GEOLOGY OF LOUISA COUNTY

BY

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Louisa county has an area of 360 square miles. It forms a broken rectangle extending from township seventy-four to township seventy-six north, and over ranges one to five west. The eastern boundary is formed by the Mississippi river while the others consist of the lines of the land survey. In range five the southernmost township is cut out and instead township seventy-six is added on the north. Counting from the south the county is the third abutting on the Mississippi river. Its river front is slightly more than twenty-two miles

in length, forming a convex line with its greatest curvature to the south. The Iowa river crosses the county diagonally from northwest to southeast, receiving the Cedar river as a tributary from the northeast.

EARLIER INVESTIGATIONS.

The earlier geologists in the west neglected Louisa county to some extent. The cause for this is quite evident: there are no good outcrops of the indurated rocks along any of the larger water courses in the region, and before the land was brought under cultivation a greater part of the present lowlands were swampy tracts over which it was very difficult to travel. Dr. D. D. Owen* in his report of 1852 relates the fact that Mr. B. C. Macy "in tracing the confines of the Carboniferous formation between the Iowa and Cedar rivers, penetrated a region of ponds and swamps through which he waded for many days, and contracted an obstinate and dangerous intermittent fever." On the map accompanying this report the lower and the upper series of the Carboniferous limestones are represented as underlying the drift of this region, and on page 509 mention is made that this limestone appears near the mouth of the Iowa river. Hall† mentions the occurrence of the Burlington crinoidal limestone in the vicinity of Columbus Junction. The reports of C. A. White contain no reference to this county. In the reports of the Geological Surveys of Illinois several fish teeth are described that were collected from the Burlington limestone in Buffington creek by Frank Springer and O. T. St. John. In later years the drift has been studied by Mr. Frank Leverett, of the United States Geological Survey.‡ He has traced the outer margin of the Illinoian drift plain from its north to its south boundary and has mapped an old stream valley extending south and

* Rep. on Geol. Wisc., Iowa, Minn., 1852.

† Geology of Iowa, Vol. I, p 203, 1858.

‡ The lower rapids of the Mississippi river. Journal of Geology, vol. VII, No. i, also Monograph U S. Geol. Surv., No. xxxviii.

west from Columbus Junction. Several references bearing on the rocks of the county are made by H. E. Bain in his report on the Geology of Washington county.§ Finally, Prof. F. M. Witter, of Muscatine, published some years ago an account of the first gas wells in the drift in the northern part of the county.‖

PHYSIOGRAPHY.

TOPOGRAPHY.

The main topographical features of the county consist of two uplands and two lowlands; the bottom lands along the Mississippi, the low prairie and bottom lands of the Iowa, an upland drift plain east of the Iowa river, and an upland drift plain to the west.

The Mississippi Bottoms.—Along the northern boundary of the county these Mississippi bottoms are five miles wide. They occupy all of the north end of Port Louisa township and a strip on the east edge of Grandview, narrowing toward the south end of the township from which point it maintains an average width of less than two miles as far as the mouth of the Iowa river, in Jefferson township. From here it widens until along the southern boundary of the county it again has a width of five miles. In its northern part this bottom land has an average elevation of 552 feet above sea level and there is a slight general slope to the south of only a fraction of a foot to the mile until the Iowa river is reached. South of here the land is a little higher again. The main topographic features are the Muscatine slough, which follows the western border for the greater part of the distance north of the Iowa river, and the Great Sand Mound in the northeastern corner of Port Louisa township. This is a remnant of an old terrace rising thirty feet above the bottom land and occupping an area of a little more than a square mile, which extends north

§ Iowa Geol. Surv., vol. V, pp. 113-174.
‖ Proc. Iowa Acad. Sci., pp. 68-70. 1890-1891. American Geologist, vol. IX, p. 319.

into Muscatine county. Lake Klim is a lagoon connecting with Muscatine slough in the southeastern corner of Grandview township.

The Iowa River Lowlands.—The lowlands along the Iowa river vary from two to six miles in width and extend from the northwestern to the southeastern corner of the county. They present two expansions along their course which are separated by an encroachment of the highlands on either side. The average gradient of this plain is about one and one-sixth feet per mile, or from 615 feet above sea level in the northwestern corner to 580 feet in the southeastern corner of the county. The northernmost expansion constitutes the south end of the West Liberty Plain, the greater part of which lies along the Cedar river in Muscatine county. It here merges into the lowlands along the Iowa river. It occupies Oakland township and forms a level plain, averaging 610 feet above sea level. The Iowa river valley follows the southwestern border, varying from one-half to two miles in width and making several extensive detours to the northeast. One of these is occupied by Horseshoe lake, Hills lake, and Prairie creek and possibly marks an earlier course of Cedar river. In sections 3, 4 and 10 the plain rises occassionally to an elevation of about 650 feet above sea level, and becomes rolling and broken by low knolls and small, shallow, undrained basins. In the north half of the first two sections above mentioned there are a few dune-like hills. The Iowa bottom lands maintain a level about thirty feet below these lowlands. Toward the junction of the Cedar and Iowa rivers the upland bluffs converge and for six miles run a nearly parallel course about three miles apart, as far as Bard station. From here they diverge and enclose a lowland, usually known as Wapello prairie, which is about thirteen miles long and six miles wide. It is a level plain with an average elevation of about 590 feet above sea level. A few low sandy ridges follow in some places the shallow valleys which have been cut into its west and south border by Long and Otter creeks. Several low hills fringe the bluff line of its

southern border, appearing as if partially submerged under its sediments. The largest of the latter is in Sec. 10, Tp. 73, N. R. III W. Others are seen in sections 8, 14 and 15. In Jefferson and Elliott townships the two bluff lines again approach each other to within less than two miles. The bottom lands of the Iowa river valley which follows the northeast side of these lowlands are on an average thirty feet below the latter with a width of two miles. Its southeast extension is characterized by frequent bayous, such as Warstoff's slough, Stone lake, Keever slough, Spitznogle lake, and Parson's lake, indicating frequent recent changes in the river channel. The smaller valleys of Long creek and Otter creek are cut to a slight depth on the west and south border of this plain.

The East Drift Plain.—This upland is a southern extension of the Illinoian drift plain in Muscatine county. It has an average elevation of about 100 feet above the lowlands. It is about nine miles wide on the northern border of the county. From there it rapidly tapers until its entire width northeast of Wapello is only two miles. From this point a tongue extends southeast eight miles farther. The surface of this upland is that of a moderately dissected plain, with a general slope to the west. Except near the center of Concord township it is sharply marked off from the bordering lowlands by bluff lines. On the east side this bluff line varies from 100 to 150 feet in height, and is very steep. It is only broken by two small creeks, one of which runs out on the Mississippi bottoms in the northeast and one in the southeast corner of Grandview township. On the west side the bluffs as as a rule have a longer and gentler slope and range in height from forty to ninety feet. This is always the case where the sand prairie beyond it has not recently been cut away. In sections 10 and 15 of Tp. 75 N., R. IV W., the upland in some places merges into the lowland, and no bluffs are present. In sections 4, 5, 23, 24 and 25, Tp. 75 N., R. IV W., in the northwest corner of Concord Tp., and in sections 9, 10 and 15, Tp. 74 N., R. III W., the border of the upland is elevated into an

interrupted dune-like marginal ridge rising from ten to thirty feet above the low uplands. This is invariably associated with a few small, shallow, undrained basins on the upland next the ridge and is apparently the result of wind action. In the northeastern half of Grandview township there are some flat, ill-defined swells with a northwest-southeast elongation, rising thirty feet above the general upland level, while in Jefferson township several shallow and wide loess-covered valleys with a northeast-southwest trend slightly indent the surface. The most conspicuous of these is in sections 1, 3 and 9 in Tp. 73 N., R. II W.

The West Drift Plain.—The southwestern part of the county is occupied by a drift plain varying in height from 650 feet to 875 feet above sea level. Its highest point, which is also the highest in the county, appears to be in the west end of Morning Sun township. The bluffs terminating this upland plain on the east and extending from Sec. 6, Tp. 76 N., R. V W., to Sec. 35, Tp. 73 N., R. II W., are everywhere well marked and range from a height of 125 feet in Union and Columbus City townships to less than seventy-five feet in Marshall township, along the west side of Wapello Prairie. The surface of the plain has a general slope to the northeast. In Union, Columbus City, and Grove townships, and in the southeastern part of Marshall township, the creeks have open valleys with slopes on either side sometimes half a mile in length, that merge into the upland plain. In Morning Sun, in the south end of Wapello, and in Elliott townships the slopes of the small drainage valleys are usually sharply marked off from the upland plain, and the creek valleys are more narrow. In nearly all the streams which run from west to east, the south slope of the valleys are more steep and bluff-like than the north slopes. This is a noticeable feature of Goose, Short, Long and Buffington creeks and of that part of Otter creek which runs from west to east. Two features of this upland deserve special notice. There is a long depression resembling a shallow drainage valley extending from the Iowa river

border of the upland, just north of Columbus Junction, southwest and then south, to the southeast corner of Elm Grove township and thence into Henry county. The average width of this depression is one and one-fourth miles, and where best defined its bottom lies about forty feet below the upland and about 710 feet above sea level. Where it crosses Long creek its banks on either side become indistinct. A smaller branch leaves it and follows the south tributary of Long creek from the northeast corner of Long Grove township to the southwest corner, where it becomes confluent with the main depression again. This channel was first observed and described by Mr. Frank Leverett of the U. S. Geological Survey*.

Another noticeable feature is a line of high level traversing this upland and following the valley just described on the east. In Columbus City township it is not well defined, but just south of Long creek it forms two parallel, well marked swells extending south through Marshall township into Des Moines county. In the vicinity of Cairo these swells reach in places an altitude of 770 feet, while farther south they rise nearly a hundred feet higher. Each swell is about a mile wide and the two are half a mile apart. A minor feature in the topography of the county which deserves mention are some sink holes occurring on the upland in the northeast quarter of Sec. 18, Tp. 73 N., R. III W., near the Concord schoolhouse. These sink holes, which are about twenty feet deep and from five to eight rods wide, are due to subterranean caverns in the lower Burlington limestone which forms the underlying rock in this section.

TABLE OF ELEVATIONS.

Below is given a table of elevations containing all the railroad stations in the county and a few other places. It appears that of the four roads represented each has a datum of its own, the difference between two of these data exceeding

*Monograph. U. S. Geol. Surv., No. xxxviii.

100 feet. As the railroads intersect, connections were easily made and the elevations here given have been reduced to a common datum, the one adopted for the C. R. I. & P. R. R. in Gannett's Dictionary of Altitudes in the United States.

STATION.	ALTITUDE.	AUTHORITY.
Bard	599	B.,C.,R.&N.Ry
Clifton	621	C.,R.I.& P. Ry.
Columbus Junction	599	C.,R.I.& P. Ry.
Cotter	708	C.,R.I.& P. Ry.
Elrick Junction	568	I. C. Ry.
Fredonia	606	C.,R.I.& P. Ry.
Grandview	706	M. N. & S. Ry.
Highest point on R.R. 2 miles W. of Morning Sun	846	I. C. Ry.
Highest point on R. R. 2 miles E. of Letts	710	C.,R.I.& P. Ry.
Letts	663	C.,R.I.& P. Ry.
Levee east of Oakville	549	I. C. Ry.
Marsh	760	I. C. Ry.
Mississippi river, opposite Keithsburg, L. W.	523	
Morning Sun, B., C., R. & N. depot	745	B.,C.,R.&N.Ry
Morning Sun, I. C. depot	760	I. C. Ry.
Morning Sun R. R. crossing	752	B.,C.,R.&N.Ry
Newport	731	I. C. Ry.
Oakville	552	I. C. Ry.
Port Louisa, L. W.	526	
Wapello	588	B.,C.,R.&N.Ry

DRAINAGE.

The greater part of the land in the county drains into the Iowa river which follows in its course an earlier drainage line established long before the deposition of the drift. The rains on the flat lowlands along the rivers sink for the most part into the ground, which is naturally drained to some extent by seepage through the sand in which the water is quite free to move. Natural superficial drainage lines on the surface are almost wholly absent here. Since these lands were brought under cultivation the natural drainage has been aided by ditching, and some of the bottom lands have been protected from overflows by the construction of levees.

With the exception of a dozen sections of land the east drift plain drains into the Iowa river. The divide between the Mississippi and the Iowa follows closely the crest of the

Mississippi bluffs in Port Louisa and Jefferson townships. North of this it turns west and runs a little more than two miles west of the bluffs. The drainage of the eastern slope of this divide at the south end is therefore for the most part effected by very short and deep gullies or ravines with steep sides, evidently the result of very recent erosion, while the somewhat longer ravines in Grandview township appear to be the upper portions of older creeks whose lower ends have been cut away by the westward recession of the bluff line. Except in the northern part of this county, where it is less, the slope of the highland to the west is quite uniformly twenty feet permile. The creeks flow in general toward the southwest. They are quite wide and rather shallow in their upper courses and sometimes have a poorly drained alluvial bottom. A considerable part of the land surface is still flat and undissected by these ravines.

The drainage of the western drift plain in the southern tier of townships is mostly to the north but otherwise resembles somewhat that of the east drift plain. Honey and Smith creeks come across the county line from the south and have alluvial valleys along their lower courses which widen out in places to almost a quarter of a mile. Farther up stream, where they cut the underlying limestone, their valleys are narrow. It is evident that these creeks follow old drainage lines which have a considerably higher gradient than the present stream. All of the streams in this region are fed by springs coming from the base of the limestone. More than half a dozen creeks running north are tributarties of Otter creek, which follows the south side of the preglacial excavation under Wapello prairie. Part of its water evidently escapes into the sand of the lowlands, for the increase down the stream is not always proportionate to the water it receives from the uplands. Its tributaries from the north side are small and few, owing to underground seepage. In the southeast part of Marshall township it occupies a broad valley with a high bottom land. Long creek has a general course from

west to east and collects the run-off from most of Elm Grove and Columbus City townships and from the north half of Marshall township. In Marshall township its valley varies from one-fourth to half a mile in width and is largely occupied by a terrace which rises from twenty to thirty feet above its own alluvial bottom. This terrace is seen with interruptions as far west as the northeast corner of Elm Grove township. In this basin the upland is less flat than in the tracts previously described and the drainage is more mature. There are some indications that that part of Long creek which lies in Tp. 75 N., R. V. W., and in the two north tiers of sections in Tp. 74 N., R. V. W., has been captured by the lower creek and taken across a rocky ridge in sections 12 and 13, Tp. 75, N. R. V. W. At this point its valley is rock bound on both sides and very narrow and it is cut in an upland that gives no indications of the presence of a drainage line before one is on the very border of its valley. The wide, well matured slopes of the valley of Johnny creek, which comes from the east and meets the upper part of Long creek just before it enters the rock bound channel, suggests that its course may run to an earlier mouth of the upper part of Long creek.

Decisive evidence of such a change seems to be lacking, however. Short and Goose creeks are very much like Long creek. For four miles northwest of Columbus Junction the watershed between the Iowa river and Short creek follows the brink of the bluff and the narrow tongue of upland between them drains into the creek. Some of its small tributaries formerly extended beyond the present bluff line and have recently been cut short by the recession of the latter. This divide is at present rapidly shifting to the west. In the southwest corner of Morning Sun township, where the surface is flat and only gently trenched by drainage lines, the run-off is collected into the head of Crooked creek and carried west. The southwest corner of Elm Grove township is drained in the same direction.

On the West Liberty Plain and Wapello prairie lowlands the rains readily soak into the sandy ground except in some low and swampy draws where the soil is black and deep. The upper thirty or forty feet of filling on these lands consist of sandy material which allows a free seepage of the water. Under this superficial sand there is a blue clay more impervious to water. In many places, and for long distances on either side of the Iowa and the Cedar rivers, springs issue from the base of the overlying sand. The bottoms of the Iowa river are more or less subject to annual overflows above its junction with the Cedar. The Iowa river has a number of meanders with curvatures having a radius of from .14 to .46 of a mile, averaging .23 of a mile, and separated by straight races a mile or more in length. Recently, some of these meanders have been vacated by the main current and the channel has been straightened, owing perhaps to the greater violence of the floods produced by the removal of the natural vegetation in the drainage basin of the river. Below Columbus Junction the meanders of the Iowa have a mean radius of .55 of a mile, ranging from .28 to .92. A considerable part of the bottom has been reclaimed for tillage by ditches and levees.

STRATIGRAPHY.

General Relations of Strata.

