
GEOLOGY OF KEOKUK COUNTY.

BY

H. FOSTER BAIN.



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INTRODUCTION.

LOCATION AND AREA.

Keokuk county lies in the southeastern portion of the state, and is bounded on the north by Jasper, Poweshiek and Iowa counties, on the east by Washington, south by Wapello and Jefferson, and west by Mahaska. It is nominally twenty-four miles square, but owing to errors in the earlier surveys it contains slightly more than that area, having in all about 370,000 acres. The county presents a considerable diversity of geological details.

PREVIOUS WORK.

For a county so well supplied with mineral wealth, there is a remarkable dearth of information regarding its geologic structure. The work of the earlier surveys under Owen and Hall was not extended into this county. White* made reference to the presence in it of both coal measure and sub-carboniferous rocks, but no detailed work was done by him in this region. Gordon† has published notes upon the strata passed through in the deep well at Sigourney. With these two exceptions nothing had been published upon the geology of this county previous to the organization of the present survey.

PHYSIOGRAPHY.

TOPOGRAPHY.

If one had a topographic model of this county to examine, probably the most notable feature exhibited by it would be the broad contrast between the northern and southern portions. In general the whole county may be considered an approximately level plain into which the streams have cut their valleys. The greater number and larger size of the streams in the southern part, however, cause it to appear rough and broken, and while this is naturally more marked in a detailed than in a general way, it does not entirely disappear even when the general view is considered. Thus it happens that the northern and

*Geology of Iowa, vol. II, p. 267. Des Moines, 1870.

†American Geologist, vol. IV, pp. 237-239. Minneapolis, 1869.

northeastern portions of the county are predominantly upland as compared with the remainder.

This northern portion presents to view a broad open plain rising in a succession of low billows varying usually from ten to twenty-five feet in height and succeeding each other at intervals of from one-quarter of a mile to one mile in distance. Sharp contours are rare except in the immediate vicinity of the streams. The land rises gently from 875 feet above sea level at the east to 910 at the west county line. Across this plain the



Figure 27. Topographic map of the region near Rowley's mine, north of Sigourney. Contours 10 feet; scale 2 inches to the mile.

streams run in direct courses, with narrow valleys bounded by low rounded bluffs and bordered by a fringe of timber which becomes a notable feature of the landscape.

In the central and southern parts of the county the topography becomes more rugged. The number of streams here increases and they with their feeders have cut deeper channels. The country is more wooded and the landscape loses its simplicity. Along the streams deep gorges and high bluffs alternate with broad savannas. Sharp contrasts are presented and all the results of the long action of a complex dendritic system of drainage are encountered. Yet through all whenever a commanding view may be obtained the general aspect of the plain is still presented. A noteworthy fact is that when in the southern portion of the county a plain is encountered, it is exceedingly level. In detail it shows no great difference in elevation. It stretches away in places three or four miles without a change in altitude of more than ten or a dozen feet. As the streams are approached there is a greater ruggedness than in the northern area. Differences of from twenty-five to one hundred and twenty-five feet are met with in as many yards or even feet; and a succession of ridges and hills succeed one another, each lower than the other until the stream is reached. The contrasts of this region are well shown in the profile of the section from Keota to Atwood (figure 3, plate viii) and a characteristic example of the relief of the region is shown in the annexed map.

The mean elevation above sea level for the entire county is in the neighborhood of 800 feet. The greatest elevation now known is 910 feet, and the lowest 657 feet. The difference between any two points is nowhere great. The following table, in part compiled from railroad levels and in part determined during the course of the present survey, exhibits the levels of the principal towns and villages as well as of some other points of geological interest. In each case the authority upon which the figures are based is given.

Table of Elevations.

LOCALITY.	Elevation.	AUTHORITY.
Atwood	721	C., R. I. & P.
Atwood quarry	738	C., R. I. & P.
Bridge creek east of Sigourney	693	C., R. I. & P.
Bridge creek north of Sigourney	713	C., M. & St. P.
Cedar creek at crossing C., R. I. & P., three miles east of Delta	693	C., R. I. & P.
Clear creek at crossing C., R. I. & P.	743	C., R. I. & P.
Cuba	745	C., M. & St. P.
Delta	802	C., R. I. & P.
East county line two miles from Kinross	772	B., C. R. & N.
English, river Cuba	725	C., M. & St. P.
German creek at crossing C., R. I. & P.	688	C., R. & I. P.
Harper	818	C., R. I. & P.
Hayesville	792	C., M. & St. P.
Hedrick	820	C., M. & St. P.
Highland between German and Bridge creeks three miles east of Sigourney	788	
Keota	808	C., R. I. & P.
Keswick	876	C., R. I. & P.
Kinross	792	B., C. R. & N.
Nassau	900	B., C. R. & N.
North English	794	C., M. & St. P.
North Skunk, Atwood	695	C., R. I. & P.
North Skunk, Delta mill	682	Survey.
North Skunk, South Sigourney	658	City levels.
Nugent	833	Survey.
Pekin	865	Survey.
Showman	691	C., M. & St. P.
Sigourney	{ 768	C., R. I. & P.
	{ 796	C., M. & St. P.
South English	844	B., C. R. & N.
South Skunk, North Hedrick (bridge 677.)	657	C., M. & St. P.
Thornburg	882	B., C. R. & N.
Tilton	849	C. & N. W.
Webster	862	B., C. R. & N.
West county line one mile west of Nassau	910	B., C. R. & N.
What Cheer	{ 760	B., C. R. & N.
	{ 788	C. & N. W.

DRAINAGE.

The drainage of the county is quite unequally divided between two systems. The northern tier of townships contributes to the South English river which forms a branch of the English river system, while the English river is itself tributary to the Iowa. This system drains in Keokuk county an area of about 100 square miles, all within the northern tier of townships and distributed approximately as follows:

	SQUARE MILES.
Liberty township	30
English River township	26
Adams township	24
Prairie township.....	20

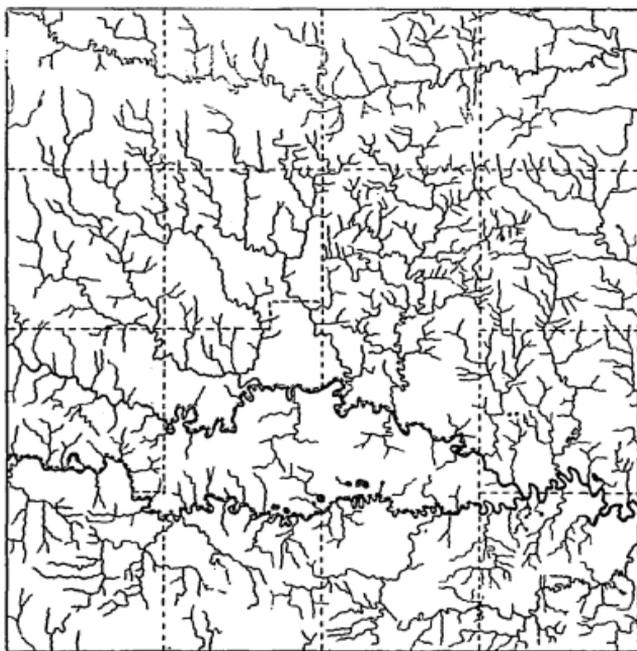


Figure 28. Sketch map showing the drainage of Keokuk county.

The streams of this system flowing in Keokuk county comprise South English, Little creek, Smith creek and a few minor tributaries of South English river. The main stream enters the county at the northwest corner and, flowing first slightly south of east, and later returning north, crosses the east county line near the north extremity, without having at any place wandered more than three or four miles from the northern boundary. Through its entire course it meanders but slightly from its main direction. In a more minute consideration it is

to be noted that the river makes but few bends and that these are small. A general absence of broad bottoms, of ox-bows, lagoons and of high steep bluffs, is also noticeable. Another striking characteristic is the small number and small size of tributaries, these rarely being more than five miles in length and of such insignificant size as scarcely to deserve an independent name. Few outcrops of rocks occur along its course, only one or two being known. The alluvium of the bottoms is confined to a shallow, narrow area in the immediate vicinity of the stream. Through the greater part of its course the stream runs over drift which also forms its bank and rises with rounded contours from twenty-five to one hundred and ten feet above the water level. The watershed between the English and Skunk rivers follows the former closely and recedes from the latter. The Skunk has sent out long arms which drain territory apparently properly belonging to the South English. All these facts point to one conclusion; that the South English is a comparatively young stream. It seems clear that the origin of this river dates from postglacial times.

The watershed between the two river systems of this county is not a marked topographic feature. Indeed it might be crossed again and again without attracting attention. The upland prairies are, as has been said, of considerable regularity. A careful scrutiny is all that reveals the direction of the drainage. On the whole it is noticeable that the country slopes gently to the south from the divide. Numerous broad, shallow valleys open out in that direction. On the other hand toward the north the prairie remains level up to almost the very brink of the South English river; the tributary streams being small and unimportant. In this regard the South English river shows well the characteristics of the rivers of the loess-drift region as pointed out by McGee* in that it is a river with a long, narrow basin, and flows along the southern edge of a gently sloping plain.

The greater part of the drainage of the county is effected through the Skunk river. This includes within the limits of the county both the North and South Skunk branches which unite about four miles from the east county line. Both

*Eleventh Annual Rep. U. S. Geol. Surv., pt. I, pp. 411-415. Washington, 1892.

forks of the river receive numerous tributaries. Among those flowing into the North Skunk are German creek, Bridge creek and Cedar creek. Into the latter flow Whiskey Run, Coal, Rock and Smith creeks. Sugar creek, Steady Run and Rock creek flow into the South Skunk; while East Cedar, Crooked and Richland creeks eventually find their way into the main river. Most of these streams are rather large and important, cutting their way below the general level to a considerable depth. German creek, four miles above its mouth, is nearly 250 feet below the adjoining uplands. Between German and Bridge creeks the land is 115 feet above German creek, but Bridge creek lies over 100 feet below this level. Cedar creek is more than 200 feet lower than the upland upon which the town of Delta is built, and the Skunk river is about 120 feet below Sigourney, though that place is fifty feet below the general level of the upland east of it, and 100 feet or more below the high prairie of the northern part of the county.

In considering the Skunk river all the features mentioned in connection with the English river are found absent. The Skunk exhibits a notable sinuosity. Neither in general nor in detail is its course straight. It turns and twists in a most complex manner. It has a large number of deep and important tributaries which reach out and drain approximately 476 square miles in this county. Broad, alluvial bottom lands, from two to six miles wide, with shallow lakes or ponds, bayous and ox-bows are not infrequent. Numerous rocky outcrops are found, and these are cut through, forming in places high, picturesque bluffs. There are evidences at numerous points of changes in the position of the channel. The river has been thrown now to one side and again to the other. It has in places made cut-offs, leaving what were once islands, but now appear only as isolated hills in the midst of the flood plains. An interesting example of this is seen north of Richland. At this point the river formerly ran nearly a mile north of its present channel. The change made has left a small hill rising out of the flood plain.

There is little evidence in this region showing that these changes are due to reoccupation of a preglacial channel. No

evidence of a larger channel cut out in the limestone and filled in with drift has been noted in this county. The stream seems to have cut its present channel since the drift was laid down. This is of interest in view of the considerable size of the stream, and the complex drainage system which must have required for its development a considerable time; a period in excess of that required by the streams in the northern part of the county.

STRATIGRAPHY.

General Relations of Formations.

The surface materials of the county are almost entirely of glacial origin. The areas over which the the hard, underlying rocks are exposed are limited, and are confined chiefly to the bottom of the principal streams. Away from these the drift almost completely conceals the indurated rocks. The geological formations present in the county and their stratigraphic relations, may be best shown by the subjoining synoptical table.

Classification of Formations.

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Cenozoic.	Pleistocene.			Allurium Loess. Drift.
		Upper Carboniferous.	Des Moines.	
Paleozoic.	Carboniferous.	Mississippian Lower Carboniferous.	Saint Louis.	Pella. Verdi. Springvale.
			Augusta.	Keokuk. Burlington.

DEEPER STRATA.

As will be seen from the above the range of geological time represented by the rocks exposed within the limits of this county is not great. In all, but two of the great periods are represented, and knowledge of the earlier history of the county can only be derived from deep borings.

