GEOLOGY OF CLINTON COUNTY.

BY

JON ANDREAS UDDEN.

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INTRODUCTION.

AREA AND LOCATION.

Clinton county has an area of 880 square miles. It is situated nearly midway between the north and the south boundaries of the state, along the Mississippi river. It extends farther east than any other county in Iowa. Its greatest length in an east and west direction is thirty-eight miles, while from north to south it measures twenty-one miles. The abutting county on the north is Jackson, on the west are Cedar and Jones, on the south is Scott. From the latter county it is separated by the Wapsipinicon river. Its east boundary is the Mississippi river. Clinton county is the fifth of the counties along this great water way counting from the north, and the sixth, counting from the south.

PREVIOUS INVESTIGATIONS.

Visiting and local geologists have both contributed to our knowledge of the geology of Clinton county. Among the earliest geologists whose observations are recorded we find J. D. Whitney, who published some notes on the drift and outcrops of rock along the Mississippi and Wapsipinicon rivers, in Hall's first report on the Geology of Iowa.* Dr. James Hall, who described the general characters of the rock in Iowa in the same volume,† has some references to this county. Dr. J. P. Farnsworth of Clinton has published an account of pockets of fire clay, which were noticed in the limestone in the vicinity of Clinton.‡ Dr. W J McGee made extensive observations on the drift in this county and published an account of his studies in his *Pleistocene History of Northeastern Iowa.*§ In this he de-

* James Hall: Geol. of Iowa, Vol. I, pp. 278-282. 1858.
† James Hall: Geol. of Iowa, Vol. I, pp. 70-71. 1858.
‡ J. P. Farnsworth: Am. Geol., Vol. III, pp. 331-334. 1888.
§ W J McGee: 11th Annual Report U. S. Geol. Surv. part I.

scribes the Goose Lake valley, and also two different drift sheets. In his monograph entitled *The Illinois Glacial Lobe*,* Frank Leverett has published a full account of his studies of the drift in a number of places in Clinton county, especially those bearing on the earlier course of the Mississippi river in the Goose Lake channel.

PHYSIOGRAPHY.

TOPOGRAPHY.

The topography of Clinton county presents several clearly distinguishable areas. The lowlands of the Mississippi, the lowlands of the Wapsipinicon, the Goose Lake valley, the uplands of the Iowan drift, and the uplands of the older drifts, each is marked by different topographic features and is best described separately.

The Mississippi Lowlands.—At the north boundary of Clinton county these lowlands are a little more than a mile wide, on the Iowa side of the river. Following them to the south they widen out to nearly two miles in width in sections 7 and 8 in Spring Valley township. In section 18 in the same township the bluffs again turn toward the river and reach out to its bank in the north part of section 20. This and the extreme northeast corner of the county are the only places where there are no lowlands between the river and the bluffs. From below this point, and all the way to the Wapsipinicon, the bottom lands continue to increase in width, and at the point where the two streams meet they extend two miles away from the Mississippi. The surface of these lowlands is that of a level, alluvial plain, for the most part only about twenty-five or thirty feet above the level of the river, with a general slope to the south of less than one foot to the mile. Near Camanche and near Follets there are remnants of old terraces which rise about thirty feet above the level of the flood plain. It is evident that the entire valley of the great river, which reaches a width of six miles, was once filled to this height, and that the river

* Leverett: Mon. XXXVIII, U. S. Geol. Surv., pp. 466-467. See also Frank Leverett, *Old Channel of the Mississippi in Southeastern Iowa.* Annals of Iowa, Vol. V. pp. 38-51.

has again removed nearly all its old deposits down to the present level of the alluvial plain. Another remnant of the same old terrace lies in the southwest corner of section 30, about one mile north, and one-half mile west, of Midland Junction.