The northeast half of Louisa county is covered with a heavy deposit of drift from one to three hundred feet in thickness. East of the bluff line which follows the west side of the Iowa river, no bed rock is known to outcrop, and its presence has been reported from only a single well not far from the mouth of the Iowa river. Several wells have reached a depth of less than 400 feet above sea level. Previous to the deposition of the drift this part of the county was excavated to this depth by some stream whose valley extends north and east under Muscantine and Scott counties. The extensive erosion of the bed rock over this wide area is due to its soft-

ness. It was a shale or clay more than 200 feet in thickness. Part of this formation may yet be left under the drift or it may have been removed, exposing the Devonian limestone underneath. In the southwestern part of this county the drift is thinner, being seldom more than 100, and frequently less than fifty feet. It rests on the Burlington limestone, which is about fifty feet thick. This in turn overlies the soft, shaly beds that have been removed from the area to the north and east.

The general classification of the formations in the county is given in the following table:

GROUP.	SYSTEM	SERIES.	STAGE.
Cenozoic	Pleistocene	Recent	Alluvial
		Glacial	Sangamon
			Illinoian
			Yarmouth
			Kansan
			Aftonian
			Pre-Kansan
			Geest
Paleozoic	Carboniferous	Upper Carboniferous	Des Moines
		Mississippian	St. Louis ?
			Augusta
			Kinderhook

UNDERLYING FORMATIONS.

The lowest rock which comes into view in this county is a blue shale. Several wells have penetrated this to a depth of more than 200 feet. One of these was sunk by Mr. P. A. Yohe at the Concord schoolhouse in Sec. 18, Tp. 73 N, R. III W. He reports 148 feet of "soapstone of a light blue color," beginning at a depth of twenty-three feet below the curb. Then there was thirty feet of black material of about the same composition as the "soapstone." Under this again there was ninety feet of "soapstone of the same kind as that above." In another well near the center of the west line of Sec. 12, Tp. 73 N., R. IV W., the same upper blue shale and the dark shale below it were again found, but the well was not sunk to quite the same depth as the previous one. In the northwest quarter of Sec. 22, Tp. 73 N., R. III W., 210 feet of shale was penetrated below ninety feet of drift. There was some dark material about fifty feet above the bottom. At Linton, in Des Moines county, about three miles south of Morning Sun, Mr. S. C. Petterson drilled a well to the depth of 365 feet. He found ninety feet of drift, below which which were 275 feet of shale. About fifty feet above the bottom there was some ten feet of dark brown material which was reported by the driller as "resembling coal." The close correspondence of the strata reported from these wells by different parties leaves no doubt that a heavy shale underlies the south and west part of the county as a continuous formation. Some wells in the northwestern part of the county give less conclusive evidence to the same effect. It is doubtless the same shale which has been found at the same horizon in several wells in the city of Burlington. Data obtained in the surrounding counties and elsewhere in the state, indicate that the downward succession of formations below the shale just described is about as follows :

THICKNESS OF FORMATIONS BELOW THE SHALE.

	FEET.
Devonian limestone	150
Niagara limestone	280
Maquoketa shale	180
Galena and Trenton limestone	300
St. Peter sandstone	150
Lower Magnesian series	700
Potsdam sandstone	100

The Mississippian Series.

The rocks which come under this heading are so intimately associated with each other in their outcrops that the details of the several subdivisions are best presented together. Briefly told, they consist of soft and easily eroded clays, sandstones and impure limestones below, usually called the Kinderhook, and of more durable limestones above, known as the Burlington. They appear to the best advantage for study in the bluffs west of the Mississippi and south of the Iowa in Elliott, Wapello, and Morning Sun townships, rising to the greatest height near the southern boundary of the county, and becoming less and less conspicuous as we follow the bluff line to the north and west. West of Elrick Junction the edge of the Burlington limestone recedes from the bluffs and seldom appears in the slope, but it can always be found in the creeks farther to the south. North of Otter creek it is not found within two miles of the Iowa river bluffs. The following typical sections are arranged in order from southeast to northwest. They describe the several rock ledges in each exposure in numerical order from below upward. Each ledge or seam is also marked by a separate number in brackets. These latter figures refer to the several divisions in the general section (Fig. 1) to which it has been referred and which will be found described after the presentation of the local details.

SECTIONS IN THE BLUFFS AND CREEKS NORTH AND EAST OF MORNING SUN.

1. SECTION ON THE FIRST CREEK IN THE MISSISSIPPI BLUFFS NORTH OF THE COUNTY LINE SOUTHWEST OF OAKVILLE, IN THE Sw. ¼ OF SEC. 35, Tp. 73, N., R. II W.

		Feet.
11.	(9) Disintegrated crinoidal limestone	6
10.	(9) Chert	1
9.	(9) Disintegrated crinoidal limestone	3
8.	(9) Blue shale	1
7.	(9) Hard, white, criniodal limestone with chert in upper layers	8
6.	(6, 7 and 8 ?) Beds changing from a disintegrated, yellow, shaly residue below, to a somewhat crumbling crinoidal limestone with much chert above	20
5.	(6) Yellow magnesian limestone with irregular bedding above and occasional quartzose concretions	7
4.	(5) Oolitic, yellow or brown, fossiliferous, disintegrated limestone	2
3.	(4) Fine sandstone, like number 1	1½
2.	(3) Compact, dark gray limestone, somewhat weathered, showing small cavities and veins filled with calcite	3
1.	(2) Bluish white, fine sandstone, weathering yellow, with casts of gasteropods and lamellibranchs	8

2. SECTION ON THE MISSISSIPPI RIVER BLUFFS ON THE SECOND CREEK NORTH OF THE COUNTY LINE IN THE EAST HALF OF SEC. 34, Tp. 73 N., R. II W.

		FEET.
15.	(11) Blue shaly beds, weathering yellow, with some calcareous and cherty bands above	15 ?
14.	Concealed	?
13.	(10) Chert	1
12.	(10) Brown limestone and chert	2½
11.	(10) Brown limestone, disintegrated	1
10.	(10) Bluish shaly material, with quartz geodes below	2
9.	(9) White crinoidal limestone, with quartz geodes in a shaly seam near base	8
8.	Concealed	?
7.	(9) White crinoidal limestone	4
6.	Concealed	?
5.	(9) Hard, white and yellow crinoidal limestone, moderately fine grained, with layers of chert	10
4.	(6) Yellow, rather fine-grained dolomitic crinoidal limestone, broken with many joints in upper part	10
3.	(5) Oolitic limestone with *Spirifer marionensis* Shum., *Productella concentrica*, Hall, *Spirifer* (undescr. sp), *Athyris*, sp., *Zaphrentis*, sp., and *Orthoceras*, sp.	3

		FEET.
2.	(3 and 4) Yellow or rusty brownish, weathered, compact limestone, with arenaceous rock above	5
1.	(2) Bluish fine sandstone, weathering yellow, with teeth of *Helodus* and casts of brachiopods in upper part. *Syringothyris extenuatus* Hall occurs near the top of the lowest number; also *Spirifer biplicatus* Hall and *Productus*, sp.	9

3. SECTION IN THE WEST BANK OF A CREEK NORTH OF THE CENTER OF THE SOUTH LINE OF THE NW. ¼ OF SEC. 23, TP. 73 N., R. 11 W.

		FEET.
5.	(9) Chert bands in decayed limestone	4 ?
4.	(9) Bluish white or white crinoidal limestone, mostly in 8 to 10 inch ledges. Contains *Eutrochocrinus lovei* W. & S., *Spirifer plenus* Hall, also *Chonetes logani* Hall. *Schinophoria swallowi* Hall, and *Actinocrinus multiradiatus* Shum. in the upper part	15
3.	(7) Irregularly bedded, coarse, crinoidal limestone	6
2.	Concealed	5 ?
1.	(6) Buff shaly material, disintegrated	3

4. SECTION ON A CREEK ONE MILE SOUTHEAST OF ELRICK JUNCTION, IN THE SOUTH PART OF SEC. 29, TP. 73 N., R. 11 W.

		FEET.
5.	(5 and 6) Yellow limestone, exhibiting oolitic structure below	10
4.	(4) Blue, evenly bedded, argillaceous sandstone	2
3.	(3) Fine grained, concretionary, yellow or brown limestone, disintegrated	4
2.	(2) Soft, fine grained sandstone, with *Helodus* teeth at base	2½
1.	(2) Blue, soft, sandy material, with wavy yellow stained bands containing *Chonopectus fisheri* N. & P., above.	6

5. SECTION ON THE EAST BANK OF SMITH CREEK JUST SOUTH OF ELRICK JUNCTION, IN THE SW. ¼ OF SEC. 29, TP. 73 N., R. 11 W

		FEET.
6.	(6) Irregularly bedded and leached limestone	?
5.	Concealed	10
4.	(2) Fine grained, soft, arenaceous rock	3
3.	(1) Soft, blue, unctuous shale	9
2.	(1) Carbonaceous shale	1
1.	(1) Blue unctuous shale with thin seams of calcareous material	6

6. SECTION IN AND NEAR ANDERSON'S QUARRY ON THE EAST BANK OF SMITH CREEK WEST OF THE CENTER OF THE Sw. ¼ OF SEC. 29, Tp. 73 N., R. II W.

		FEET.
9.	(9) Crinoidal white limestone (quarry rock).....	5
8.	(6 and 7) Apparently weathered crinoidal, cherty limestone, mostly concealed.....	13
7.	(6) Brown limestone, with scant crinoidal fragments in a single ledge.....	7
6.	(6) Seam of chert and shale.....	1
5.	(5 and 6) Single ledge of yellowish, hard limestone, with geodes of calcite, sparse crinoidal fragments above and two ten inch bands of oolite below	8
4.	(4) Arenaceous soft rock	3
3.	(3) Irregularly bedded, leached brown limestone.....	3½
2.	(2) Bluish gray, arenaceous, soft rock with *Deltodus occidentalis*, Leidy, *Cladodus* and *Chomatodus* and fragments of brachiopods and lamellibranchs, such as *Grammysia plena* Hall, *Pugnax striatocostata* M. & W. and *Loxonema* sp.....	4
1.	(1 and 2) Soft gray beds above, and shaly beds below, mostly concealed under the quarry rock but appear a few rods south, containing *Orthoceras (indianensis?)* and other fossils near the middle.....	20

7. SECTION ON THE EAST BANK OF SMITH CREEK NEAR THE BRIDGE IN THE Nw. ¼ OF SEC, 31, Tp. 73 N., R. II W

		FEET.
9.	(9) White or bluish crinoidal limestone with *Productus burlingtonensis* Hall, and a *Pentremites*.....	8
8.	(8) Chert	1
7.	(7) Irregularly bedded, knotty limestone with chert above.....	5
6.	(6) Mostly thin bedded, shaly limestone with crinoid stem fragments	3
5.	(6) White crinoidal limestone above, more irregularly bedded and cherty below.....	10
4.	(6) Brownish, fine granular limestone in two ledges with small fragments of crinoid seams.....	6
3.	(5) Oolitic limestone with fossils: *Spirifer marionensis* Shum. *Athyris crassicardinalis* White, *Rhipidomella burlingtonensis* Hall, *Straparollus obtusus* Hall, *Chonetes logani* N. & P., *Athyris* sp., *Zaphrentis* sp.....	2½
2.	(4) Bluish, fine grained arenaceous rock with brachiopods. A thin seam of shale above and near middle..	3½
1.	(3) Compact, fine grained limestone, thin bedded (bituminous smell).....	1½

8. SECTION IN A QUARRY BELONGING TO JAMES ELRICK NEAR THE SOUTH COUNTY LINE ON THE LEFT BANK OF SMITH CREEK.

		FEET
12.	(?) Weathered limestone	22
11.	(10?) Chert	½
10.	(9?) Crinoidal limestone with fish teeth near top	2
9.	(9) Soft limestone	1
8.	(9) Blue shale with some chert below	2
7.	(9) Fine grained, yellowish limestone with *Productus semireticulatus* (Martin) *Spirifer plenus* Hall, a *Pentremites*, in straight even ledges with fish teeth above.	2
6.	(9) Blue shale	¼
5.	(9) Bluish, rather fine grained limestone	2
4.	(9) Chert layers, interrupted	1
3.	(9) Coarse grained, yellowish or white crinoidal limestone	4½
2.	(9) Bluish white crinoidal limestone, upper ledges very evenly bedded, lower ledges somewhat fine grained with *Dielasma rowlei*, Worthen	8
1.	(8?) Softer limestone with some quartz geodes	1

9. SECTION IN J. H. SPRINGSTEEN'S QUARRY ON THE SOUTH BANK OF SMITH CREEK, IN THE Sw. ¼ OF THE Sw. ¼ OF SEC. 36, Tp. 73 N., R. III W

		FEET
2.	(10?) Blue shaly beds	3
1.	(9) White crinoidal limestone in very regular ledges near middle, and with some chert in the upper part	7

10. SECTION SEEN IN SOME QUARRIES ON GOSPEL RUN, NEAR THE NORTH LINE OF SEC. 27, Tp. 73 N., R. III W.

		FEET.
8.	(9) Chert and disintegrated limestone with *Eutrochocrinus lo"ei* W. and S.	3
7.	(9) Crinoidal limestone, somewhat thin-bedded, with a *Pentremites*	9
6.	(9) Thin bedded, criniodal limestone	2
5.	(8) Chert	¾
4.	(7) Yellow, irregularly bedded limestone	4
3.	(6) Yellow, disintegrated crinoidal limestone	3½
2.	(6) Coarsely aggregated crinoidal limestone with *Lobocrinus pyriformis* Shum	2
1.	(6?) Shaly disintegrated material	1

11. SECTION ON THE NORTH BANK OF A TUIBUTARY TO HONEY CREEK, IN THE Ne. ¼ OF THE Nw. ¼ OF SEC. 21, Tp. 73 N., R. III W.

		FEET.
4.	(9) Crinoidal limestone with some chert	5
3.	Concealed	25

		FEET.
2.	(?) Yellow disintegrated limestone with cast of a large *Aviculopecten*	2
1.	(4?) Bluish, arenaceous rock of fine texture	4

12. GENERAL SECTION IN THE QUARRIES ON HONEY CREEK, NEAR THE NORTH LINE OF THE Sw. ¼ OF SEC. 28, Tp. 73 N., III W.

		FEET.
18.	(10) Yellow limestone and chert, alternating	4
17.	(10) Crinoidal limestone	1⅝
16.	(10?) Blue shale	2
15.	(10?) Shaly and cherty limestone	1½
14.	(9?) Chert	1
13.	(9) Blue shale	½
12.	(9) Disintegrated crinoidal limestone	3
11.	(9) Disintegrated crinoidal limestone, brown or yellow, with *Deltodus spatulatus* N. & W., *Venustodus robustus* St. J. and W., and *Ctenacanthus* spine	½
10.	(9) Yellow weathered crinoidal limestone with some chert	2⅝
9.	(9) White chert	½
8.	(9) Yellowish crinoidal limestone with chert above and containing *Teleiocrinus umbrosus* Hall, *Dorycrinus quinquelobus* Hall, *Actinocrinus multiradiatus* Shumard, *Batocrinus pistillus* M. & W., *Dichocrinus striatus*. Ow., and Sh., *Eutrochocrinus christyi* Shum., *Spirifer logani* Hall, *S. grimesi* Hall, *Productus burlingtonensis* Hall, *Zaphrentis centralis* E. and H., and a *Syringopora*	4
7.	(9) Yellowish, fine grained limestone with small open pockets	1
6.	(9) Bluish white crinoidal limestone in ledges from one to three feet in thickness, without chert, containing some of the fossils of number 8, and also *Platycrinus nodostriatus* W. and Sp., and *P. glyptus* M. and W.	6
5.	(8) Crinoidal limestone with much chert	3
4.	(7) Very irregularly bedded yellow limestone	7
3.	(6) Chert in large masses	½
2.	(6) Yellow, weathered crinoidal limestone with scattered irregular layers of more solid limestone and chert	9
1.	(6?) Yellow shaly material resembling leached, disintegrated limestone, with occasional cavities lined with crystals	3

Numbers 1 to 5 are seen in the creek bank, just below the main quarry; numbers 6 to 12 appear in the face on the main

quarry on the west side of the ravine; and numbers 6 to 18 appear on the opposite side of the creek, in following it one-fifth of a mile up stream. *Rhipidomella burlingtonensis* Hall was seen in one of the beds numbered 5, 6 or 7.

13. SECTION ON THE RIGHT BANK OF HONEY CREEK, BELOW THE RAILROAD BRIDGE IN THE SOUTHWEST CORNER OF SEC. 28, Tp. 73 N., R III W.