During the summer of 1888, a deep well was drilled at Sigourney*. Captain Parker, who was at that time mayor, carefully preserved samples of the different strata passed through. These samples have recently been re-examined, and form the basis of the following notes. While the unreliability of records derived from the ordinary or churn drill is fully recognized, it is believed that the care with which these samples were selected and preserved, at least considerably reduces that element of doubt as to the correctness of the record. Previous accounts of this record have been published in the local newspapers. Recent studies in this region, as well as a revision of the material, give considerable information not available at that time.

The following table represents the record as recently determined, as well as the interpretation:

1- 98	Earthy matter.....	98	Drift.....	98
98- 120	Limestone, impure, earthy	22		
120- 135	Limestone, cherty.....	15		
135- 155	Shale, calcareous.....	20		
155- 165	Limestone and shale.....	10		
165- 170	Limestone, hard, bluish grey.....	5		
170- 187	Limestone, cherty, light	17	Saint Louis.....	89
187- 189	Shale.....	2		
189- 314	Limestone, hard, white with brown particles	125		
314- 315	Shale, dark green.....	1		
315- 356	Limestone, greyish white to drab, Ryn- chonella at 342 feet.....	41	Augusta.....	168
356- 554	Shale, soft, green.....	198		
554- 556	Limestone.....	2		
556- 585	Shale, soft, green.....	29	Kinderhook.....	229
585- 835	Limestone.....	250	Devonian.....	250
835- 865	Sandstone.....	30		
865- 871	Limestone.....	6	Niagara.....	36
871-1030	Shale, blue argillaceous.....	151	Maquoketa.....	151

*Proc. Iowa Acad. Sci., vol. I, pt. IV, pp. 36-38. Des Moines, 1891

1030-1275	Limestone	245	
1275-1281	Shale	6	Trenton and
1281-1315	Limestone	34	Galena..... 285
1315-1430	Sandstone	115	Saint Peter..... 115
1430-1717	287	
1717-1888	Limestone	171	Oneota.

A comparison between this and the previously published record* shows several discrepancies. The drift is in both cases given as 98 feet deep. The next 89 feet is now referred to as the Saint Louis, whereas it was formerly regarded as Keokuk. There are many reasons for this change. In the first place, an examination of the samples shows that the beds are not such a single homogeneous limestone as represents the Augusta of this region, but are made up of alternating bands of limestone and shales such as compose the Saint Louis. It is also worthy of note that the particles of limestone preserved are of the fine grained, compact character and ash to brown color, so constantly seen in the Saint Louis of this immediate region, and not of the coarser crystalline variety shown in the nearest exposures of Keokuk. The topographic features also bear out the assumption. A line of levels shows that the mouth of the well is 118 feet above the bed of the river two miles south of town. Saint Louis limestone is exposed along the river, reaching here a height of nearly twenty feet, or about what it would be if on a level with the strata found in the wells which are referred to the same age.

The two limestones found in southeastern Iowa, and long known as the Keokuk and Burlington, are regarded as members of the same formation, to which the name of Augusta has been given. Worthen, in his notes on Washington county, calls attention to a remarkable thinning out of the Keokuk, it being greatly reduced or entirely absent over the regions studied. This observation has recently been completely substantiated, not only for Washington, but for Keokuk county. These facts taken together, all point to the same conclusion: that the first eighty-nine feet of limestone pierced belongs to the Saint Louis, while the Keokuk is represented merely in a small portion of the upper part of the succeeding 168 feet of strata. The

*Gordon: Am. Geologist, vol. IV, pp. 237-239. Minneapolis, 1889.

two bands of heavy limestone comprised in the strata thus referred to the Augusta, are closely similar in lithological character, and resemble the Augusta limestone of the region as nearly as can be determined.

At a depth of 342 feet a fossil *Rhynchonella* sp. und., was brought up, this being the only form preserved. Below this point the element of uncertainty becomes greater. The succeeding 229 feet of shale is probably all referable to the Kinderhook. The 250 feet of limestone which succeeds is most probably Devonian. The succeeding 30 feet of sandstone and 6 feet of limestone are more probably Niagara, since Calvin has shown that the Niagara at Washington is arenaceous.

The Maquoketa shale seems, by comparison with neighboring records to be well recognized.

The heavy limestone band, 285 feet, succeeding the shale is probably representative of the Trenton and Galena, though it seems impossible to draw a good line between them.

The 115 feet of sandstone which succeeds seems to be the Saint Peter. Beneath this for some distance no samples were obtained as the current of water struck was so strong as to wash away all the drillings. The lower portion of the well yielded samples which, on examination, proved to be limestone as Gordon surmised, and not sandstone as published. This seems to clearly prove that the well ended in the Onocota, though the top of the formation was not definitely located nor was it penetrated, so that its thickness under this portion of Iowa is as much a problem as ever.

STANDARD SECTIONS.

The following sections, chosen from a large number exposed within the county, represent typical exposures of the formation as occurring here.

MANHATTAN MILL SECTION		FEET.
6.	Sandstone, quartzose, in part calcareous, yellow, soft	1½
5.	Limestone, finely brecciated	1
4.	Limestone, compact, grey, cherty	20
3.	Limestone, earthy, brown, containing numerous chert nodules	15

	FEET.
2. Limestone, coarse, sub-crystalline, blue and grey in color, fossiliferous; in ledges 9 to 20 inches thick, separated by clay shales 6 to 8 inches in thickness; bands of chert nodules 3 to 10 inches thick near the top.....	26
1. Limestone, as above.....	14

Number 1 of the above section is Augusta and is seen in the Weber quarry near the mill; number 2, also Augusta, is the stone formerly worked in the Cook quarry on Rock creek; number 3 is exposed above the quarry track and represents the Springvale beds; numbers 4 to 6, representing the Verdi beds, are exposed along the railway track (Tp. 74 N., R. XI W., sec. 15, Ne. qr., Nw. $\frac{1}{4}$) leading to the Cook quarry.

NUGENT SECTION.
(Tp. 74 N., R. XII W., sec. 12, Ne. qr.)

	FEET.
4. Sandstone, soft, with alternating layers of grey cherty limestone.....	18
3. Sandstone, massive, soft.....	10
2. Limestone, grey, fine grained.....	10
1. Unexposed to water.....	10

These beds may be recognized as middle Saint Louis (Verdi beds). They are exposed in an old quarry from which the stone used in the construction of the neighboring bridge over Skunk river was evidently taken.

SECTION AT SHAFT NO. 1, WHAT CHEER COAL COMPANY.
(Tp. 76 N., R. XIII W., sec. 15, Sw. qr., Nw. $\frac{1}{4}$.)

	FEET.
4. Drift.....	50
3. Shale, bituminous, fissile.....	20
2. Coal.....	5 $\frac{1}{2}$
1. Fire clay (exposed).....	4

Numbers 1, 2, and 3, represent the coal measure deposits of the county as characteristically developed.

TYPICAL OUTCROPS.
EXPOSURES ON SOUTH SKUNK RIVER.
SECTION FIVE MILES NORTH OF RICHLAND.
(Tp. 75 N., R. X W., sec. 35.)

	FEET.
4. Sand, yellow to red, coarse grained, cross-bedded.	8
3. Limestone, earthy, brown, arenaceous in part; heavy bedded, exposed.....	6 to 8
2. Limestone, grey, cherty, fine grained, in twenty inch ledges.....	6
1. Unexposed to river.....	30

Number 3 of the above section may be correlated with number 3 of the Manhattan mill section.

CLEAR CREEK SECTION.

(Tp. 75 N., R. X. W., sec. 27.)

	FEET.
2. Limestone, in part fine grained, drab, cherty; in part brecciated; interstratified with coarse grained sandstones; (imperfectly exposed).....	10
1. Unexposed to river.....	30

This exposure may be referred to the middle Saint Louis (Verdi beds.) Particularly good examples of the brecciated limestone may be seen at this point.

SAW HILL SECTION.

(Tp. 71 N., R. X W., sec. 6, Nw. qr., Se. ¼.)

	FEET.
1. Limestone, (Augusta) sub-crystalline, white; an impure marble, rising above the river.....	6

Between this section and the one following, the Manhattan mill and Nugent exposures occur. A few hundred feet up the river from the latter is a small ravine which reveals the presence of a coal measure outlier. The bed of black shale which represents the coal measures is deposited in a channel which has been cut down through numbers 4 and 3 of the Nugent section.

SPRINGVALE SECTION.

(Tp 75 N., R. XIII W., sec. 27, Se. qr., Ne. ¼, and sec. 34, Ne. qr.)

	FEET.
3. Limestone, alternating with sandstone, imperfectly exposed.....	30
2. Limestone, blue, shaly when fresh, weathering readily to earthy brown; exposed near bridge	20
1. Limestone, coarse, sub-crystalline, fossiliferous....	6

Number 1 of the above is the Augusta. It is seen on the north side of the river some distance from the remainder of the section. Number 2 is the typical exposure of the Springvale beds with the normal thickness, and only unusual in the small amount of arenaceous matter. Number 3 is the middle Saint Louis (Verdi beds), as usual very imperfectly exposed.

The Verdi beds as seen here are well developed along the river from this point to the west county line. At two points

they have been cut through and the coal measure deposits laid down in the cutting. The first of these localities is about one mile west of the section just described. The exposure is very imperfect. About fifteen feet above the water is a thin ledge of bituminous limestone containing *Chonetes mesoloba* and other forms common to the beds of the Des Moines stage.

Within half a mile of the west line of the county the Saint Louis beds are again replaced by sandstones, and in the adjoining portions of Mahaska county by shale containing a small coal seam.

EXPOSURES ON NORTH SKUNK RIVER.

BLACK HAWK MILL SECTION.

(Tp. 75 N., R. X W., sec. 30, Sw. qr.)

At the Black Hawk mill, the Augusta is exposed, showing a thickness of probably twenty feet. It extends down the river nearly a mile, outcropping at intervals along the bluff. It also extends a distance of a mile and a half up the creek, which at this point flows into the river. About one mile north of the mill, the Springvale beds are seen to cover the Augusta.

GERMAN CREEK SECTION.

(Tp. 75 N., R. XI W., sec. 15)

In the bluff back a mile or more from the river there are two exposures of a coarse, reddish sandstone probably of coal measure age.

BRIDGE CREEK SECTION.

(Tp. 75 N., R. XI W., sec. 18, Nw. qr., Nw. ¼)

	FEET.
1. Limestone, coarse, grey, fossiliferous.....	12

This limestone is also exposed in the southeast quarter of the southwest quarter and in the northeast quarter of section nineteen.

SECTION TWO MILES SOUTH OF SIGOURNEY.

(Tp. 75 N., R. XI W., sec. 14, Ne. qr.)

	FEET.
1. Alternating layers of coarse sandstone and of limestone; the latter in part of a well marked brecciated character, and in part, of the fine grained, compact variety.....	35

This outcrop is immediately above the wagon bridge south of Sigourney. It represents the Verdi beds, but as usual the exposure is too imperfect to allow the details to be made out.

CEDAR CREEK SECTION.

(Tp. 75 N., R. XII W., sec. 16, Se. qr., Sw. ¼.)

	FEET.
5. Drift.....	25
4. Limestone, thin, shaly.....	5
3. Limestone, massive, cherty, slightly bituminous..	4
2. Limestone, arenaceous in places, thin, shaly, not fully exposed.....	20
1. Limestone, compact, fine grained.....	4

These beds may be referred to the upper part of the Verdi.

CONNOR'S QUARRY.

(Tp. 25 N., R. XII W., sec. 15, Se. qr., Sw. ¼.)

	FEET.
2. Limestone, yellow, soft, magnesian; apparently arenaceous in part, massive; exposed.....	10
1. Limestone, coarse, sub-crystalline, exposed at water's edge.....	4

Number 1 of the above is the Augusta; number 2 belongs to the Springvale beds.

About two and a half miles west of Connor's quarry (Tp. 75 N., R. XII W., sec. 18, Se. qr., Se. ¼), the Augusta limestone, having its usual characteristics rises above the water four feet. Both above and below this point the Saint Louis is well developed.

DELTA SECTION.

Immediately south of Delta is a small group of mines working in an outlier of coal measures cut off in each direction along the stream by Saint Louis. The section passed through in sinking the Martin Fisher shaft (Tp. 75 N., R. XIII W., sec. 14, Ne. qr., Ne. ¼) is as follows:

	FEET.
5. Drift.....	4
4. Shale, bituminous.....	9
3. Coal.....	4½
2. Fire clay.....	4½
2. Shale, bituminous.....	