To the southwest of Clinton an island-like part of the uplands is cut off from the main upland to the west by a valley about one-half mile in width. This valley connects with the Mississippi bottoms at both ends, and it is drained by a small stream known as Hart's Mill creek. Its origin dates back to a time when the drainage of the Mississippi was impeded, and its waters flowed over several long and low sags to the east. The opening up and the lowering of the Mississippi valley farther down was evidently so slow and gradual that the river was able to maintain and widen out several channels in this region at one and the same time. The relation of the Hart's Mill valley to the other lowlands leaves no doubt that it is the result of the work of the river; and the size of the valley makes it clear that it can never have held more than a part of the great stream at one time. The strip of upland extending to the southwest of the city of Clinton was thus at one time a high island in the midst of the Father of Waters.

The Wapsipinicon Lowlands.—The Wapsipinicon river enters Clinton county in section 7 of Liberty township. The width of its bottom lands at this place is about one mile, and this continues as far down as the village of Toronto. Below this place the channel widens to more than two miles, sometimes to nearly four miles, as between Wheatland and Calamus, and at a place about three and one-half miles north of Calamus. This wide bottom is again contracted to less than one mile near the north boundary of Scott county, east of Dixon. From this point all the way to the Mississippi, the valley is open, varying from two to four miles in width. The surface of the Wapsipinicon flood plain is mostly from fifteen to twenty-five feet above the low water mark in the river. Nearest the channel its surface is frequently indented by ox-bow lagoons, that mark lines formerly followed by the main channel. Within the limits of the county this flood plain descends at the rate of about two and one-half feet to the mile towards the Mississippi.

The Iowan Drift Plain.—About two-fifths of the uplands of Clinton county consist of a plain which has an average elevation of about 680 feet above the sea, and which ranges from 620 to 760 feet. This plain has a relief which is quite different from that of the other uplands. Its surface is somewhat uniformly level and but little dissected by erosion. There are extensive flat lands with now and then some low ridges that have a tendency to extend from the northwest to the southeast. This we call the Iowan drift plain, for its boundaries coincide with the boundaries of the area that is covered by the Iowan drift. It occupies a belt that extends in a general direction from the northwest to the southeast, and ranges from six to ten miles in width. On the west it enters the county in Liberty township. Here its southern boundary lies in section 31, extending to the east-southeast for three miles, to a point about one mile north of Wheatland. From here it follows the Wapsipinicon river towards the southeast, and crosses this stream near Dixon. It continues with an eastward trend in Scott county to near the confluence of the Wapsipinicon with the Mississippi. The north boundary lies in section 30 in Sharon township, and from there extends east about one mile on the north side of the Chicago Milwaukee & Saint Paul railroad, as far as Lost Nation. From here the north boundary follows a nearly straight line in a direction east-southeast, passing a point about one mile south of Welton to Elvira, and to all appearances meeting the lowlands of the Mississippi some three miles north of Camanche.

The Older Drift Plain.—North of the Iowan drift plain, in the north part of the county, and south of the Wapsipinicon river in Spring Rock township, the land is built up from older drifts and has a different topographic character. Most of its relief lies from 700-900 feet above the sea level. This land is thoroughly dissected, and consists mainly of slopes which follow the ramifications of the drainage and join in ridges between these. In Elk River and Spring Valley townships, along the Mississippi, these slopes are steep and high, sometimes precipitous. Away from the larger valleys they are more gentle with a convex contour above and a concave contour below.

The highest points in the county lie in this drift plain. These are in section 34 in Brookfield township, where the elevation exceeds 920 feet above the sea level, and in section 8 in Hampshire township, where the elevation is about 910 feet. Both of these points lie in the line of the divide between the Wapsipinicon and the Maquoketa basins. In the small tract of the older drift plain which occupies the southwest one-half of Spring Rock township, the most elevated point is located in section 30, and reaches a height of 860 feet above sea level.