		FEET.
6.	(9 & 10) Yellow, very much weathered limestone, with cherty layers and fish teeth near the middle	10
5.	(9) Grayish yellow, crinoidal limestone with some seams of chert	5½
4.	(9) Grayish yellow, crinoidal limestone without chert (main quarry ledges)	6½
3.	(8) Chert in small irregular nodules	2½
2.	(7) Disintegrated brown rock, almost shaly, with a more solid layer near middle	7
1.	(7) Chert	1

14. SECTION ON THE EAST BANK OF A RAILROAD CUT AT THE EDGE OF THE UPLAND, THREE MILES NORTH OF MORNING SUN.

		FEET.
5.	(6?) Disintegrated brownish magnesian limestone with *Athyris incrassatus* Hall and *Chonetes illinoiensis* W.	3
4.	(3 & 4?) Yellow, weathered, fine sandstone, with *Edmondia burlingtonensis* M & W., *Spirifer biplicatus* Hall, *Chonopectus fisheri*, N & P.: *Pugnax striatocostata* M. & W. (var) *Orthothetes inequalis* (?) Hall, *Chonetes* sp., *Fenestella*	3
3.	(2) Fine blue sandstone with few fossils	10
2.	(2) Fine grained blue sandstone with casts of *Productus laevicostatus* White, *Productus cooperensis* Swallow, *Athyris corpulenta* Winch., *Orthothetes inegalis* (?) Hall, and other lamellibranchs in abundance	2
1.	Blue shale	1

15. SECTIONS IN A RAVINE FOLLOWING THE WEST BANK OF THE RAILROAD ONE AND A HALF MILES NORTH OF MORNING SUN, IN THE NORTHEAST CORNER OF SEC. 19, Tp. 73 N., R III W.

		FEET.	INCHES
4.	(9) Chert layers		10
3.	(9) White or yellowish crinoidal limestone, with teeth of *Orodus*, *Deltodus* and *Cladodus*	2½	
2.	(9) Greenish white crinoidal limestone with *Lobocrinus pyriformis* Shum., *Dizygocrinus rodundus* Yand and Shum., *Dorycrinus quinquelobus* Hall, *Eutrochocrinus lovei* W. and S., *Pentremites elongatus* Shumard, *Actinocrinus scitulus* M. and W.	1½	

1. (9) White crinoidal limestone with *Rhipidomella burlingtonensis* Hall, and *Spirifer plenus* Hall..... 4

16. SECTION IN DELZELL'S QUARRY, NEAR CONCORD SCHOOLHOUSE, IN THE Ne. ¼ OF THE Ne. ¼ OF SEC. 18, Tp. 73 N., R. III W.

FEET

2. (6) Yellow limestone, rather fine grained, with fragments of crinoid stems, in heavy ledges..... 7
1. (6) Disintegrated and soft yellow limestone..... 4

It will be noticed that in nearly all the sections in the bluffs bordering the river lowlands the lower soft Kinderhook beds appear. They have evidently been protected from destruction by the overlying Burlington limestones. West of Honey creek these bluffs seldom show anything but drift. Along that branch of Otter creek which runs through the north tier of sections in Tp. 73 N., R. IV W., nothing but drift is seen, and explorations in several wells show that these beds have been deeply eroded. The drift is at least one hundred feet deep. In Sections 11, 13, 14, 23 and 24 the Burlington limestone is, however, frequently in evidence along the watercourses, and it appears even as far north as near the center of the Sw. ¼ of Sec. 3 in Tp. 73 N., R. IV W. But these exposures have a limited vertical range, as is evident from the following instances.

SECTIONS IN OTTER CREEK BASIN.

17. SECTIONS IN AND NEAR AN OLD QUARRY ON THE EAST BANK OF OTTER CREEK, IN THE Ne. ¼ OF THE Ne. ¼ OF SEC. 14, Tp. 73 N., R. IV W.

FEET.

4. (9) White crinoidal limestone 8
3. (9) Blue shale..... 1 ?
2. Concealed..... 8 ?
1. (7) Crinoidal limestone and shaly material with some quartz geodes (exposed farther up in the creek) 5

18. SECTION ON THE WEST BANK OF OTTER CREEK, NEAR THE CENTER OF THE WEST LINE OF SEC. 24, Tp 73 N., R. IV W

FEET.

1. (9 & 10?) Somewhat disintegrated limestone, yellow or brown, with frequent bands of chert. 17

19. SECTION IN CHURCHMAN'S QUARRY IN THE WEST BANK OF OTTER CREEK NEAR THE SOUTHWEST CORNER OF SEC. 14, Tp. 73 N., R. IV W

		FEET.	INCHES
3.	(9) Crinoidal limestone	1	
2.	(9) Chert		10
1.	(9) Bluish white crinoidal limestone in ledges from 6 to 12 inches in thickness	8	

SECTIONS IN LONG CREEK BASIN.

Following Long Creek west we find bed rock for the first time near the east line of Sec. 13, Tp. 74 N., R. V W. From this point the exposures are almost continuous along the south fork for two miles, but have a limited vertical range. The Kinderhook beds gradually disappear under the overlying limestones. The Buffington fork is rocky a mile from its mouth and has a few scattered exposures farther west. The north or main branch runs through a valley in which the Burlington limestone is frequently exposed in the bluffs or on the small tributaries. But with few exceptions these rocky cliffs are less than twenty feet in height.

20. SECTION ON A SMALL TRIBUTARY OF LONG CREEK, SOUTH OF THE CENTER OF THE Se. ¼ OF SEC. 13, Tp. 74 N., R. V W.

		FEET.
4.	(?) Brownish gray, compact, siliceous rock, possibly changed locally from a dolomitic limestone by infiltration	8
3.	(?) Not exposed	2
2.	(2) Blue, soft, fine sandstone with *Orthothetes inequalis*, *Chonopectus fisheri* Hall, *Aviculopecten caroli* W., *Productus levicostus* White, *Rhipidomella burlingtonensis* Hall, *Macrodon cochleris* Winch., *Orthoceras whitei* Winch, *Conularia* (*micronema?*), *Edmondia* sp.	4
1.	(1) Soft shale (seen farther east)	?

21. SECTION IN THE WEST BLUFF OF LONG CREEK, SOUTH OF THE CENTER OF THE Nw. ¼ OF SEC. 13, Tp. 74 N., R. V W.

		FEET.
5.	(6) Irregularly bedded, compact, brown or gray dolomite; some brachiopods, with a few crinoid fragments	10
4.	(3 & 4) Rather harder than that below, brown earthy stone	2
3.	(2) Soft, rather uniform, bluish gray, light colored fine sandstone, with lamellibranchs and teeth of *Helodus* near top	5

		FEET.
2.	(2) Alternating layers of fine loose sandstone	5
1.	(1) Green clayey shale	3

22 SECTION IN J. H. WASSON'S QUARRY IN THE SOUTH BANK OF THE SOUTH BRANCH OF LONG CREEK IN THE NORTHWEST CORNER OF SEC. 23, Tp. 74 N., R. V W

		FEET.
6.	(10) Disintegrated limestone with bands of chert	3
5.	(?) Yellow disintegrated limestone	3
4.	(9) Blue shale	1
3	(9) Yellow, slightly disintegrated crinoidal limestone with small hollows filled with calcite crystals (also zinc blende)	4
2.	(9) Yellowish, partially disintegrated limestone with fish teeth such as *Deltodus spatulatus* N. & W., *Psammodus glyptus* St. J. & W., *Cladodus* sp., *Helodus* sp., and *Orodus* sp	1½
1.	(9) Crinoidal white limestone in ledges from 6 to 10 inches in thickness with *Eutrochocrinus lovei* W. & S., *Batocrinus laura var. sinuosus* Hall, *Batocrinus laura* Hall, *Dizygocrinus rotundus* Yand and Shum	4½

23. SECTION IN GRAY'S QUARRY NEAR THE NORTH BANK OF THE NORTH BRANCH OF LONG CREEK IN THE Ne. ¼ OF THE Nw. ¼ OF SEC. 3. Tp. 74 N., R. V W.

		FEET.	INCHES.
5.	(9) Yellow, disintegrated encrinital limestone with fish teeth near the base and with *Schizophoria swallowi* Hall, *Eutrochocrinus christyi* Shum., *Batocrinus laura* Hall, *Dizygocrinus rotundus* Yand and Shum., and teeth of *Deltodus*	5	
4.	(9) Ecrinital white limestone in heavy ledges with *Productus semireticulatus* Martin, *Productus burlingtonensis* Hall, *Spirifer grimesi* Hall	3	
3.	(9) Chert		10
2.	(9) Brownish yellow, porous, disintegrated limestone	3	
1	(9) Bluish white crinoidal limestone with occasional crinoids near top	5	

24. SECTION ON THE WEST BANK OF LONG CREEK ONE-FOURTH MILE SOUTH OF THE MOUTH OF JOHNNY CREEK NEAR THE CENTER OF THE SOUTH LINE OF SEC. 12, Tp 74, R. V W.

		FEET.
5.	(6 or 7) Gray compact limestone	8
4.	Concealed	13
4.	(3 or 4) Brownish gray gritty rock	3
2	(2) Blue, soft, fine sandstone with casts of *Bellerophon bilabiatus* M. & W., *Straparollus macromphalus* W., *Spirifer subrotundatus* H., *Orthoceras whitei* Winch.,	

FEET

Glossites elliptica, Straparollus, Modimorpha (?) Bellerophon (two species)..... 3

1. (1 & 2) Blue arenaceous soft rock with shale below..... 12

25. SECTION ALONG LONG CREEK IN THE SOUTHEAST CORNER OF SEC. 33, Tp. 75 N., R. V W.

FEET.

2. (10 & 11) Weathered shaly limestone and shale with cherty layers 15
1. (9) Sound, bluish white or gray, crinoidal fossiliferous limestone. 15

26. SECTION IN F. J. MOORE'S QUARRY ON THE EAST BANK OF LONG CREEK IN THE Sw. ¼ OF THE Ne. ¼ OF SEC. 33, Tp. 75 N., R. V W.

FEET

6. (9?) Bands of chert 1
5. (9?) Yellowish shaly material or disintegrated limestone 2
4. (9) Yellow, partially disintegrated limestone with chert bands and fish teeth in the upper part, containing *Deltodopsis bialveatus* St. J. & W., *Deltodopsis convexus* St. J. & W., *Deltodus spatulatus* N. & W., *Cladotus*, fragments of spines 2
3. (9) Bluish white crinoidal limestone in ledges from 6 to 10 inches in thickness with *Productus burlingtonensis* Hall 2
2. (9) Shelly limestone with many brachiopods and *Igoceras capulus* Hall 1
1. (9) Crinoidal white limestone..... 2

27. SECTION ON THE SOUTH BANK OF LONG CREEK NEAR THE WEST LINE IN THE Nw. ¼ OF SEC. 32, Tp. 75 N., R. V W.

FEET.

3. (11) Shaly limestone..... 5
2. (11) Blue shale..... 1
1. (11) Yellow limestone, somewhat fine grained..... 8

SECTIONS ON CLIFTON CREEK AND IOWA RIVER.

North of Long creek basin the drift rapidly increases in thickness and the bed rock is rarely exposed. It has been observed only in sections 22 and 27, Tp. 75 N., R. V., W., and in and near the bluffs of the Iowa river in sections 16 and 17, Tp. 76 N., R. V. W. At this latter place the blue Kinderhook shale is exposed in the bank of the river, rising some five or six feet above the water for a distance of a few rods.

It is covered by the shale and sandstone of the coal measures. Over most of this northern territory the Burlington limestone has been removed and the unprotected Kinderhook beds have been deeply eroded.

28. SECTION IN A TRIBUTARY OF CLIFTON CREEK IN THE Ne. ¼ OF THE Ne. ¼ OF SEC. 27, Tp. 75 N., R. V W.

		FEET.
7.	(6) Crinoidal fossiliferous limestone, with chert seams (exposed farther up in the creek)	10
6.	Concealed	4?
5.	(?) Chert of oolitic aspect and with fragments of fossils	½
4.	(?) Yellow decayed limestone, with sparse crinoid joints	2
3.	(?) Chert of oolitic appearance and containing small fragments of fossils	½
2.	(?) Yellow disintegrated limestone with scattered joints of crinoids, a productus, and various gasteropods	½
1.	(2) Bluish gray arenaceous rock with fish teeth near the top and various gasteropods; also *Athyris corpulenta* W., *Productus curtirostra* Winch., *Productella nummularis* Winchell, *Orthoceras inequalis* Hall, *Edmondia burlingtonensis* M. & W., *Eumetria altirostris* White, *Porcellia obliquinoda* White, *Grammysia plena* M. & W. *Bellerophon* (undescr?) and a *Platyschisma*	4

29. SECTION ON THE SOUTH BANK OF CLIFTON CREEK NEAR THE CENTER OF SEC. 22, Tp. 75 N., R. V W.

		FEET.
2.	(6?) Yellow decayed limestone	3
1.	(2) Arenaceous blue material	5

30. SECTION ON THE SOUTH BANK OF A SMALL CREEK IN THE SOUTH BLUFF OF THE IOWA RIVER, IN THE SOUTHWEST CORNER OF SEC. 16, Tp. 76 N., R. V W.

		FEET.
1.	(1) Bluish green shale cut up by joints into small rhomboidal blocks	4

General Section of the Subcarboniferous Rocks.—In comparing the sections above described with each other and with many others seen in the field, and on noting theirrelative positions, it becomes evident that they form a conformable succession of beds approaching a depth of one hundred feet. Certain parts of this section are much affected by weathering or else are quite generally concealed under the drift. At such

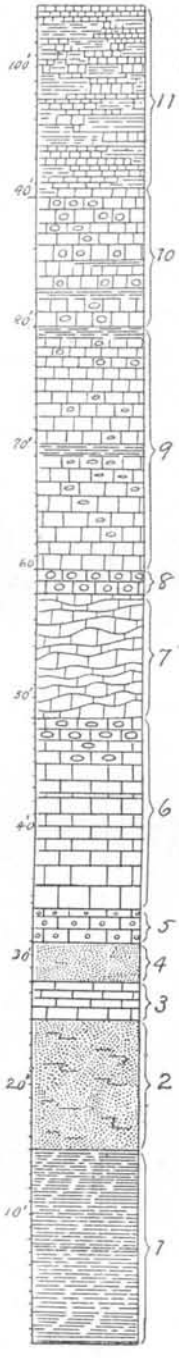


Fig. 1. General Section of the Lower Carboniferous (Mississippian) Rocks in Louisa County.

horizons it has been impracticable to make close comparisons or exact correlations, either on the basis of fossil remains or of lithologic characters. Both of these characters seem otherwise quite constant for each horizon, and doubtless much smaller subdivisions than those here attempted might be identified in different places with a closer examination of the rock and in a region where disintegration were less far advanced. As it is, eleven different divisions appear sufficiently constant to be capable of identification in this county. These will here be described in succession from below upward. See general section, Fig. 1.

(1) Maple Mill Shale:—The lowest member consists of a greenish, unctuous shale. In one place this has a dark band containing carbonaceous material some five or six feet below its upper limit. At another place it is cut up by two sets of joints into small and quite regular rhomboidal blocks. No fossils have been found by the author in this shale in Louisa county but at Burlington, where it is exposed deeper down, it contains several brachiopods, some decapods and a dictyospongia. In Louisa county only some fifteen feet are exposed, but several wells have, as already stated, penetrated it to a depth of at least 180 feet.

(2) English River Gritstone (Chonopectus Sandstone of Weller):—The Maple Mill shale changes somewhat gradually upward into a soft bluish gray, fine grained sandstone with intervening thin seams of shaly

material. It consists of rather angular quartz fragments of very uniform size, averaging one-sixteenth of a millimeter in diameter. By boiling in acid about eight per cent in weight is dissolved, consisting mostly of carbonate of iron and carbonate of magnesia. In weathering this rock turns a dull yellow color. In this condition the upper layers frequently exhibit fine, parallel curving, concentric, red or rusty lines on the surface. These are seemingly the result of some kind of progressive oxidation and concentration of the ferruginous material which it contains. A few inches below its upper surface there is a thin layer which contains imbedded fish teeth. A species of *Helodus* is almost invariably present and other observed forms are *Deltodus occidentalis* Leidy, *Cladodus* and *Chomatodus.** In the upper as well as in the lower part of this rock casts of various other fossils, mostly brachiopods and lamellibranchs, are quite frequent and ocasionally abundant. The following have been identified by Dr. Stewart Weller in a collection made by the author:

Fenestella, sp.
Athyris corpulenta Winch.
Syringothyris extenuatus Hall.
Pugnax striatocostata M. & W.
Orthothetes inequalis Hall (?)
Rhipidomella burlingtonensis Hall.
Eumetria altirostra White.
Productus curtirostra Winch.
P. cooperensis Swallow.
P. levicostatus White.
Productella nummularis Winch.
Chonetes, sp.
Chonopectus fisheri Hall.
Spirifer biplicatus, Hall.
S. subrotundatus Hall.
Modiomorpha, sp.
Grammysia plena Hall.

*The identification of these fossils were kindly made by Dr. C. R. Eastman.