The mouth of this shaft is 762 feet above sea level and eighty feet above the river. At the mill one mile southwest of

here, there is an exposure of coarse, reddish, heavily cross-bedded sandstone twenty feet thick. This evidently thins before passing below the coal northeast of it.

ATWOOD QUARRY.

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

	FEET.	INCHES.
3. Sandstone, irregular in thickness.....	8	
2. Limestone, fine grained, compact.....	2	6
1. Sandstone, coarse, yellow.....	6	8

This section is measured at the west end of the railroad quarry, the base being 738 feet above sea level. The layers in the quarry are quite irregular, the section measured farther toward the east end of the quarry showing:

	FEET.	INCHES.
5. Sandstone	2	4
4. Limestone.....	1	6
3. Sandstone3 to	8	
2. Limestone, persistent band.....	2	6
1. Sandstone, irregular in thickness.....	15	

The beds at this place belong to the middle Saint Louis (Verdi beds) and probably represent the upper portion of them. They show local disturbances.

EXPOSURES ON ENGLISH RIVER.

Along English river there are but few outcrops of rock. About two miles northwest of Keswick (Tp. 77 N., R. X W., sec. 16) the Augusta limestone at one point rises two feet or more above the water. Two miles north and one east of South English (Tp. 77 N., R. X W., sec. 7, Sw. qr., Sw. $\frac{1}{4}$) a boring made on the hill shows the presence of coal measures.

SOUTH ENGLISH BORING.

	FEET.
3. Drift.....	150
2. Sandstone, alternating with shale	50
1. Shale, bituminous.....	7

Nothing corresponding to this has been found elsewhere in the region, and it is probably merely a small outlier, the more so since the shale lies at a level considerably below that of the surrounding limestone.

KESWICK BORING.

(Tp. 77 N., R. XII W., sec. 32, Sw. qr.)

	FEET.
2. Drift	100
1. Limestone, in thin bands, with alternating beds of sandstone.....	96

This boring was made at the creamery for a well. Number 1 evidently represents the middle Saint Louis which has been encountered in other borings in the vicinity and is at one point poorly exposed on South English river directly north of town.

Geological Formations.

The general sequence of the rocks in the county has already been given. The formations present belong entirely to two systems; the Carboniferous and the Pleistocene. Of the Carboniferous rocks, representatives of both the series most prominently developed in the Mississippi valley occur.

MISSISSIPPIAN SERIES.

The rocks of this series, forming the lowermost of the major divisions of the Carboniferous of the continental interior, underlie the greater portion of the county. Of the three divisions of the series which are found in Iowa—the Kinderhook, Augusta and Saint Louis—the latter two only are present in this county.

AUGUSTA.

The best exposures of the Augusta limestone within this county are near the mouth of Rock creek just north of Ollie. Here the rock is well displayed and is exposed over a considerable area. It is here also that the only serious attempts have so far been made to utilize it as a building stone. The formation rises forty feet above the South Skunk river. The stone varies from light brown or white to grey or drab in color. It is medium to coarse grained, sub-crystalline, and lies in ledges usually three to ten inches in thickness, separated by clay and chert bands. At certain points the latter become especially prominent, as at the Weems quarry (figure 24) near Manhattan mill (Tp. 74 N., R. XI W., sec. 10, Nw. qr., Ne. $\frac{1}{4}$). The limestone contains an abundant crinoidal and molluscan fauna. Portions of the stone are almost entirely made up of fossils, particularly of crinoid stems.

The distribution of the formation is shown on the accompanying map. There is a small area immediately south of Delta on the South Skunk, another three miles northeast of this on the North river, one near Connor's quarry two miles north of Hayesville, one near the mouth of Bridge creek, the area noticed near Manhattan mill and a small area near the mouth of East Cedar creek in Clear creek township. From the junc-



Figure 24. Augusta limestone on Rock creek, north of Ollie.

tion of the two branches of Skunk river to the east county line the Augusta does not appear though it probably underlies at least a portion of the bottom land. In the region of Keota borings show that this rock immediately underlies the drift. North of Kinross it is at one point exposed on English river rising scarcely three feet above the water.

The rocks now known under the name of Augusta have long been known and studied in southeastern Iowa and neighboring regions. They were here considered to make up two formations; the Keokuk, and Burlington. More recently, however,

they have been united and are now known under the name Augusta. It is of interest to note that in Keokuk county there is no evidence of two formations. The rocks mapped as Augusta are markedly distinct from any others occurring in the region and are just as markedly entirely one. The lithological character which distinguishes them in one place is present just as prominently at every other outcrop. The same faunal features are common to all the beds. At a few points only do fossils which have been considered to belong distinctively to the one or the other formation occur. In the main the forms found are more nearly related to the Burlington. The outcrop directly south of Delta, that near the mouth of Bridge creek, and that near the mouth of East Cedar contain certain forms considered as distinctively Keokuk. On the other hand the better developed exposures near Manhattan mill show Burlington forms. Beyond the occasional presence of these few distinctive forms there is no reason for separating the formation. To one not already familiar with the exposures of southeastern Iowa it would never occur that there was any need for such a separation.

SAINT LOUIS.

The rocks which underlie the greater portion of the county belong to the Saint Louis stage. They include both sandstones and limestones, the latter predominating. The sandstones are quite irregular in distribution and ordinarily occur as intercalated beds between limestone bands. The limestone is usually quite fine grained and compact; in places it becomes magnesian, and in other places quite arenaceous. It is this formation which contains the brecciated limestone beds which once gave name to the whole formation.

Springvale beds. Within this county the Saint Louis is seen to be made up of three separate formations, which while not always entirely distinct, are usually well marked. The lower or basal member is well exposed at the old Springvalé mill five miles south of Delta on the South Skunk river. As seen here, it is a blue, earthy limestone of a marked shaly character, weathering readily into a soft, brown to buff limestone. It is magnesian and in the other outcrops is frequently arenaceous.

The stone weathers so readily that the blue shaly character is seldom seen. It is, however, the character of the fresh stone found on Rock creek and along the Skunk in Washington and Henry counties. This bed is seen overlying the Augusta at nearly all its outcrops on the Skunk river, though on account of its soft nature good clear exposures are rare. It is exposed in Connor's quarry two and a half miles north of Hayesville (Tp. 75 N., R. XII W., sec. 15), five miles north of Richland (Tp. 75 N., R. X W., sec. 35, Ne. qr.), and may be examined in the J. S. Cook quarry north of Ollie. At this latter place the stone shows a probably pseudo-conglomeratic character. The matrix is the usual soft, brown, earthy mass, within which are imbedded irregular pieces of white limestone and chert such as mark the upper part of the Augusta. It is very suggestive of a basal conglomerate.



Figure 25. Pseudo-conglomerate in Springvale beds, Cook quarry, near Ollie.

The Springvale bed, as this member has been called, preserves its place in the section along both rivers and is usually twenty to twenty-five feet thick. It has so far proven to be largely non-fossiliferous. Its thinness does not give it a large areal exposure and the borings which show the presence of the Saint Louis in the northern part of the county have not been made with sufficient care to settle the question of its presence. At present it is only known along the two branches of the Skunk river where it has been traced across the entire county.

The exact geological position of the bed is open to some doubt. It is very rarely fossiliferous and the forms so far found in it have but slight value as indices of its stratigraphic position

In Van Buren and Lee counties a formation which occupies apparently a similar stratigraphic position and greatly resembles the Springvale beds in lithological character has been traced by Mr. Gordon. It has been usually referred to the Saint Louis though its Warsaw age has also been suggested. So far the Springvale beds have not been directly correlated with those farther south. While there are some reasons for believing that they are homologous with the beds known as the Warsaw, the evidence so far as presented in Keokuk county, tends rather to confirm the idea of their Saint Louis age and to that formation they are provisionally referred.

Verdi beds. The second or middle member of the Saint Louis is that which covers the greater portion of the county. It contains both limestones and sandstones in varying proportions and is the record of a time of exceedingly varied and rapidly changing conditions. Local unconformities are frequently

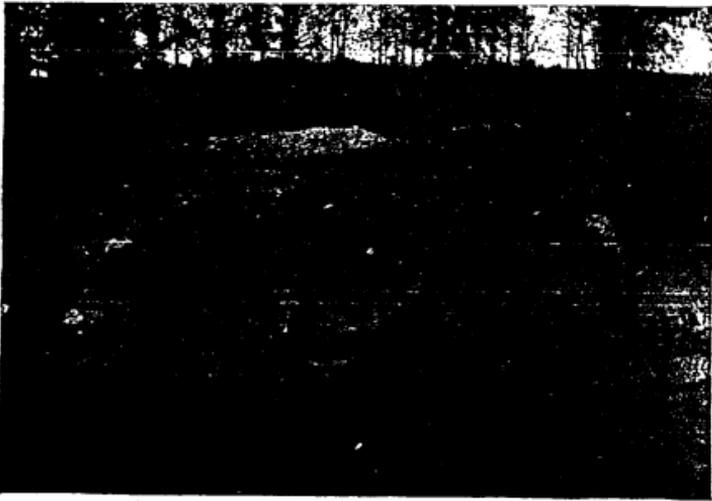


Figure 25. Local unconformity in Verdi beds, north of Hedrick.

encountered and may be excellently seen north of Hedrick. These sandstones found are white to orange in color, medium fine in grain and occasionally quite calcareous. They usually occur

in bands from two to six feet in thickness interbedded with the limestone. In some places, however, clean sandstones thirty to forty feet in thickness, with limestone both above and below, are seen.

The limestones are of two different characters. The most usual type is a light ash to buff color, fine grained, exceedingly compact and hard, almost cherty in character. This is the limestone found interbedded with the sandstone. A better known, though not more common type, is that seen in the brecciated beds. In these beds the limestone is broken up into irregular blocks or pebbles and cemented together, the whole forming a distinct calcareous conglomerate or breccia. In a majority of cases the cementing material is calcareous, though this is not always so. In some instances it is a more or less ferruginous sandstone. The blocks or pebbles in the breccia are usually of the fine grained, compact limestone characteristic of the Saint Louis itself and seem to be derived from that formation. Though occasionally slightly rounded, they more usually show sharp angles. They vary in size all the way from a fraction of an inch in diameter to large slabs four feet long and six to eight inches thick. As usually seen, however, the brecciated blocks are from one to two inches in diameter.

The brecciated beds do not seem to occupy a distinct, well marked horizon in the middle Saint Louis but are, in different localities at different levels. At Sigourney they may be seen well toward the top of this member, while along the Skunk river they frequently occupy a medial position. Near the mouth of Clear creek and at Verdi, in Washington county, they are near the base.

The middle Saint Louis in this region shows several well marked facies. The more common is that of the interbedded sandstones and limestones excellently shown at the bridge north of Nugent. This is the facies which borings show to be commonly present under the northern portion of the county. Another facies is that in which the disturbance of conditions during deposition has been so great that there is little or no regularity. This is also well shown north of Hedrick. At this point, near Showman station, on one side of a railway cut, is a

sixteen foot exposure of characteristic brecciated limestone. On the other side is a considerable development of sandstone interbedded with clear limestone.

Another characteristic section of middle Saint Louis is exposed in a railway cut one and a half miles west of Ollie (Tp. 74 N., R. XI W., sec. 32, Nw. qr., Nw. $\frac{1}{4}$).

	FEET.	INCHES.
7. Clay soil, reddish, with drift boulders	10	
6. Sandstone, cross-bedded, lemon yellow to orange, fine grained; becoming harder for six inches and apparently calcareous below	6	
5. Limestone, compact.....		8
4. Marl and limestone.....		6
3. Limestone, fine grained, grading below into number 2.....		4
2. Limestone, finely brecciated, in places almost oölitic.....	2	
1. Limestone, compact, with conchoidal fractures to track.....	6	



Figure 27. Saint Louis west of Ollie. The prominent heavy bed showing a slight flexure is number 6 of the above section.

The middle Saint Louis is perhaps best shown at the old railroad quarries at Verdi, in Washington county, where nearly all the different facies are presented. For this reason the member has been called the Verdi beds. Its total thickness can not be much less than one hundred feet, as single exposures of more than sixty feet are known.

Towards the close of the period represented by these beds conditions seem to have been more stable, and heavy bedded limestones of considerable thickness began to be deposited. These upper beds are found exposed north and west of Sigourney and have yielded considerable stone.

