeasterly direction, receiving from the north Buck creek, Moore creek and Pleasant Run, and from the south, near the east county line, Middle creek, which takes its rise well toward the northwestern corner of the county. North Skunk throughout a considerable portion of its course has cut through the drift and into the indurated rocks exposing both coal measures and underlying beds. Its tributaries do not show exposures of the older strata any considerable distance from the river.

South Skunk river enters the county about three miles south of the northwest corner and leaves it about seven miles north of the southeast corner. It is of considerable size, though the presence of parallel streams at a short distance, makes its tributaries in this county few and insignificant. The more important are Buckley creek, flowing from the north near Peoria, and Spring creek coming from the south near Oskaloosa.

Muchakinock creek is formed by the union of two small streams near Leighton. From here it flows southeast eight miles to Beacon, from which point it flows slightly east of south to the Des Moines river, with which it unites a short distance below Eddyville. It does not receive many tributaries, Kennebec and Lost creek, both flowing in from the east, being the most important.

The Des Moines river crosses the southwestern portion of the county, entering it about ten miles north of the southwest corner and leaving it about the same distance east of the same point. The upper portion of its course especially shows the record of important changes. Near the mouth of Cedar creek a recent cut off makes a change of nearly four miles in the course of the river. Farther down the river is not so sinuous. The valley is quite broad and deep. The bluffs along the river rise abruptly 120 to 150 feet with a still farther, but more gradual rise back from it of twenty to fifty feet more. The most important tributary which the river receives from the east is Saint Joe creek, which rises well toward the northeast corner of Scott township, flows southeast six miles back of the hills, cuts through the bluffs, runs three miles along the eastern edge of the Des Moines flood plain, and thence west to the river.

On the south side of the Des Moines the drainage lines all run toward the northeast, the river receiving three important streams from this direction, Cedar creek, Coal creek and Bluff creek. These streams have numerous branches and thoroughly drain the region.

In addition to the streams mentioned above there are two others, Cedar creek, in the northeast portion of the county, flowing southeast through Keokuk county to the North Skunk, and Cedar creek in the southeast portion of the county flowing southeast through Wapello and Jefferson counties.

STRATIGRAPHY.

General Relations of Strata.

The surface deposits of Mahaska county consist of the unconsolidated material of Pleistocene age. Below this are the indurated rocks of the Carboniferous. Along the principal stream the Lower Carboniferous or Mississippian rocks are exposed, while over the upland the Upper Carboniferous (coal measures) lie between these rocks and the drift.

Classification of Formations.

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Cenozoic.	Pleistocene.			Alluvium Loess. Drift.
Paleozoic.	Carboniferous.	Upper Carboniferous.	Des Moines.	
		Mississippian.	Saint Louis.	Pella. Verdi.

The indurated rocks of Mahaska county are made up in the main of coal measure strata. These consist largely of shales of all varieties, ranging between the three extreme types of

argillaceous, arenaceous and bituminous. Every gradation between the three, the first a firm, black fissile bituminous shale, the second a loose, coarse, sandy shale and the third a fine grained, compact, blue to gray, argillaceous shale is exhibited. Sandstone also forms a considerable portion of the deposits. It usually exists in thick, heavy beds or as lenses in sandy shales. Coal seams are of not infrequent occurrence, but limestones are rarely found. These rocks spread over the entire county with the exception of certain narrow strips along the streams where they have been cut entirely through and the lower beds are exposed. These lower beds, which belong to the Mississippian or Lower Carboniferous, consist almost entirely of limestones. The upper beds contain thin layers of marl which are usually crowded with various fossils. Below these marly layers the limestone becomes in places interstratified with sandstone bands. The limestone is usually fine grained, compact, ash to brown in color and splits with a clean, conchoidal fracture. The intercalated layers are frequently of considerable thickness. These beds rise at various places along the principal water courses from two or three to as much as fifty feet in height. They usually exhibit sharp, clean bluffs and good exposures. The distribution of the Saint Louis is somewhat irregular. While it is only seen in the neighborhood of the larger streams, it is known to occur at no great depth below the surface at numerous other points.

The surface materials of Mahaska county are in common with those of the surrounding region of Pleistocene age. They are made up largely of till, sand and gravel, loess and alluvium; the latter being found along all the different streams.

DEEPER STRATA.

Our knowledge of the deep-seated rocks underlying Mahaska county is quite limited. It must be derived entirely from the results of deep borings made in neighboring counties. A deep well was put down at Oskaloosa, but the record of the strata passed through does not seem to have been kept with sufficient accuracy to render it valuable for purposes of geological correlation.

A deep well was put down at Sigourney* in the county just east, and it is probable that a well put down in Mahaska county would encounter essentially the same strata.

TYPICAL SECTIONS.

ON NORTH SKUNK RIVER.

MEYERS SECTION.

(Tp. 77 N., R. XVI W., sec. 1, Nw. qr., Se. ¼.)

		FEET.	INCHES.
7.	Drift	2	
6.	Sandstone, white, fine grained, with plant remains	2	
5.	Shale, bituminous	12	
4.	Coal	1	2
3.	Fire clay	1	6
2.	Shale, in part bituminous	10	
1.	Limestone, in ledges of 5 to 20 inches	6	

Of the above section numbers 2 to 6 represent the Des Moines stage, number 4 is Saint Louis. Borings show sixty feet of limestone below the base as exposed.

WILLIAMS MINE SECTION.

(Tp. 77 N., R. XV W., sec. 9, Nw. qr., Sw. ¼.)

		FEET.
5.	Drift, variable	12
4.	Shale, bituminous, containing limestone band one foot thick	14
3.	Coal	4½
2.	Fire clay, variable in thickness from 0 to 5 feet	2½
1.	Sandstone, massive, exposed	2

All of the above section below number 4 belongs to the coal measures. Number 1 is partially exposed at the neighboring bridge over North Skunk.

UNION MILLS SECTION (a.)

(Tp. 77 N., R. XV W., sec. 23, Sw. qr., Se. ¼.)

		FEET.
4.	Drift	4
3.	Glaciated boulders in irregular line	1½
2.	Marl, blue, arenaceous	8
1.	Limestone	5

*Proc. Iowa Acad. Sci., vol. I, pt. iv., pp. 35-38. Des Moines, 1894.

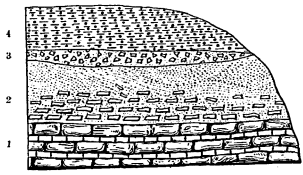


Figure 31. Quarry at Union Mills.

Numbers 1 and 2 of the above are Saint Louis. The coal measures do not appear at the river edge though known to underlie the drift a short distance back on the hill.

UNION MILLS SECTION (b).

(Tp. 77 N., R. XV W., sec. 23. Nw. qr., Se. ¼.)

		FEET.
3.	Drift	12
2.	Shale, bituminous	26
1.	Limestone	6

The limestone of the above section belongs to the Saint Louis. The shale is imperfectly exposed in the lower part and a coal seam may be concealed there.

DRIFT SECTION.

(Tp. 77 N., R. XIV W., sec. 30, Sw. qr.)

		FEET.
4.	Soil	3
3.	Loess	20
2.	Clay, yellow with gravel	10
1.	Alluvium of flood plain	10

The soil graduates into the loess, the latter being slightly modified to a depth of at least three feet.

ROBERTS MILL SECTION.

(Tp. 76 N., R. XIV W., sec. 4, Nw. qr., Ne. ¼)

		FEET.
1.	Limestone with sandstone interbedded; imperfectly exposed (Saint Louis)	12

MC BRIDE MILL SECTION.

(Tp. 76 N., R. XV W., sec. 15, Sw. qr.)

		FEET.
6.	Limestone, gray, sub-crystalline with interbedded fossiliferous marl-layers	10
5.	Unexposed	11
4.	Limestone, ash grey, compact	1
3.	Sandstone, soft, yellow	1
2.	Limestone, as above	2
1.	Sandstone, as above	2

Numbers 1 to 4 are seen under the east pier of the bridge crossing the river at this point. They apparently represent the upper Verdi beds. Number 6 is seen in a small, now disused quarry about 200 yards west of the mill. The hills here rise ninety-five feet above the river and apparently are made up mainly of drift.

COLUMBIA MILL SECTION.

(Tp. 76 N., R. XIV W., sec. 36, Ne. qr., Sw. ¼.)

		FEET.
7.	Boulder clay, yellow	30
6.	Sand	2
5.	Boulder clay, blue	40
4.	Shale, sandy, in part bituminous	15
3.	Coal	6
2.	Fire clay	3
1.	Sandstone, coarse, ferruginous	15

The whole section may be referred to the coal measures. The sandstone, No. 1, is exposed in the wagon road near the mine where it lies at a higher level than under the coal farther east. The shale No. 4 is absent over a considerable portion of the coal field. The coal lies on a level only slightly above the water in the river.

ATWOOD SECTION.

(Tp. 75 N., R. XIII W., sec. 8, Ne. qr.)

		FEET.
5.	Sandstone, coarse, quartzose	2 to 4
4.	Limestone, compact, fine grained	1½
3.	Sandstone as above	3 to 8
2.	Limestone as above	2½
1.	Sandstone as above	15

This section is exposed in a railway quarry in Keokuk county, a short distance east of the Mahaska county line. It

Figure 32. Verdi beds near Atwood.

belongs to the Verdi beds of the Saint Louis which may be seen, not so well exposed, rising twenty feet above the river less than a half mile below the Columbia mine.

ON SOUTH SKUNK RIVER.

THUNDER CREEK SECTION.

(Tp. 77 N., R. XVIII W., sec. 25, Se. qr.)

		FEET.
7.	Sandstone, coarse, quartzose, yellow	2
6.	Limestone, compact, fine grained	1½
5.	Sandstone, coarse, massive, yellow	3
4.	Sandstone as above, with interbedded limestone bands	3
3.	Sandstone, massive, yellow	3
3.	Sandstone, with interbedded limestone, in places conglomeratic	6
1.	Sandstone, coarse grained, cross-bedded; to water-edge	12

This exposure is in Marion county near where Thunder creek flows into the river. The beds are Saint Louis, belonging apparently to the upper part of the Verdi.

BALLENGER'S BRANCH SECTION.

(Tp. 76 N., R. XVII W., sec. 11, Nw. qr.)

		FEET.
2.	Marls, calcareous, in part laminated	2
1.	Limestone, grey, sub-crystalline	2

The outcrop is directly opposite the mouth of Ballenger's branch and down close to the river. From the wall was collected *Productus ovatus*, (*?*) *Rhynconella ottumwa*, *Spirifer littoni* and other Saint Louis forms.

WATER WORKS SECTION.

(Tp. 76 N., R. XIV W., sec. 25, Sw. qr., Se. ¼.)

		FEET.
3.	Drift	30
2.	Shale, bituminous, thickening under the hill	6
1.	Limestone, fine grained, compact	12

This exposure is seen immediately below the Oskaloosa city water works. The limestone is Saint Louis and quite fossiliferous, bearing the Pella fauna. It extends along the river some distance, varying considerably in exposed thickness. The coal measure shales above it are not here exposed to their full thickness.

SPRING CREEK SECTION.

(Tp. 75 N., R. XV W., sec. 4, Nw. qr.)

		FEET.
5.	Limestone, thin bedded, with fossiliferous marls	2
4.	Limestone, compact, grey	2
3.	Limestone, fine grained, white	10
2.	Sandstone, calcareous	4
1.	Unexposed	10

Number 2 of the above section is seen on Spring creek near its mouth. Number 3 is exposed farther up the creek and has been quarried for lime. Numbers 4 and 5 are exposed immediately below the mouth of the creek on the river.

CURRIERS MILL SECTION.

(Tp. 75 N., R. XIV W., sec. 7, Se. qr., Nw. ¼.)

		FEET.
2.	Drift	60
1.	Sandstone, soft, yellow; in irregular layers interbedded with sandy shale, becoming argillaceous toward the base	50

ROSE HILL BRIDGE SECTION.

(Tp. 75 N., R. XIV W., sec. 15, Sw. qr.)

		FEET.
1.	Limestone, brecciated (Saint Louis) exposed 30 feet above the river	10

TIOGA SECTION.

(Tp. 75 N., R. XIV W., sec. 14, Sw. qr.)

		FEET.
1.	Sandstone, soft, yellow, with heavy cross-bedding extending along the river a mile or more; capped in places by limestone	35

HOWELLS MINE SECTION.

(Tp. 75 N., R. XIV W., sec. 36, Nw. qr.)