The Goose Lake Channel—Goose Lake channel is one of the most interesting features in the topography of the state. It consists of a large stream valley, which crosses the two drift plains from north to south, in the east half of the county. Starting from the Maquoketa river, in Jackson county, it enters Clinton county in sections 5 and 6 in Deer Creek township, and extends from there in a direction a little east of south to near the center of Center township. At this point it turns to a course a little west of south and joins the lowlands of the Wapsipinicon in the southwest corner of Eden township. This valley averages one and one-half miles in width. Its flat bottom lies about one hundred feet below the nearest part of the uplands of the older drift, and from twenty-five to seventy-five feet below the plain of the Iowan drift. It is limited on either side by a well marked line of bluffs. The highest point on the floor of the valley is to the south of Goose lake where its elevation is 690 feet. From this point the surface descends north as well as south. In the latter direction the descent is about six feet to the mile.

DRAINAGE.

Only a small part of Clinton county drains directly into the Mississippi river. This is a strip adjoining the river, nine miles wide at the north boundary and narrowing to five miles near its south end. It includes the townships of Elk River, Hampshire, Spring Valley, Clinton, Lincoln and Camanche. The south end is covered by the Iowan drift. It has a low relief and a sluggish drainage. There are several sections of marshy land north and east of Low Moor, and these cover a

bottom which resembles that of the Goose Lake channel and connects with the latter about two miles south of Elvira. The north end of the belt has a higher relief, and is drained by several small systems of ramifying creeks which lead out to the west bluffs of the great water way.

Along the north boundary of the county another narrow area drains into the Maquoketa river, in Jackson county. The basin of the latter stream extends about two miles into Clinton county, at the northwest corner, but as we proceed eastward it reaches farther to the south so as to include section 1 in Berlin, and section 12 in Welton township. From here its south boundary follows closely the south line of the north tier of townships across Goose Lake channel to section 35 in Deer Creek township, which is the meeting point of the divides that separate the three drainage basins. All of the area of the county not included in these two belts drains into the Wapsipinicon river. The history of the development of the present drainage in this region is exceedingly complicated, and far too much involved to be satisfactorily made out in all of its details at the present time. There are a few general features, however, whose significance is quite clear. In the first place it is evident that some features of the drainage date back to the time preceding the Glacial epoch. There can be no doubt that the main course of the Mississippi river follows a preglacial channel of some considerable stream. So does also the Wapsipinicon river. Many of the creeks in the region of the older drift also occupy valleys that existed before this drift was deposited. Prairie creek, Elk creek and probably Sugar creek are examples of this kind.

But there are other creeks whose present courses have been determined by the drift deposits. Deep creek, which runs for nearly fourteen miles from west to east and follows the north side of a belt of comparatively heavy drift, was in all probability turned into that course by the same drift. The drainage of the Goose Lake channel is of still later origin. It is supposed to date back to a time when the Illinoian glacial lobe pushed across into Iowa from the east, and caused the Mississippi to find a new channel in passing its outer and western border.

This valley now drains a strip of the uplands on either side, a little less than two miles in width. This is the distance to which its lateral gullies have had time to recede or cut back into the old drift plain. The bottom of this valley has a very sluggish drainage. With a slope of only five feet to the mile in either direction north and south, from the divide one mile south of Goose lake, the greater portion of its surface was formerly marshy and is not yet well drained, though several ditches have been constructed for that purpose. There can be no doubt that since the time the channel was abandoned by the stream that made it, accumulations of silt have raised its bottom, which must have had a general descent to the south. At present its surface slopes to the north from a point near Goose lake, and is drained in that direction by Deep creek.

The drainage of the Iowan drift plain is of still later date, and is as a result still less perfect. Its streams have wide and shallow valleys, and marshy ground is frequently seen. The drainage is sluggish. There are even a few small basins without outlets. Along the north border of this drift some valleys extend out beyond it, which are in size out of proportion to the streams that now drain them. These are evidently drainage lines that were once much deeper, and which now lie partly buried under a filling that has accumulated as the drainage became clogged. Silver creek is the most pronounced instance of this kind. Its valley extends north up to Deer creek, and is even continued across and beyond this stream. Deep creek, evidently, now drains a part of what formerly was the north extension of the basin of Silver creek. The Wapsipinicon valley is evidently also following some old and filled channels throughout the greater portion of its course in this county. Northeast of Dixon it perhaps crosses an old divide. Above this place, in the region between Calamus and Wheatland, water stands on its bottoms for weeks during rainy seasons. In the lower part of its course there is an efficient under-drainage in the sands which fill the old channel, and at some points the river almost entirely disappears during stages of low water.