Pella Beds. The upper member of the Saint Louis of this region is but sparingly present in Keokuk county. It is best seen at Pella, in Marion county, and at the numerous exposures in Mahaska county. It may be characterized as a thick bed of limestone having near the top interbedded calcareous marls. These, as well as the limestone itself, are exceedingly fossiliferous, and indeed it is from this portion of the Saint Louis that almost all the fossils found in it in this region are collected. From their typical exposure these beds have been called the Pella beds. To this division the limestone found south and east of What Cheer, with some of that along the Skunk, may be referred. There is a gradation from the Verdi to the lower Pella beds, and no sharp line can be drawn between them. The latter may be recognized by the absence of the sandstone and the presence of the fossiliferous marls.

UPPER CARBONIFEROUS.

The upper carboniferous overlies the heavy limestones of the Mississippian series conformably in portions of the Mississippi valley, but unconformably in Iowa. The formation is made up in its lower portion of shore deposits which are succeeded by marine deposits which in Kansas, Nebraska and elsewhere apparently merge into the higher beds which are sometimes called the Permo-carboniferous. The Upper Carboniferous is represented in Iowa by two stages, the Des Moines and Missouri, only one of which is present in Keokuk county.

DES MOINES STAGE.

The beds of this terrain constitute what are generally known as the Lower Coal Measures. The distribution of these strata is in this county quite irregular. The main body of the strata extends into the county along the west and south line. In the southwestern part of the county modern erosion has very seriously limited the area underlain by the beds. Beyond the eastern border of this main body there are many small outliers, a considerable number of which have been mapped. Others are doubtless present, though concealed by drift, and may in time be discovered. Some few of these outliers yield workable coal; most of them do not.

The largest area of coal measures in the county is that found near What Cheer. A boring put down two miles south of What Cheer (Tp. 76 N., R. XIII W., sec. 22, Nw. qr.) showed the following:

	FEET.	INCHES.
6. Drift	147	
5. Shale, bituminous, "slate"	40	
4. Coal	2	2
3. Fire clay	2	
2. Sandstone	3	2
1. Limestone (Saint Louis)		

This section represents well the general order of the strata found in the region; the thickness of course varies greatly and not all these strata are always present. Number 2 is quite rarely found; number 3 may be almost entirely absent, or may become seven or eight feet thick. The coal is usually much thicker; in the mines it generally runs from four to six feet in thickness and is frequently much more. The thickness of the shale (number 5) and of the drift is dependent upon the erosion, preglacial and recent, to which it has been subjected. There is but the one coal horizon in the coal measures here though there is considerable difference in the level at which the coal lies. At the North Star it is 723 feet above sea level while at the Towers mine it is 695 feet. Equally great differences are, however, found in individual mines. The coal itself is very irregularly distributed, though between the levels mentioned it is usually found in greater or less quantity unless erosion has interfered.

It must be remembered, that not only the erosion which has taken place since the deposition of the beds of the Des Moines terrain, is to be considered but also the pre-coal measure erosion. It is due to the latter that in places the Saint Louis is encountered at levels considerably above the neighboring coal beds. At a number of points such conditions exist; hummocks of limestones protruding entirely through the coal measures. The coal itself lies in irregular semi-detached basins. These are usually in the form of troughs with thicker coal in the center thinning out towards the edges. These troughs are generally about 100 yards wide and run in very irregular lines. Some have been traced a distance of a mile or more. A good example of such a coal basin is seen on the land now being developed by the Crescent Coal Company two miles northwest of What Cheer. Here a basin has been located in which the coal is nearly forty-five feet below the general level of the seam on the same land and is from two to three feet thicker.

In the Crescent No. 2, a basin of excellent thick coal was traced some distance in a curved line. It followed close along the edge of a "cut out." In the What Cheer No. 4, a similar basin of coal, in this case in part of an impure or bony character, was encountered. It was in places twelve feet thick, and was exceptional in the thickest part being in some instances far to one side of the center of the basin. This basin has been traced in a parabaloid direction for some distance.

The exceedingly irregular distribution of the coal measures and the influence of the various erosion periods is shown in the following section from east to west through the field.

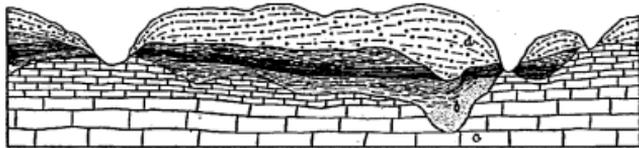


Figure 23. Section through What Cheer coal field.

There is a small Des Moines outlier about four miles east of What Cheer on Smith creek. Several country mines were

opened here ten to twenty years ago, the coal being reached both by shafts and drifts. The coal was from five to seven feet thick and was covered by a good shale roof, but the area is quite small; the Saint Louis beds being exposed ten to twelve feet thick on all sides along Rock and Smith creeks and their tributaries.

Northeast of South English, coal measure strata have been found at a single point as already described.

About three miles north of Sigourney there is a small group of Des Moines outliers which contain considerable coal. There are in all four such areas now known. They do not seem to be connected, and between certain of them at least, there are abundant Saint Louis outcrops. The coal in this field runs from three to four and a half feet in thickness and has usually a fire clay floor and a grey shale roof which is rarely more than twelve feet in thickness. It is usually much thinner and part of the coal must be left for a roof.

Between the old Branner and the Rowley mines there is an outcrop of Saint Louis which has been to some extent quarried. At the base of the quarry is a thin layer, three to four inches thick, of bituminous shale similar in character and on nearly the same level with the shale overlying the coal near by. This same shale has been found at several points in this neighborhood and has led to some confusion. Coal is known to occur at the old Branner mines (Tp. 76 N., R. XII W., sec. 24, Nw. qr., Se. $\frac{1}{4}$), at the Rowley mine (same section, Sw. qr., Nw. $\frac{1}{4}$), and at the Wertz mine (sec. 25, Nw. qr., Sw. $\frac{1}{4}$). In a well near the Rowley mine (sec. 24, Sw. qr., Ne. $\frac{1}{4}$), shale probably of Des Moines age was encountered.

Four miles east of Sigourney a twenty-two inch seam of coal was at one time worked at the Lockridge mine, but the opening is now abandoned. There is also a small coal measure area directly south of Delta, of which a section has already been given. The exact limits are not well defined, though the area cannot well be a large one. All the coal is taken from the north side of the river in section fourteen. On the opposite side is a sandstone probably of Des Moines age. In section thirteen, the Saint Louis rises in the bluffs a considerable distance

above the coal measure horizon. In the southeast quarter of the same section a small coal measure pocket, probably connected with the Delta area, occurs. It is cut off above and below on the river by the Saint Louis. The exposure shows:

	FEET.
3. Sandstone, coarse, red; imperfectly exposed.....	30
2. Shale, bituminous.....	4
1. To river.....	10

On the South Skunk river west of Springvale mill are coal measure outcrops already mentioned. The one at the west seems to be connected with the main body of coal measures, and a half mile west of the county line a small mine is in operation.

On Steady Run three miles north of Martinsburg (Tp. 74 N., R. XII W., sec. 8, Se. qr., Se. $\frac{1}{4}$), is a small coal measure outlier from which clay is taken for the manufacture of brick at Martinsburg. An eight inch seam of coal is underlain by fire clay and covered by a drab clay shale. The Saint Louis is exposed at each side in the bluffs of the creek and along its branches.

On German creek, as already mentioned, is a sandstone probably of Des Moines age. Borings on the hills around here show that the Saint Louis immediately underlies the drift so that the sandstone certainly covers only a limited area.

About one mile northeast of the Black Hawk Mill (Tp. 75 N., R. X W., sec. 29, Nw. qr., Ne. $\frac{1}{4}$), is a small quarry worked intermittently in a red sandstone. The quantity of stone seems to be limited. It lies a few feet above a small stream and a considerable distance above the river. The ledges are now covered by talus and the stone can only be seen in the blocks left on the surface. These show it to be a coarse, ferruginous variety becoming in places conglomeratic. The matrix is composed of quartz grains cemented by ferruginous matter. In this is set pebbles, in part of limestone, in part of quartz, waterworn and resembling river gravel, and in part of worn pieces of chert similar to that found in the Augusta of neighboring outcrops. If indeed that be their origin then we have here either a Saint Louis sandstone laid down upon the Augusta after an erosion interval, or a basal Des Moines

glomerate, which has in itself evidence that the pre-coal measure erosion cut entirely through the Saint Louis and exposed the Augusta. The evidence seems to favor the latter view. No fossils occur in the deposit. Two miles northeast of here, or a mile west of Tallyrand, is an exposure of sandstone very similar in character, though the conglomeratic facies seem absent. At this point there is, in connection with the sandstone, a body of bituminous shale which is similar in character to the usual coal measure shale, hardly admitting a doubt that the deposit is of that age.

South and west of Richland is a Des Moines area apparently connected with the coal measures of Jefferson county. The coal lies at a depth of about eighty feet under the uplands. The greater portion of the covering is drift, only a few feet of light shale being found over the coal. A section of the strata at the Smith mine (Tp. 74 N., R. X W., sec. 3, Se. qr., Se. $\frac{1}{4}$), is fairly representative:

	FEET.
6. Clay, yellow	10
5. Clay, blue, with boulders.....	20
4. Clay, fine, light colored.....	40
3. Shale, light grey.....	6
2. Coal	4
1. Fire clay.....	

The coal here is quite irregularly distributed, in places being entirely absent. It is mined now along the south fork of Richland creek. At one time coal was taken out directly west of Richland, though this opening has long been abandoned.

PLEISTOCENE.

The deposits which cover the greater portion of the county belong to the Pleistocene period. They consist of till, gravel, sand, clay, loess and alluvium. In thickness the beds are usually from 100 to 125 feet, though in the northern part of the county it reaches a probable maximum of 200 feet over the uplands, while individual borings show occasionally slightly greater depths.

DRIFT.

As seen along the streams and in well sections the most usual material is glacial till, consisting of a fine yellow clay

through which is disseminated the smaller sizes of gravel. Boulders are frequently encountered and are of all sizes and materials. Below this yellow boulder clay a blue variety is frequently encountered but has not as yet been traced from point to point. Gravel beds are infrequent and of small extent. Sands are also comparatively rare in any quantity. Directly north of Keswick two semi-detached hills of stratified sand are found at the edge of the bluffs.

LOESS.

Over the uplands is usually a thin covering of a loess-like deposit which never becomes prominent. Genetically related to it, being indeed probably merely an altered form of the loess, is a bed of stiff blue-grey to yellow clay, usually free from gravel and lime. This covers the whole of the upland south of the South Skunk river and also the piece of level land lying between Harper and Keota. Indeed it is not rare in any part of the county where there is level land. An important clay industry has been founded upon it.

ALLUVIUM.

The broad bottoms of the Skunk rivers and the narrow lowlands along the various other streams are made up of alluvium. This is a black loamy soil derived from the washing of the hills. It is from fifteen to twenty feet thick over the larger bottoms and in the minor valleys from two to eight feet deep. Along the smaller streams it is frequently cut through showing the glacial clay below, while on the larger bottom lands, the alluvium usually entirely conceals the drift, the latter showing along the streams only at intervals. This difference is probably due to the present relatively more rapid action of the side streams.

Geological Structure.

CROSS SECTIONS.

North Skunk Section. (Figure 1, plate viii.) Near the mouth of the North Skunk, the Augusta begins to appear from beneath the water. At Black Hawk mill it has risen to twenty feet or more, and the Saint Louis is seen above it. Beyond here an old

channel of German creek makes outcrops rare. A sandstone of Des Moines age is seen at one point, and well records show the hills to be made up of Saint Louis. At the mouth of Bridge creek there are several exposures of Augusta, the Springvale and Verdi rising over them. South of Sigourney the Springvale beds are prominent. About four miles west of here the Augusta is again exposed, both the Verdi and Springvale being also seen. South of Delta is the coal measure area already described, while from Delta west to Atwood the Verdi beds are frequently seen along the railroad.