		FEET.	INCHES.
6.	Drift	30	
5.	Shale, bituminous	12	
4.	Coal	1	10
3.	Fire clay	1	6
2.	Sandstone	6	
1.	Unexposed to river	10	

Farther up the river from this mine, as well as a short distance below it, the middle portion of the Saint Louis is seen to rise a considerable distance above this coal seam, the latter resting in an erosion channel in the former. The upper part of the Saint Louis outcrops near here, is not always clearly exposed, but may be seen at several places to consist of limestone. The sandstone below it is well exposed, the irregular cross-bedding frequently being quite prominent, as shown in the sketch.

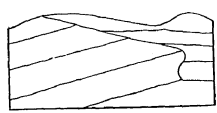


Figure 33. Lines of cross-bedding seen in the sandstone near Tioga.

ON DES MOINES RIVER.

HARVEY SECTION (a).

(Tp. 75 N., R. XVIII W., sec. 4, Nw. qr., Sw. ¼.)

		FEET.
3.	Drift and loess exposed	10
2.	Grey and ash colored marl with abundant fossils	5
1.	Limestone, blue, weathering brown in places, thinly bedded above (exposed)	12

From number 2 of the above section Dr. Keyes collected *Pentremites konickiana* Hall; *Spirifer littoni* Swallow; *Zapherentis pellæensis* Worthen; *Athyris subquadrata* Hall; *Productus marginocinctus* Prout and other forms.

HARVEY SECTION (*b*).

(Tp. 75 N., R. XVIII W., sec. 12.)

		FEET.
3.	Loess and drift	12 to 30
2.	Coal, impure; in part shaly, badly weathered	12 to 15
1.	Clay ironstone, nodules covered with cone-in-cone, partly exposed	3

This is the locality mentioned by Owen for the occurrence of "tutenmergel." The exposure stretches along the river half a mile or more. A short distance below (Tp. 75 N., R. XVII W., sec. 18) is an exposure of Saint Louis as follows:

		FEET.
2.	Limestone, fine grained, blue	12
1.	Sandstone, white, calcareous	8

The outcrop stretches some distance along the river. The section given was measured near the center of the exposure.

BELLEFOUNTAINE (*a*).

(Tp. 75 N., R. XVII W., sec. 19.)

		FEET.
3.	Drift	55
2.	Sandstone, and sandy shales, imperfectly exposed	104
1.	Limestone, with irregular cross-bedded sandstone layers	15

The lowest member of this section is the Saint Louis, and seems to resemble the middle or Verdi beds. It is well exposed on the west side of the river, immediately above the ford. Number 2 represents the coal measures as seen in the hills east of the river.

BELLEFOUNTAINE SECTION (*b*).

(Tp. 75 N., R. XVII W., sec. 3, Se. qr.)

Near the mouth of Cedar creek is seen the section shown in the following figure. The measurements represented are about 200 feet for the horizontal and seventy-five for the vertical. The sandstone at the base is capped by eight feet of compact,

somewhat earthy limestone. Both have been deeply eroded by an ancient water course having a channel with an east and west trend. This channel is filled with dark clay and shale, the

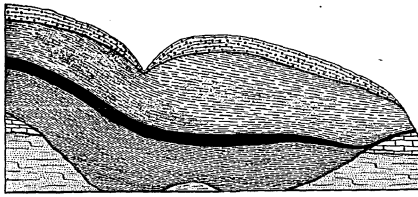


Figure 34. Coal Measures resting unconformably upon Saint Louis; Bellefountaine.

whole rising fifty-five feet above the river. There is a bed of coaly shale, somewhat irregular and rising rapidly toward the east where it is four feet in thickness. Toward the west it thins out to about eighteen inches, rising over the limestone. This layer is covered by thirty to forty feet of argillaceous and sandy shale.

RAVEN CLIFF.

(Tp. 75 N., R. XVII W., sec. 32 and 33.)

This cliff is 137 feet high, and is made up of a coarse grained coal measure sandstone having a dark red color. It extends down to within ten feet of the river, the base being concealed. The stone is massive and gives in places single precipitous faces of fifty or more feet. The exposure extends nearly two miles along an old deserted arm of the river. Near the west end is a small coal seam, probably continuous with the coaly layer mentioned in the preceding section, and lying well toward the base of the sandstone. Immediately below the cliff, well diggings reveal the presence of the upper fossil bearing portion of the Saint Louis at a level slightly above the base of the sandstone.

COAL CREEK SECTION.

(Tp. 74 N., R. XVII W., sec. 1, Ne. qr.)

		FEET.
2.	Shale, bituminous, exposed	2
1.	Limestone, grey	12

In this section the lower member is the Saint Louis, seen at the river. The upper member belongs to the Des Moines beds and is exposed a short distance from the mouth of Coal creek.

GIVEN SECTION.

(Tp. 74 N., R. XVI W., sec. 10, Sw. qr.)

		FEET.
2.	Shale, argillaceous, drab to black	20
1.	Limestone, compact, grey	2

The lower member (Saint Louis) is seen at the river's edge directly west of Given. The upper member (coal measures) is exposed a short distance from the mouth of a small stream flowing into the river at this point.

BLUFF CREEK SECTION.

(Tp. 74 N., R. XVI W., sec. 23, Nw. qr.)

		FEET.
6.	Loess	15
5.	Sand, yellow	5
4.	Gravel, coarse, with erratics	1
3.	Limestone, thin bedded above, heavier below	12
2.	Sandstone, soft	4
1.	Unexposed to river	15

This section is exposed on the east side of the river opposite the mouth of Bluff creek. The surface of the limestone very plainly shows the effect of water erosion.

EDDYVILLE SECTION.

(Tp. 73 N., R. XVI W., sec. 1, Ne. qr., Ne. ¼.)

		FEET.
5.	Drift	20
4.	Shale, bituminous	3
3.	Coal	4½
2.	Fire clay, grading below into shale	20
1.	Limestone, grey, compact, imperfectly exposed	70

The limestone (Saint Louis) is well exposed here along the river on both sides. The coal seam is not now worked.

Geological Formations.

MISSISSIPPIAN SERIES.

The Carboniferous rocks of the Mississippi valley may be divided into two series: (1) Mississippian (Lower Carboniferous). (2) Upper Carboniferous. The former is represented in

Iowa by three formations, the Kinderhook, Augusta and Saint Louis. The Kaskaskia which, in Missouri overlies the Saint Louis, is not present over this region. Of the three divisions of the Mississippian series present in Iowa, only the upper is exposed in Mahaska county.

SAINT LOUIS.

The oldest rocks exposed within the limits of the county belong to this terrain. Their surface, which is characterized by great irregularity, lies at a general level about 120 feet below the present surface. Thus it happens that these rocks are only exposed along the major streams. As a general statement it may be said that the flood plains of the North and South Skunk and Des Moines rivers are underlaid by the Saint Louis. This is not, however, everywhere true of any of these streams.

On the North Skunk river the Saint Louis is exposed north of New Sharon at the Peter Meyer's quarry, the section of which has already been given. Below here no Saint Louis appears until Union mills is reached, the interval being occupied by the beds of the Des Moines terrain, which are seen to lie at or below the level of the water.

The Saint Louis is well developed at the McBride mill and extends down the river from this point a mile or more. It is succeeded by the coal measure area in which the Columbia Coal mines are located, and which is, in turn, abruptly cut off by the Saint Louis extending up the river from Atwood.

On the South Skunk river the Saint Louis is well developed at numerous points as seen in the sections already described. Directly east of Oskaloosa, at Currier's mill, is an area extending along the river nearly two miles in which the coal measures are well exposed down to the water's edge. At each end of this area they are quite abruptly replaced by Saint Louis. A similar instance is seen at Raven Cliff where it seems probable that the coal measure sandstone extends down to the water's edge, though this can not be determined.

With the exceptions just enumerated the Saint Louis will be found to underlie the bottom land of these rivers. In the southeastern portion of the county on Cedar creek (Tp. 74 N.,

R. XIV W., sec. 29, Se. qr., Ne. ¼) a ledge of rock was formerly exposed and some stone taken out for foundation work. The loose blocks remaining on the surface show this to have been Saint Louis. North of Fremont the same rock is exposed along all the streams and it is not improbable that it may directly underlie a portion of this land. The surface is covered with drift and there are no indications by which such areas if present may be separately mapped. Their determination must accordingly be left to future prospecting with the drill.

While the very great irregularities in the surface of the Saint Louis already mentioned, importantly modify the statement, yet in general it is true that the Saint Louis lies under the hills at about the same level as along the streams.

Lithologically the formation is made up largely of limestones. Sandstones form however a not unimportant portion of the formation particularly in the southeastern portion of the county. The limestone is usually a compact, fine-grained, ash grey to blue variety, with a conchoidal fracture. It is in layers usually from six to twenty-four inches in thickness though in places it is thinner bedded. The stone is usually quite free from impurities and burns readily to a good quality of lime; often however it takes on an arenaceous or bituminous facies. The latter is not as common in Mashaska county as in counties farther south and east. At certain points the upper layers of the limestone are interbedded with light calcareous marls which are exceedingly fossiliferous. This is characteristic of the upper portion of the formation. The lower portion of the Saint Louis in this county becomes decidedly arenaceous.

Near Bellefountaine is an interesting exposure (Bellefountaine section a) in which the sandstone layer No. 1, is heavily cross-bedded. Between the sandstone layers there is a thin development of limestone which in weathering stands out and thus brings out prominently the lamination plains. This is represented in figure 35, from a photo taken just above the ford.

In the region adjoining Mahaska county the Saint Louis formation is seen to be made up of three series of beds. The uppermost member is most markedly calcareous, being made up largely of heavy bedded limestones. In its upper portion

the strata becomes thinner bedded and the interstices are filled with a light, calcareous marl which is exceedingly fossiliferous. From the excellent exposures near Pella, in Marion county, these have been called the Pella beds.

The median member of the Saint Louis, the Verdi beds, is the thickest and the one most prominently developed in southeastern Mahaska, southern Keokuk and southwestern Washington counties. It is characterized by a great diversity of

Figure 35. Cross-bedded sandstone near Bellefountaine.

structure containing, as it does, limestones, sandstones and breccias. The formation is prevailingly arenaceous as contrasted with the formations lying above and below it. The sandstones are usually interbedded with thin limestone bands which are frequently more or less cherty in appearance, but in places clear sandstones of considerable thickness are encountered. The brecciated beds, while quite prominent south and east of here, are not often exposed in Mahaska county.

The basal member of the Saint Louis as developed in this region consists of twenty to twenty-five feet of blue calcareous shale, becoming in places an earthy or an arenaceous limestone

and weathering readily into a soft brown mass. This subdivision, which has been called the Springvale beds, does not appear within the limits of Mahaska county.

The sections already described as the Meyer's section, Union Mills section, the upper portion of McBride Mill section, Ballinger's Branch section, Water Works section, upper part of the Spring Creek section, Harvey section, lower part of the Raven Cliff and the Given sections, the Bluff Creek section and the limestone of the Eddyville section, may all be referred to the Pella beds. The Roberts Mill section, the lower part of the McBride Mill section, the Atwood section, the Thunder Creek section, the Rose Hill Bridge section, the Tioga section, and the Bellefountaine sections, may be referred to the Verdi beds. The character of the two formations, as developed in this county, is sufficiently indicated by the details of these sections.

UPPER CARBONIFEROUS SERIES.

The coal measures of Iowa are composed of two different stages, the lower or Des Moines, and the upper or Missouri. Of these the Des Moines terrain is alone present in the region under immediate consideration, the Missouri being represented in the marine deposits of the southwestern portion of the state.

DES MOINES STAGE.

Practically the entire county, with the exception, as already noted, of the low land along the major streams, is underlaid by the beds of this terrain. The general surface of the upland region, as may be seen by referring to the table of elevations, varies in altitude from 822 to 915 feet. This difference is due entirely to the irregularities of the present surface and affects the thickness of the drift formation only. The low lands along the streams vary in elevation from 695 to 718 feet. There is thus an average difference of from 120 to 150 feet between the upland and the lowland. The upper surface of the Saint Louis, as has been explained, is very irregular, yet its general elevation is in the neighborhood of 725 feet, so that almost the entire difference between the upland and the lowland may be reckoned as made up of coal measures and drift.

The relative proportion of these two is not constant. In places the coal measures are entirely absent, the drift resting directly upon the limestone. In others a thickness of sixty feet or more of Des Moines beds intervenes.

As is now well understood the coal measures of this region as a result of the rapid thickening and thinning of the individual strata, are of such an irregular character that no general section which would be true for the entire region can be given. The greater portion of the coal so far worked has been taken from the Muchakinock valley and by reason of the large number of shafts and bore holes put down, the individual strata are perhaps better known here than elsewhere. The following section, being that found at Shaft No. 8 of the Consolidation Coal Co. (Tp. 75 N., R. XVI W., sec. 34, Sw. qr., Se. ¼) is fairly representative.