TABLE OF ALTITUDES IN CLINTON COUNTY.

STATION.	ABOVE SEA LEVEL AT STATION.	AUTHORITIES.
Big Rock	697	C., M. & St. P. R.R.
Browns	685	C., M. & St. P. R.R.
Calamus	710	Gannett's Dictionary.
Camanche	725	Gannett's Dictionary.
Charlotte	685	Gannett's Dictionary.
Clinton	588	C., M. & St. P. R.R.
Clinton	593	Gannett's Dictionary.
Clinton—low water	566	Gannett's Dictionary.
Clinton—high water	586	Gannett's Dictionary.
Delmar Junction	822	C., M. & St. P. R.R.
Delmar Junction	811	C. & N. W. R. R.
Dewitt	711	C., M. & St. P. R.R.
Dewitt	687	Gannett's Dictionary.
Elk River Junction	594	C., M. & St. P. R.R.
Elwood	736	C., M. & St. P. R.R.
Goose Lake	703	Gannett's Dictionary.
Grand Mound	710	Gannett's Dictionary.
Lost Nation	744	C., M. & St. P. R.R.
Low Moor	647	Gannett's Dictionary.
Lyons	590	C., M. & St. P. R. R.
Lyons	590	C. & N. W. R. R.
Malone	663	Gannett's Dictionary.
Midland Junction	594	C., M. & St. P. R.R.
Midland Junction	594	C. & N. W. R. R.
Riggs	785	C., M. & St. P. R.R.
Teed's Grove	686	C., M. & St. P. R.R.
Toronto	721	C., M. & St. P. R.R.
Welton	702	C., M. & St. P. R.R.
Wheatland	672	C., M. & St. P. R.R.
Wheatland	686	C. & N. W. R. R.

STRATIGRAPHY.

General Relations of Strata.

The country rock in this county is, almost everywhere, the Niagara limestone. In Spring Valley and Elk River townships this has been wholly removed by erosion in a few places, and the underlying Maquoketa shale is exposed. On top of the Niagara limestone the Coal Measures have once rested unconformably, but these have been almost entirely removed. A few small outliers are left in some places near the north boundary of the county. These sandstones are the latest sediments preceding the glacial drift. The geest, bowlder clay, loess and alluvial deposits constitute the mantle rock, which usually conceals the underlying rocks of the Paleozoic group

except in some places where these rise to an unusual height, or where the drift cover has been washed away by recent erosion. The succession of these formations, as far as known from exposures and explorations in this county, is set forth in the following table:

TABLE SHOWING THE GENERAL RELATIONS OF THE ROCKS EXPOSED IN CLINTON COUNTY.

GROUP.	SYSTEM.	SERIES.	STAGE.
Cenozoic.	Pleistocene.	Recent.	Alluvial.
		Glacial.	Iowan.
			Illinoian(?)
			Kansan.
			Pre-Kansan(?)
Paleozoic.	Carboniferous.	Upper Carboniferous.	Des Moines.
	Silurian.	Niagara.	Gower.
			Delaware.
	Ordovician.	Trenton.	Maquoketa.

Underlying Formations.

DATA.

The formations enumerated in the above table are all that appear in surface exposures. The Maquoketa shale, which is the lowermost rock, does not come into view in its entire thickness, only its uppermost strata being laid bare in the northeast part of the county. Nevertheless, the thickness of this shale is known from some deep explorations which have been made. These explorations show the nature of the underlying formations to a depth of 1,632 feet below the base of the Niagara limestone.