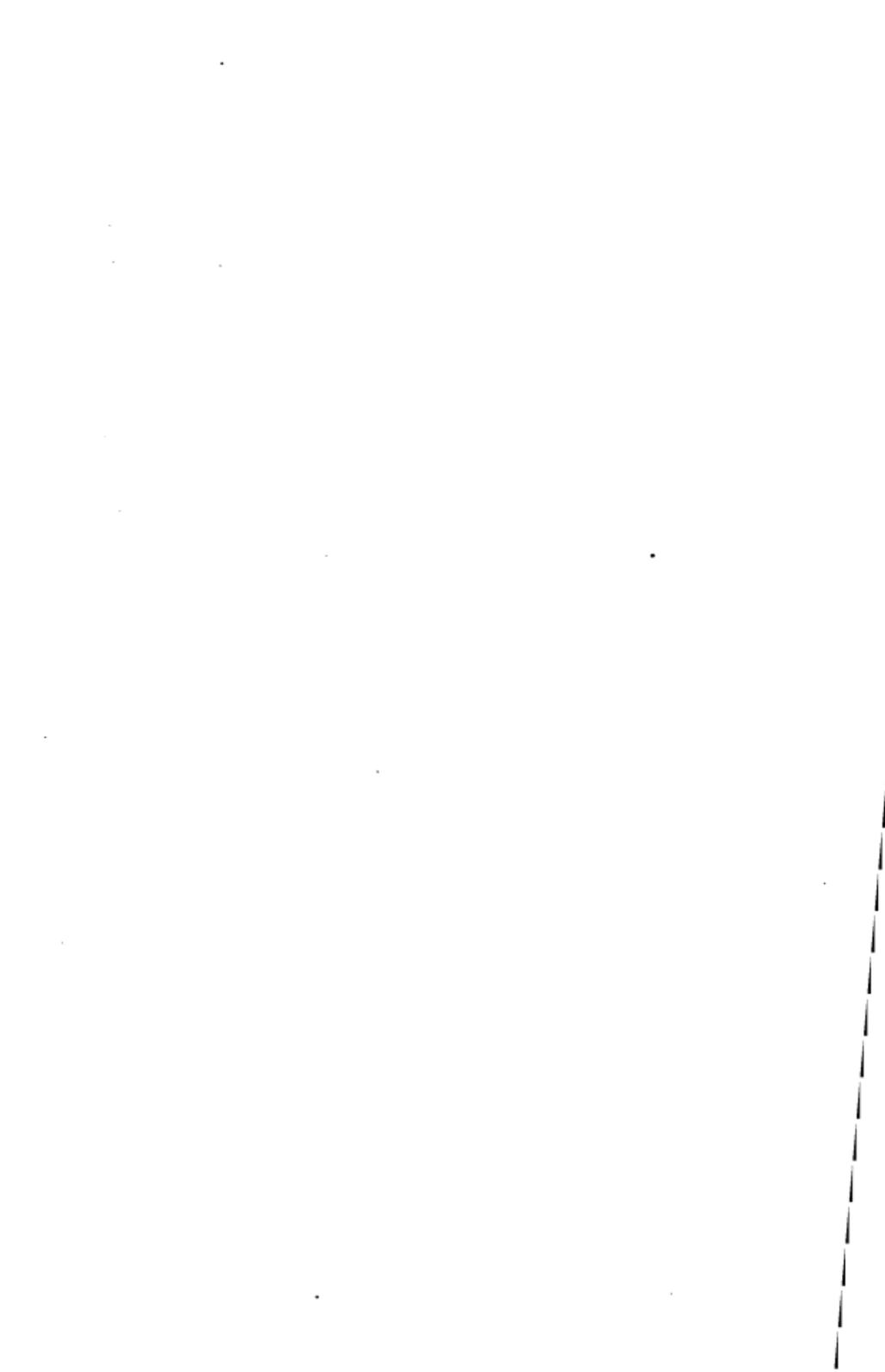
South Skunk Section. (Figure 2, plate viii.) In Washington county near the west county line there is an outcrop on the Skunk river which shows the Springvale beds at the edge of the water with part of their thickness apparently below that level. When the county line is crossed westward, broad bottom lands are encountered. The Saint Louis is imperfectly exposed in the bluffs some distance from the river. The Verdi beds and the upper portion of the Springvale beds are seen. Their height above the water indicates that the river level must have cut down close to the Augusta, though no rocks of this formation are seen more than a few miles below Manhattan mill. At the latter point they rise forty feet above the water, the Springvale and Verdi beds running up over them, the latter somewhat reduced in thickness. West of this point the Springvale beds come down towards the river, the Verdi beds regaining their usual thickness of forty to sixty feet. At the bridge north of Nugent the Springvale beds are partly below the water. Immediately west of here shales of the Des Moines terrain appear in a gorge cut down nearly through the Verdi. North of Hedrick the Verdi and Springvale beds are well exposed along the river, the former being especially prominent. On the north side of the river at the old Springvale mill the Augusta rises above the river, while at the bridge the Springvale beds have their typical exposure. This is the last point on the river at which their full thickness is shown. West of here they may be seen at a few points near the water. The bluffs are, however, made up largely of Verdi strata which are here particularly arenaceous.

They have been cut into largely and coal measures are frequently seen overlying them.

Section, Keota to Atwood. (Figure 3, plate viii.) At Keota the Augusta limestone is covered by about sixty feet of drift. Between that point and Sigourney there are no outcrops along the railway. It seems probable that the Saint Louis extends as far east as Harper with probable outliers beyond. Four miles east of Sigourney there is a very small coal measure outlier. Sigourney itself is built on the Saint Louis, the upper part of the Verdi outcropping just west of the town. Between Sigourney and Delta the Saint Louis outcrops along Cedar creek, and from Delta to Atwood it is again prominent.

South English River Section. (Figure 4, plate viii.) Over the northern portion of the county the drift is thick and outcrops are rare. In the northwestern corner of Washington county is a deep gorge cutting apparently entirely through the Augusta and into the Kinderhook. This is filled in with drift and crossed nearly at right angles by the present river. This old river valley probably extends into Keokuk county a short distance. About three miles west of the county line and north of Kinross, the Augusta outcrops along the river. North of South English coal measures occupy a pocket in the Augusta, and at Webster the Saint Louis underlies the drift. The Des Moines beds apparently do not extend beyond the eastern line of Prairie township. Throughout the greater portion of the township they apparently underlie the drift, being entirely absent only exceptionally.

North English to Hedrick. From North English to Webster the drift seems to directly overlie the Saint Louis. At the latter point it is particularly heavy as it is here that the watershed between the drainage system of the English and Skunk rivers is crossed. At Rowleys mine is a small coal measure outlier. At Sigourney the drift overlies the Saint Louis which is exposed north of town on Bridge creek and south on both the branches of the Skunk river. At Hedrick the greater elevation seems to be due to an increased thickness of drift rather than to the presence of any coal measures.



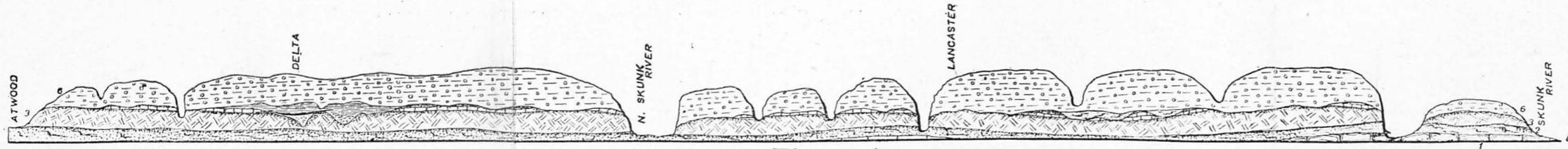


Figure 1.

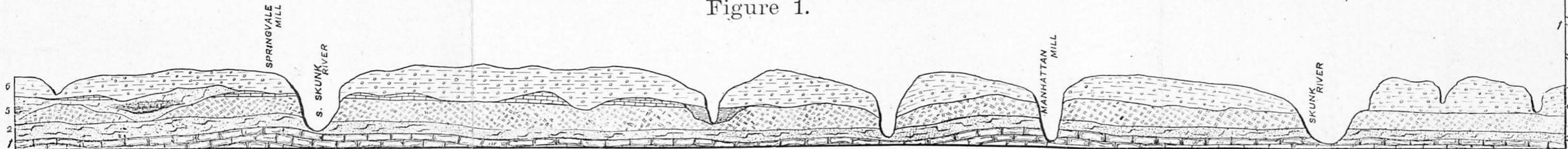
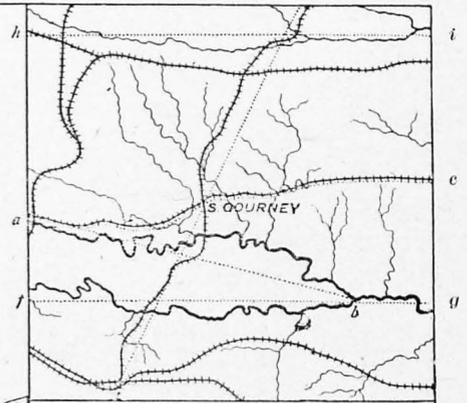


Figure 2.

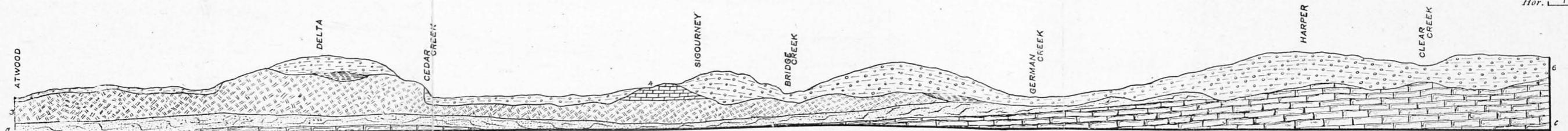


Figure 3.

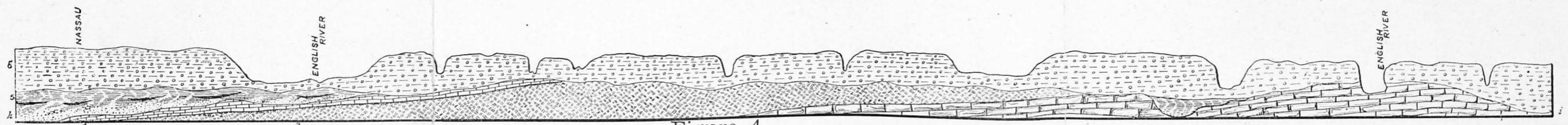


Figure 4.

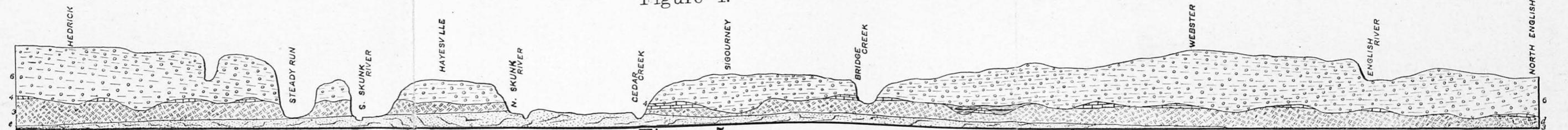


Figure 5.

Ver. 200 FEET
 Scale
 Hor. 1 MILE

EXPLANATION OF PLATE.

In Plate viii are represented the cross-sections described above. The numbers refer to the formations as follows: (1) Augusta, (2) Springvale, (3) Verdi, (4) Pella, (5) Des Moines, (6) Drift.

DEFORMATIONS.

The geological structure of Keokuk county is comparatively simple. As usual the rocks have a slight general dip to the southwest, the strike running nearly at right angles. The latter has been greatly modified by erosion and in the case of the Des Moines beds the present strike is exceedingly irregular.

The record of disturbance since the deposition of the strata is but slight. Two well marked though slight anticlinals have been determined with the probability of a third between the two. The first of these may be called the Manhattan anticlinal since the Manhattan mill is located nearly upon its crest. Its height is forty feet, and its direction is almost exactly north-east. The north branch of Skunk river crosses it at the Black Hawk mill.

The second anticlinal runs parallel with this and is crossed by the South Skunk at the old Springvale mill. The North Skunk crosses it about five miles southwest of Sigourney, and the South English seems to cross it about two miles north of Keswick. At this point is the only exposure of Augusta limestone found on South English in this county. The three outcrops are on a direct line. Midway between these two anticlinals at the mouth of Bridge creek on North river the Augusta rises above the water. No corresponding exposures are seen on South Skunk, though it must be admitted that the locality is unfavorable for outcrops.

In tracing these deformations very little help can be obtained from either the Saint Louis or the Des Moines beds, and results must be based almost entirely upon the Augusta. The coal measures and the Saint Louis limestone have both been so profoundly eroded that inferences drawn from the elevation of different outcrops, or the present distribution of the rocks is of small value. In the Saint Louis of this region there seems to

be no certain line of division above the base of the Verdi. The Springvale beds are constant in thickness and character, and thus are of considerable value for purposes of stratigraphy. They, however, immediately overlie the Augusta and follow the irregularities of its surface so that in the end it is the outcrop of the Augusta which allows the structure to be determined.