		FEET.
8.	Drift	18
7.	Shale, grey, argillaceous	32
6.	Coal	1½
5.	Sandstone	4
4.	Shale, bituminous	49
3.	Coal	7
2.	Fire clay, graduating below into grey shale	35
1.	Limestone (Saint Louis)	

Throughout this valley the order of these strata remain approximately the same. The fire clay (No. 2) in the cases where it has been penetrated is usually somewhat thinner, most frequently about twenty feet. Naturally the strata below the coal have not been so thoroughly explored and are not so well known as those above. The bituminous shale (No. 4) is quite constant. The sandstone (No. 5) the upper coal (No. 6) and the grey shale (No. 7) are usually found, though with considerable variation in thickness, wherever they have not been cut away by erosion. An impure, bituminous limestone known as "hydraulic rock" sometimes occurs in the bituminous shale. It frequently happens that the preglacial erosion has cut down into or entirely through the latter.

At the shaft of the Long Brothers Coal and Mining Company in Oskaloosa, the strata present a general agreement with

those of the Muchakinock valley, as seen by the following section:

		FEET.
7.	Drift	60
6.	Sandstone	3
5.	Shale, bituminous	21
4.	Hydraulic rock	1
3.	Shale, bituminous	18
2.	Coal	6½ to 7
1.	Fire clay	4

The full thickness of the fire clay was not here penetrated. The coal, however, is evidently of the same horizon as that formerly worked in the Standard mine just west of Oskaloosa College, at which point it was about twenty-five feet above the limestone. Northeast of Oskaloosa the erosion has cut still deeper, as seen in the mines of the Excelsior Coal Company at Carbonado. Of the coal measure strata overlying the coal at this point, the bituminous shale alone remains, and it does not reach its full thickness. In a slope at mine No. 5, a total thickness of fifteen feet was measured. Its thickness is in parts of the mine still less, and in a few places no shale at all remains. Still farther northeast, in the region between the two branches of the Skunk river, such drilling as has been done, shows that erosion has been even more active; the shale is in most cases quite thin or entirely absent. The coal in this direction also thins considerably, and in only small areas have beds of good workable thickness been so far located.

In the area northeast of the North Skunk river, as shown by the operations of the Columbia Coal Company, the same erosion phenomena occur. The section found here shows only a few feet of shale.

		FEET.
6.	Soil	1
5.	Drift	8½
4.	Shale, bituminous	10
3.	Coal	5½
2.	Fire clay	9
1.	Sandstone	

The sandstone in this section is exposed in the road west of the mine. It is seen here to be a coarse-grained, reddish yellow

to white quartzose stone similar to that found elsewhere in the Des Moines terrain. At the exposures the stone lies at an elevation slightly above that in the section described.

The coal measures, as seen at Currier's mill on the South Skunk river, seven miles east of Oskaloosa, consist of fifty feet of interstratified shale and sandstone. The following represents a typical portion of the exposure:

		FEET.	INCHES.
8.	Shale, with intercalated layers of sandstone three to four inches thick	12	
7.	Sandstone, soft, yellow		3
6.	Shale, blue, argillaceous	2	
5.	Sandstone	1	
4.	Shale	1	
3.	Sandstone	6	
2.	Shale		2
1.	Sandstone	6	

The individual layers as shown here are not persistent even throughout the length of the outcrop.

Both of the Currier's mill and the Columbia mine exposures lie between contiguous outcrops of Saint Louis limestone and in each instance the latter rises a considerable distance above the base of the sandstones. In each instance it is also true that the nearest coal lies above the sandstone. At the Columbia mines this fact has been demonstrated by borings. At Currier's mill there is no coal directly above the sandstone, the drift resting immediately upon it. Back on the hill a short distance is the Bacon shaft, a local mine. The section shown here is:

		FEET.
5.	Drift	18
4.	Shale, bituminuous	17
3.	Coal	5
2.	Fire clay	2½
1.	Sandstone	

The top of this shaft is 100 feet above the river, so that the sandstone No. 1 may be directly correlated with that exposed at the mill. Drilling carried on between the Columbia mine and Currier's mill tends to confirm the impression gathered from the map that the sandstone exposed at these two points is in reality continuous. West of the mill it has not been

definitely traced though certain borings seem to indicate that it bears south and east.

Sandstones do not in this region form a relatively large proportion of the Des Moines formation. They usually cover but small areas and while they frequently attain considerable thickness, with the exception of the thin bed frequently encountered in sinking shafts in the Muchakinock valley, none have been traced over any great extent of territory. In addition to the sandstone exposed near the Columbia mine and Currier's mill the principal sandstone exposures of Des Moines age are in the neighborhood of New Sharon and at Raven Cliff (Tp. 75 N., R. XVII W., sec. 32 and 33). One mile north of the former point a cut on the Iowa Central railway shows twelve feet of coarse red to yellow sandstone, quite soft and heavily cross-bedded. A sandstone occupying the same position is seen at the Peter Meyers brick yard. At this point it is full of stigmaria.

Near Raven Cliff are some of the most interesting exposures in the county. For a distance of two miles along an old channel of the Des Moines there are extensive exposures of sandstone. The bluff here rises to a total height of 137 feet above the water. Nearly this entire height is made up of coal measure sandstone, it being covered by only a few feet of drift. The stone is massive, quartzose, red to brown, rather soft and standing in single precipitous bluffs as much as fifty-two feet high. The lower ten feet is covered by a narrow flood plain deposit. Toward the south the sandstone runs up against the Saint Louis which rises thirty feet or more above the water. (Tp. 75 N., R. XVII W., sec. 34, Ne. qr., Nw. ¼.) On the opposite side of the river it has yielded gently to erosion and good exposures do not occur, though its presence may occasionally be detected for some distance both up and down the river. At the upper, west, end of the exposure the stone is abruptly replaced by twenty feet of Saint Louis limestone covered by coal measure shales containing a small coal seam which has been mined at one or two points. The contact between the sandstone and the shale is such as to indicate that the former occupies an erosive channel in the latter which has cut down

through the shale and into the underlying Saint Louis. Immediately west of where the wagon bridge crosses Cedar (Tp. 75 N., R. XVII W., sec. 3, Ne. qr., Se. ¼) this bed of shale is seen to rest unconformably upon the Saint Louis as represented in figure 34,

The Saint Louis is here represented by about twenty feet of sandstone, much more regular in character than that shown above the Bellefountaine ford (see figure) and which is doubtless its equivalent. Resting on this sandstone is about four feet of compact grey to buff limestone such as is most characteristic of the Saint Louis of this region. Cutting down into both the limestone and the sandstone below the surface of the water, is a channel which has been filled with a dark clay or shale twenty to thirty feet in thickness. Running through this is a bed of highly bituminous shale or impure coal. The latter is quite irregular and rises quite rapidly toward the east where it is four feet in thickness. Toward the west it thins out to about eighteen inches, rising over the limestone. This coaly layer is covered by thirty to forty feet of argillaceous and sandy shale. The coal seam may be traced down to within a few feet of the Raven Cliff sandstone and is abruptly cut off by the latter. It is thus evident that there are two unconformities here. One between the limestone and the coal, the general unconformity between the Des Moines beds and the Saint Louis, and the other marking an erosive period later than the formation of the coal and of sufficient extent and duration to cut down and entirely through it.

An examination of the section preceding, as well as those given on succeeding pages, will show at once that the coal measures of Mahaska county are most largely composed of shale. Shales of two general types are usually encountered. The most common is the bituminous shale, a black fissile form known among the miners as slate. The second form is the argillaceous shale which is usually not so fissile, and is found in all colors, dark and drab to grey predominating. These shales are most frequently known among miners as soapstone. The fire clay found under the coal is usually a modification of the latter, being the upper few feet which served as a

soil to the coal plants when growing. As a result certain chemical changes have taken place, consisting principally of a loss of alkalies and iron, rendering the clay available for refractory purposes. This change does not usually affect more than the upper portion, and the lower part of a thick bed is indistinguishable from the ordinary grey clay shale. Arenaceous or sandy shales are common in coal measures of the Des Moines age, but do not in this county form so prominent a portion of the whole as either the bituminous or argillaceous shales. When encountered the sand content is usually relatively small.

PLEISTOCENE.

Covering the indurated rocks of the Carboniferous is a thick series of unconsolidated materials of much later origin. They are divided into three more or less distinct divisions, the drift, loess and alluvium.

DRIFT.

The drift deposits cover the entire area of the county. They consist here, as elsewhere, of till, gravel, sand, and clay. The till is more widely and generally distributed than either of the other constituents of the drift, and consists of fine yellow clay through which is scattered pebbles and erratic boulders of various sizes. It is seen in nearly every road side cutting and along all the streams.

A blue boulder clay is frequently encountered but does not seem to be so widespread as the yellow clay. When found it is lower than the latter. It has been found filling a preglacial gorge in the Excelsior mines, and here contains frequent pebbles, bits of coal and sticks of wood.

Sands and gravels, while found in the drift, rarely form large beds. Their greater development is along the flood plains of the modern rivers. Eddyville is built upon such a flood plain, the base being an approximately level bench of Saint Louis limestone which is covered by fifteen to twenty feet of loose sand and gravel. The latter has been dug for some time for railway ballast.

Glacial Scorings. The direction of the ice flow over northeastern Iowa has been determined by McGee, and Keyes has

recently summarized the observations on glacial striæ throughout the state. It is of interest to note here that just outside of Mahaska county such striæ have recently been found. Opposite Eddyville, as has been said, the Saint Louis limestone is extensively exposed. It has been quarried at several points. A recently opened quarry showed the stone directly covered by the coarse pebbly clay of the drift. At one or two points there were small patches of the limestone which showed the carving action of the ice. The direction of most of these striæ was S. 42° E. These striæ were, at one point, cut into and across by a later set running S. 70° E.

LOESS.

The loess is frequently encountered resting on the till. An interesting section, showing the relations between the two, is exposed on North Skunk river. (See page 325.)

The loess covers the uplands and has been used at New Sharon and Lacey in clay work. It is more usually found in an altered form, having largely lost its porosity and become more clay-like. There are slight differences in the amount of sand content found at different depths. It very frequently shows an apparent merging below into the yellow clay.

ALLUVIUM.

Alluvial matter is here as elsewhere developed along the principal streams. It consists of the usual dark loamy soil covering the flood plains. Its distribution along the major streams may be inferred from the map showing the extent of the Saint Louis areas in the county since both are practically confined to the bottom lands. There is the important difference however that the Saint Louis only underlies a portion of the bottoms while the alluvium covers all these areas.

Wind Blown Sands.—About two miles southeast of Peoria (Tp. 77 N., R. XVI W., sec. 26) is an interesting ridge of moving sand. It is about thirty feet high and a half mile or more long with a northwest to southeast trend. The sand is loose, fine, and coarsely stratified. It has a motion toward the northeast which has made necessary the removal of several houses which

stood in its path. The sand has covered up several fences and where the road now crosses the ridge the third fence in vertical succession has been put up. The motion has finally been stopped by a grove of trees in its path.

The explanation of the phenomena is not difficult. The combined valleys of the Skunk river and Buckley creek here form a broad bottom land which is bounded by drift hills. These on the east side of the valley have a northwest to southeast trend. Being made up of loose unconsolidated strata and exposed to the prevailing winds from the southwest which sweep across the wide bottom lands, the finer sands on the top of the hill have become ridged up and are driven forward by the wind. While most of the material is doubtless taken from the hill upon which the sand ridge rests, it is not improbable that a considerable portion is deposited by the wind itself which sweeps across the bottom land and when checked by contact with the ridge drops a portion of its load.

Geological Structure.

CROSS SECTIONS.

Harvey to Eddyville (figure 1, plate ix). Near Harvey, just west of the Mahaska county line, the Saint Louis rises to an elevation about equal to that of the railway station at that place, or 718 feet. North and west of here it is covered by seventy-five feet of shale which are in turn seen to be overlain by the Redrock sandstone. South and east the shales are present and contain a seam of coal. The Redrock is not seen below Harvey. At Bellefountaine the middle Saint Louis or Verdi beds are exposed, the heavy sandstone member being finely cross-bedded (see figure 35). Near the mouth of Coal creek, and at other points, the limestone is seen to be overlain by coal measures, as also opposite Eddyville. At the latter place the Saint Louis rises seventy feet above the water. The fall of the river between Harvey and Eddyville is about fifty feet, so that the Saint Louis reaches about the same level at both points.