The Older Clinton Wells.—In the city of Clinton no less than five deep wells have been made. Four of these have been reported on by Prof. W. H. Norton in an earlier publication

of this survey.* His determinations of the formations explored are based on records furnished by drillers and others, and also upon the nature of some samples from the Dewitt Park well and the well put down by the Chicage and Northwestern Railway company. These determinations are given in the table below:

TABLE SHOWING THE THICKNESS (IN FEET) OF THE FORMATIONS EXPLORED IN THE WELLS IN CLINTON, AS DETERMINED BY PROF. W. H. NORTON.

	1	2	3	4
	FIRST CITY WATER-WORKS, WELL	DEWITT PARK WELL.	C. & N. W. R. R. WELL.	PAPER COMPANY WELL.
Niagara limestone	120	90	130	224
Maquoketa shale	180	140–180	295	175
Galena-Trenton limestone	325	410–450	275	Limerock to 1,075 feet.
Saint Peter sandstone	100	40	60	
Oneota limestone	300	Mixed limestone and sandstone, 800 feet.	380	
Jordan sandstone	125			

The samples of drillings taken from two of these wells are described as follows:

1. *Samples from the Dewitt Park well.*

DEPTH, IN FEET.

10–80.....Buff dolomite.
300–350.....Gray and somewhat porous dolomite.
500.....Buff dolomite.
680-720.....Sandstone, pure, white and soft, numerous larger grains about 0.37 mm. in diameter.
790, 830, 900..Dolomite.
960..... .White dolomite, with considerable chert and grains of quartz sand.
1025.....Gray, cherty, dolomite.
1135.....Arenaceous dolomite.

*See Artesian Wells of Iowa, Vol. VI, pp. 241–246.

2. *Samples from the Chicago & Northwestern Railroad Company's well.*

DEPTH, IN FEET.	
400	Hard, gray dolomite.
575	Fossiliferous limestone and reddish shale.
769	White, saccharoidal sandstone, with rounded grains.

Some other descriptive notes are also furnished: The 100 feet of Saint Peter sandstone reported in the first City Waterworks well include some shale as well as sand. In the Dewitt Park well there was some sandstone at the depth of 1,000 feet. and in the Chicago & Northwestern railroad well the 130 feet of Niagara rock is described as consisting of 100 feet of "shelly rock" and 30 feet of "hard rock." Another record of the strata of the first City Waterworks well is given by Mr. D. W. Mead, running thus: drift, 10 feet; Niagara limestone, 290 feet; Hudson River shale, 150 feet; Galena limestone, 275 feet; Trenton limestone, 275 feet; Saint Peter sandstone, 100 feet; Lower Magnesian limestone, 175 feet; Potsdam sandstone, 364 feet.* A second record of the Dewitt Park well given by Superintendent S. M. Highlands is quoted by Professor Norton as follows: Niagara, 150 feet; Maquoketa, 300 feet; Galena-Trenton, 250 feet; Saint Peter, 60 feet.

It is clear that there are some discrepancies in the above records which can not be accounted for except as due to difference in the interpretations on the part of the observers, or else as due to errors in making the measurements. When measurements are made by the drill rods, such errors are not uncommon. In making out the section for the Clinton wells, Professor Norton has, as it seems, taken all such sources of error into consideration and made estimates which find substantial verification from later explorations.

The Latest Waterworks Well.—The latest well for the city waterworks was made in 1902, several years after Norton's report was published. The driller's log describing the rocks penetrated was obtained from the superintendent of the waterworks by the writer. The well was drilled by J. P. Miller & Company of Chicago. This record is given in full on plate VI.

*Notes on the Hydro-Geology of Illinois in Relation to its Water Supply, table XI. D. W Mead.

SECTION OF THE WELL DRILLED IN 1902 FOR THE CLINTON WATER WORKS BY J. P. MILLER. [ELEVATION OF CURB: 588 FT. A T.]