Skunk River Anticline. McGee in his monograph on the Pleistocene history of northeastern Iowa has described several deformations in the strata of the state*. These are approximately parallel and trend northwest to southeast. One of these has been called the Skunk river anticlinal and of this he says:

"(10) A parallel anticlinal brings the St. Louis limestone to the surface in the valley of Skunk river for many miles, probably from Ames, in Story county, to the southern part of Keokuk county; and still farther southeastward it finds expression in the exceptionally high altitude of the subcarboniferous rocks in western Henry county."

The appearance of the Saint Louis along the narrow line, as shown in the maps before published, was indeed striking. Recent work, however, has led to the belief that this is due, not so much to an anticlinal, as to the work of erosion. This appearance largely disappears on the new map of Keokuk county and is greatly changed on that of Mahaska county. For the reasons just given any determinations of structure must be based upon the base and not the top of the Saint Louis. It must be remembered that the effect of erosion on the latter has been such that differences of sixty feet in elevation in as many yards are not unusual. Another fact of importance in this connection is the extreme thinness of the coal measures which renders them easily cut through by erosion and so exposes the underlying limestone along the streams. The deep mines in both Keokuk and Mahaska counties are invariably upon the uplands, and the greater thickness of strata passed through is usually made up of drift. Numerous connected levels show that the coal lies along the same general

* Eleventh Ann. Rep. U. S. Geol. Sur., pp. 338-347. Washington, 1880.

horizon and that the Saint Louis rarely shows any irregularities which cannot be amply accounted for by the erosion it has suffered. The few deformations which have been definitely located run almost at right angles to the Skunk river anticlinal.

UNCONFORMITIES.

There are two great unconformities which have exerted a marked influence upon the distribution of the formations.

UNCONFORMITY BELOW THE DRIFT.

The widespread unconformity between the indurated and recent rocks has left its marks here as elsewhere. In this county the period of erosion marked by this unconformity has had an important economic effect in the removal of the greater portion of the coal deposits which once doubtless covered the whole county. So profound has the erosion been that over the greater portion of the area only scattered outliers, remnants of the once thick sheet of coal measure strata are left. These are of very irregular distribution so far as now located. Doubtless others are concealed beneath the drift.

The older rocks better resisted this erosion yet they too show its profound effects. In Poweshiek county just north, and in Washington county east, traces of an old drainage system have been found. At one point near Deep River a gorge has been cut in the limestone 250 feet deep. Apparently this same gorge just touches the northeast corner of Keokuk county. This older drainage system was apparently blocked up and buried some time during the glacial period, and so far as Keokuk county is concerned it does not seem to have influenced the modern river system.

UNCONFORMITY BELOW THE COAL MEASURES.

That the coal measures in this state rest unconformably upon the underlying rocks has long been recognized, and the relations between the two formations have been discussed by many workers till now the nature of the unconformity and many of its details are well understood. In brief it may be said that the time represented by the Kaskaskia deposits farther south was in Iowa a period of erosion rather than of deposition;

and that the Des Moines beds rest directly upon the Saint Louis limestone.

At the close of the Saint Louis epoch there was a period of elevation. The sea retreated and Iowa became an area of dry land, remaining so until the opening of the Upper Carboniferous. During the intervening period the land was exposed to erosive agencies and the old Saint Louis surface was given a topography not greatly unlike that of the present surface. The streams of that period carved their way down through the level strata to a depth in many cases exceeding a hundred feet. The hills on either side rose with quite precipitous slopes. Deep valleys and level-topped plateaus, narrow gorges and sharp ridges were all engraved on the face of the newly made limestone.

It was upon such a surface as this that the coal measure deposits were laid down and its irregularities profoundly influenced their distribution. These old hills served not only to limit the individual beds, but often directly conditioned their deposition. Whether at any point a coal bed was deposited depended very largely on whether the coast line was high, steep and forbidding, or whether it was low, retreating and fitted for the formation of coal swamps. It seems probable that the exceedingly irregular distribution of the coal along the basal coal horizon may be largely due to this factor.

The length of time that the land was exposed to erosion cannot even be approximately estimated. In this county there are a few facts bearing on the question. It seems probable, from the sandstone exposed at and near Talleyrand as described above, that the interval was sufficiently prolonged to allow the entire Saint Louis to be cut through. In Keokuk and Mahaska counties there are exposures showing about one hundred and fifty feet of strata which may be referred to the Saint Louis. How much has been removed from above that cannot be said. Over the greater portion of Keokuk county the Saint Louis beds which remain are less than 100 feet thick, and at many points were apparently not more than that when covered by coal measures.

Near Tioga, in Mahaska county, and running down into Keokuk county, is a coal measure outlier which rests upon the Verdi beds apparently near their base. At Nugent shales of the same age have been deposited in a channel in the Saint Louis which was cut down to within a few feet of the top of the Springvale beds.

ECONOMIC PRODUCTS.

COAL.

Keokuk county lies well toward the eastern margin of the Iowa coal field and consequently the coal measure strata covering it are comparatively thin. For reasons already explained, the Des Moines terrain does not spread over it in an even bed but occupies rather a series of detached areas. It does not seem probable that in this county the coal measure strata underlie much more than seventy-five square miles of territory. Nevertheless the county has for some years ranked among the more important coal producing districts of the State.

As has already been shown the conditions at the opening of Des Moines time were exceedingly favorable for the formation of coal. Hence the basal portion of this formation is especially productive. It is just this portion which erosion has left undisturbed, and so it happens that while the area is small it has been a very large producer. There are now in the county four regions in which coal is being mined. These are the What Cheer, Delta, Richland and Sigourney districts.

WHAT CHEER DISTRICT.

This is not only the largest producing region in the county, but has been and is yet one of the more important coal districts of the State. Of recent years the production has fallen off considerably and the impression has gained ground that the field is worked out.

In and around What Cheer there are about fifty square miles which are underlain by coal measures. What portion of this area contains coal can not be definitely stated. Drilling has shown that a considerable part contains no coal and that some contains coal which is unavailable for large mining

operations, either because of the thinness or irregularity of the vein, or the absence or poor quality of the roof. A considerable portion of the coal will undoubtedly be ultimately mined for local purposes by smaller mines.

Up to the present time only about twelve square miles of territory have been thoroughly mined out. Some of the region has never been prospected in any adequate manner, and during the present year a new mine has been opened in coal running from four to seven feet in thickness on land which had once been prospected and declared valueless. Recently considerable bodies of coal have been located and several new mines have been opened so that the prospect of the camp seems now quite good.

There is here but the one coal horizon and the irregular distribution of the coal along that horizon has already been mentioned. The coal found is of good quality and is in steady demand for steaming purposes.

The conditions of deposition, as exemplified at What Cheer, are characteristic of the Des Moines beds. The considerable amount of prospecting and mining done here has made them better understood than elsewhere. The old limestone hills are seen to protrude through the coal measures which were laid down around them. The slow currents charged with fine impurities have left their record in the ridges of bony coal,

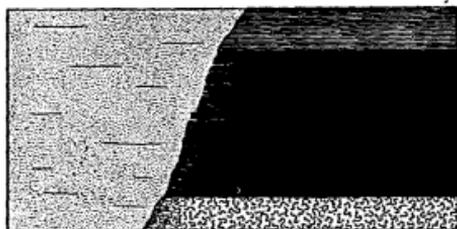


Figure 29. Cutout in What Cheer No. 5.

and the action of swifter currents cutting out the new-formed beds and depositing in their place sand and other material is seen in the various forms of "cut outs." One of these gullies, probably of later origin, now filled with sand and shale,

has been noted in the What Cheer No. 5. It is represented in figure 29, in which the coal is cut off abruptly and the space occupied by sand. The face of the coal in contact with the sand is badly weathered for a distance of several inches. The following is the section of the coal seam:

	FEET.
3. Shale, black, fine grained, fissile.....	2
2. Coal.....	6½
1. Fire clay, fine, grey.....	½

In the process of consolidation by which the soft, woody tissues were transformed into coal, there was considerable settling. This has given rise to a large number of true faults which, however, are of insignificant throw and seem to have no relation to any general movement. This settling may also have caused certain of the "rolls" and "horse-backs" encountered at numerous points. The basins already described seem in places to owe their form in part to this readjustment. In general, however, the preexistent topography was probably their determining cause.

What Cheer Mines.

NAME.	Township.	Range.	Section.	Quarter.	¼	Elevation.	Depth.	Thickness of Coal.
What Cheer No. 1.....	76	XIII	15	NE	NE	-----	70	5½
What Cheer No. 2.....	76	XIII	5	SW	SW	839	120	-----
What Cheer No. 3.....	76	XIII	3	NW	SE	-----	125	4
What Cheer No. 4.....	76	XIII	3	SE	NW	-----	135	5
What Cheer No. 5.....	77	XIII	34	SW	SE	852	117	6
North Star.....	77	XIII	34	SE	NW	828	105	-----
Broomhall H.....	77	XIII	34	SE	SW	818	125	-----
Rosetta.....	76	XIII	4	SE	NW	787	70	-----
Muscatine.....	76	XII	5	NE	SE	792	80	-----
Morgan.....	76	XIII	4	SW	SW	-----	Slope	-----
Keystone No. 1.....	76	XIII	9	NE	NW	-----	-----	-----
Keystone No. 2.....	76	XIII	9	NW	NE	-----	Slope	-----
Star F.....	76	XIII	10	NW	SE	-----	-----	-----
Tower & Co.....	76	XIII	10	SE	SW	748	53	-----
Thomas Brothers.....	78	XIII	10	SW	SE	728	33	-----
Moline.....	76	XIII	10	SW	SW	-----	-----	-----
Thompson.....	76	XIII	10	NW	NE	-----	44	6
Armstrong.....	76	XIII	15	NE	NW	766	44	6
Thos. Armstrong.....	76	XIII	10	NE	SW	-----	-----	-----

What Cheer Mines—Continued.

NAME.	Township.	Range.	Section.	Quarter.	½	Elevation.	Depth.	Thickness of Coal.
Crescent No. 1.....	76	XIII	4	NW	SE	820	72	5-7
Crescent No. 2.....	76	XIII	33	SW	SE	826	104	5-6
Crescent No. 3.....	76	XIII	5	NW	SE	845	125	-----
Blankquart.....	77	XIII	32	SE	SE	-----	Slope	-----
Black Diamond.....	76	XIII	9	SE	SW	-----	33	6
Shaft B.....	76	XIII	4	SE	NW	-----	-----	-----
Pioneer No. 1.....	77	XIII	27	NE	NW	-----	Slope	-----
Pioneer No. 2.....	77	XIII	22	SE	SE	-----	93	6
Starr A.....	70	XIII	9	NE	NE	879	-----	-----

The principal operations in this district have been carried on by the What Cheer Coal Company. This company acquired control of several of the larger earlier mines and after they were worked out opened up five large mines of their own. Two of these, Nos. 2 and 3, have been abandoned for some time, while No. 1 has only recently ceased to operate. Nos. 4 and 5 are nearly worked out and the company is preparing to open up new territory northeast of town where a considerable body of coal has recently been located.

Another of the larger mining companies of the district is the Crescent Coal Company. The two mines operated by it for some years past, the Vulcan and the Cory, have lately been abandoned. The plant is being removed to the new territory recently developed by the company northwest of town where mine No. 3 is now being opened. One of the borings put down at this point showed:

	FEET.	INCHES.
3. Drift.....	107	9
2. Shale, bituminous "slate".....	19	
1. Coal.....	7	6

There is, as usual, considerable variation in the thickness of the different strata. The coal runs from three and one-half to seven and one-half feet in thickness and seems to be covered over most of the field by a good thickness of "slate."

The North Star mine has been operated by various firms for some years, supplying considerable coal for the local trade. Recently this, with considerable adjoining property, has passed into new hands. The new company is preparing to develop the property and work it as a shipping mine. A number of borings have been put down, and a well protected seam of coal, running from three to six feet in thickness, and lying about 723 feet above sea level, has been located. A representative boring on the property is as follows:

	FEET.
3. Drift	100
2. Shale, bituminous.....	23
1. Coal.....	54

The Thomas Brothers mine is a slope opened in 1893. The firm loads coal on the Burlington, Cedar Rapids & Northern railway, and also supplies considerable for the local trade. The coal lies at an elevation of 695 feet. Towers & Co. reach the same bed of coal by means of a shaft a short distance east of the Thomas slope. They also ship on the Burlington, Cedar Rapids & Northern railway.