Along Skunk River (figure 5, plate ix). Near the mouth of Thunder creek, in Marion county, the Saint Louis rises twenty-five to thirty feet above the water, the massive sandstone layers showing that the beds belong to the Verdi. Near Peoria, and south of there on the river, the beds of the upper or Pella division are seen. For some distance southeast from this point no good exposures are found. At the city water works north of Oskaloosa the Pella beds are again exposed, being covered by the black shale of the coal measures. The Saint Louis from this point is exposed almost continuously down to Currier's mill. It forms a well defined terrace about twenty feet above the river. Near the mouth of Spring creek the lower portion is seen to be made up in part of the heavy sandstones of the Verdi.

At Currier's mill the limestone is abruptly cut out, and a bed of sandstone and shale takes its place. This extends only a short distance along the river when the limestone again appears. Through White Oak township the limestone contains thick layers of heavily cross-bedded sandstone, and may be referred to the Verdi. Near the east county line, at one place, a small basin has been excavated in the Saint Louis and is filled in with shale containing a thin coal seam which has been, to some extent, worked.

Atwood to North Skunk (figure 3, plate ix). A mile south of where the North Skunk crosses the county line, the Des Moines beds are seen to overlie the Saint Louis. Southeast from here the only exposures seen belong to the coal measures until Union Mills is reached, where the Saint Louis reappears. It is exposed for some distance along the river, being covered at times by black shale (Tp. 77 N., R. XV W., sec. 26, Se. qr.) and other coal measure strata. At one point (Tp. 77 N., R. XIV W., sec. 30, Sw. qr.) both the Des Moines beds and Saint Louis are cut through by a channel now filled in with drift. At both the Roberts and the McBride mills the limestone is interbedded with sandstone bands. At the latter place the upper layers of the formation also appear with their characteristic fossils.

At the Columbia mine the Saint Louis is again cut out and replaced by the Des Moines beds which extend along the river

nearly three miles. The limestone ledge again appears a mile or more above Atwood. Between North Skunk and Atwood the river falls nearly sixty feet. The top of the Saint Louis at Atwood is twenty feet or more below that at North Skunk, a difference that seems to be due wholly to erosion.

North Skunk to Eddyville (figure 4, plate ix.) At North Skunk the Saint Louis is covered by twenty-five feet of coal measure shale, above which is a sandstone exposed on the railway north of New Sharon. It is seen here to be twelve feet thick and its total thickness is probably not far from twenty-five feet. Nothing but drift is seen between New Sharon and the South Skunk river. At the latter point the Saint Louis is again seen to be covered by shale. At Oskaloosa the Saint Louis is about 125 feet below the surface, the upper sixty feet of this distance being drift and the remainder being beds of the Des Moines stage. At Given the limestone is probably not more than twenty feet below the bed of the Muchakinock. It is exposed in the banks of the stream a short distance south of here and rises in the hills twenty feet or more above the railway track near Eddyville.

Atwood to Harvey (figure 2, plate ix.) Along this line the Saint Louis is exposed at Atwood, south of Rose Hill and at Harvey. Between these points the coal measures are covered by drift. At Oskaloosa the coal lies about 110 feet below the surface, or at an altitude of 733 feet. At Evans it is about fifteen feet below the railway or 728 feet above sea level. Near Rose Hill it lies at about 720 feet, and at other points at about the same level.

DEFORMATIONS.

The structure of Mahaska county is quite simple. The rocks have a gentle dip to the southwest in common with those of the entire state. In the beds of the Des Moines formation local dips in various directions are found, but these are due usually to the slight differences in level brought about during the settling coincident with the solidification of the strata.

The county has been singularly free from disturbances since the deposition of the rocks and the exposures present are due entirely to erosion. The differences in altitude occasionally

noted between different outcrops of the same formation may be referred in nearly every instance to unconformities of erosion.

No deformations of any great extent have been found in the county. McGee in his work on northeastern Iowa has traced several slight anticlinals and synclinals having a general northwest to southeast direction. He thought he found evidence of one or two running parallel to these and crossing Mahaska county. One of these was called the Skunk river and the other the Des Moines anticlinal between which lay Oskaloosa synclinal. Speaking of the latter anticlinal he says: "The Des Moines river unquestionably follows the crest or southwestern slope of a gentler anticlinal by which the sub-carboniferous rocks are brought, not only to the surface, but well up in the bordering bluffs from the central part of Marion county nearly to the extreme eastern corner of the state"*.

So far as Mahaska county is concerned no evidence has so far been found confirmatory of these observations. As has been shown the Saint Louis limestone is exposed along both the Des Moines and the Skunk rivers. While its surface is, in consequence of the profound pre-coal measure erosion to which it has been subjected, quite irregular, it still lies at about the same level throughout the county where exposed.

A line drawn from Atwood to Harvey would cross, though not directly, the Skunk river anticlinal, the Oskaloosa synclinal and the Des Moines river anticlinal. Fortunately the levels along this line are at hand, being taken from the Chicago, Rock Island & Pacific railway. According to this authority Atwood is 721 feet above sea level. Just east of the station the Saint Louis rises ten to twenty feet above the track. At the point where the railway crosses South Skunk the Saint Louis is replaced by coal measures, but a short distance below is seen to lie at about the same level as the track, 718 feet. The coal at Oskaloosa, at the Long mine, lies about ninety feet below the track. This coal belongs to the horizon formerly worked at the old Standard mine where it was found to lie about twenty feet

*Pleistocene History of Northeastern Iowa, Eleventh Annual Report, U. S. Geol. Sur., pt. I, p. 341. Washington, 1892.

above the limestone. This would make the elevation of the Saint Louis at Oskaloosa nearly 733 feet. Other borings in the neighborhood confirm this estimate. At Evans the coal lies at 728 feet and the limestone is known to be not far beneath. At Harvey the limestone is on nearly the same level as the track, or 718 feet, though at Durham and Flaglers it is slightly higher.

A comparison of these levels shows that the total variation in elevation is not greater than that known to be due at numerous points to erosion alone. A number of the deeper mines near Oskaloosa have been carefully connected by barometer levels, and in each case their greater depth was found to be amply accounted for by the greater elevation of the mouth of the shaft. The coal all lies at about the same general level and the differences in the level at which it is reached, are due to the modern topographic features of the region.

While no evidence can be found of a series of deformations running from northwest to southeast, there is some slight evidence of a series running at right angles to that direction. Owen, as early as 1852, called attention to certain evidence of an anticlinal crossed by the Des Moines near Bellefountaine*. The greater part of the difference in elevation noticed here is again due to erosion. In view, however, of the fact that the Saint Louis exposed here consists of the alternating lime and sandstone layers characteristic of the middle part of that formation, while at Harvey above, and at the east end of the Raven Cliff exposure below, the exposures are of the upper fossil-bearing ledges, it is not improbable that a slight anticlinal is in reality present. This appears more probable when exactly similar phenomena are observed on South Skunk, near the mouth of Thunder creek, and on North Skunk near both the Roberts and the McBride mills.

These deformations do not appear to be of great extent and in Mahaska county cannot be directly connected with one another. In Keokuk county to the east similar deformations have been noted and traced across the county.

*Geol. Sur. Wis., Iowa and Minn., p. 115. Philadelphia, 1852.

UNCONFORMITIES.

Two widespread unconformities occur within the strata of the county, and several local unconformities mark time breaks of less extent.

UNCONFORMITY BETWEEN SAINT LOUIS AND DES MOINES STAGES.

The first erosive interval of which we have any record in this county is that which succeeded the deposition of the Saint Louis strata. The time intervening between the Saint Louis and the Des Moines stages and represented further southward by the Kaskaskia deposits of Missouri, is throughout Iowa a period of erosion rather than of deposition. The Saint Louis beds were raised to a considerable elevation above the sea; the waters retreated south and west; a drainage system was developed and the continent was gradually carved into topographic forms not greatly different from those now found.

After a period of time, of the length of which we have no guides for measurement, the land again sank beneath the encroaching waters and the shore deposits of the lower coal measures filled up the irregularities of the old surface. Naturally enough the first deposits laid down in the new series were the coarser sandstones and shales. The former are more usually found filling the irregularities of the old surface, as near the Columbia mine. At Currier's mill sandstone is interstratified with shale, and near the mouth of Cedar creek shale alone is seen. As the conditions became more stable the finer shales and coal seams were formed over these earlier beds.

This unconformity has been noticed by many workers and carefully studied. There are probably no places where it is shown to better advantage than at the localities already mentioned. (See figure 34.)

RAVEN CLIFF UNCONFORMITY.

Local unconformities in the coal measures themselves are by no means uncommon. They have been found at many points and are occasionally encountered in mining. Keyes* has called attention to a profound erosion immediately subsequent to the deposition of the Red Rock sandstone. The Raven

*Stratigraphy of the Carboniferous in Central Iowa. Bul. Geol. Soc. America, II, 277-292. 1891.

Cliff sandstone seems to have been deposited after a similar, if not the same, period of erosion. The argument for its unconformability has already been stated. Its relations to the Red Rock sandstone do not seem to be close. The latter rests apparently conformably upon a series of coal-bearing shales seventy-five feet thick which are unconformable upon the Saint Louis. They may be traced down the river to Raven Cliff where the Raven Cliff sandstone is seen to rest unconformably upon the lower portion of these shales. The Raven Cliff sandstone is then, later than the Red Rock and probably contemporaneous with the coal seam which is unconformable upon the latter. The Raven Cliff sandstone is the latest member of the Des Moines formation found in Mahaska county and cuts through a bed of shales which is apparently connected with those found above the Currier's mill sandstone. The Raven Cliff Rock does not appear to cover any large area. It may be traced on the east side of the river for a few miles but has not been encountered in the mining operations near Evans and Beacon. It seems to have been a local deposit only and lay in a narrow channel cut through the coal measure into the limestone.

DRIFT AND INDURATED ROCKS.

The later widespread unconformity is that existing between the unconsolidated deposits of the Pleistocene and the indurated rocks below. During the period preceding the ice invasion this county suffered profound erosion by which a large proportion of the coal measures was carried away and deep channels cut in the remainder. These channels have been found at several points, but are not well enough known to allow the

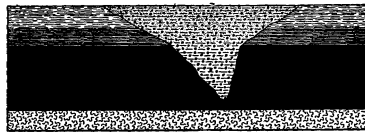


Figure 36. Drift channel in coal; Excelsior mine, Carbonado.

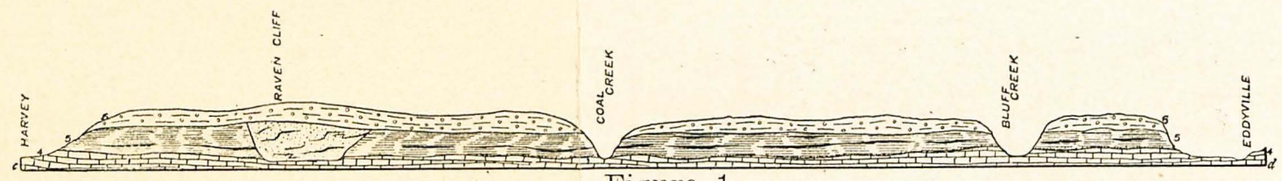
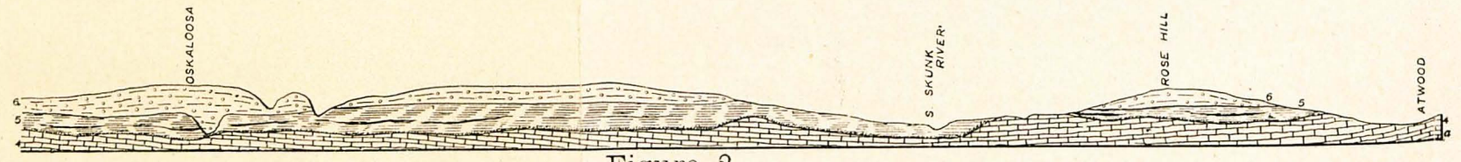


Figure 1.