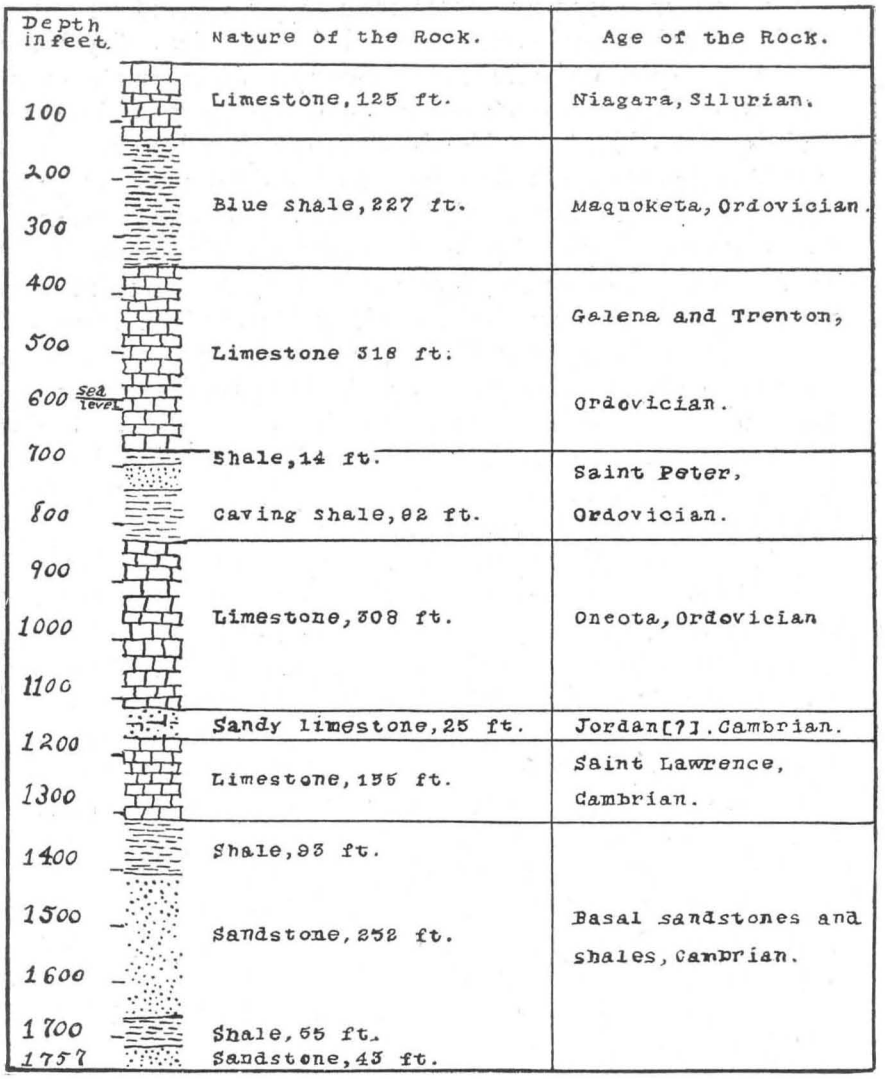


PLATE VI. Log of the latest well drilled for the city waterworks, at Clinton.

It will be noticed that the difference between this record and that of the first city waterworks well is quite unimportant, and mainly consists in that the later drilling furnishes a somewhat more detailed description than the earlier. The elevation of the curb of this well is about five hundred and eighty-eight feet above the sea level.

Wm. Pitch's Well.—Two more wells in this county extend below the base of the Maquoketa shale. One of these belongs to Mr. William Pitch, and is on the southwest $\frac{1}{4}$ of section 1, in Brookfield township. This exploration penetrated the following strata:

1. Yellow clay (drift) ..... 10 feet.
2. Limestone (Niagara) ..... 160 feet.
3. Blue shale (Maquoketa)..... 200 feet.
4. Limestone of gray color (Maquoketa?) ..... 15 feet.
5. Black and soft shale (Maquoketa?) ..... 8 feet.
6. Gray limestone ..... 18 feet.