The Morgan, Black Diamond and Thomas Armstrong are all small mines worked mainly for the local trade.

The Pioneer Coal Company is located just south of Thornburg. The original mine was a small slope operated for local trade. Later, No. 2 a shaft mine, was opened north of here and the slope abandoned. The mine is now working and considerable coal is being taken from it.

DELTA DISTRICT.

The Delta area lies about six miles south of What Cheer and the two districts do not seem to be connected. Coal has been taken from several shafts and slopes all located within a short distance of each other. At present only two mines are being worked. The Martin Fisher mine (Tp. 75 N., R. XIII W., sec. 14, Ne. qr., Ne. 4) is a shaft fifty-five feet deep, the coal being about 712 feet above sea level. The Charles Olive mine is a slope reaching the same bed of coal (Tp. 75 N., R. XIII W., sec. 14, Ne. qr., Se. 4). The vein runs from four to five and one-half

feet in thickness and is of an excellent quality. The quantity seems to be quite limited.

RICHLAND DISTRICT.

In the Richland district, as has been explained, the coal is but poorly protected; the roof is thin shale and hence only small mines can be opened. There is, accordingly, a large number of deserted shafts, only two mines being now in operation. The Smith mine is about four miles southwest of Richland (Tp. 74 N., R. XIII W., sec. 31, Ne. qr., Se. $\frac{1}{4}$). The coal averages four feet in thickness. The roof is a gray clay shale from six to ten feet thick and requires considerable timbering. The section seen in the mine is:

	FEET.	INCHES.
4. Shale, light grey	2	
3. Coal, impure, shaly		2
2. Coal, without partings	4	
1. Fire clay, soft, white to grey	2	

The coal is more or less undulatory and shows in places step faults with a total displacement of six feet or more. A few clay seams and one or two "pinch outs" have been met with. The latter are in no case of great extent. Near this mine is a number of deserted shafts. It is customary, in this field, to work only a small area from each shaft, and when any difficulty is encountered the mine is abandoned and a new one opened. In this way as many as five shafts have been sunk on a forty acre tract.

About one mile east of the Smith mine is the Cordis mine, which is on a branch of Richland creek. This mine works in coal similar to that at the Smith mine, and it probably belongs to the same coal horizon. The roof here is of the same character and the coal from three to four feet thick. The fire clay under the coal is said to be fifteen feet in thickness. In the vicinity are also many abandoned mines.

SIGOURNEY DISTRICT.

The Sigourney region has already been quite fully described. There are now only two mines in operation here. The Rowley mine (Tp. 76 N., R. XIII W., sec. 24, Sw. qr., Ne. $\frac{1}{4}$) and the

Wertz mine (sec. 25, Nw. qr., Sw. $\frac{1}{4}$). The coal in each is from three to four feet in thickness and has usually a very poor roof, it being necessary in some places to leave part of the coal to protect it. At the Rowley mine the following section was taken.

	FEET.
3. Shale, black fissile.....	1
2. Coal, no partings.....	3 $\frac{1}{2}$
1. Fire clay (exposed).....	1

The old Branner mines, in which the coal was reached by drift, was located immediately north of Rowley's mine (sec. 24, Nw. qr., Se. $\frac{1}{4}$).

CLAYS.

CHARACTER AND DISTRIBUTION.

There are within the limits of this county three series of clays which are available for manufacturing purposes; alluvial, drift and coal measure. Along both branches of the Skunk river, and to a considerable extent along their tributaries, as also along the South English and its tributaries, the first of these formations is well developed. The Skunk river bottoms are usually from two to four miles wide, this bottom land representing the flood plain of the river. This plain is covered with an alluvial deposit of fine homogeneous black earthy soil, varying in thickness up to twelve and fifteen feet. A very considerable portion of this is of a grade not in the least inferior to alluvial matter elsewhere worked up into the rougher grades of clay wares. There seems no good reason to doubt that it could also be used, though no such attempts have so far been made.

The drift supplies the greater portion of the clays at present used. A very considerable portion of the drift here, as elsewhere, consists of yellow and blue clays, throughout which are scattered pebbles and boulders. At a number of places this clay is found in beds of considerable extent quite free from gravel. This seems to be more especially true upon the highlands where the upper portions of the clay beds are found. It is this portion which supplies the major number of brick and

tile factories of the region. The clay usually varies from yellow through grey or drab to blue in color, and, while having numerous local characteristics, is, in the main, a quite plastic, easily worked clay wherever found. It burns to a good color and does not, as a rule, check badly in drying if reasonable care be used. It is especially valuable as a tile clay. It seems to be a deposit closely akin to the loess and probably genetically related to it. Very likely it is but a phase of that deposit, though differing from it in its plasticity, color and density.

The coal measure clays and shales which are well developed over a portion of the county, are not as yet extensively utilized. At What Cheer, Thornburg, Sigourney and Delta, and also near Richland and Martinsburg, are clays which might be used to advantage. The Des Moines beds of this region contain but one coal horizon. Below the coal found along this horizon is the usual bed of fire clay, while above is a bed of clay shale of varying thickness.

Besides being excellent for common brick and tile it is probable that the shale would work up into good paving brick. Practical tests have shown that the fire clay is, at most points, of excellent quality and well adapted to numerous uses. Increased use, and consequently increased value of the clay beds, may safely be expected in the not distant future.

CLAY INDUSTRIES.

What Cheer. Wilson Brothers and Company operate a large brick and tile factory in the southern part of What Cheer on the Chicago & Northwestern railway. On the premises is an old mine from which it is intended to take fire clay. At present the drift or loessal clays alone are used. These are found on the premises and here contain a little gravel which is avoided as much as possible in mining. The clay is run through a Hoosier disintegrator and moulded on a No. 3 Brewer machine. Some of the ware is dried under sheds, but the greater portion is run on tracks direct from the machine into a furnace-heated brick dry-house 20x102 feet in size, where it is kept about fifty hours and then carried on the same truck to the kilns to burn. Three down drafts and one cased kiln are used in burning.

Bolton Brothers operate a brick yard in the northern part of What Cheer. The clay used belongs to the loess formation and is of good quality, free from gravel. One horse power Chief brick machine is used, and the ware, common brick, is dried for two weeks under open sheds. The bricks are burned in cased kilns, and are of a dark red color. The main portion of the output goes to an important local trade.

South English. Lawler Brothers' brick and tile factory is located in the southern portion of South English. Two different Pleistocene clays are used. One is a dark blue clay of exceptional strength which is used for the larger sizes of tile. The principal output, however, consists of brick and the smaller sizes of tile which are made from a yellow to gray loessal clay found near the factory. This is quite free from gravel or other foreign matter. It is spaded and carted to the mill where it is re-spaded and tempered. The supply for one day is prepared usually the day before. The ware is moulded on a McKenzie brick and tile machine and dried under closed sheds heated by steam pipes, where it dries in about one week's time. Three down draft kilns are used in burning.

Delta. Mr. E. Whistler formerly operated a plant immediately north of Delta. The usual drift clay was used, being prepared one afternoon for use the next morning. One F. Clarke brick machine was used. The brick were dried in a closed shed and burned in cased kilns. The output consisted entirely of building brick consumed locally. Since 1893 this plant has not been in operation.

Sigourney. J. S. White owns a brick and tile plant located two miles south of Sigourney on the Chicago, Milwaukee & Saint Paul railway. The usual loessal clay is here of a yellow color and about fifteen feet is taken. The clay is moulded as a stiff mud on a Brewer machine, and dried in closed sheds. In burning two cased kilns are employed, and wood is used for the fuel. Building brick and the smaller sizes of drain tile form the main output, though a few sidewalk blocks have been made. The trade is largely local.

Hedrick. F. W. Heidenreich operates a tile factory in the northern part of Hedrick. An altered loess of gray to yellow

color, occurring twelve feet thick, is used. It is moulded on a Brewer machine and dried in closed sheds. All sizes of tile from two and one-half to ten inches are made, but no brick has been turned out for two years. The clay used for tile is too strong for brick, and they were made of the top dirt. The ware is water-smoked with wood and then burned with coal.

Martinsburg. The Harbey & Gaston brick and tile works are located just west of Martinsburg on the Iowa Central railway. At this place both altered loess and coal measure clays have been used. The former is of the usual gray to yellow variety and is here quite clean. The fire clay is obtained from a small coal measure outlier two miles north of town on Steady Run. At present the main output of the factory is tile, which is mainly four-inch, though some threes and larger sizes are made. These are made of the loess clay alone. The bricks are made of two-thirds loess clay and one-third fire clay, the combination producing an excellent building brick. The fire clay was tried alone, and, while it makes a fine building brick, it is here not sufficiently pure for a good grade of fire brick. The clay is moulded on a Brewer machine. The ware is dried in closed sheds and does not usually check badly. In hot weather there is some trouble, but it is obviated by covering the more exposed parts with canvas. Two down drafts are used in burning.

Richland. Orvil Draper owns a brick and tile factory in the southwestern part of Richland. A loess clay, here fifteen feet thick, is used. The ware is moulded on a Brewer machine and dried under closed sheds, and afterward burned with wood in cased kilns. Brick forms the main output, though some tile, mainly fours and fives with a few threes and eights, are made. The trade is largely local.

Keota. Clarke & Leacox at Keota use an altered loess clay similar in character to that used elsewhere in the county. It is moulded on a Bennett side delivery brick and tile machine and dried under closed sheds. The clay here checks even worse than usual, and extreme care is necessary in drying. Tile dry in from two to three weeks, while brick requires about a week

longer. The clay burns to a good color, three down draft kilns being used.

BUILDING STONES.

All the indurated rocks exposed within the limits of this county have at some time been more or less quarried. Nearly every portion of the county contains an abundant supply of rock for all local purposes, and at a few points stone of an excellent quality occurs in quantities sufficient to warrant shipping.

DES MOINES.

The coal measures here yield but little stone. At one or two points a sandstone referable to that age outcrops. It is usually too soft and incoherent to be of any value. At the mill on the North Skunk river, two miles south of Delta, there is a heavy, red to yellow sandstone which has been used to some extent about the mill, mainly in the construction of the dam.

SAINT LOUIS.

Of the Saint Louis formation, which covers the greater portion of the county, the upper or Pella beds furnish the best stone. The stone is of the compact, fine grained variety, usually of a drab color, and lies in ledges eight to eighteen inches in thickness. In the region southeast of What Cheer, it is exposed along the various streams usually to a height of seven to twelve feet. It has been opened up here at a number of points, the quarries all showing stone of the same general character. The stone is used for local trade and the output varies greatly from year to year. The greater portion is used for foundation stones and well curbing.

At the quarry of Terry Lotscher, two miles east of What Cheer (Tp. 76 N., R. XIII W., sec. 11, Se. qr., Se. $\frac{1}{4}$) the surface of the stone has an elevation of 730 feet, rising ten feet above the bed of Rock creek. On Smith creek, two miles east, stone is also quarried at about the same level. The rock quarried north of Sigourney belongs in part to this division and in part to the upper portion of the Verdi; the two grading into each other. The section at the Rowley quarry (Tp. 76 N., R. XIII W., sec. 24, Nw. qr., Se. $\frac{1}{4}$) is:

	FEET.
5. Clay, yellow, with boulders.....	12
4. Limestone, in thin, 2-inch layers.....	4
3. Limestone, solid ledge.....	1
2. Limestone.....	2
1. Shale, black.....	‡

In ledge No. 4 *Rhynchonella ottumwa* White, and other Saint Louis forms occur. This quarry supplies considerable stone for local purposes. Stone has also been quarried a short distance west of here (sec. 23, Ne. qr., Ne. $\frac{1}{4}$). This quarry is not now in operation though considerable rock has apparently been taken from it. Stone has also been quarried northwest of Sigourney (Tp. 76 N., R. XII W., sec. 34, Nw. qr., Ne. $\frac{1}{4}$) and (Tp. 75 N., R. XII W., sec. 2, Nw. qr., Sw. $\frac{1}{4}$). These quarries work stone belonging to the Verdi beds, the sandy member as also the brecciated limestone being present.

The Verdi beds have been opened up at a number of 'points, usually for obtaining stone for immediate purposes, as north of Nugent (Tp. 74 N., R. XIII W., sec. 12, Nw. qr., Ne. $\frac{1}{4}$) where stone was taken out for the piers of a neighboring bridge.