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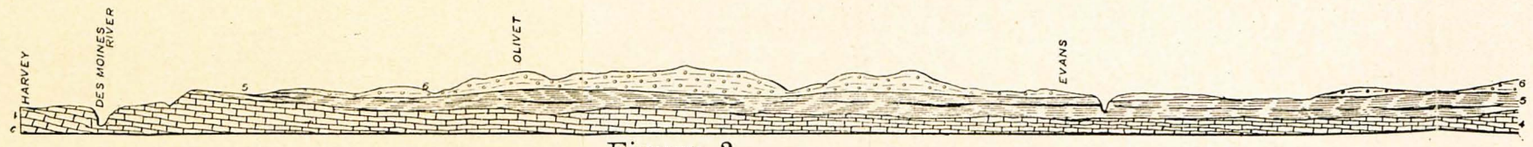

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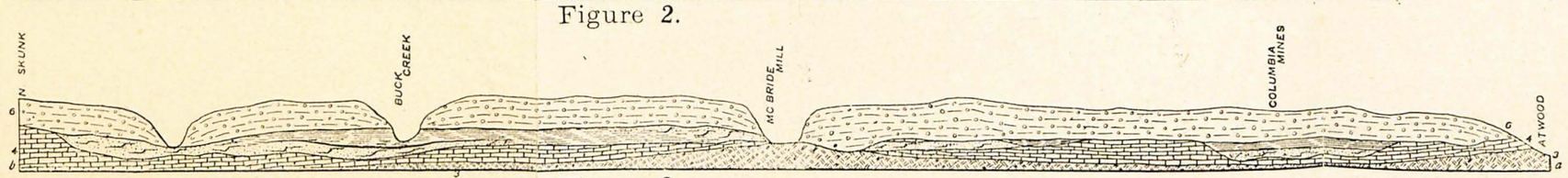
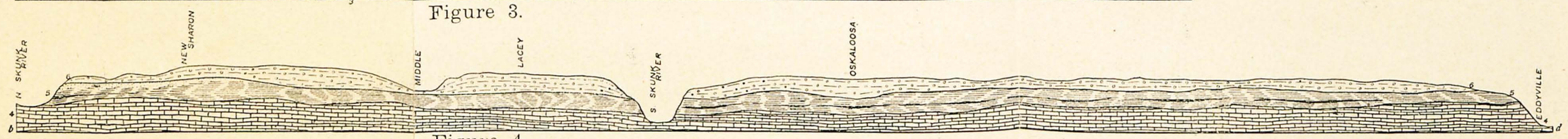


Figure 3.



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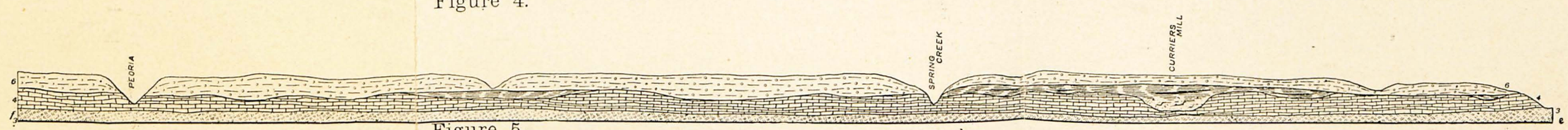

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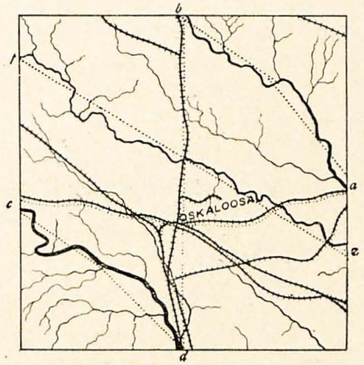


Ver. (200 FEET)

Scale

Hor. (1 MILE)

GEOLOGICAL CROSS-SECTIONS IN MAHASKA COUNTY.

reconstruction of the drainage system of that time. There is some evidence of a deep drift channel running under a part of Oskaloosa, and from there southeast to Fremont, though this has never been accurately traced. In the mines minor channels filled with blue clay containing gravel and wood, or with sand have been encountered at several points. One of the most interesting of these is seen in Excelsior No. 5, at Carbonado. Here in driving an entry such a channel was encountered running from northwest to southeast. It was found to be sixty feet wide at this point, while 300 feet distant, on a parallel entry it did not cut through the coal. The channel has sharp, clear cut sides and it is at one point V-shaped. (Figure 36.) At another the channel is very narrow, and it is filled with loose, red sand. The sides of the coal, as seen here, are polished in a manner suggestive of ice action.

Figure 37. Ideal cross-section in Mahaska county.

These two major unconformities lie above and below the coal beds, and both are factors in the present limitation of available beds. The general relations of the strata are shown in figure 37, an ideal cross section of the county from northeast to southwest.

EXPLANATION OF PLATE.

In plate ix the numbers refer to the various formations as follows: (1) Augusta, (2) Springvale, (3) Verdi, (4) Pella, (5) Des Moines, (6) Drift.

COAL.

MINES.

Mahaska county has long been the most productive coal county in the state. At present there are thirty mines in operation, about

half of the number being commercial or shipping mines with outputs of from 200 to 1,000 tons per day. The annual output for the county is considerably more than one million tons.

Mines are now operated in nine townships, but the mining industry is very irregularly distributed, a very large proportion of the coal being mined within a few miles of Oskaloosa, and the greater portion being obtained within the Muchakinock valley. The mines of the county may conveniently be considered in several groups more or less arbitrarily defined, yet on the whole having a natural basis for classification. These groups include the Buck Creek mines, Columbia mines, Rose Hill mines, Spring Creek mines, Oskaloosa mines, Leighton mines, Evans mines, Beacon mines, Muchakinock mines, Lost Creek mines, Cedar Creek mines and Coal Creek mines.

Buck creek mines. Buck creek is a small stream flowing southwest into the North Skunk river about three miles east of New Sharon. Both Buck creek and the North Skunk in this region flow over the drift which here directly overlies the coal measures. On the latter stream the Saint Louis is exposed within a few miles both above and below the mines, and probably lies at no great depth beneath the coal. Between these two outcrops of the limestone is a small basin in which coal measures occur and over a considerable area of which coal is known to be present. Mines are now being worked here at three points. The most northerly is the Evans mine, a slope located nearly within a mile of the north county line. Near by is the Smith mine and a half mile southward is the Williams opening, all operating in the same coal.

As seen at the latter place the coal is four and a half feet thick though it shows considerable variations and an average for the district would probably be nearer three and a half feet. The section at this mine is:

		FEET.	INCHES.
4.	Shale, bituminous, fissile, below, with one-foot limerock band	14	
3.	Coal	4	6
2.	Fire clay, drab, variable in thickness from 0 to 5 feet	2	6
1.	Sandstone, massive (exposed)	2	

Figure 38. Coal bed in Williams mine, near New Sharon.

The greatest thickness of coal known in this area is six feet, but as stated most of it is thinner. The coal is not greatly faulted, only an occasional small slip being found. It is slightly undulatory in character. The shale is usually, so far as known, of sufficient thickness to afford a good roof.

The mines so far opened in this region have all been small country banks so the extent of the seam is not known. At one point west of the river (Tp. 77 N., R. XV W., sec. 18, Se. qr.) coal has been mined which probably belongs to the same seam. If so the known area extends in an irregular northeast-southwest direction for a distance of three miles with a maximum width of one and a half miles.

Columbia mines.—These mines, which include the two shafts of the Columbia Coal Company and a local mine, are located in the extreme southeast corner of Monroe township a short distance north of Atwood. The Columbia mines have a switch from the Chicago & Northwestern railway, but the other mine is operated for local trade only. A section of the strata at this point has already been given. The basal sandstone seen here has been traced some little distance south and west and is known to attain a considerable thickness.

The details of the section through the coal are as follows:

		FEET.
5.	Blue clay	4
4.	Shale, dark colored, variable thickness	2
3.	Coal, containing some clay-ironstone	6
2.	Fire clay	3
1.	Sandstone, light colored, rather massive (exposed in road near by)	15

Figure 39. Seam of coal in Columbia shaft. Rose Hill.

This coal shows the usual variations with regard to position and thickness. Over a considerable portion of the area of known coal the shale roof has been cut away and a stiff blue clay laid down upon it. This is not suitable for a roof, and hence only a limited amount of the coal can be removed. Its total extent is not known. The coal measure may be traced some distance up the river as indicated by the presence of shale at one or two points. Prospect holes also reveal the presence of coal measure shales on sections 20 and 30 of the adjoining township in Keokuk county (Tp. 76 N., R. XIV W.) though no workable coal is known to exist nearer in that direction than the What Cheer mines. It is not probable that the Columbia coal extends over more than a limited area.

Rose Hill mines.—The mines near this place do not strictly belong to one group, but may be conveniently grouped together under a single heading. Three miles northwest of Rose Hill is the Bacon mine, now operated by Michael Carey. The coal found here is stratigraphically above the coal measure sandstone exposed at Currier's mill. It is five and one-half to seven and a half feet in thickness. There is a slight difference in the quality of the upper and lower coal, the upper appearing brighter and heavier though there is no true parting. The roof is a dark shale of good quality throughout. About one mile west (Tp. 75 N., R. XV W., sec. 1, Nw. qr.) a coal believed to belong to the same seam was formerly mined.

Four miles southwest of Rose Hill and on the opposite side of the river, coal has also been mined some distance back from the river. The Bolton mine, located at this point, is worked in a coal occupying a position but little above the Saint Louis. The section of the shaft shows:

		FEET.
4.	Drift	30
3.	Shale, bituminous	25
2.	Coal	3½
1.	Fire clay	

The exact distance intervening between the coal and the limestone has not been ascertained. A mile and a half northeast of the Bolton mine (Tp. 75 N., R. XIV W., sec. 16, Sw. qr.) coal presumably of the same horizon was formerly reached by a drift driven in from the river. A short distance east of this drift at the bridge south of Rose Hill, the limestone appears, as well as in the hills opposite this old mine.

Seven miles southeast of Rose Hill, or four miles north of Fremont there is a small coal measure area. The coal is twenty-two inches thick and is covered by about twelve feet of shale, the whole occupying a narrow gorge gouged out of the Saint Louis. The coal is reached by a drift, and only one small mine, the Howell, is in operation. The coal measures extend for a half mile or less along the south bank of the river, but do not appear on the north side.

The coal apparently has only a limited extent as the Quarton prospect shaft, a short distance northeast of Fremont, showed hardly enough coal to be distinguished from the shale. The section passed through by that shaft was as follows:

		FEET.
5.	Drift, sand, gravel and clays	70
4.	Shale, black, fissile, coaly below	8
3.	Fire clay	2
2.	Shale, grey, indurated, somewhat sandy	10
1.	Saint Louis limestone, fossiliferous	30

Spring creek mines.—About two miles northeast of Oskaloosa at Carbonado is a group of mines including shafts 4 and 5 of the Excelsior Coal Company and the Hoover mine. These all

work the same coal which lies at a depth of about 15 to 90 feet below the general level of the country. The Excelsior mines ship over a switch from the Iowa Central railroad and have been in operation for five years. Before they were opened the company operated mines in the Muchakinock valley. The Hoover mine is older and takes coal from territory completely surrounded by that of the Excelsior Coal Company. It is operated for local trade.

The following measurements represent the average details of the beds:

		FEET.
4.	Shale, argillaceous, grey; with some plant remains	10
3.	Shale, bituminous, fissile; with many plant remains	1½
2.	Coal	6
1.	Fire clay, exposed	3

The coal is of good quality and presents usually a good workable thickness. It shows considerable variation in altitude, this variation being in places so rapid as to make the haulage difficult. A tail rope is used on the main haulage ways in the Excelsior mines. The roof has been badly weakened by erosion, and in places is entirely cut away. The drift channel encountered here has been already described.

Southwest of the Carbonado mines and within the limits of the city is the Economy mine which takes coal from a depth of eighty feet. The coal is four and a half to five and a half feet in thickness and covered by thirty-five feet of grey shale. Near this mine in the pit of the Oskaloosa Paving Brick Company a coal seam is exposed which is doubtless a continuation of that at the Economy mine. The coal at these two points serves as a connecting link between the coal of the Spring creek and Oskaloosa districts. Though the coal of these districts is probably not now directly connected, it is not unlikely that at one time it was and that the separation is due to later erosion.

Oskaloosa mines.—While there are places under Oskaloosa where coal has been cut away or is only thin and of poor quality the greater part of the city is built over a good coal bed. A number of small mines were formerly operated just north of town, but these are all abandoned. South and west of the city good coal is mined at several points.

The Long Brothers Coal and Mining Company operate a mine in the southern part of the city. They have a switch from the Burlington & Western railway and also ship on the Chicago, Rock Island & Pacific.

The coal lies at a depth of 110 feet. It varies in thickness up to eight feet, the average being from six to six and a half. It is usually quite level, the undulations being neither rapid nor great in total variation. A washout north and west of the shaft has been traced some distance. The coal found at the Long mine is probably identical with that exposed at the Guthrie brick yard and mined at several points near there. The mines now working it are small and supply a local trade only, though formerly some of the large and important mines, including the Acme and Standard (Tp. 75 N., R. XVI W., sec. 14, Se. qr.) obtained coal from this horizon.