Macrodon cochlearis Winch.
Aviculopecten caroli W.
Glossites elliptica Hall.
Edmondia burlingtonensis M. & W.
Bellerophon bilabiatus M. & W.
Bellerophon (two other species).
Porcellia obliquinoda White.
Platyschisma, sp.
Straparollus macromphalus W.
Loxonema, sp.
Orthoceras (*indianensis* ? Hall.)
O. whitei Winch.
O. inequalis Hall.
Conularia micronema Meek (?)

The thickness of this sandstone is about ten feet.

(3) "Lithographic Limestone:"—The next number is sharply marked off from the other beds both above and below. It consists of a compact gray limestone of fine texture and pure composition containing less than two per cent of insoluble material. A ground and polished surface has the appearance of lithographic rock. A part of the residue from a dissolved specimen is siliceous, but it also contained some dark carbonaceous substance. Specimens taken south of Oakville and Elrick Junction and also from Des Moines county are impregnated with bituminous material. This rock has been observed only in the southeastern part of the county and is sometimes absent here also, apparently having been dissolved and carried away by underground water. In Long creek basin, where the terranes are most thoroughly weathered and leached, it has not been definitely identified at any locality. In some of the sections where it appears it has been changed to an earthy brownish layer and is shrunk in thickness. No fossils have been secured from it in this county. Where not leached or altered its thickness is from three to four feet.

(4) Upper Gritstone:—The succeeding member consists of a soft blue or yellow, arenaceous rock quite similar to the English river gritstone in texture and composition, consisting of quartz grains of small and very uniform size. Fossils have not been observed. Where the underlying limestone is absent it rests upon the lower sandstone from which it is usually separated by a yellow or brown rusty seam. The thickness is three feet.

(5) Oolite ledges:—Above the upper gritstone there is a ledge of white or yellowish oolitic limestone. It is distinctly marked off from the bed below but somewhat continuous with that above it. The oolitic spherules are small and imbedded in a matrix of calcareous material which resembles in texture the limestone above it. This ledge is often greatly affected by leaching, being either wholly removed or else appearing as a yellow porous rock. The calcareous spherules have been dissolved, leaving imperfectly rounded vesicles testifying to their former presence. Where not affected in this way it usually contains numerous fossils, the following forms having been recognized.

Zaphrentis, sp.
Athyris crassicardinalis White.
Rhipidomella burlingtonensis Hall.
Productella concentrica Hall.
Spirifer marionensis Shum.
Chonetes logani, N. & P.
Straparollus obtusus Hall.
Orthoceras, sp.

Its thickness is from two to three feet.

(6) Wassonville Limestone:—This limestone is separated from the previous one by no other sharply defined lithological character than the disappearance of the oolitic structure. It consists of variable, usually moderately fine-grained limestone, normally in very thick ledges below. It contains

sparse fragments of crinoid stems, but seldom any entire fossils. Sometimes there are layers of a gray chert and in the lower ledges this chert sometimes has an oolite structure. Elsewhere it is mostly filled with traces of small fossil fragments. The upper part of these ledges are sometimes characterized by well marked close joints, which cut the rock into small blocks. Overlying as it does the less pervious aud less soluble beds of fine sandstones and shales this limestone has served as a highway for percolation of underground water Everywhere along the creeks it marks a horizon where springs issue, some of which are small streams. Except in a few places the rock is so thoroughly changed by leaching, solution and weathering as to be quite unrecognizable, frequently appearing as a brown, earthy, crumbling mass. Sometimes it is wholly absent, only a few cherty layers remaining. *Athyris incrassatus* Hall and *Chonetes illinoiensis* Worthen have been observed. The thickness of these ledges is perhaps as much as fifteen feet. Possibly a part of them should rather be referred to the next division.

(7) Lower Burlington Limestone:—Above the rock just described there is a horizon of limestone with layers that have a peculiar wavy, curving or sometimes twisted and knotty appearance. On one of the ledges which was seen in the bed of Gospel Run, some giant ripple marks six inches high and from four to six feet apart from crest to crest, extended in a direction a little north of east. Occasionally this rock is quite fine-grained and of a whitish gray color, but in most of the outcrops it is filled with crinoidal fragments. There are also frequent seams of chert. At one place a specimen of *Lobocrinus pyriformis* Schum. was observed. The thickness does not much exceed eight or ten feet.

(8) Main Lower Chert:—A persistent layer of chert usually overlies the irregularly bedded limestone. Occasionally it consists of a single seam, measuring a foot or more in thickness, while at other places there are several thinner layers, measuring in all two or three feet.

(9) Upper Burlington Limestone:—The most conspicuous rock in this region consists of a white, or greenish or yellowish white, typical crinoidal limestone in ledges from six inches to almost two feet in thickness. The lower ten feet are usually quite free from chert, but in the upper part chert seams are frequent and there are also some seams of green shale. One of the upper ledges contains teeth and spines of fishes such as *Ctenacanthus*, *Deltodus*, *Cladodus*, *Venustodus robustus* St. J. & W., *Psammodus glyptus* St. J. & W., *Detodopsis bialveatus* St. J.& W., D. *convexus* St. J. & W., *Deltodus spatulatus* M. & W., and *Orodus*.* Occasional fish remains are also seen in some of the ledges above and below this one. Many other fossils were observed by the writer in this rock, namely:

Syringopora, sp.
Zaphrentis centralis E. & H.
Glyptopora, sp.
Pentremites elongatus Schum.
Actinocrinus multiradiatus Schum.
A. scitulus M. & W.
Batocrinus laura Hall.
B. laura var sinuosus Hall.
B. pistillus M. & W.
Dorycrinus quinquelobus Hall.
Platycrinus glyptus M. & W.
P. nodostriatus W. & Sp.
Teleiocrinus umbrosus Hall.
Dizygocrinus rotundus Yand & Schum.
Lobocrinus pyriformis Schum.
Eutrochocrinus lovei W. & Sp.
E. christyi Schum.
Dichocrinus striatus Ow. & Schum.
Schizophoria swallowi Hall.
Rhipidomella burlingtonensis Hall.

*The identifications were kindly made by Dr. C. R. Eastman.

Dielasma rowlei W.
Productus burlingtonensis Hall.
P. semireticulatus Martin.
Spirifer plenus Hall.
S. grimesi Hall.
S. logani Hall.
Chonetes logani Hall.
Igoceras capulus Hall.
Orthoceras, sp.

The thickness of this division is about eighteen or twenty feet.

(10) Montrose Cherts:—The Upper Burlington limestone runs into a more cherty and impure rock with somewhat fewer crinoidal fragments and more frequent seams of green shale. Good exposures of this part of the section are not frequent for it is much affected by weathering. Fossils are scarce. Round quartz geodes occur in it near the upper limit, ranging from two inches to half a foot in diameter. Otherwise the character of the ledges appears quite variable. Their whole thickness is about ten feet.

(11) The Upper Shales and Limestones:—The uppermost beds consist of soft and fine grained limestone ledges alternating with, or imbedded in, softer yellow or bluish gray beds of shale and shaly limestone. This is only rarely seen in exposures, being usually concealed under the drift. No fossils have been noticed. The greatest thickness exposed does not exceed fifteen feet.

Correlations.—The five lower numbers in this general section together with at least the lower half of the sixth number constitute the upper part of what is generally known as the Kinderhook group. It is a most perfect parallel to the Kinderhook section at Burlington. On examining the section at the latter locality for the first time, I knowing the succession in Louisa county, the writer had no difficulty in placing his hammer on that thin seam in the second member

containirg fish teeth and in promptly finding some specimens of *Helodus*. It is equally evident that the upper part of number 6 and all of number 7 are the northward extension of the Lower Burlington; that number 9 corresponds to the Upper Burlington, and at least a part of number 10 to the Montrose chert as described by Keyes in Des Moines county. But it is uncertain whether the upper part of number 10 and the shaly beds above this should also be regarded as a part of the Upper Burlington, or as a thin and modified representative of the Keokuk group. It resembles the latter in having a geode horizon and in containing much shaly material. In the absence of fossils and of an opportunity to compare the lithological characters in the field the question must be left unanswered for the present.

Comparing the series with the section described by Bain in Washington county number 1 is evidently equivalent to the Maple Mill shale and number 2 to the English River gritstone. The lower part of number 6 is the Wassonville limestone. Dr. Bain has himself verified this correlation in the field.

It appears likely that the shales at the base of this section and below it, are the upward continuation of the Sweetland creek shale of Muscatine county. With the general dip of the terranes to the south the dark main body of the latter should come in at the level where the deep wells in this region have gone into a black shale. In the lowest exposure of this same shale at Burlington, the author has lately found a *Dictyospongia*. This gives its fauna a resemblance to that of the Waverly and the Genesee, to which the fauna of the Sweetland creek beds is also related.

These shales were deposited at no great distance from the shore, for they contain remains of vegetation. The overlying gritstones seem to consist of such fine sand as has been observed to be sometimes laid down farther out by off-shore submarine currents. It is not a littoral sand and is free from the fine mud common in shore deposits of the same fine-

ness. This indicates a deepening and a clearing of the waters. Progressive though oscillating changes toward such conditions are indicated by the succession of muddy clay, fine clear sand, a calcareous precipitate, fine clear sand again, an oolitic calcareous precipitate, and then organic calcareous sediments. In these last calcareous sediments there is at first a rapid increase in the organic ingredient, as if a new fauna were establishing itself under the new and favorable environment of a clearer medium. The upper divisions of the Kinderhook may thus represent a period of return from this region to the deep sea conditions existing in the Middle Devonian. The uppermost beds of the last mentioned age are known to indicate a change in the opposite direction.

Geographic Conditions.—A comparison of the development of the Kinderhook and the Burlington rocks in Des Moines and Louisa counties throws an interesting sidelight on the geographical conditions of the period to which they belong, and corroborates some conclusions drawn from other evi dence. The thickness of these formations is greatly reduced in their northern outcrops. Leaving out those parts in each of the two sections of which the measurements are somewhat uncertain the thickness of the formations in the two counties is as given in the following table. The measurements for Des Moines county has been taken from the report of Keyes.*

Parts of the Section Compared.	Thickness in Louisa County, in feet.	Thickness in Des Moines County, in feet.
Number 10. (Montrose cherts)	10	30
Numbers 6, 7, 8 and 9 (Upper and Lower Burlington)	40	95
Number 5. (Oolitic rock).....	2	3
Number 4. (Upper "yellow sandstone") ..	3	6
Number 3. (Lithographic limestone).....	4	18
Number 2. (Lower "yellow sandstone")...	10	25
Total of measured parts of section.....	69	117

It is well known that the nearest shore of the Mississippian

*Iowa Geol. Surv., vol. iii, p. 422, 1893

sea lay somewhat to the north. This has caused the diminished development of these sediments in the same direction. The thinning may to some extent be due to a reduction by leaching and solution of later date, but even after making all allowances for such changes the full original thickness of these beds thirty miles north of Burlington can not have been much more than one half of what it was at the latter place. The shore of the Mississippian sea was evidently not very far distant and may have been less than fifty miles away. But the thinning was perhaps not uniform beyond the present northernmost extension of the terranes. The presence of Subcarboniferous pebbles in the basal conglomerate of the coal measures suggests a greater northern extension of the lower beds than is indicated by this thinning in Louisa county.

The Saint Louis Limestone.

On the left bank of Honey creek, in the Se. ¼ of the Sw. ¼ of Sec. 32, Tp. 73 N., R. III W., some twenty rods north of the boundary of the county, there is a limestone breccia of greenish gray color composed of fragments of varying sizes, imbedded in a calcareous matrix of the same color. Some of the limestone blocks contain fragments of crinoid stems and other unrecognizable fossils. There are also seen in them some small cavities filled with a bright green clay. The breccia is only three or four feet high in the bank and rests on an uneven surface of the lower formation, which is yellow and weathered. An unconformability is here indicated. The rock extends only a few rods along the stream. A little farther down some reddish shaly beds appear on the same side of the creek. These are apparently continuous with the geode-bearing horizon of the Augusta, exposed nearby. The limestone breccia on this creek is entirely unlike anything else seen in the county. Dr. Bain, who visited the locality in company with the author, inclines to the opinion that it represents the Saint Louis stage. If such is the case there are

possibly some more outliers of the same formation under the drift in the southwest part of the county, where the bed rock occurs in wells at a considerably higher level than that of Burlington limestone in the nearest outcrops.

The Des Moines.

After the deposition of the Subcarboniferous sediments in this region the bottom of the sea in which they were laid down was raised and new land formed. The deposits were then subjected to considerable erosion. There is no doubt that the Burlington limestone originally extended beyond its present northern border. The marginal remnant of the Burlington often has cavernous tunnels and crevices filled by the deposits of the next succeeding period and the base of these later deposits are found frequently to contain Subcarboniferous chert farther to the north. It is quite evident that the erosion preceding the next submergence cut this limestone down almost to its present condition. Accompanying this erosion there was a tilting of the land to the south. Following the erosion and tilting of the land it was again submerged and the Coal Measures were laid down in the marginal waters of a sea advancing an unknown distance to the north.

Only a small part of these deposits are left in the area included within the limits of this county, and they occur as small isolated outliers. The largest of these is less than half a mile in visible extent. It appears in the west bluff of the Iowa river near the adjoining corners of sections 16, 17 and 21 in Union township. A few rods up a ravine known as "Coal Hollow" there lies on the north bank a dark shale containing lumps of Kinderhook shale. The latter appears in an undisturbed condition in the same ravine near the river. This debris contains the characteristic concretions of clay ironstone of the Coal Measures. A short distance farther up there outcrops four feet of grayish white sandstone alternating with black shale and a few inches of coal. The

sandstone shows several imprints of *Stigmaria*. In the base of the river bluff one-third of a mile above this ravine several similar outcrops occur resting on the bluish green Kinderhook shale. Worn pieces of Burlington and Kinderhook chert are imbedded, as if worked into the upper surface of the older shale, which is capped by a foot or two of black Coal Measure shale. Close by to the south a Coal Measure sandstone forms the river bank. It was found to contain impressions of Lepidodendrons and rises several feet above the water. The greatest thickness observed was about fifteen feet. Most of the exposures are at the present time partly covered by talus. It seems probable that this outlier may for some distance underlie the deep drift to the southwest. Fragments of the sandstone are frequently seen in the bowlder clay exposed in the opposite bank of the river. About forty rods south of Long creek and north of the center of the south line of the Se. ¼ of Sec. 13, Tp. 74 N., R. V W., a yellowish gray sandstone appears in several places under the drift along a small ravine, and a pit sunk in the left banks of the ravine some years ago went through a few feet of Coal Measure shale with some thin seams of coal. Bowlders of sandstone are frequent in the drift at this place and also for two miles to the east and a mile to the south. In Secs. 20, 21 and 28 in Tp. 74 N., R. V W., three wells have been sunk into a sandstone some twenty feet in thickness. Pieces thrown up from an open well were found to consist of Coal Measure sandstone. Rock of this kind has also been reported as encountered in wells under the drift in Sec. 27, Tp. 75 N., R. V W., at Cotter Station, and at Newport.

Some interesting occurrences of the same sandstones are found in dike-like fillings which occupy crevices in the Burlington limestone. The end of one of these runs out in the south bluff of Long creek, where this takes an abrupt turn to the north in the Se. ¼ of the Sw. ¼ of Sec. 13, Tp. 74 N., R. V W. This "dike" is sixty feet in width and fifteen feet high, lying with vertical walls against the limestone on both

sides and forming an almost homogeneous mass of rock without marked bedding. It apparently extends for some distance back into the bluff. About one-fourth of a mile east another deposit of the same rock follows for several rods, the west slope of a ravine coming in from the south. Still other masses in similar situations occur south of the old Delzell quarry in the west bluff of the creek which runs through the Ne. ¼ of Sec. 17, Tp. 73 N., R. III W., and near the base of the east bluff of Honey creek east of the center of the Ne. ¼ of Sec. 32, Tp. 73 N., R. III W. Near this last place the channel of the creek for a short distance follows a crevice which is filled with the same sandstone. No doubt other "dikes" of this same rock are to be found in the county. All those here described appear to run in a north and south direction. The sandstone forming them has a particularly sharp grittiness, due to what must be a secondary enlargment of the grains. The grains are more or less perfect small quartz crystals with regular faces and edges. All of of the "dikes" have doubtless been formed as fillings in old caverns in the eroded limestone. The enlargement of the sand-grains may have been brought about by percolating water which has followed the drainage of the ancient caverns.

Subsequent History.—Over how large an area the Coal Measures were laid down it is impossible to say, but there must have been a considerable thickness here and they must have extended a considerable distance north. The land was then again elevated and subsequent erosion removed all but these few remnants of the basal part of the beds. As far as known there is no evidence within this county that it has been submerged since that time. During most of Mesozoic and Cenozoic time the land has undergone erosion. This finally resulted in the development of the topography now presented by the surface of the bed rock under the drift. This topography is the only record left of what occurred here during the long period of erosion already mentioned.