The Verdi does not furnish as much good stone as the Pella beds, since the brecciated and soft sandy members form so considerable a portion of the whole formation. The Verdi was at one time quite extensively quarried by the Chicago, Rock Island & Pacific railroad a mile east of Atwood, the stone being used to some extent for bridgework, but mainly for ballast. The very irregular character of the ledges and the softness of the sandy members caused the effort to be abandoned.

The Springvale beds yield some stone. At the typical locality stone from this formation has been used in dam work. North of Hayesville at Connor's quarry (Tp. 75 N., R. XII W., sec. 15, Se. qr., Sw. $\frac{1}{4}$) it is also worked slightly. The stone here is in part a soft yellow, earthy limestone and in part a sandstone. The latter is the more prominent facies in a small quarry north of Richland (Tp. 75 N., R. X W., sec. 35). At the Cook quarry north of Ollie the Springvale must be stripped off to reach the Augusta. It is, however, too soft to be of any value.

AUGUSTA.

The best quarry stone occurring in the county is found in the Augusta formation. This is a hard sub-crystalline limestone occurring in buff, blue and white colors. It runs in even ledges of good workable thickness. It is easily dressed and stands exposure excellently. Polished specimens show that it is well adapted to certain kinds of monumental and interior work.

While the area occupied by the Augusta is in this county quite limited, the stone is readily accessible in large quantities. It has been opened up principally near the mouth of Rock creek north of Ollie. Quarries are now operated for local purposes only. S. C. Cook opened up a quarry here and built a switch connecting it with the Iowa Central railway at Ollie. The quarry has not been worked for some time but is to be reopened shortly.

Across Rock creek from this opening is the Riley Eye quarry which supplies the principal local trade. Nearer the mouth of the stream is the Eye Brothers quarry, and the Weber quarry, the latter supplying the stone used at the Manhattan mill dam.

SOILS.

There are two well marked soil types in this county, both of which are derived from the Pleistocene deposits. The indurated rocks are exposed so rarely that residual soils are not found. While there is considerable variety in the glacial deposits the variety does not extend very largely to the soils. Sometimes at or near the close of the glacial period the uplands become covered by a mantle of loess. This has since been altered considerably and forms the more common soil type. The upper portion is oxidized and mixed with humus, giving it usually a black appearance as seen in the field. The subsoil is a fine grained, usually tough, gray clay. It is normally free from gravel and seems to be an altered form of the loess which has lost its porosity to a considerable extent. Indeed, this change has advanced so far that where there is not a good natural drainage tiling must often be resorted to. Fortunately this same material is excellent for the manufacture of tile.

The second soil type is the alluvium which is found covering the bottom lands. It is simply the upper, blacker portion of the soil just described, and which has been washed down from the hills and re-deposited. This re-deposition has given it a loose, open texture. It is usually of considerable thickness, and since it lies down close to the water does not readily dry out. In some places it must be under-tiled.

Along the upper hillsides the soil proper has frequently been washed away, leaving the boulder clay exposed. This is, however, rarely the case except upon hillsides steeper than are cultivated, so that the boulder clay need not be considered as a soil.

WATER SUPPLY.

This county is well watered. The two river systems, with their numerous tributaries, supply an abundance of water for general and stock purposes. The thick mantle of drift with the diverse character of the different layers, makes it easy to obtain a good well at almost any point. At Sigourney there are several well marked water horizons in the drift. They are at depths of twenty-five, fifty-five, seventy and eighty-four to ninety-eight feet. In the first three cases the water is encountered in loose gravel or gravelly clay beds lying above layers of "hard pan" or "gumbo," while in the remaining instance the water-bearing gravel lies above the Saint Louis limestone.

It is rarely necessary, in any part of the county, to go into the older rocks for water. The Saint Louis is, however, usually water-bearing, a good supply being found in the soft sandstones lying between the limestone bands. Two such wells have been sunk at Keswick and similar wells have been bored at other points in the neighborhood.

The coal measures rarely furnish good water, a fact causing serious difficulties in mining regions. At What Cheer extensive prospecting has so far failed to reveal any good supply and surface waters are used. The Augusta is not water-bearing.

Two deep wells have been sunk in the county, one at What Cheer and one at Sigourney. Neither proved to be flowing wells, though in each case some water was found. At the latter

point a vein of mineral water with a strong odor was encountered at a depth of 1,320 feet. At 1,360 feet in the same stone a strong current of fresh water was struck which increased in force down to 1,388. This water flowed over the top while the drill was in motion, but now stands within about thirty feet of the top. It is of excellent quality and is unlimited in quantity, but it has never been used to any great extent.

WATER POWER.

The fuller utilization of the power of our streams is a subject which is now attracting considerable attention. In the earlier days when distance was more considered, industry less closely organized, and manufacturing methods more primitive, the streams of this region were more completely utilized. At nearly every available point dams were built and the power made to grind grains or weave wool. The advent of railroads and the introduction of more expensive machinery, dealt a death blow to these industries, till to-day for one such mill in operation there are many which are abandoned. Yet the streams have as much power as before, and power is probably in even greater demand than in earlier times. The problem is how economically to use the power. In many portions of the country the solution is being found in the introduction of electricity. When power is transformed to electricity it may be easily and cheaply transferred to some distance and applied to a variety of purposes. More usually it has been used directly as electricity in lighting.

The gradient of the Skunk rivers is quite low so that the power must be gathered rather by numerous smaller dams than by a few large ones. On North Skunk there are five mill sites, two of which, the Delta and the Black Hawk, are now in use. The remaining three have been abandoned. On South Skunk there is one mill site now used, the Manhattan, and two which are abandoned. At present not to exceed 240 horse power from this source are used. With very little expense about 1,000 horse power could be obtained. The experience of a number of years has shown that it very seldom occurs that there is not sufficient water in the river to meet all demands, and it seems

not improbable that sooner or later this waste power will be economically applied.

ROAD MATERIALS.

The value of good roads is becoming more and more generally recognized, and studies of their construction and the materials available are becoming popular. In Keokuk county there are two materials which are readily available, stone and clay. The gravel beds are of local extent only, and while of considerable value when found are badly scattered. The stone used must in the main be limestone since most of the sandstone is too soft. Nearly all the limestone found in the county could be readily used for macadam work. Certain of the Saint Louis strata are especially valuable owing to their hard compact nature. The distribution of these limestones has already been given in considerable detail.

In some quarters railways have used burned clay as a ballast. It is easily and cheaply prepared and makes a fine road material. Immense quantities of suitable clay are found all over the county.

Near What Cheer the old dump heaps of deserted mines are being used to some extent on the roads with excellent results.

LIME.

Formerly lime was burned from both the Augusta and the Saint Louis formations at a number of points. Of recent years the competition of more favored lime regions in the eastern part of the state has caused the abandonment of most of these kilns. At present only one is in operation, that of Mr. J. F. Kline near Hayesville. The stone burned is from the middle Saint Louis and a fine grained lime of good strength is obtained.

MINERALS.

Keokuk county is not a mineral district and any expectations of sudden wealth based upon discoveries of precious metals must lead to disappointment. Gold has been found in limited quantities at a few points in the drift or in rocks from the drift. It is not probable that it will ever be found in paying quantities.

Through the Kinderhook, Augusta, Saint Louis, and even coal measures of this region there are bands of chert or quartz. It has recently been found that some of these at least bear silver in limited quantities, one specimen assayed being said to have shown thirteen ounces to the ton. It does not, however, seem probable that these cherts will ever have any real value.

MINERAL PAINT.

Near Hayesville is a deposit of red ocherous clay which was at one time used locally as a crude paint. The deposit has never been developed.

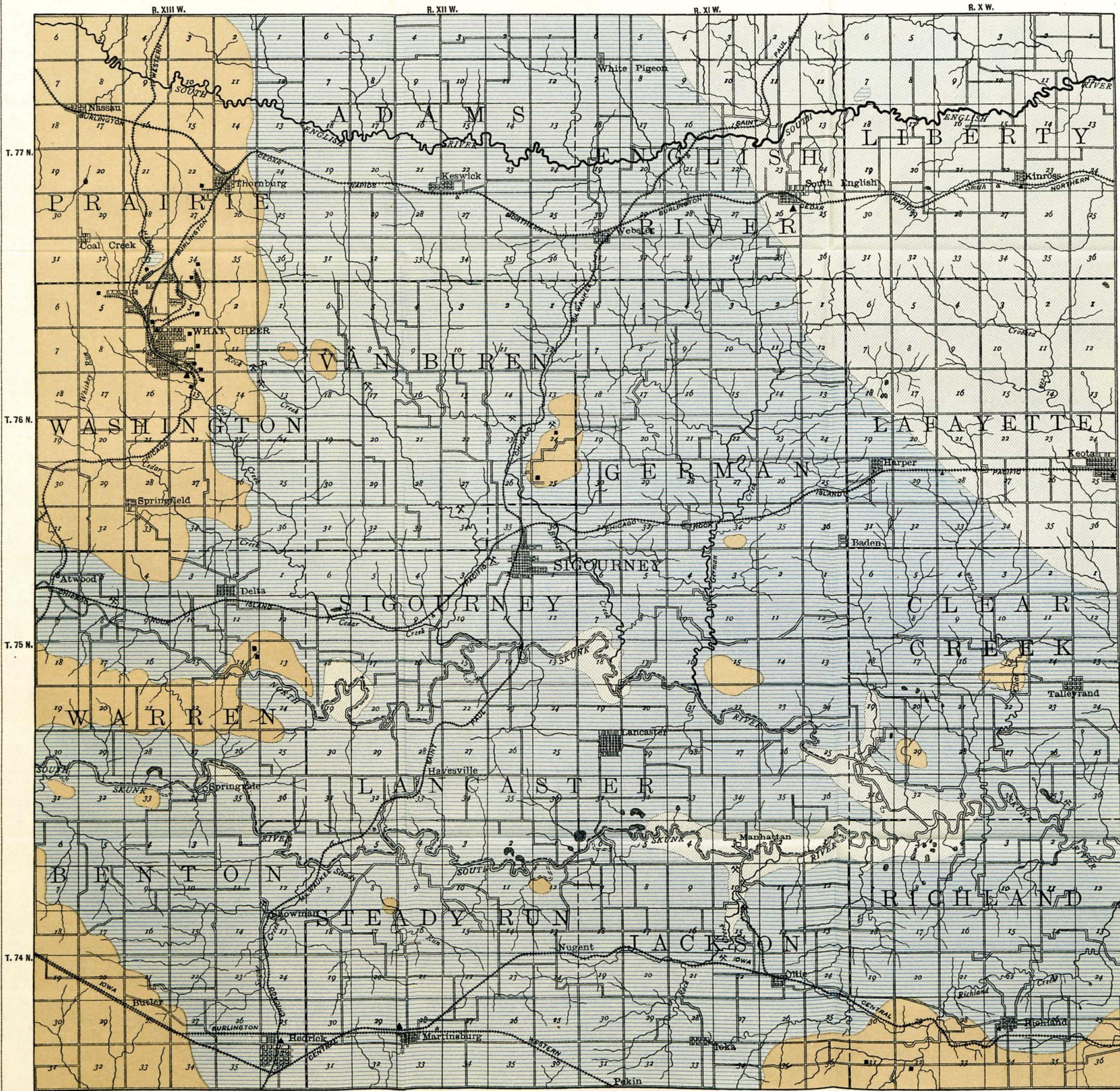
STATISTICS.

The total production of the various minerals found in Keokuk county is shown for the year 1893 in the following table:

Coal—		
Amount—tons.....	270,350	
Value.....		\$427,153.00
Clay—		
Brick—		
Amount.....	2,810,000	
Value.....		20,280.00
Tile—		
Amount.....	3,080,000	
Value.....		34,750.00
Building stone—		
Amount—perches.....	60	
Value.....		750.00
Total value.....		\$482,933.00

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IOWA GEOLOGICAL SURVEY

GEOLOGICAL
MAP OF
KEOKUK
COUNTY,
IOWA.

BY
H. FOSTER BAIN.
1895.

LEGEND
GEOLOGICAL FORMATIONS.

- DES MOINES (Coal Measures)
- SAINT LOUIS
- AUGUSTA

INDUSTRIES.

- QUARRIES
- COAL MINES
- CLAY WORKS
- LIME KILNS

DRAWN BY F. C. TATE.