The mines now working include the McFay and Cook slope where the coal is four feet four inches thick, the Andrews mine, a shallow shaft having coal varying from three and a half to five feet thick, and the Guthrie mine sixty feet deep and with coal from five to seven feet thick, all located north of the Chicago, Rock Island & Pacific railway. Between the main line and the Beacon cut-off track are two small mines. At Logue's mine, a shaft, the section shows:

		FEET.
3.	Drift	16
2.	Shale, bituminous	20
1.	Coal	3 to 4

This coal is also reached by a slope just south of this mine and may be a higher seam than that met in the others, though more probably, it is the same. In the same section is Mine No. 1, of the Oskaloosa Coal Company located on a switch from the Iowa Central railroad. The coal is here from six to seven feet in thickness and is reached at a depth of eighty feet.

Leighton mines.—The mines of this and the succeeding groups with the exception of the Cedar Creek and Coal Creek mines all fall within the Muchakinock valley and to a certain extent belong together. Inasmuch, however, as they are not known to constitute a continuous coal seam, but rather are

known in many cases to be discontinuous and to belong to different basins, it seems best to consider them separately.

The coal near Leighton and Fishville lies near the surface and has been reached in part by drifts and slopes. The Davis mine, formerly known as the Leighton, is a shaft thirty feet deep with coal five feet in thickness and with a good hard roof. Near this mine are a number of abandoned drifts formerly known as the Hoover mines. The Patterson mine, southwest of the Davis, is seventy-six feet deep and works in coal four and a half to five feet thick. Near the Fishville station is Fishville mine No. 2, a shaft fifty feet deep. The section exposed in this mine is:

		FEET.
3.	Shale, dark gray, exposed	5
2.	Coal	3½ to 5½
1.	Fire clay, exposed	2

Evans mines.—The American mine, located a half mile west of the railway station on the Chicago, Rock Island & Pacific railway, is one of the largest mines in the state. It has been in operation fifteen years, in which time the workings have extended south nearly two miles. The coal is hauled to the foot of the slope in trains of twelve to fifteen cars by a continuous rope and is there hoisted to the dump in trains of six cars by an independent rope. The main hauling is done on two parallel entries one for ingoing and the other for outgoing cars.

A bore hole near the mine (Tp. 75, N., R. XVI W., sec. 18, Sw. qr.) showed the following strata:

		FEET.	INCHES.
6.	Drift	18	
5.	Shale, grey	8	
4.	Coal	1	
3.	Shale, grey	25	
2.	Shale, bituminous	47	
1.	Coal	6	2

The coal is reached at the mine by a slope and lies about fifteen feet below the railway, or at an altitude of about 728 feet. It varies in thickness from five to seven feet or more but averages a little over six feet. A section measured as follows:

		FEET.	INCHES.
4.	Shale, grey, somewhat fissile, often banded in layers of grey and white, exposed	4	
3.	Coal, often with a local development of a four-inch cannel-like layer in the lower part		10
2.	Shale, black, bituminous, fissile, many coal plants		3
1.	Fire clay, white, exposed	3	

The parting shown here is not always present, being in fact usually absent. It consists of a hard cannel-like layer, which while having the appearance of bony coal really burns as well as the remainder. Ironstone nodules and bands occur in parts of the mine, being usually found near the top of the seam. There occurs at one point a mass of this material twelve feet in length and two feet in thickness.

A number of small faults have been found in the mine one being represented in figure 38, where the line of movement in passing through an irregular band of ironstone has been deflected from its course. The American Mine now only takes

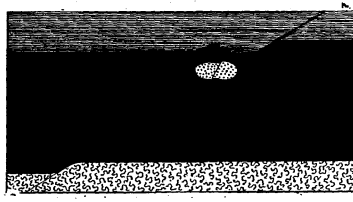


Figure 40. Fault in American mine, Evans. Line of slip passing through ironstone.

out coal from south of the railway, but it is expected soon to open up territory lying immediately north of the present opening.

Near Olivet some coal has been mined for local purposes and a mile and a half south of Evans is the Hull mine also supplying local trade.

Beacon mines.—Coal has been extensively mined in this vicinity for many years and there is a considerable number of

abandoned mines. Those which are now working belong in reality to three groups of two each. How closely the coal of these different groups is connected can not now be stated. It is more than probable that areas of low coal separate them.

The Garfield Coal Company operates a slope mine about one mile west of Beacon station using tail rope haulage and shipping on the Chicago, Rock Island & Pacific. The section as measured in the mine is:

		FEET.	INCHES.
4.	Shale, bituminous, with fossils in pyrite, full thickness 30 to 40 feet; exposed	8	
3.	Coal	5	2
2.	Fire clay	2	
1.	Fire clay with considerable grit	1	

The coal shows the usual variation in thickness, but the above section is a fair average. At one point the coal is divided by a layer of shale as shown in the accompanying figure,

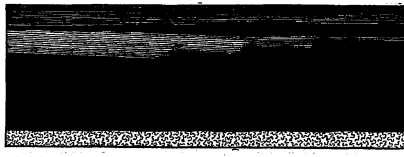


Figure 41. Shale bands in coal seam. Garfield Mine, Beacon.

which probably represents an incursion of sediment during the formation of the coal. An impure limerock containing brackish water forms, occasionally makes its appearance above the coal. The Beacon Coal Company operates a small slope near the station.

There is a small stream flowing into the Muchakinock from the northwest just below Beacon. A spur from the Chicago, Rock Island & Pacific railway has been built up this stream. On it are located the Green mine and the Oskaloosa No. 2, about two miles west of the station. The coal at the two mines is essentially the same, running up in places to seven and a half

feet in thickness with an average of about six feet. It has the usual black shale roof, here quite fossiliferous.

A mile and a half south of Beacon is an area of coal which is being opened up by two mines, the Consolidation No. 8 and Oskaloosa No. 3, both having connection with the Chicago, Rock Island & Pacific and both having been recently opened. The section of the former has already been given and that at the other does not differ essentially. The coal in this basin is marked by greater irregularities in position and thickness than that worked farther east. The presence of impure limestone or "hydraulic rock" is more frequent; six feet of this rock being found immediately over the coal at the Oskaloosa shaft. In the Consolidation No. 8, the usual number of small faults and rolls is found. There are also two points at which the action of underground water is shown in cutting out the strata below, probably in part the Saint Louis, which is known here to be not far below the coal, and allowing the coal to be crushed down into the depression. The phenomena are identical in all particulars with those seen in limestone countries and known as sink holes. At one point in the mine such a hole twenty-one feet in diameter was encountered. The fire clay had washed down into it and the coal above had in part given way. The passage was sufficiently clear to act as a drain. At another point the coal has given way beneath the pressure and the area is now one of loose, finely broken or crushed coal, with fine calcite seams.

The upper coal seam is exposed in the ravine near Mine No. 8. It is here quite thin as shown in following section:

		FEET.
3.	Limestone, impure, bituminous	1½
2.	Coal	1
1.	Sandstone, exposed	4

Muchakinock mines.—The mines formerly located at Muchakinock have been worked out and abandoned, the newer mines being located farther north. The greater part of the area underlaid by the Muchakinock coal has already been exhausted as it has been worked as heavily as any coal in the state. In addition to the Consolidation mines, the old Excelsior mines drew

their supply from this basin. The coal lies in an irregular area about two and one-half miles east and west by three and a quarter north and south. Its eastern limit is just beyond the mine of the Iowa Fuel Company at Colon, and its northern runs just north of the Consolidation mines 6 and 7. The coal does not connect directly with that of the other basins, low coal shales and "hydraulic" rock occupying its place along the dividing lines. The bed lies at a general elevation of thirty feet above the underlying limestone with fire clay, graduating below into shales, between. The upper coal is usually found wherever the cover is sufficient to have protected it. It varies in thickness from one to four feet, but it is poor quality and of no value.

There are three mines now working in this basin all being large and well equipped and having connection with the Chicago & Northwestern railway. They are Consolidation No. 6, Consolidation No. 7 and Iowa Fuel Company. At the first the section passed through by the shaft was:

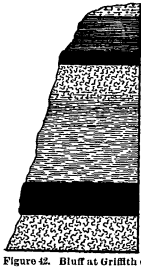
		FEET.
6.	Drift	70
5.	Shale, grey, argillaceous	28½
4.	Coal	2
3.	Sandstone	3½
2.	Shale, bituminous	40
1.	Coal	7

At No. 7 the shaft is not so deep and the strata over the black shale have been cut away, drift taking its place. At the mine of the Iowa Fuel Company the "hydraulic rock" forms the roof over a part of the mine. This overlies the coal for a distance of 150 feet from the shaft. The coal varies from four to six and a half feet in thickness. A section measured in the mine showed:

		FEET.
3.	Shale, bituminous	1½
2.	Coal with occasional pyrite near the middle of the seam	5½
1.	Fire clay, exposed	2

West of Given is a small coal area distinct from that of Muchakinock yet closely related to it. Formerly a considerable number of mines were operated in it, but now the Griffith,

a local mine, is the only one running. The bluff near the Griffith mine shows the following:



		FEET.
6.	Soil	1
5.	Shale, dark grey, somewhat fissile	3
4.	Coal	1
3.	Fire clay, and clay shale	10
2.	Coal	3
1.	Fire clay (exposed)	3

Figure 42. Bluff at Griffith drift; Given.

Lost creek mines.—Southeast of the Muchakinock mining district is one from which considerable coal has been taken. The mines along Lost creek itself were small local mines and are not now worked. The principal mine now in operation is the Pekay mine of the Whitebreast Fuel Company. This is located on a branch of the Iowa Southern railway connecting at Pekay junction with the Iowa Central. The coal here varies from four and a half to six feet in thickness one section showing:

		FEET.
3.	Shale, dark colored, greatest thickness observed	8
2.	Coal, normal thickness	6
1.	Fire clay and light colored shale (exposed in entry below fault)	9

A "hydraulic rock" occurs over the slate in places and frequently comes down close to the coal.

The coal outcrops on the creek west of the mine. It forms a separate basin being cut off from the coal north and west by the usual poor coal and hydraulic rock. The area east shows thin coal in pockets, the better portion of the field running off to the southeast.

Figure 42. Fold and step-fault at Pekay mine.

An interesting step fault occurs in the main entry near the shaft. In a distance of twenty-five yards going south the strata rise nine feet. Then there is a fault having a throw of about two feet. Five yards farther on there is a drop of five feet. From this point the strata gradually fall by a series of flexures, reaching to the level of the track in a distance of twelve yards. Northwest of the Pekay mine is the Perkins, a small local mine. About three miles north of Eddyville prospecting has shown the presence of an area of thick coal in which a mine is to be opened at once. It will be connected with the Iowa Central railway by a spur.

Cedar creek mines.—Near the mouth of Cedar creek is a small seam of coal as already mentioned. This has been worked for local purposes at one or two points near Tracy. The Hallowell and Ream mines, working only in the winter, obtain coal from this seam.

Coal creek mines.—In the area southwest of the Des Moines river but little coal mining has been done, the absence of a railway probably being the main retarding cause. Along Coal creek shale and coal outcrop at numerous points. Near Eveland postoffice an impure coal seam ten feet thick shows in the creek. The section here is:

		FEET.
3.	Sandstone, shaly	12
2.	Coal, impure, shaly	10
1.	Fire clay, seen in mine	3

A drift, the Richardson, is operated in this coal. Of the whole section exposed barely four feet are worth mining and of this a

considerably less amount is really valuable. Other mines have at times been operated near here.

Figure 41. Coal near Eveland.

COAL LANDS.

The territory in the southwest has been in part prospected by drilling and is known to contain considerable thick coal which, however, lies as usual in irregular basins of small extent. A considerable amount of it can be profitably mined, 200 acres now being held by one company. A large proportion will however, never sustain anything larger than local mines. The Muchakinock valley has so far proven the most productive portion of the county. The lower part of the valley has been heavily worked and contains but little undeveloped territory. Farther north, between Evans and Pella, there are large areas of land which may prove productive. Thick coal is known to occur at one or two points. In the southeast the coal, so far as known, is thin and scattered. It is not improbable that considerable areas are not even underlain by coal measures but the facts are not known with sufficient accuracy to admit of

detailed mapping in this particular region. Between the two branches of the Skunk river, while prospecting has so far revealed the presence of thin coal only, thicker veins probably occur. In the northeast there are probably considerable areas of workable coal. The drift is thick and very little drilling has been done.

In general it may be stated that all the area marked on the map as Des Moines is legitimate ground for prospecting, though only a part of it will ever be found to contain workable coal. The exact limits of the individual coal basins can only be determined by thorough prospecting with the drill.

Mahaska County Mines.