THE OZARKIAN AND THE GEEST.

Since the old land surface has been covered with drift a knowledge of it can only be secured from records of wells that have penetrated the drift and the underlying formations. Eighty-four records from such wells, mostly on the uplands, have been obtained for this purpose. The facts thus gleaned are here presented in tabular form and also on a map. This map shows, in fifty-foot contour lines, the elevation of the old land surface above the sea level. (Plate IV)

WELL RECORDS IN LOUISA COUNTY.*

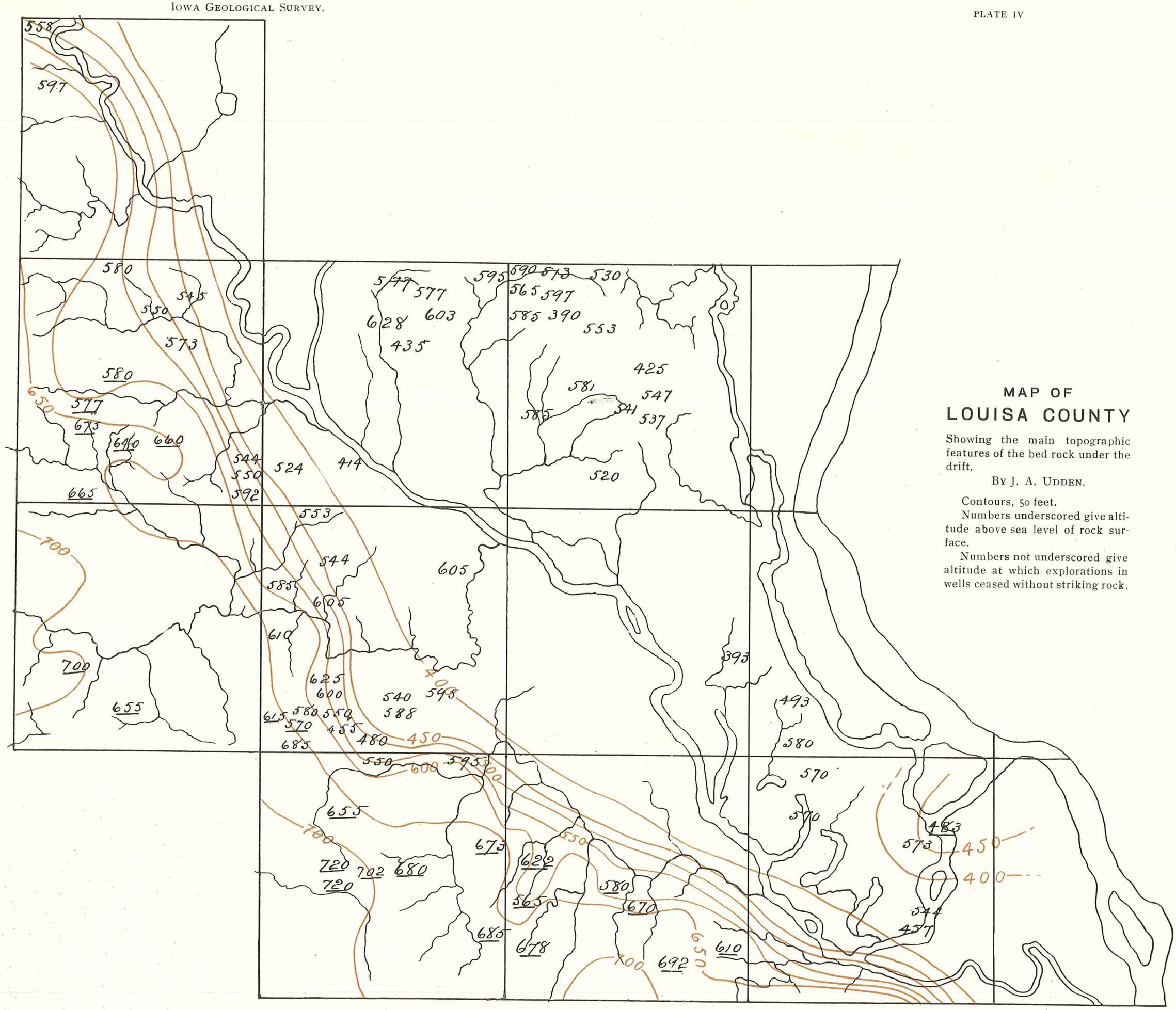
TOWNSHIP 73 NORTH, RANGE II WEST.

Number.	LOCATION AND OWNER.	SITUATION.	Elevation of curb.	Depth.	NOTES.	Bed rock above sea level.
1	Sec. 5	Upland	66.	90	All drift	570
2	W. Clark, Sec. 8.	On bluff slope	630	60	Yellow clay 30 ft, sand 30 ft	570
3	John Hays, center, south line, Sec. 11.	Upland	700	127	Yellow clay 40 ft, blue clay 80 ft, sand	573
4	J. Parson, Sec. 11	Upland	695	212	Yellow clay 30 ft, sand 6 ft, blue clay 80 ft, sand 14 ft, blue clay 25 ft, sand with timber 25 ft, blue clay. Rock at bottom.	*483*
5	Dr. Parsons, Sw ¼ Sec. 23.	Second bottom	575	118	Sand, gravel and loam 31 ft, blue clay 62 ft, wood and black loam 10 ft, sand with water, 6 ft	457
6	T. M. Parsons, Sec. 23.	Upland	630	86	All drift	544

TOWNSHIP 73 NORTH, RANGE III WEST.

7	Concord School, Ne. ¼ Sec. 18.	Upland ravine	630	300	Drift 8 ft, limestone 15 ft, "soapstone" 148 ft, dark shale 30 ft, "soapstone" 99 ft	*622*
8	H. Harris, Ne. ¼ Sec. 20.	Upland	700	140	Drift 135 ft, Kinderbrook shale 5 ft	*565*
9	J. G. Keck, Sec. 22.	Upland	700	130	Clay 30 ft, rock 90 ft, "soapstone" 10 ft	*670*
10	W. D. Jamison, Nw. ¼ Sec. 22.	Near bluff	670	300	Drift 90 ft, shale 210 ft, carbonaceous material 50 ft above bottom	*580*
11	Sw. ¼ Sec. 25					*610*
12	Dobson & Jamison, Se. ¼ Sec. 27.	Upland	731		Drift 39 ft, soft sandstone 11 ft, then limestone	*692*
13	Cyrus Hewitt, Nw. ¼ Sec. 29.	Upland	750	76	Drift 72 ft, limestone 3 ft	*678*

*Where the elevation of the surface of the bed rock is known, it is given in italics in the last column of the table. Other figures in this column give the elevation of the bottom of the well when explorations stopped in drift.



MAP OF
LOUISA COUNTY

Showing the main topographic features of the bed rock under the drift.

BY J. A. UDDEN.

Contours, 50 feet.

Numbers underscored give altitude above sea level of rock surface.

Numbers not underscored give altitude at which explorations in wells ceased without striking rock.

TOWNSHIP 73 NORTH, RANGE IV WEST.

Number.	LOCATION AND OWNER.	SITUATION.	Elevation of curb.	Depth.	NOTES	Bed rock above sea level.
14	Thomas Harris..... Sw ¼ Sec. 1.	Bluff.....	670	75	Rock at bottom,.....	595
15	Wm. Miller..... Ne. cor. Sec. 4.	Slope	670	120	All drift	550
16	D. C. Marshall ..... Nw. ¼ Sec. 9.	Upland.....	750	126	Drift 95 ft., limestone 31 ft.	655
17	E. W. Sniverly ..... South line Sec. 12.	Slope	670	87	Dr.ft 17 ft., rock 70 ft.....	673
18	John S. Curran ..... Sec. 15.	High upland ..	841	202	Drift 160 ft., shaly rock 42 ft.	680
19	J. K. Brown..... Se. cor Sec. 16.	High upland ..	820	141	Drift 118 ft., limestone rock 23 ft	702
20	R. C. Dryden ..... Center east line, Sec. 17.	High upland ..	840	160	Dri t 120 ft., rock 40 ft.	720
21	James Chilson ..... Sw. ¼ Sec. 20.	Level upland ..	760	126	Drift 40 ft., rock 86 ft.....	720
22	Morning Sun..... Town Well.	Upland.....	750	162	Dritt 65 ft., limestone with some shale 97 ft	685

TOWNSHIP 74 NORTH, RANGE II WEST.

23	Fred Weiderecht ..... Center So. line, Sec. 29.	Upl.nd..	670	177	Rotten wood, sand and mud at 125 ft.	493
24	F. B. Stetson..... Center E. line, Sec. 31.	Edge of upland.....	650	70	Yellow clay 8 ft., blue clay 10 ft., rotten wood, blue clay 12 ft, rotten wood, blue clay 20 ft., wood and sand 5 ft., blue clay 10 ft., wood and sand	580

TOWNSHIP 74 NORTH, RANGE II WEST.

25	Joseph Schofield .... Center Sec. 24.	Low upland ...	640	247	Yellow clay 10 5t., blue clay 8 ft., old soil 3 ft., blue clay, sand at 70 ft., old soil at 160 ft., white cemented sand at bottom.....	393
26	Average of several wells.....	Low upland ...	640	123	Soil 4 ft., loess and yellow clay 40 ft., blue clay 76 ft., sand 3 ft	517

TOWNSHIP 74 NORTH, RANGE IV WEST.

27	John Hanft..... Center W. line Sec. 5	Upland.....	718	165	All drift.....	553
28	Lyman Huff..... Se. ¼ Sec. 8	Upland.....	720	176	All drift.....	544
29	Geo. Harrison ..... Center Sec. 17	Low upland...	690	85	No rock	605
30	Geo. Boulton ..... Ne. ¼ Sec. 18	Upland.....	710	125	All drift.....	585
31	James Dalton ..... Se. ¼ Sec. 19.	Upland slope..	730	120	All drift.....	610

TOWNSHIP 74 NORTH, RANGE IV WEST—CONTINUED.

Number.	LOCATION AND OWNER	SITUATION.	Elevation of curb.	Depth.	NOTES.	Bed rock above sea level.
32	Patrick Cotter..... Sw cor. Sec. 26.	Upland.....	700	160	All drift.....	540
33	Unknown ..... Sw. cor. Sec. 26.	Upland.....	700	245	Blue clay with boulders at 150 ft., timber at 125 ft.....	455
34	Jesse Van Horn..... Sw. cor. Sec. 27.	Upland.....	720	180	All drift.....	540
35	Cornelius Murphy..... .... So. ½ Sec. 27,	Upland.....	700	105	Yellow clay and gravel 60 ft., blue clay 40 ft., water sand 5 ft	595
36	Wilson Sellers.... ..... Cairo, Sec. 28.	High upland ..	750	125	All drift.....	625
37	Cairo Village.	High upland ..	750	150	Black soil 8 ft., yellow clay 25 ft., blue clay 83 ft., gravel 8 ft.....	600
38	James Mullen . ..... Se. ¼ Sec 29.	High upland..	745	165	All drift.....	580
39	Henry Freeman..... Sw. ¼ Sec. 29.	Upland.....	720	180	Drift 150 ft., sand at 120 ft.. shale 30 ft	570
40	Skinner Bros..... Sw. ¼, Sec. 30.	Low upland...	705	70?	Mostly drift, rock at bottom.....	645
41	R. S. Cummings..... .... Sw. ½ Sec. 32.	Upland.....	730	120	Drift 45 ft., limestone 75 ft.	685
42	Jos. Bates..... Center of E. line, Sec. 33.	Upland.....	690	209	Yellow clay 70 ft., blue clay 68 ft. sand 1 ft., blue clay 25 ft., sand and clay 23 ft., dark drift 22 ft.....	480
43	E. S. Briggs..... Nw. ¼ Sec. 33.	Upland.....	710	122	All drift	588

TOWNSHIP 74 NORTH, RANGE V WEST.

44	L. M. Samson..... Se. cor. Sec 20.	High upland..	760	60	Loess 10 ft., boulder clay 40 ft., sand 3 ft., rock below	700
45	Evan Davis ..... Ne. ¼ Sec. 28.	Upland.....	750	115	Drift 95 ft., sandstone 20 ft.....	655

TOWNSHIP 75 NORTH, RANGE III WEST.

46	Dan'l Westbrook..... Se. ¼ Sec. 4.	High upland .	710	180	Sand at 150 ft.....	530
47	John Sneider ..... near Letts.	Upland	690	300	Yellow clay 18 ft., quicksand 3 ft., blue clay 70 ft., yellow clay and gravel 20 ft., blue clay and gravel 30 (?) ft., sand to bottom.....	390
48	Letts	Low upland...	683	170	All drift.....	513
49	Joseph Wagner ..... Sec. 6.	Upland	703	135	Yellow clay and sand 15 ft., blue clay 60 ft., coarse gravel 2 ft., sticky blue clay with wood below 47 feet, sand 13 ft.....	565
50	P. M. Reisch..... Letts, Sec. 6.	Low upland...	685	100	All drift	585

TOWNSHIP 75 NORTH, RANGE III WEST—CONTINUED.

Number.	LOCATION AND OWNER.	SITUATION.	Elevation of curb.	Depth.	MATERIALS PENETRATED.	Bed rock above sea level.
51	C. Vincent ..... Se. cor. Sec. 6.	Low upland...	685	106	All drift	597
52	W. W. Wagner..... Center S. line, Sec. 6.	Upland	700	110	All drift	590
53	Charles Wabintz. ..... Center W. line, Sec. 9.	Upland	713	160	All drift	553
54	Peter Hass (?) ..... W. ½ Sec. 13.	In bluff.....	615	180	All drift	435
55	Fay Letts ..... Se. cor. Sec. 19.	Low upland..	665	80	All drift	585
56	Noah Letts .. Ne. cor. Sec. 20.	Low upland...	675	94	All drift.....	581
57	Martin A. Gray ..... N. ½ Sec. 22.	Upland	720	173	Soil 6 ft, yellow clay 50 ft, quick sand 40 ft, white and blue clay, mixed, down to 170 ft. then sand with gas, which would not burn	547
58	George Young ..... N. of Grandv. Sec. 22.	Upland	710	173	Yellow clay 38 ft, black mucky soil 6 ft. sand 1 ft, blue clay 104 ft, sand 20 ft, clay 4 ft	537
59	John Bike. .... Sec. 22.	Upland	706	165	Drift at 165	541
60	John Schafer . ..... Center Sec. 28.	Upland .	690	170	Sand at 80, 136 170 ft, rest mostly boulder clay	520

TOWNSHIP 75 NORTH, RANGE IV WEST;

61	I. Idle ..... Sec. 1.	Upland	710	115	All drift.....	595
62	B. Littner .... Nw. ¼ Sec. 2.	Upland	718	115	All drift...	603
63	R. W. Lee .... Center east line, Sec. 3.	Upland	680	103	All drift	577
64	Charles Estle. .... Ne. ¼ Sec. 3.	Upland	680	120	All drift	560
65	M. Lee..... Center west line, Sec 3.	Upland ...	690	113	All drift.....	577
66	M. A. Turkington Center south line, Sec 10	Low upland...	950	215	Loess, 5 feet; yellow boulder clay, 16 feet; yellow sand, 3 feet; blue sand 26 feet; white sand, 80 feet; dark bluish hard sand, 25 feet; light soft sand, 40 feet.... ..	435
67	Etta Littrell ..... Ne. ¼ Sec. 10.	Upland	728	100.	All drift.....	628
68	Danl Overholt .. .. Se. ¼ Sec. 23.	Bottom land..	580	164	Alluvium, 8 feet; blue pebbly clay 72 ft, sand, 2 feet; blue clay, 14 ft; sand 68 feet.	416
69	Robert Owens ... . Sw. ¼ Sec. 30.	Upland	700	176	All drift.....	524

TOWNSHIP 75 NORTH, RANGE V WEST.