NAME	Township N.	Range W.	Section.	Quarter	¼
American	75	XVI	18	Nw	Ne
Andrews	75	XVI	14	Sw	Se
Bacon	75	XIV	6	Nw	Ne
Bolton	75	XIV	20	Sw	Ne
Carbonado 4	75	XV	8	Sw	Ne
Carbonado 5	75	XV	8	Sw	Se
Columbia	76	XIV	36	Ne	Sw
Consolidation 6	75	XVI	36	Nw	Ne
Consolidation 7	75	XVI	36	Ne	Ne
Consolidation 8	75	XVI	34	Sw	Sw
Davis	75	XVI	1	Sw	Nw
Economy	75	XV	18	Ne	Sw
Evans	77	XV	8	Ne	S½
Fishville	75	XVI	12	Ne	Ne
Garfield	75	XVI	22	Sw	Se
Green	75	XVI	28	Ne	Ne
Guthrie	75	XVI	13	Ne	Nw
Hoover	75	XV	8	Ne	Sw
Howell	75	XIV	36	Nw	Ne
Iowa Fuel Company	75	XV	31	Ne	Ne
Logue	75	XVI	23	Ne	Nw
Long	75	XVI	24	Ne	Ne
McPay	75	XVI	14	Sw	Se
Oskaloosa 1	75	XVI	23	Se	Nw
Oskaloosa 2	75	XVI	28	Ne	Nw
Oskaloosa 3	75	XVI	34	Se	Ne
Patterson	75	XVII	2	Se	Se
Pekay	74	XV	20	Nw	Nw
Perkins	74	XV	19	Ne	Nw
Ream	75	XVII	32	Ne	Nw
Richardson	74	XVII	10	Sw	Se
Smith	77	XV	9	Ne	Sw
Tompson	74	XV	18	Sw	Sw
Williams	77	XV	9	Sw	Nw

CLAYS.

DISTRIBUTION AND CHARACTER.

Mahaska county is well supplied with excellent material for the manufacture of clay products. The coal measures, drift and the alluvial deposits all furnish material of considerable value. As has been explained the coal measures practically underlie the entire county. They are made up to a very considerable extent of shales. These shales have three type forms, arenaceous shales, bituminous shales and argillaceous shales, with an infinite variety of inter-forms. The arenaceous or sandy shale grades on the one hand imperceptibly into solid sandstone, and on the other into argillaceous, or clay shales. Rarely it grades directly into the bituminous form. The latter may become more and more bituminous until it becomes a bony coal from which the transition into good coal is often seen. It may on the other hand lose its bituminous content and become an argillaceous shale. The latter is the form in which the great mass of the coal measure shales of the region occur, the others representing exceptional developments or facies. It is also the form valuable in clay work. The others can not be used alone and only to a limited extent in connection with clay shales. The latter are usually drab to blue in color, though the most brilliant colors, such as red and yellow are also found. Clay shale occurs in beds of considerable thickness all through the coal measures and affords the best of material for common brick and tile, paving brick, sewer pipe and other coarser grades of clay ware. It is often of considerable purity and adapted to the manufacture of various forms of pottery. This grade of clay when found in close connection with the coal seams is known as fire clay. Not all of the material, however, known by that name in mining regions is of the same grade, and not all of it can be used for refractory wares. Nevertheless there are here abundant supplies of such material of excellent quality. It has so far only been used experimentally for local purposes.

The clays which are of glacial origin are found in the upper portion of the drift. Those which occur in the lower portion

are too impure for use. They belong to the till and are filled with gravel, sand and other impurities. The upper clays, which are found throughout the county covering the higher lands are probably derived from the loess by alteration. The upper portion is oxidized and altered into a soil. In this form it is used for the manufacture of hand-made brick exactly as alluvium is used. The greater portion of the clay is, however, taken from beneath this soil layer, a thickness of ten to twenty feet being usually available. This clay is drab to blue with blotches of yellow. It does not usually show stratification. Jointing is frequently developed. It exists in large quantities, in a pure state, is easily worked and burns to a good color. The chief difficulty to be encountered in its use is that of checking while drying. Great care must be used to prevent this. The clay will not dry rapidly and so far patent dry houses have been only measurably successful.

In addition to the two sources of material mentioned above there is a third. In this county as elsewhere the flood plains of the larger streams, and to some extent of the smaller streams also, are made up of alluvial material. This is the black, loose textured soil which covers the bottom lands. It has long been used for the manufacture of brick. It is everywhere available, easily worked, and makes a good grade of common brick.

CLAY INDUSTRIES.

NEW SHARON.

Martin and Burket have a new and well equipped plant at the north edge of town. The clay used belongs to the Pleistocene being the altered loess described above. It is mixed with about ten per cent of a soft coal measure sandstone which is ground and mixed with the clay. It is moulded on a Freese machine and dried in an Andrews dry house. This has a capacity of 28,000 brick, or 14,000 tile. The brick and tile are loaded on No. 70 Raymond cars at the machine and run directly into the dry shed. The brick drys in about five days and the tile in half as long. The product is burned in down draft kilns, being water-smoked two days. An excellent grade of both brick and tile with a good color is made.

Peter Meyers operates a small brick plant one and a half miles north of New Sharon. The clay now used is a drift clay similar to that used at the Martin and Burket factory. Coal measures also occur, and both shale and fire clay have been used experimentally with good results. The material is moulded on a Penfield machine, dried under open sheds, and burned in a down draft kiln.

LACEY.

Charles Hull manufactures brick and tile at this point, the factory being located on the Iowa Central railway at the north edge of town. The clay is of the usual character being taken from the loess. It is obtained from a railway cut near the factory. The clay is moulded on a Penfield machine and dried under closed sheds. It is burned in two down draft kilns. A center draft kiln is also used and has given excellent satisfaction. It burns the brick more evenly than the others.

BARNES CITY.

Just southeast of the depot is a brick yard. The clay is taken from a cut at the end of the yard and is of the loess type already described. It is worked as a stiff mud, dried on plates under sheds with canvas curtains and burned in cased kilns. The brick have a good color.

OSKALOOSA.

The Oskaloosa Paving Brick Company has a large plant about one mile east of the square on a switch from the Chicago, Rock Island & Pacific railway. The material used is largely of Des Moines age, though some drift clay is mixed with it. The section exposed in the pit is:

		FEET.
5.	Drift, largely altered loess with some gneiss pebbles and a few large boulders dissiminated in it	20
4.	Shale, blue; makes a good brick, but does not stand the frost as well as the bottom shale	10
3.	Shale, very bituminous, "black jack"	2
2.	Coal, good quality; apparently the attenuated edge of a six foot seam formerly worked on the southern slope of this same ridge	1½ to 2
1.	Shale, grey, homogeneous except for thin lines of coal and occasional pyrite balls; plant remains abundant	30

The shale is mixed with drift clay in the proportion of about four to one. A Galesburg dry pan crusher is used, a Penfield temperer and a large Penfield brick machine. The brick are dried in a Standard dry kiln. The total capacity of the kiln is 40,000, and the brick are dried in twenty-four hours. In burning three large Dewhurst and two clamp kilns are used, the brick being water-smoked two or three days and burned in about twelve. The company has a large annual output mainly of paving brick, only a few building brick being made.

The L. C. Guthrie plant is located a half mile west of Oskaloosa on the extension of Third street. The section as seen in the clay pit here is as follows:

		FEET.
6.	Soil	2
5.	Gravel, fine	2
4.	Clay, yellow, jointy	12
3.	Clay, blue, shaly	13
2.	Coal	3
1.	Fire clay	?

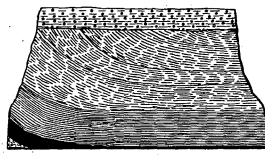


Figure 45. Clay at the Guthrie clay pit.

Of the above section Nos. 5 and 6 are Pleistocene age while all below may be referred to the Des Moines terrain. The disturbance shown in the sketch is not due to the settling resulting from the mining of the coal seam under the surrounding territory, but has taken place before the gravels of the Pleistocene were deposited as shown by the figure. The clay used is from Nos. 3 and 4 of the above section. It is moulded on a Kilk & Soris (Arian, Mich.) brick and tile machine, dried under

open sheds and burned in cased kilns. The product is of excellent quality. This factory has not been in operation since the season of 1893.

Mr. N. Logue is located just west of Guthrie. This yard has been in operation for a number of years and has an important trade. The clay corresponding to No. 1 of the Guthrie section is mixed with the black surface soil taken from a neighboring field in the proportion of 1 to 3. The bricks are hand made dried in the sun and burned in cased kilns of which four are now in use.

Northeast of Oskaloosa on Spring creek the alluvium has long been used for brick. Mr. Wes. Kirkham operates a yard. The material gathered from the immediate vicinity is worked by hand, sun dried and burned in cased kilns. Mr. Sam Kirkham has recently opened a similar yard in the immediate vicinity.

FREMONT.

John Dawson and Company have long manufactured brick and tile at Fremont. The works are located directly east of town on the Iowa Central railway. The clay used is glacial, being an altered loess similar to that used throughout the region. It is mixed with one to one and one-half per cent of coke and cinders obtained by grinding the furnace ash. This causes the clay to dry more easily and lessens the loss from checking of the ware. Coal slack has also been used, but proved not to be so satisfactory as the cinders. Experiments have also been made with saw dust. One Bennett brick and tile machine is used, and there are closed drying sheds in which the ware dries in from one to two weeks. The burning is done in Dawson kilns. The fire brick needed are made on the place from fire clay obtained at Kirkville. That occuring north of town on the Skunk river has also been experimented with, but the results so far have only been moderately successful.

EDDYVILLE.

A considerable number of the older buildings in Eddyville were made of brick manufactured in the vicinity. Of recent years the brick yards have not been very extensively operated.

James Heki is opening a new yard a short distance north of town where hand-made brick will be made from the alluvial material covering a small bottom land. A cased kiln will be used in burning the product.

Mr. Frank Harbor is also opening a yard not far from Consolidation Mine No. 8, some distance north of Eddyville. Alluvial materials will be made up by hand.

BEACON.

About one and a half miles south of Beacon Mr. William Crossin burns a few brick. Alluvial material from the bottom land of the Muchakinock is used, being moulded by hand and burned in cased kilns.

POTTERIES.

The only pottery in the county is that of Klinkoff Brothers, about three miles north of Eddyville. The clay used outcrops near the old Excelsior No. 5 mine, and is hauled from there to the pottery. Other clays have been tried, that from the Pekay mine being found to be quite good. Clay from a mile and a half north of Frederick is too sandy to be used alone, but mixed with one-fourth of fire clay makes a good ware.

The Excelsior clay alone is now used. It is soaked one hour and then ground in a pit and moulded on wheels. Three wheels are now in use and another is to be put in operation soon. The ware is dried over a furnace in about two hours. It can be dried in the sun. It is burned in a 10 by 11½ foot up draft kiln in about thirty-six hours, mainly with coal. Wood is used to finish the firing. The output consists of jugs, jars, churns, milkpans, flower pots and similar wares varying in size up to fifteen gallons. Black ware only is made, though a good grade of white ware will soon be put on the market. The operation of the pottery was suspended for a time, but work has recently been resumed. In former years about 90,000 gallons were sold annually, the output going mainly to Oskaloosa and neighboring towns.

LIME.

In the earlier days lime was burned at a number of points throughout Mahaska county. Recently the competition of the

Port Byron and the Louisiana limes has nearly forced the local product out of the market.

The limestone found within the county is not of the best quality for lime. A good rock for lime-burning must be free from impurities. A perfectly pure limestone ($Ca\ CO_3$) is rarely or never found, the rock containing some if not all of the following impurities: silica, alluminum, oxide of iron, oxide of magnesia, and traces of the alkalies. The presence of these influence largely the reactions which occur during the process of manufacture and use. It has been found that the presence of magnesia under certain circumstances is beneficial, yielding a lime of greater strength and which stands the weather better. It is very largely this which gives the limes from eastern Iowa their pre-eminence. Limes made from rock containing less than ten per cent of the ingredients mentioned above are called common, fat or rich limes. They have a specific gravity of about 2.3, are amorphous, somewhat spongy, highly caustic, quite infusible and possess a great avidity for water. In the process of slacking their volume is augmented from two to three and a half times the original mass. In hardening into carbonate of lime they shrink so much that they cannot be used as mortar without being mixed with sand. They have no hydraulic properties and are unsuitable for use under water or in damp situations, though widely applicable elsewhere.

It is lime of this character which may be burned from the limestone occurring in this county. The process of manufacture as followed here is quite simple. A rough kiln is built in the side of the hill and walled with rock or brick. Into it are loaded alternate layers of limerock and coal and the whole is fired. The capacity of the various kilns varies as does also the length of time for burning. The rock used is a very pure white limerock but only occurs in thin ledges. The Saint Louis limerock of the region is characteristically irregular in character and the rock of a quality suitable for burning lime is only a small portion of the total amount present. The fact that the different ledges vary greatly, some requiring more time than others for burning, has not been sufficiently noted by persons engaged in the manufacture of lime. All the rock at a given

place is burned together and this probably to some extent accounts for the fact that while the product is a clear, white lime, well adapted to finishing work, it is not so strong as the imported limes.

At present only two kilns are in operation. One is northeast of Oskaloosa on Spring creek and is operated by C. P. Seip. The second is about four miles northwest of Oskaloosa near the South Skunk river and is operated by Peter Nelson. Both are small common kilns and only a small amount of lime is burned. Mr. John Malone formerly operated a draw kiln near the mouth of Spring creek where a good lime was made, about 100 bushels per day being burned. This has not been in operation for four years. Other kilns were located near here, as well as just north of town near the Quaker church, near Fremont and near Bellefontaine. At the latter point considerable quantities were formerly burned and shipped down the river by boat. These kilns have not been operated for some years.

BUILDING STONES.

The quarry industry of the county is not great, being confined to a few openings for the purpose of supplying local trade only. Of the two formations occurring in the county the Saint Louis alone furnishes rock for building. A soft sandstone belonging to the Des Moines formation and occurring near New Sharon has been used to some extent in a pulverized form in making brick, but is not suitable for use as a building stone.

The upper part of the Saint Louis in Marion county near Pella, and in Monroe county opposite Eddyville, yields considerable stone. In Mahaska county, however, the most productive ledges have been cut away by erosion and only a few feet of good rock is left. These few ledges yield all the rock now quarried. They may be well seen at Peter Meyer's quarry north of New Sharon. The stone exposed here is the usual fine grained, ash to grey limestone, breaking with a conchoidal fracture and lying in thin ledges separated by partings of clay. The ledges present, which are fairly representative of those occurring in the county, are as follows.

		INCHES.
8.	Limestone	6
7.	Limestone	5
6.	Limestone	5
5.	Limestone	14
4.	Limestone	20
3.	Limestone	8
2.	Clay	6
1.	Limestone	?

At Union Mills is a small quarry not now operated, where the stone shows an exposure of five feet. It has been worked intermittently for the last nine years and has supplied foundation rock for the mill and other buildings near. A similar quarry, also abandoned, is located opposite the McBride mill three miles southwest of Indianapolis.

Near Peoria in the northwest part of the county, stone is occasionally taken out at a number of points along Skunk river and Buckeye creek. W. P. Barnard and A. D. Smith operate small quarries for the local trade about three miles south of Peoria. North of Oskaloosa, near the city water works, is a bluff where stone is frequently quarried. The rock is of the usual character. Northeast of town, near the mouth of Spring creek, rock has been taken out for the construction of a dam and the foundation of a mill. The stone comes mainly from two ledges from sixteen to twenty inches thick. A short distance south of Given similar ledges are quarried to a small extent from the banks of the Muchakinock. About one mile south of the station is the Castle quarry, in which, beneath eight to ten feet of stripping, there is an exposure of thin shelly limestone about three feet thick. Below that are two ledges of heavy limestone from which the main outcrop of the quarry is taken.

The sandstone found at Raven Cliff has never been utilized. It is of good color, is easily quarried and of inexhaustive quantity. Though soft it is believed it is sufficiently hard for all ordinary purposes. The ease with which it could be worked and its good color would render it quite valuable.

The stone quarried in the county sells at from $1.50 to $3.00 per perch, depending upon the quality of the stone and the locality at which it is quarried.

SOILS.

The soils of Mahaska county belong to two types which, while different in origin, are not greatly different in character.

The uplands over the entire county are made up of the drift over which has been spread a thin mantle of loess. The loess has usually a thickness of ten to twenty feet. It differs somewhat from the loess found along the Missouri river and long known as the bluff formation. It is less porous and has more of a clay-like character. The upper portion, from six to eighteen inches, has become changed, being blacker and containing humus. This graduates below insensibly into the clay-like loess. The black upper portion forms the soil over the greater part of the county and the loess-derived clay is the usual subsoil. The combination is very productive, being especially well adapted to corn.

Along the river and the smaller streams are flood plains of widths depending largely on the size and age of the river, and over these the second type of soil occurs. This resembles in general appearance the upper portion of the soil just described and is distinguished from it by the fact that the subsoil is exactly similar to the soil itself. This deposit is further distinguished in its mode of origin, not being developed *in situ* from the material beneath but being washed in from outside sources.

That the river itself frequently changes its position relatively to the sides of the valley is a fact patent to the observation of all. A big ox bow becomes cut off, is then a slough, and finally silts up and becomes bottom land, the river in the meantime running on the opposite side of the valley. The river thus running first on one side and then on the other, cuts out a wide valley. In times of high water these low lands are covered by water which, having only a slow motion, is forced to drop part of its load and thus the low lands are built up. Another factor quite important is that the bluffs on either side on being exposed to the air crumble down easily and wear back often to a position considerably beyond any at which the river ever washed their base. The loess above being loose and here thin, yields readily to overplacement and creeps down the slopes of the hills. The upper or changed portion being that

which is looser, yields most readily, and thus the soil of the uplands is in reality the source of the lowland soil. In the latter position it is however, mixed more or less with the extraneous drift matter and is somewhat thicker so that its properties are slightly different. On the whole however, it requires the same cultivation and yields much the same crops.

WATER SUPPLY.

Mahaska county is quite abundantly supplied with surface water. The three larger streams of the region do not go dry even in the most protracted drouths, while their numerous tributaries usually afford an abundant supply of excellent water for agricultural and stock purposes. This together with the large amount of grass land has made the region famous for stock raising. Wells may be obtained in almost any portion of the county at moderate depths. Throughout the drift are small pockets of sand and gravel which yield an unfailing supply of good water. These are of irregular distribution and do not form horizons which can be traced over any large area. At the base of the drift, between it and the indurated rocks is a good water horizon.

The Des Moines beds do not often yield good water, it being usually impregnated with sulphur and mineral salts. For this reason the mines largely depend upon reservoirs of surface water. The Saint Louis here as elsewhere usually yields water, it being found in the sandy layers between the limestone ledges.

WATER POWER.

The larger streams of Mahaska county are capable of yielding considerable power. The total fall of the North Skunk, within the limits of the county is sixty feet; of the South Skunk seventy-five feet, and of the Des Moines fifty-four feet. The amount of water in these streams has not been calculated, but it is considerable and has always been adequate to all demands made upon it.

There are now on the North Skunk three mills which derive their power from that stream. The Union Mill (Tp. 77 N., R. XV W., sec. 22, Se. qr.) has a five foot fall and thirty-five

horse power is now used. At the Roberts mill (Tp. 77 N., R. XIV W., sec. 4. Nw. qr.) there is a seven foot fall and thirty-five to forty horse power is generated. At the McBride mill (Tp. 76 N., R. XIV W., sec. 15, Se. qr.) there is an eight foot fall and power is generated for two forty horse power wheels. These mills have been in operation for a number of years and only in a few instances has the water supply been insufficient.

On the South Skunk river two mills are now in operation, and another is being built. The Albert mill near the Oskaloosa city water works station, (Tp. 76 N., R. XVI W., sec. 25, Sw. qr.) has been in operation for twenty-seven years. There are three wheels here and from forty to sixty horse power is utilized. In the last ten years the condition of the water has only caused the mill to be idle a few days. Four miles northeast of Oskaloosa a new mill is being built which will use about sixty horse power. Courier's mill, seven miles east of Oskaloosa, is one of the older mills on the river and uses the usual horse power, forty to sixty. At this mill power is used not only for grinding but a small dynamo is also driven which lights the mill and a few neighboring houses.

There are no mills along the Des Moines, for, while there is an abundance of water and good sites are not rare, the cost of damming so large a stream has heretofore proven prohibitive. At the time it was proposed to utilize the river for slack water navigation, it was carefully surveyed and three of the proposed dams were located in the county. Number 18 was a short distance above the mouth of the Muchakinock, number 19 was almost directly west of Given and number 20 was near the Bellefountaine. All of these sites are available and considerable power could be readily obtained.

The importance of water power derived from the smaller streams is being newly appreciated. The cheapness and ease with which it is obtained, combined with its permanent and desirable character, render it a source of profit. Transformed into electricity it is readily available at considerable distances from its source.

ROAD MATERIALS.

There is in this county a large and readily available supply of good road material. The gravel beds which in some localities form so prominent a part of the drift are not here common. Such gravel as is obtained usually comes from along the rivers, and the beds found there are largely the result of the resorting action of the present streams whereby the finer materials of the drift is washed away and the gravel left in beds. The gravel terrace at Eddyville, already mentioned, seems to have been formed at some earlier period in the history of the river.

Sand is obtained at a number of points in the drift and large quantities are shipped from Eddyville to Oskaloosa for use in street paving.

Clay of such a character as to be readily available for road making in the form of burned clay can be obtained at almost any point in the county. The shale and slack from the old dumps at the mines, after burning, yield a very desirable article for road making. The use of this material before burning is, however, usually a great mistake, as it slacks and in wet weather is nearly as bad as the loose dirt. Paving brick of excellent quality can be manufactured at several points and are already largely used in Oskaloosa. The expense of manufacture renders them unavailable for use outside of cities.

Rock of good character for road purposes can readily be found along any of the larger streams. For its use it is imperative that the ground be thoroughly prepared before it be laid down and the rock be broken carefully before being laid. No stone more than one and one-half to two inches in diameter should be placed on the road. At certain points in the county where rock has been used in macadamizing, the pieces used have been so large the people prefer to drive in the mud along the roadside rather than jolt over the rough stone of the "improved" road bed. Such work might almost as well not be done at all.

STATISTICS.

The following table shows the amount and value of the various mineral products of Mahaska county for the year 1893:

Coal—		
Amount—tons	1,093,530	
Value		$1,727,777.40
Clay—		
Brick—		
Amount—		
Building	2 353,000	
Paving	4,500,000	
Value		53,857.00
Tile—		
Amount	1,125,000	
Value		11,425.00
Building stone—		
Amount—perch	900	
Value		1,800.00
Total		$1,794,859.40

ACKNOWLEDGMENTS.

In the preparation of this report the writer has received important help from many people. The officers of the various mining companies have been especially hearty in their co-operation and much of the value of the report is due to the freedom with which their information has been given. Because of their wide experience the officers of the Consolidation, Excelsior, American, Whitebreast and Columbia mines have been especially helpful. The others have without exception been equally willing, and have in many cases conveyed important information. Acknowledgments are also especially due Mr. Arthur C. Spencer from whose field notes, pages 351–365 are largely compiled.

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF MAHASKA COUNTY, IOWA.

BY

H. FOSTER BAIN.

1895.

R. XVII W. R. XVI W. R. XV W. R. XIV W.

T. 77 N. T. 76 N. T. 75 N. T. 74 N

RICHLAND PRAIRIE UNION LEE PLEASANT GROVE MONROE BLACK OAK MADISON ADAMS GARFIELD SCOTT OSKALOOSA SPRING CREEK WHITE OAK HARRISON DES MOINES JEFFERSON CEDAR

Granville, Tainter, Barnes, NEW SHARON, Peoria, Union Mills, Lacey, Indianapolis, Leighton, Fishville, Olivet, Evans, Rose Hill, Tiona, Bellefountaine, Beacon, Gainford, Wright, Stark, Given, Muchakinock, Cedar, Fremont, Eveland, Eddyville

SOUTH SKUNK RIVER, NORTH SKUNK RIVER, DES MOINES RIVER, CHICAGO, ROCK ISLAND & PACIFIC RAILROAD, CHICAGO, BURLINGTON & QUINCY RAILROAD, CHICAGO & NORTH WESTERN RAILROAD, IOWA CENTRAL RAILROAD, MUCHAKINOCK SOUTH RAILROAD, CHICAGO, BURLINGTON & IOWA RAILROAD, DES MOINES & NORTH WESTERN RAILROAD, IOWA CENTRAL RAILROAD, CHICAGO, ROCK ISLAND & PACIFIC RAILROAD, CHICAGO & NORTH WESTERN RAILROAD

LEGEND

GEOLOGICAL FORMATIONS.

DES MOINES (Coal Measures)

SAINT LOUIS

INDUSTRIES.

QUARRIES

COAL MINES

CLAY WORKS

LIME KILNS

DRAWN BY F. C. TATE.

Photo-Lith. by A. HOEN & CO., Balto., Md.