Number.	LOCATION AND OWNER.	SITUATION.	Elevation of curb.	Depth.	MATERIALS PENETRATED.	Bed rock above sea level.
70	H. E. Orr ... . Center Sw. ¼ Sec. 3.	Upland	720	175	All drift	545
71	Nels Spurgeon .. .. Ne. ¼. Sec. 5.	Up'and ...	720	140	All drift....	580
72	Jane S. McKay..... .... Nw. ¼ Sec. 10.	Upland	720	147	All drift	573
73	F. M. Duncan .... Sec. 10.	Upland slope	710	160	All drift....	550
74	Ruben Stapp..... ... Sec. 16	Upland	730	400	Drift 150 feet, shale 250 feet ..	580
75	E. Robinson . . .. Se. Cor Sec 20.	High upland.	740	65	Rock at bottom...	675
76	Cotter Station .... Sec. 20.	Upland ...	710	136	Drift, 133 feet; sandstone, 3 feet.. ...	577
77	J. W. Garner ..... Co umbus City.	Upland	720	170	Loess,13 feet; blue till, 157 feet; sand,	550
78	D. W. Overholt ..... Se. ¼, Sec. 25.	Upland	710	166	Loess and yellow till, 35 feet; blue till, 125 feet; sand and gravel, 6 feet	544
79	Martin Schaum .... Center Sec. 27.	Upland	725	68	Drift, 65 feet; sandstone, 3 feet..	660
80	F. J. Moore . . .. S. line Sec 28	Upland	730	90	Rock at bottom.....	640
81	Humphrey Jones..... . . Se. ¼ Sec. 32.	Upland	745	80	Rock at bottom	665
82	L. Williams ..... Columbus City.	Upland	720	128	Loess, 20 feet; blue till 108 feet; sand.	592

TOWNSHIP 76 NORTH, RANGE V WEST.

83	Edward Murdock. . ..... Nw. ¼ Sec. 6.	Upland ..	710	152	All drift	558
84	Josh Lucky .... Nw. ¼, Sec. 18.	Upland	730	133	All drift..	597

It will be observed that the main features of the ancient topography consist of an upland plain in the southwestern part of the county having an average elevation of 650 feet above the sea and of a wide lowland under the two rivers and under the east drift plain. By following the lowlands into the adjacent counties on the north we find that it is a local widening of some deep drainage valley. Its great width here is due to the presence of the soft Kinderhook beds which have been more easily removed than the overlying limestones.

The deep trenching of the ancient water-courses into the general prairie peneplain indicates that a general rising of the land took place some time before the end of the long erosion period. This elevation resulted in a rejuvenation of the drainage. The period when this occured has been called the Ozarkian or Sierran, from the fact that a like elevation took place at the same time in the region of the Ozarks and in the Sierra Nevadas. Before erosion had brought the land surface down to a new base level glacial conditions set in and covered the land with drift.

Very little is left of the products of disintegration from the Ozarkian period. During a time of rejuvenated drainage its surface accumulations would be promptly removed. Perhaps much of what remained was removed at the time of the first ice invasion. The only undoubted occurrence in this county of geest, as this old surface material has been called, appears on top of the bed rock in the limestone quarry in the west bank of Honey creek northwest of the center of Sec. 28, Tp. 73 N., R. III W. It fills a small depression in the surface of the ledges to the depth of three or four feet and may be described as a stiff, brownish yellow clay-like material, mingled with fragments of chert from the disintegrated limestone. A lower extension of the same cavernous hollow contained several pockets of a black, earthy oxide of manganese. On the top of the geest there are indistinctly stratified layers of a fine yellow sand or clay, containing occasional fragments of Archaean rocks. Above this there is typical bowlder clay.

The Pleistocene.

The bowlder clays and other drift materials of the glacial age have a greater development in this county than in most other parts of the state. Over the townships east of the Iowa river it probably averages three hundred feet in depth and on the west side it ranges from twenty to more than 200 feet. Three distinct sheets of bowlder clay are believed to have been brought here by three different ice fields

at three successive epochs. These have been named the Albertan or pre-Kansan, the Kansan and the Illinoian, enumerated in the order of their sequence in time and from below upward. The base of the Albertan is everywhere beyond the reach of direct observation in surface exposures. Several well records indicate that it is underlain in the old lowlands by deposits of gravel, sand and silts, containing remains of preglacial vegetation. These deposits are probably a filling laid down in front of the first advancing ice sheet. Neither at that time nor since does there seem to have been any active plaining of the uplands by the ice. No scorings have been observed anywhere on the bed rock in this county. The general result of glaciation has been a filling up of the lowlands.

THE ALBERTAN OR PRE-KANSAN.

This till is dark gray or almost grayish black in color and of a rather soft and mealy texture. On being exposed to the action of the atmosphere this color rapidly changes to dirty yellow or brown. It invariably contains pieces of wood of gymnospermous trees. The fragments are mostly small, less than three inches in length, and are either broken off branches or splinters of larger pieces. Occasionally entire small logs are seen. Another constant feature is the presence of small fragments of coal averaging two or three grains in weight. A study of the pebbles contained in this drift shows that in comparison with the overlying tills this contains about twice as many fragments of local rocks. There is also a greater representation of rocks whose outcrops lie to the northwest, such as fragments of the Kinderhook and of the Burlington beds. In the north as well as in the south part of the county this till occasionally contains good sized bowlders of the latter rock, something which is never the case in the other two tills north of the northern margin of these formations. Of the crystalline rocks there is more greenstone, hornblende rock and schists than in either of the other drift sheets. On the other hand there is a smaller proportion

of dolomitic limestone and rocks common in the Kewenawan. The largest exposures of this till do not disclose more than ten or fifteen feet and well records do not indicate a greater thickness than twenty-five feet. Over the uplands it is almost absent except in situations where the preglacial surface was low. The most important localities for this drift which were noted are as follows: (1) On the right bank of Honey creek near the south line of Sec. 21, Tp. 73 N., R. III W. (2) On the south bank of Smith creek near the center of the Se. ¼ of Sec. 35, Tp. 73 N., R. III W. (3) In a well on the upper slope of the bottom land in the Nw. ¼ of Sec. 6, Tp. 76 N., R. V W. (4) In the southwest bank of Smith creek near the southeast corner of Sec. 30, Tp. 73 N., R. II W. (5) In the south bank of Long creek near the center of Sec. 22, Tp. 74 N., R. IV W. (6) In the bank of the Muscatine North and South railroad cut, in the east bluff of the Iowa river, in the Se. ¼ of Sec. 9, Tp. 74 N., R. III W. (7) Oh the west bank of the Iowa river at Wapello. (8) On the west bank of the Iowa river one mile north of Columbus Junction and farther north. (9) In the west bank of the Cedar river two miles north of Columbus Junction. (10) In the railroad cuts in the bluffs of the Mississippi river in Sec. 2, Tp. 75 N., R. III W.

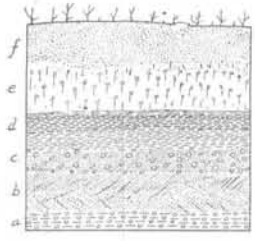


FIG. 2. General relation of the drift layers in the north bluff of the Iowa river in Nw. ¼ of Sec. 15, Tp. 74 N., R. III W.; *a* Albertan till (seen to the Nw. along railroad); *b* Aftonian sand, cross-bedded; *c* dark leached till and sandy boulder clay; *d* dark peat with a forest bed above and a diatomacious earth below; *e* typical loess, becoming sandy above; *f* fine wind-blown sand. Note: The Illinoian till is apparently absent.

This oldest till apparently underlies most if not all of the lowlands, and wells on the eastern upland indicate that it underlies the main water sand as a continuous sheet. Its upper surface in this territory approximates a level plain with an elevation of from ten to thirty feet above the bottom lands. This plain is particularly well shown in the cuts along the Muscatine North and South railroad in the Se. ¼ of Sec. 9, Tp. 74 N., R. III W., three miles south of Wapello. It follows the roadbed for about a quarter of a mile and finally disappears, as the latter rises above it, near the wagon road bridge on

Indian creek (Fig. 2, *a*). This locality suggests that the plain may have been the main shearing plain under the Kansan ice. On such a supposition it seems difficult to account for the presence of the sand which intervenes between this till and that next above. In one instance there seems to be a soil horizon on its upper surface. This is at the foot of the west bluff of the Iowa river, along the wagon road in the Se. ¼ of Sec. 21, Tp. 76 N., R. V W. (Fig. 4 *a*.) At one or two points it appears partly replaced by a dark blue laminated silt with indurated, thin concretionary laminæ of calcerous material. This phase is to be seen in the east bank of the Iowa, on both sides of the north line of Sec. 16, Tp. 76 N., R. V W.

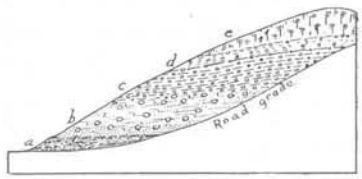


FIG. 3 Relations of strata of drift seen on the south side of the road leading down the Iowa river bluff in the Se. ¼ of Sec. 21, Tp. 76 N., R. V W. *a* Black, tough, leached silty soil (top of Albertan till ?) *b* tough boulder clay with ferruginous joints, yellow above, grayish blue below (Kansan); *c* somewhat stratified and sandy, yellow till; *d* leached horizon (Sangamon); *e* loess.

THE AFTONIAN.

The till just described is almost invariably overlain in this county by sand and gravel, varying in thickness from two to ten feet. This is occasionally cemented into a mortar rock. The prevailing color of the deposit is yellow. A peculiar relation which it maintains to the till below is that pockets of the sand extend down in the otherwise level surface of the latter. These pockets are from one to several feet in width and of equal depth. (Fig. 4, *e e e*.) Occasionally they form filled tunnels in the drift. This stratum is the main water sand in all the deep wells of the upland. Along the level of its outcrops in the bluffs there are a number of springs. Typical exposures of a similar sand

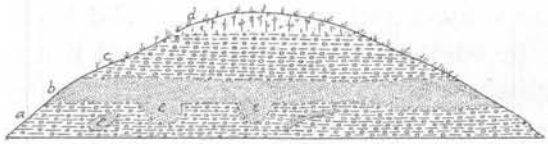


Fig. 4. Section of the drift in the south bank of Smith creek near the center of the Se. ¼ of Sec. 35, Tp. 73 N., R. III W. *a* Albertan till; *b* Aftonian sand; *c* Kansan till; *d* Loess; *e e e* pockets of Albertan sand extending into Albertan till.

in the drift near Afton Junction have been described by Bain* and the name is taken from that locality.

THE KANSAN.

The till which lies above this sand constitutes the bulk of the upland drift in the county. In its unweathered state it has a gray or yellow color and is tough and hard when dry. (Figs. 2–7.) It is generally cut by an irregular set of joints along which some oxidation has taken place. When thoroughly weathered it usually acquires a deep ferruginous stain. In comparison with the other tills there is among its pebbles a greater proportion of diabase and other Kewenawan rocks and of granite. Limestone and dolomite pebbles have about the same relative frequency as they do in the Albertan till. In respect to other rocks it seems to have an intermediate character between the till above and below. In the west tier of townships it directly underlies the loess and the topography of its surface presents a state of comparatively well advanced maturity, as already stated. In the eastern part of the county the inequalities of its surface seem to have been evened up by a later deposit of glacial detritus.

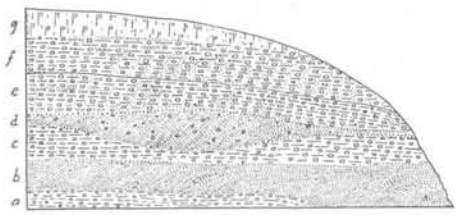


Fig. 5 Section of the drift in the north bank of the cut of the Muscatine North and South railroad in the bluff of the Mississippi river in the Se. ¼ of Sec. 2, Tp. 75 N., R. III W. *a* Silt associated with Albertan till; *b* Aftonian sand; *c* Kansan till; *d* Buchanan gravel and cand?; *e*, *f* Illinoian till with sand; *g* Loess.

*Iowa Geol. Surv., Vol. vi, p. 464, 1896.

THE BUCHANAN GRAVELS AND THE YARMOUTH SOIL.

Above that part of the Kansan till which is east of the Iowa river there often lies another sand which has the same relation to the Kansan as the Aftonian has to the Albertan. This is seen in several places along the Muscatine North and South railroad particularly in Sec. 10, Tp. 75 N., R. III W.

In the Ne. ¼ of the Ne. ¼ of this section it rests on an almost horizontal plane surface (Fig. 6, *b*) on the Kansan bowlder clay. This plane is sharply marked and can be seen for a quarter of a mile. The sand is evidently a glacial product. It is somewhat gravelly, contains occasional striated pebbles, and is rather imperfectly assorted. Here or there it has a long slanting or curving oblique lamination, and is also seen to run into silt. Occasional pockets extend into the underlying drift. In the Sw. ¼ of the Sw. ¼ of Sec. 11, Tp. 75 N., R. III W., it is ochreous from the infiltration of ferruginous material. In other places it is leached to a gray color. Sometimes its upper part changes into a soil-like stratum, either directly overlain by loess or plainly covered by another till.

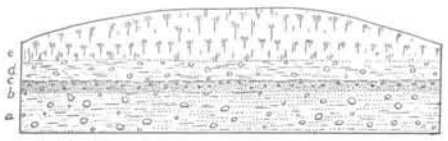


Fig. 6. Section of the drift in the southeast bank of the Muscatine North and South railroad in the Ne. ¼ of Ne. ¼ of Sec. 10, Tp. 75 N., R. III W. *a* Kansan bowlder clay; *b* gravelly sand; (Aftonian); *c* trace of leached horizon; *d* silty bowlder clay (Illinoian); *e* loess.

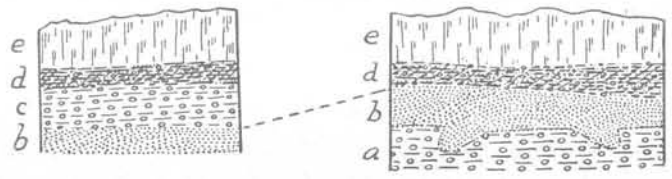


Fig. 7. Relations of different drift sheets as seen in the exposures in the banks of the Muscatine North and South railroad along Indian creek in the Ne. ¼ of Ne. ¼ of Sec. 4, and Nw. ¼ of Nw. ¼ of Sec. 3, Tp. 74 N., R. III W. I Sec. 4, II Sec. 3. *a* Kansan till; *b* Buchanan sand;? *c* Illinoian drift; *d* Sangamon soil; *e* loess.

A soil evidently occupying the same position in the drift series but not associated with any sandy deposits is seen in a ravine near the south line of the Sw. ¼ of the Sw. ¼ of Sec. 32, Tp. 73 N., R. III W., and again in the wagon road near the top of the east bluff of Honey creek, near the northwest corner of section 33. There rests on this soil a pebbly, sandy, leached till several feet deep. The Kansan till which con-

tinues downward from this soil is deeply leached. The soil at these places has the same relation to the tills above and below as the Yarmouth soil, studied by Mr. Leverett in the county to the south, has in the latter locality.

THE ILLINOIAN.

The till above the gravel and soil just described has been shown by Mr. Leverett to belong to another extensive sheet and to have been laid down at a time considerably later than the Kansan drift, after the latter had been extensively eroded and leached.* He has shown that it is the result of an ice invasion from the northeast and that it pushed westward over this county to within about six miles of Washington county. Along the outer edge of the ice field a terminal moraine accumulated which appears as an interrupted broad belt of high upland, already described, extending from north to south through range IV. It is well marked in Secs. 3 and 4, Tp. 75 N., R. IV W. South of this point there is a broad interruption caused by the lowlands along the Iowa river. South of Columbus Junction it appears again somewhat indistinctly in the eastern part of Columbus City township. South of Long creek it rises to a greater height, in places as much as fifty feet above the general upland level. It is here a double belt, one flat ridge lying on the east and another on the west of an intervening sag. Its general trend is a little east of south and it crosses the south boundary of the county almost three miles west of Morning Sun. In Secs. 3 and 4, Tp. 73 N., R. IV W., the westernmost branch of Otter creek cuts across the east ridge and thus drains the sag between the two parallel ridges of the moraine. It is evident that the upper course of this branch has been fixed by these two ridges. At the time the ice had withdrawn to the inner moraine this sag drained away from the ice field through two wide and well marked valleys that cross the outer moraine. One of these is an extension of the main course of Otter

*Monograph U. S. Geol. Surv. XXXVIII.

creek and extends west from the bend of the latter, following the south line of Secs. 5 and 6, Tp. 73 N., R. IV W. The other crosses the same ridge in the north half of Secs. 20 and 21, two miles farther south and is now occupied by a small tributary to Crooked creek. Both of these transverse valleys in the moraine are much too large to have been made by the present streams, but they are readily accounted for as incident to the marginal drainage on the Illinoian ice field. The cluster of low knolls on the uplands in the vicinity of Grandview were no doubt also made by the Illinoian ice. Its area is characterized by a similar topography in Illinois as noted by Leverett.

In its best development along the terminal moraine the Illinoian drift is of a yellowish or grayish color and of slightly less compact texture than the Kansan. It is probably more than fifty feet thick. Inside of the moraine, where it is thinner, it is usually more sandy. In places it is apparently absent or represented by a stratum of sand. Along old drainage lines this till is sometimes associated with a fine, calcareous, laminated silt which contains striated pebbles. Such a silt is exposed in the bank of Muscatine North and South railroad in Sec. 2, Tp. 75 N., R. III W., where it has at times slid down over the road bed. It is evidently a marginal glacial wash. As to the rocks represented by the pebbles of the Illinoian drift, the most notable difference between them and those of the two other drifts is that the former contains a greater proportion of magnesian limestone and a smaller proportion of calcareous limestone and of crytalline rocks. Both of these features are in accordance with Leverett's conclusion that the Illinoian drift came from the northeast, for the principal country rock in northern Illinois and southeastern Wisconsin consists of dolomitic limestone.

While the Illinoian ice field was building up the terminal moraine which traverses this county from north to south, the Mississippi river was forced to take a course west of the margin of the ice. It then occupied the broad, shallow val-

ley already described in discussing the topography. The significance of this valley was first made clear by Mr. Leverett, who has traced its course as it is marked on the map of the surface deposits. It should, perhaps, be noted as a singular fact that within this county no deposits of river sand or stream silt have been observed in this ancient channel on top of the Kansan drift.

THE SANGAMON.

The upper surface of the Illinoian till is usually leached to a depth of several feet and is either a ferretto zone or a leached gray soil, occasionally overlain by a peaty material. This soil phase is particularly conspicuous in Sangamon county, Illinois, where it has been studied by Leverett, and from which locality it takes its name. The red and oxidized condition of the Illinoian surface is most frequently seen where the old Illinoian land surface lies on well drained slopes. It is common in the country east of Morning Sun and also along the lower course of Long creek. Between the two ridges of the double Illinoian moraine west and northwest of Morning Sun there is almost always a dark soil at the base of the loess in the ravines forming the headwaters of the west branch of Otter creek. The uplands east of the Iowa river usually have a soil intervening between the loess and the uppermost till. This is particularly conspicuous on the lowest part of this upland and where its general slope to the west is least, as in the basin of Indian creek and in the country north and south of Grandview. In the Sw. ¼ of the Sw. ¼ of Sec. 11, Tp. 75 N., R. III W., it is black and peaty and deeper than usual. This peaty phase becomes most pronounced in the east bluffs along the Iowa river northeast of Wapello. Along the wagon road leading up to the old townsite of Harrison, near the center of Sec. 23, Tp. 74 N., R. III W., the peat is quite pure and rests on a leached soil with dark curving cylinders extending down from the bottom of the peat and resembling filled animals' burrows. At a place

locally known as the "Hog Back," just east of the Muscatine North and South railroad bridge, in the Nw. ¼ of the Nw. ¼ of Sec. 15, Tp. 74 N., R. III W., this peat is in part replaced by a thick tangle of decayed gymnospermous wood (Fig. 2 d). At the present time the peat is not well exposed here owing to its having been burnt out during a dry season some years ago, causing a landslide in the face of the bluff. The peat is associated with small pockets of a pink colored diatom-bearing earth, and among the vegetable rubbish there were seen some small pine seeds and a fragment of the elytra of a beetle. In the judgment of the writer it is in this same Sangamon soil that the remains of elephants have been found at two other points in the county. A tooth was once taken out in digging a shallow well in a small tributary to Indian creek in Sec. 28, Tp. 75 N., R. III W. Some years ago there were dug out from the bed of Otter creek, near the center of the Nw. ¼ of Sec. 25, Tp. 73 N., R. IV W., a tooth, lower jaw, part of the pelvis, several ribs, and a large piece of a tusk of an elephant. At the locality where these bones occurred the bank of the creek consists of materials resembling the soil of the Sangamon horizon. It should be mentioned also that Mr. Geo. Gresham reports the finding of a deer's antler in the same soil layer in the Nw. ¼ of Sec. 14, Tp. 74 N., R. III W.

The old Sangamon land surface frequently runs down with the slope in the ravines. This is nearly always the case where these slopes are gentle and give no evidence of recent cutting. As we find it now it evidently represents a time when the Illinoian till had already become deeply leached and extensively dissected by the present drainage. These conditions correspond with those which doubtless prevailed at the time of the advent of the Iowan ice field, for the Illinoian drift had then long been subjected to erosion and presented a well dissected plain. The southern border of this ice was only some forty or fifty miles off to the north, for it reached as far south as Scott county. At that time, or just

before it, this region was covered with gymnospermous trees and a boreal climate no doubt prevailed.

THE LOESS.

Subsequently the Sangamon land surface was covered over by a yellow dust-like, sometimes sandy, deposit known as loess. This is the common upland "clay," which is really no clay at all, being composed of uniformly much coarser particles than those making up the bulk of true clay. Nor does it have the laminated and stratified structure seen in water deposited clays. On the contrary, the loess has a marked vertical structure with an irregular horizontal bedding, if any. Its real origin is yet in doubt, but there seems to be good reason to believe that it is a deposit of terrestrial dust.

In this county the loess is heaviest over the western upland, averaging nearly twenty feet along the bluffs of the Mississippi river. From these bluffs there is a general thinning westward. South of Elrick Junction there are places where it is fifteen feet thick. Along the west bluffs of the Iowa river it is occasionally as much as fifteen feet, but averages somewhat less. From a mile west of this bluff over the west upland it rarely attains this thickness and appears to average less than eight feet. In the territory of the Kansan drift it usually extends down over the gentle north slopes to the small streams with a somewhat attenuated fringe. In all recently cut steep slopes it comes out over a more horizontal surface, and its edge is plainly bevelled with the rest of the bluff. Frequently there is a perceptible thickening of the loess along the edge of the bluffs adjoining larger valleys. This is most common where the bluffs face to the west. Sometimes this feature is pronounced and the edge of the upland consists of a bordering ridge which may be composed of fine sand. Such is the "Hog Back" north of Wapello, and some sandy ridges along the same bluffs to the northwest. Shallow ponds may lie back of these ridges, which are evidently blown up by the wind. Otherwise the loess never appears to have

modified the drainage. Only a few very shallow and small undrained depressions are noticeable along some of the high divides.

The loess, or at least a deposit exactly like it in texture, also covers extensively the lowlands of the Iowa and the Cedar rivers, excepting of course the present flood plain. On these lowlands its thickness is, however, much less than on the uplands, usually only three or four feet.

A singular structural feature was noticed in the loess where the wagon road leads down the bluff in the Ne. ¼ of Sec. 1, Tp. 74 N., R. III W. It here rests on a ferruginous sand and is only some twelve feet thick. Near the base the loess is cut up by some scarcely visible joints into irregular spheroidal blocks of uniform size, which become apparent on digging into the bank. Going up from the base of the deposit the blocks deminish in size from nearly an inch in diameter at the base to less than the size of a pea four feet higher up. On close inspection it was found that these joints are partly filled with some bright sand grains. From the relation of the different sizes of the blocks to different levels in the deposit it can be inferred that this peculiar brecciation, as it may be called, is not due to any very recent or superficial cause.

The author has collected loess fossils from only two localities in the county. From the bottom of a well twelve feet deep at Grandview the following shells were taken in loess of blotched yellow and gray color:

Succinea avara Say.
S. grosvenorii Lea.
Linnaea caperata Say.
L. humilia Say.

Grandview lies on the main divide between the Mississippi and the Iowa.

Another lot was collected in the bank of the wagon road near the centre of the west line of Sec. 13, Tp. 75 N., R. V

W., about a mile north of Columbus Junction. The loess at this place is about twelve feet thick and has a faint yellow band half way up from the base. As explained before, the bluff here occupies the line of what at some earlier time was a divide. The fossils occur in the lower part of the loess, which here has an ashen gray color. The species collected were as follows:

Polygyra multilineata (Say) Pils.
Pyramidula strigosa iowensis Pils.
P. perspectiva (Say) Pils.
P. striatella (Auth) Pils.
Zonitoides arboreus (Say) St.
Z. shimeki (Pils) P. & J.
Conulus fulvus (Draph) Mull.
Vallonia gracilicosta Reink.
Sphyradium edentulum alticola (Ingers) P.
Bifidaria pentodon (Say) St.
Helicina occulta Say.
Succinea avara Say.
S. obliqua Say.
S. grosvenorii Lea.
Limnæa humilis Say.*

Terrace and Alluvium. The greater part of the higher low lands along the Iowa and the Cedar rivers lie from thirty to forty feet above the flood plains. This higher lowland, usually known as the "second bottom," is an ancient terrace which probably was built up, in part at least, at the time of the Iowan ice invasion. It consists of sand and some gravel with a thin veneer of loess. In many places the surface materials have been drifted by the wind into sandy ridges. The depth of the terrace sand is not certainly known, except at some points along the river. Around Wapello and north of Columbus Junction it is seen to rest on the Albertan till

*The identifications in this list, as well as in the previous one, were made by Professor B. Shimek.

and is some thirty or thirty-five feet deep. This same terrace is continued up the valley of Long creek as far as to Sec. 13, Tp. 75 N., R, V W. It is also present along the lower courses of some of the other tributaries coming from the uplands. Along Long creek the terrace sand is sometimes overlain by a few feet of a fine, laminated, grayish blue silt, above which there is the usual loess capping. Along Otter creek in Secs. 1 and 2, Tp. 73, R. IV W., this loess capping with a soil layer on top has been covered over by a few feet of more recent alluvium.

On the bottoms of the Mississippi river a similar terrace extends south from Muscatine county in Secs. 4 and 9, Tp. 75 N., R. II W. This is probably a remnant of an extensive terrace built up over these lowlands by the drainage of the Wisconsin ice.

The most recent deposits are represented by the alluvium from the present streams now laid down over their flood plains during high water. This consists in the main of dark sandy silt and gray sand. The most extensive alluvial tracts are along the Mississippi river, where only a few vestiges remain of the earlier terraces.

Geological Structure.

The only structural feature which can be made out with certainty in this area is a slight general dip to the south. West of Columbus Junction the English river gritstone lies at a level of about twenty feet above that which it has in the bluffs north and northeast of Morning Sun. The distance between these two localities is about a dozen miles. The dip is therefore one or two feet per mile. This probably accurately represents the attitude of the formations in the southern part of the county. In the city of Burlington the English river gritstone is still forty feet above the river level. In the northern part of the county the dip should be considerably greater than this in order to make room for the 200 feet of the Kinderhook shales. In Muscatine county,

IOWA GEOLOGICAL SURVEY

MAP OF THE SURFACE DEPOSITS OF LOUISA COUNTY, IOWA.

BY

J.A.UDDEN

1900.

Scale 1/125000

1 1/2 0 1 2 3 4 5 Miles.

1 1/2 0 1 2 3 4 5 Kilometers

LEGEND

- ALLUVIUM
- TERRACE OR LOWLAND PLAIN
- IOWAN LOESS OVERLYING ILLINOIAN DRIFT.
- IOWAN LOESS OVERLYING KANSAN DRIFT.

Tp 76 N.

Tp 75 N.

Tp 74 N.

Tp 73 N.

R.V W.

R.IV W.

R.III W.

R.II W.

R.I W.

OAKLAND

UNION

CONCORD

GRAND VIEW

PORT

COLUMBUS

RIVERBED

OLD LINDIANA

ELM GROVE

WAPELLO

MARSHALL

JEFFERSON

MORNING SUN

Letts

Fredonia

Grandview

Columbus City

Cotter

Buffington

Wyman

Cairo

Toolsboro

Marsh

Morning Sun

Newport

Oakville

West Reithsburg

MISSISSIPPI RIVER

DRAWN BY F.C. TATE

IOWA LITHO. CO.

which abuts on the north, the dip is much greater. It may hence be inferred that the northern part of Louisa county marks a line of change in dip to the south—the line of a slight synclinal flexure, as it were.

Joints.

In the course of the survey of this region some observations were made with a three-inch hand compass on the direction of joints in the country rock. Usually several sets of joints are to be seen and the direction of two or three of the most prominent ones are noted. The recorded directions are given in a table below and plotted in Fig. 8. It will be noticed that these trend in nearly all directions. This is no doubt due to the fact already noted that there is no appreciable dip to the strata in the southern part of the county, where most of these joints were observed. It may probably also be the result, to some extent, of insignificant local fractures caused by the settling of the cavernous Burlington limestone. There is, however, a slight clustering of the joints in three chief directions, namely: approximately N. 35° W., N. 52° E., and N.-S. The joints approximating to the northeast and northwest directions were no doubt produced in connection with the general southwest tilting of the surrounding

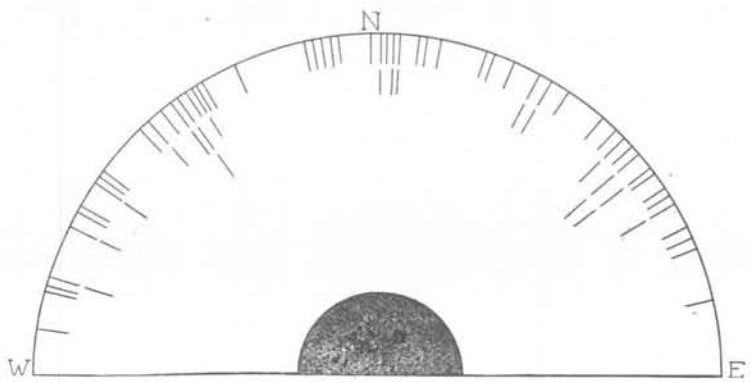


Fig 8. Diagram showing trend of joint planes in the bed rock.

region and the other main set may have been formed during a tilting to the south. The data seem too few and uncertain for further discussion.

TABLE SHOWING BEARINGS OF JOINTS IN THE COUNTRY ROCK IN LOUISA COUNTY.

In the Kinderhook Beds.

Tp. 73 N., R 2 W.	N. 25° W.	N. 84° W.	.....	.....	.....
Tp. 73 N., R 3 W.	N. 28° E.	N. 57° W.	.....	.....	.....
Tp. 74 N., R 4 W.	N. 48° E.	N 54° W.	N. 73° W.	.....	.....
Tp. 75 N , R 5 W..	N. 57° E.	N. 12° W.	N. 7° E	N. 3° E.	.....
Tp. 76 N., R 5 W .	.....	N. 55° W.	.....	.....	.....

In the Burlington Limestone.

Tp 73 N., R 2 W.	N 53° E.	N. 60° E	N. 53° W.	N. 34° W.	....
Tp. 73 N , R. 2 W.	N. 68° E.	N. 22° E.	N. 61° W.	N. 54° E.	.....
Tp 73 N., R. 2 W	N 87° E.	N 13° W.	N 75° W.	.....	....
Tp 73 N , R 3 W	N 41° E.	N. 10° E.	N. 31° W.	.....	....
Tp. 73 N., R. 3 W.	N 58° E.	N. 68° W.	N. 50° E.	N. 68° W.	.....
Tp 73 N , R. 3 W	N. 50° E.	N. 11° W.	N. 10° W.	.....	.....
Tp 73 N., R 3 W	N. 18° E.	N. 42° W.	N. 60° W.	N. 10° W.	....
Tp 73 N., R. 3 W	N. 2° E.	N. 19° E.	.....	....	.....
Tp. 73 N , R. 3 W.	N. 3° E.	N. 5 ° W.	N 66° E.	.....	.....
Tp. 73 N., R 3 W.	N 30° E.	N. 42° W.	N.-S.	.....	.. ..
Tp. 73 N., R. 4 W	N. 46° E.	N.-S.	N. 9° W.	.....	.....
Tp. 74 N., R. 5 W	N. 53° E.	N 44° W.	N. 36° W.	.....	....
Tp 74 N , R 5 W.	N. 64° E.	N. 34° E.	N. 2° E.	N. 46° E.	N 36° W.
Tp 74 N., R. 5 W.	N. 28° E.	N. 50° E.	N. 36° W.	N. 6° E.	N. 30° E.
Tp. 74 N., R. 5 W.	N. 54° E.	N. 37° W.	.....	.....	.....
Tp. 75 N., R. 5 W	N. 66° E.	N. 33° W.	....	....	.....
Tp. 75 N., R. 5 W	N. 39° W.	N. 37° W	N. 82° W.	N. 2° W	....
Tp. 75 N., R 5 W	N 53° E.	N. 64° W	N. 82° W.	N. 1° E	

Minerals.

Large crystals of calcite are frequently found in the Burlington limestone. Calcite in the form of stalactite is occasionally seen in caverns in the same rock. Pyrites occurs in concretions and small crystals in the Kinderhook shales and sandstone and in the Burlington limestone. On the surface of the Kinderhook beds incrustations of epsomite sometimes accumulate. A black sphalerite occasionally fills little irregular hollows in the quarry ledges of the Burlington limestone. In larger caverns in the same rock small deposits of wad have been noticed and in its upper shaly ledges there are geodes lined inside with quartz crystals or with amor-

phous chalcedony. A bowlder of native copper was found by Mr. John F. Marshall in a ravine a mile east of Cairo some years ago. It weighed thirty-five pounds and was about the size of a brick.

ECONOMIC PRODUCTS.

Building Stones.

The Burlington limestone is quarried in a great number of places along its line of outcrop south and west of the Iowa river. Dalzell's old quarry, now abandoned, near the center of the north line of Sec. 17, Tp. 73 N., R. III W., and about two miles north of Morning Sun, is in the ledges of the Lower Burlington. The same ledges have also been quarried on John D. Anderson's property just south of Elrick Junction on Sec. 27, Tp. 75 N., R. V W. This rock is usually too much weathered to furnish durable building material. On Anderson's property the Upper Burlington is now quarried and good rock is obtained. Nearly all of the small quarries throughout the county are in the same beds. The largest output is from the quarries east of Morning Sun, on Honey creek, where Mr. Wm. Turner is now (1899) taking out rock on land belonging to Mr. Charles Wilson. About 2,000 perch are annually quarried and bring an average price of seventy-five cents a perch. The local market is supplied and some of the product is shipped to Mediapolis, Weyland, Olds, Winfield and other neighboring towns. Most of the rock is of excellent quality. It is used for foundations and for bridge piers. Some has been dressed at the quarry as finishing stone and has brought thirty-one cents a square foot. The total thickness of the ledges which are used is about eight feet, and the different beds vary from four to eighteen inches. The quarry gives employment to from four to eight men. Some of the rubbish has been sold to the city of Morning Sun, crushed, and used in macadamizing the streets. The quarry next in importance is worked by Mr. J. H. Wasson in the south bank of Long creek near the northwest corner of

Sec. 23, Tp. 74 N., R. III W. The ledges are the same as those in the Morning Sun quarries, and the rock is of about the same quality. An extensive drift covered country lies to the west of this place and there is a large local market, which for many years has been supplied from this point, as may be seen from the many old quarry pits. Three men are usually employed, and the price of the rock varies from 58 cents to $1.25 a perch according to quality.

A tabulated statement of the quarry industry in this county is given below.

STONE QUARRIES IN LOUISA COUNTY.

OPERATOR.	LOCATION.	Number of men employed	Average price per perch.	Number of perches of rock quarried in a season.
Wm Turner.....	Sec 27, Tp 73 N , R III, W.....	6	$ .75	2,000
J. H. Wasson.....	Sec 23, Tp 74 N., R V, W.....	3	1.00	900
J Gray	Sec. 3, Tp. 74 N., R. V, W.....	2	1.00	550
F. J. Moore	Sec. 33, Tp. 75 N , R V, W.....	2	.....	300
W. C Bryant.....	Sec. 22, Tp 73 N., R III, W.....	3	.80	400
....	Sec 4, Tp. 73 N , R. IV, W.....	4	.80	500
John D Anderson...	Sec. 31, Tp 73 N., R II, W.....	2	.....	300
J. H. Springston....	Sec. 36, Tp. 73 N , R. III, W.....	1	.....	.....

Very litte sandstone is found in this region and none has been quarried except in the old Dalzell quarry near the center of the north line of Sec. 17, in Tp. 73 N., R. III W. Here some sandstone is found as an outlier in an old cavern in the Subcarboniferous limestone. Some of the rock is still left but explorations with the drill have shown that it is of limited extent. More of it is seen near the forks of Long creek in Sec. 13, Tp. 74 N., R. V W., but this has not yet been utilized. The rock is massive, almost without bedding, and very difficult to quarry. It would without doubt prove a durable and strong stone for foundations.

Clay Industries.

The clay industry in Louisa county is carried on by three firms which are engaged in making brick and tile, one in Columbus Junction, one in Morning Sun, and one near Wapello. These employ about twenty men and their total product is 1,050,000 common brick and about 500,000 tile.

McClurkin, Ockletree & Company own and operate a brick-yard located in the Sw. $\frac{1}{4}$ of the Se. $\frac{1}{4}$ of Sec. 25, Tp. 73 N., R. 4 W., just outside the city limits of Morning Sun. The average annual product is 300,000 common brick and 200,000 3-inch tile. The principal market is in Morning Sun, but some brick is also sold in Wapello and Oakville. The bricks bring $6.50 per 1,000, and the 3-inch tile is sold for $10 per 1,000. Some larger tile is also made. Six men are employed. The bricks are made by a Mackenzie machine, run by steam power. The burning is done mostly in two down-draft kilns. Some of the hardest brick have been used for sidewalks. Most of the clay is an upland loess, thoroughly weathered and free from lime. In making the largest tile this clay is mixed with a leached bowlder clay, quite free from pebbles. The latter is found close by on a branch of Otter creek, and seems to be from an outcrop of an ancient drift under the Kansan bowlder clay.

At Columbus Junction the only brick factory now running is Oaks Brothers' brick and tile works in the north part of the city. This factory uses the Acme brick and tile machine with a capacity of about 25,000 brick per day. Steam power is used. The brick is dried under cover and burnt in open covered kilns. The tile is burnt in a down-draft kiln. Eleven men are employed and the average product for a season is 600,000 brick and 150,000 tile. The brick is sold at $6.50 per 1,000 and the 3-inch tile at $10.00 per 1,000. Most of the tile is sold at home. The brick is red, fine in texture, hard, and makes a good building brick. About one-half of the output is shipped to the surrounding towns, Nickols, Letts, Lone Tree, Wapello, Cotter and Washington and the rest supplies the home market. The clay used in this factory is a loess, from

eight to twelve feet in thickness, which covers a low terrace-like extension of the upland lying between the Iowa river and Clifton creek. The lower part of this loess has a grayish blue color and is slightly calcareous. This portion of the deposit burns to a lighter shade and the bricks made from it have a specially fine texture.

A mile and a half east of Wapello, near the northwest corner of Sec. 25, Tp. 74 N., R. III W., Mr. O. M. Zerber has been operating a brick yard for the last five years. He manufacturers about 150,000 brick each season, supplying the home market in Wapello and the surrounding country. The average price of the products has been $6.00 per 1,000. The brick is made from the surface material of the loess on the upland adjoining the Iowa river bottom. The clay pit covers an acre and is only two feet deep. The surface mould, which is six inches in thickness, is not used. The brick is hand made, sun dried, and burnt in open kilns. A summary of the clay industries in the county is given in tabular form below:

CLAY WORKS IN LOUISA COUNTY.

NAME OF FIRM	No. of men employed.	Price of brick per 1,000.	Price of tile (3-inch).	Quantity of brick made in one season	Quantity of tile made in one season.
Oaks Bros., Columbus Junction	11	$6.50	$10.00	600,000	150,000
McClurkin, Ockletree & Co, Morning Sun	6	6.50	10.00	300,000	200,000
O. M. Zerber, Wapello	3	6.00	.....	150,000	.....

Coal.

Though there is no doubt that the Coal Measures at one time covered the county, it is equally certain that all of the workable coal occurring in these strata has been removed with them. Nevertheless two attempts have been made at coal mining, both of them in the small outliers of the black

Coal Measure shale already described. If any larger outliers of this formation remain under the drift they are more apt to be found along the west boundary of the county, where the bed rock is least affected by preglacial erosion. Some well drillers have supposed that coal might be found in the lower dark Kinderhook shale which has been explored by some of the deeper wells in the southern part of the county. It is well known that this supposition has no foundation whatever, since these shales are barren elsewhere. Money expended in prospecting for coal in this county can bring no return.

Natural Gas.

Twelve years ago natural gas was discovered in Louisa county. It occurs in quantities large enough to be utilized. The gas appears to come from the fine sand or silt that lies under the Kansan till. The overlying bowlder clay evidently serves as an impervious capping under which the gas collects as it is distilled from the bituminous material in the pre-Kansan drift. It has been shown that there is an old soil horizon at this level. This in all likelihood is the chief source of the gas, though the lowest till itself contains bituminous material. Possibly some of this bituminous matter was originally derived from the Sweetland Creek shale, which has doubtless been worked into the lower till in considerable quantity. Gas has been found in more than a score of wells in larger or smaller quantity and it is quite likely that it might have been found in many more places if properly searched for. It occurs in the upper part of the fine sand already referred to and may sometimes be overlooked as the tubing is sunk in a new well. This may reach and enter the sheet water which usually is present in the same sand farther down. If the tubing be raised gas may escape. There have been several instances of this kind in the experience of the well drillers of the region. It has also happened that a well which has just reached the gas-bearing sand has at first given no indications of gas but after having been left standing over night it has begun to blow gas.

In such cases the pressure was evidently too small at first to overcome the weight of the water in the casing. When this water is left to settle into the dry sand its head is lowered until its pressure is balanced and overcome by the gas pressure. There should then be a more or less sudden outburst of the gas and such instances are actually on record. A whole family was in one case awakened in the middle of the night by a loud roar from a new well which at the close of the previous day showed no sign of gas. Some of the well drillers fully understand this principle and have of late been successful in sinking gas wells where others have failed. To stop the tubing at the right level requires good judgment and experience. Sometimes it has proved profitable to test for gas in this way at different levels in the same well. Even a few feet may make a difference between failure and success.

The oldest productive well was sunk eleven years ago and is yet giving a good supply. Three or four wells have ceased furnishing gas after having been productive for some time. One of these is said to have become clogged. It seems probable that in the other instances the supply was really exhausted. Most of the wells are less than three years old. In a few cases the supply has been unsteady and apparently changes with the weather, as if affected by barometric pressure. At times one or two wells have furnished a wave like flow, the gas coming in puffs at intervals of a few minutes. The supply is not always proportionate to the pressure. When escape is shut off the pressure may rise comparatively high in wells where the yield is otherwise small.

To make any predictions as to the life of the wells in this region would perhaps be unsafe. The history of other small fields of drift gas will probably be repeated here. Some new wells will now and then be found, while many of the old wells will cease to yield. The gas is evidently held in many small and irregular reservoirs under the till which probably correspond with upward bends of the silty and sandy stratum in which it is held. It is not likely that all of these reservoirs

have yet been tapped. A few of them may have been emptied in the case of wells which have ceased to flow. Possibly the gas is still slowly being formed and this may help to lengthen the life of some of the wells. In any case the first supply must represent an accumulated quantity which when once withdrawn never quite returns as long as there is escape.

The pressure of the gas has been measured in fifteen different wells and was found to vary from four to ten and one-half pounds. These measurements were made with a small steam guage adapted for low pressure. In general the highest pressure is found in the deepest wells and these are mostly located on the highest ground. Possibly the head of the ground water is the principal factor which determines pressure. Apparently the gas can escape naturally only against the head of this water.

The principal uses of the gas have been for lighting, cooking, and heating. In a few cases it has been used for fuel in small steam engines. It is piped into the farm houses by means of small iron tubing. Regulators are used to make the pressure more steady. Where the gas is plentiful the farmers cook the feed for their hogs and this has proved to be of considerable advantage in pork production.

At one time there was considerable talk of exploring for gas in the older rocks underlying the drift at Letts. While there is not the least reason to believe that gas will be found by deep borings here, the undertaking would very likely result in procuring a good water supply for this village and would therefore be a commendable enterprise.

Below I give in tabulated form such data as were secured during the survey concerning the gas in this region up to the month of November, 1899.

TABLE OF DATA ON GAS WELLS NEAR LETTS.

OWNER'S NAME.	LOCATION.	USES.			Elevation in feet.	Pressure in pounds	Depth in feet.	AGE. (NOV. 1899.)	
		Engines.	Stoves.	Light.				Years.	Months.
Joseph Wagner	Nw. ¼, Sec. 6, Tp 75 N., R. III W	...	3	4	700	9	122	1	.....
Mrs Amelia Hadley	Se. ¼, Sec. 36, Tp. 76 N., R. IV W. (Muscatine county)	1	3	5	735	10	126	2	.....
I. Idle	Nw. ¼, Sec. 1, Tp 75 N., R. IV W	...	...	...	710	6	114	...	6*
B. B. Lintner	Nw. ¼, of Nw. ¼, Sec. 2, Tp 75 N., R. IV W	...	2	4	718	10½	115	1	.....
H. H Westbrook	S ½, Sec. 36, Tp 76 N., R IV W. (Muscatine county)	...	2	4	723	Unsteady	117	1	.....
Wm. Griffin	Se. ¼, Sec. 35, Tp. 76 N., R IV W. (Muscatine county	...	2	4	700	6½	120	...	.....
John Idle	Sw. ¼, Sec. 35, Tp. 76 N., R. IV W. (Muscatine county)	...	2	5	690	6	98	...	.....
R W. Lee	Ne ¼, Sec. 3, Tp. 75, N., R IV W	...	...	...	680	9½	103	...	2
Charles Estel	Nw. ¼, Sec. 3, Tp. 75 N., R. IV W	...	4	5	680	4	86	...	8
R. M. Lee	Sw. ¼, Sec. 3, Tp 75 N., R. IV W	1	8	10	690	4	113	11	.....
Etta Littrell	Ne. ¼, Sec. 10, Tp. 75 N., R. IV W	...	3	3	728	7	100	...	2
Robert Wilson	Ne ¼, Sec. 10, Tp. 75 N., R IV W	...	...	...	710	?	90	...	Recent.
Fay Letts	Se. ¼, Sec 19, Tp 75 N., R. III W	..	2	3	665	4	80	...	1
Noah Letts	Ne ¼, Sec. 20, Tp. 75 N., R. III W	1	...	...	675	4	94	4	.....
Two wells in Letts	Letts	...	2	5	685	5	100	1	.....
C. Vincent	Se. ¼, Sec 6, Tp 75 N., R III W	...	2	2	685	7	106	2	.....
Wm. Wagner	Sw. ¼, Sec. 6, Tp 75 N., R III W	...	3	4	700	7	110	3	.....

*Well made in 1892, and gas was observed then, but was shut off until 1899.

Gravel and Sand.

Glacial sand and gravel are infrequent in this region where they lie deeply buried near the base of the drift. Some sand deposits of apparently limited extent have been exposed in the cuts along the Muscatine North & South railroad, as in a curve in the Nw. ¼ of Sec. 14, Tp. 75 N., R. III W., and in Sec. 2 in the same township and range, but these have not been utilized to any extent. Plastering sand is taken from the banks of the principal rivers and creeks and is frequently hauled many miles.

Soils.

The soil on the loess-covered uplands has an open, loose texture of the kind usually found in this part of the state. It is an excellent corn soil. A large part of the Iowa river lowlands has a thin veneer of the same material and the soil in some places does not differ much from that on the upland farms, though there are apt to be frequent sandy patches. As a rule the soil is somewhat sandy on these lowlands, and, in places, it is almost all sand. Some of these sandy lands are used for melon crops in Oakland township and in the vicicity of Wapello they are used for other vegetables. In the northern part of Louisa county the Mississippi bottoms are quite sandy, and, in places, gravelly, and a considerable part of the ground is used for growing watermelons.

Water Supply.

This county has no artesian wells. Should it p rove desirable, a copious flow may be found anywhere on the lowlands at a depth of from 1,200 to 1,400 feet. On the uplands where the drift is deep, water is usually obtained in drift gravel at depths varying from seventy to three hundred feet. The supply in the shallow wells, which go down to the bottom of the loess only, is now frequently unreliable, except on flat lands which are not well drained. Along the outcrop of the Subcarboniferous west of the Iowa river there are many copious

springs in the ravines. In almost every case these springs come from the transition beds between the upper Burlington and the Kinderhook shales. On the lowlands water is everywhere plentiful in the sand which underlies the surface silt and driven wells are universal. The city of Wapello uses a system of such wells placed at regular intervals along the streets for fire protection. A steam pump can be attached to them as to so many hydrants.

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IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF LOUISA COUNTY, IOWA.

BY

J. A. UDDEN.

1900.

Scale 1/125000

1 ½ 0 1 2 3 4 5 Miles.

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

DES MOINES

AUGUSTA

KINDERHOOK

CEDAR VALLEY (NOT EXPOSED)

INDUSTRIES

QUARRIES

CLAY WORKS

GAS WELLS

Tp 76 N.

Tp 75 N.

Tp 74 N.

Tp 73 N.

R. V W.

R. IV W.

R. III W.

R. II W.

R. I W.

OAKLAND

UNION

CONCORD

GRAND VIEW

LOUISA

COLUMBUS

COLUMBUS

ELM GROVE

MARSHALL

WAPELLO

WAPELLO

JEFFERSON

MORNING SUN

LOUISA

Letts

Cotter

Fredonia

Grandview

Columbus City

Bard

Buffington

Wyman

Cairo

Toolsboro

Marsh

Morning Sun

Oakville

West Reithsburg

Newport

Mississippi River

Iowa River

Cedar River

Skunk River

Short Creek

Long Creek

Johns Creek

Spring Creek

Sugar Creek

Chicago, Rock Island & Pacific R.R.

Iowa, Central & Northern R.R.

DRAWN BY F. C. TATE

IOWA LITHO. CO.