The Dewitt Well.—The other well is in the city of Dewitt and was made by the Chicago, Milwaukee & Saint Paul Railroad Company. The record of the strata penetrated here is given in the table of well records in the pages following the description of the Geest. (See well No. 42.)

DESCRIPTION OF SECTION.

Believing that differences of interpretation will account for most of the differences shown in the records of the Clinton wells, it must be presumed that such records as most nearly agree with each other are probably nearest to representing the actual conditions. It is, therefore, believed that the close correspondence of the section of the first well with that of the latest made in Clinton, testifies to the correctness of both. The record of the latest well gives a description of the materials penetrated and thus materially increases our basis of known facts upon which the identification of the several members must rest. Making use of the best data at hand, we may describe the different members, which, for convenience, may be taken in order from below upward.

The Basal Sandstones and Shales.—The records of the two wells which have penetrated this lowest formation are not exactly alike. One mentions merely "basal sandstones" while the other gives two sandstones with a combined thickness of two hundred and ninety-five feet. The two are in the latter case separated by fifty-five feet of shale and are overlain by ninety-three feet of the same kind of material, making the total thickness penetrated four hundred and forty-three feet. The same rocks have been explored in the wells in Davenport, and in Rock Island in Illinois. The resemblance of the sections in the three cities is strikingly close. In each instance the upper part of this division consisted of some fine and indurated sediments, which are variously reported as "shale," "indurated sandstone" or "sandy limestone". This is from sixty to ninety feet in thickness. Below this bed there is a water-bearing sandstone, from one hundred and fifty to two hundred and fifty feet in thickness, and this rests again on some fifty-five to seventy-five feet of finer material, sometimes described as a mixture of shale and limestone. Farthest down, in Clinton as well as in Rock Island, is a sandstone explored to depths of from forty to nearly one hundred feet. For a comparison of the three principal explorations in the three cities, the records are placed side by side in the table below. The indicated correlations are necessarily uncertain, but they are suggested by the similarity in the succession. This whole series of sediments is usually referred to the Cambrian age, and they probably belong to the Potsdam series. The following table elucidates this succession:

TABLE SHOWING THE DIVISIONS OF THE BASAL SANDSTONE IN THE CITIES OF CLINTON, DAVENPORT, AND ROCK ISLAND.

Clinton, Waterworks well, 1902.	Davenport, Glucose Factory well.	Rock Island, Mitchell and Lynde's well.
Shale, 93 feet.	Shale, 40 feet. Sandy limestone, 20 feet.	Compact sandstone, 30 feet. Limestone, 35 feet.
Sandstone, 252 feet.	Sandstone, 160 feet.	Sandstone, 130 feet.
Shale, 55 feet.	Shale, 51 feet.	Shaly limestone and shale, 75 feet.
Sandstone, 43 feet.	Not explored.	Sandstone, 97 feet.

Saint Lawrence, Jordan, and Oneota.—Above the basal sandstone and shale, the wells in this region penetrate a magnesian limestone which is five hundred to eight hundred feet in thickness. This rock is somewhat variable in character. It contains an admixture of sand which sometimes increases to the exclusion of other ingredients. Drillers generally report it as limestone, but in places where the sand is copious they sometimes report it as sandstone. In most wells the sand is most abundant near the middle. Keyes has therefore separated these beds into three divisions, which he correlates with the Saint Lawrence, the Jordan, and the Oneota, the two former belonging to the Cambrian series, and the latter being equivalent to what is usually known as the Lower Magnesian limestone of the Ordovician, or Lower Silurian system. The middle (Jordan) sandstone is reported from all the wells that have reached its depth in Clinton, and its thickness, when recorded, varies from twenty-five to one hundred and twenty-five feet. These differences in the reports are probably chiefly due to differences in judgment as to the most suitable terms descriptive of varying mixtures of lime and sand. That the limestone both above and below contains some sand is known from samples of wells in Davenport, although the fact is reported from only the Dewitt Park well in Clinton. The similarity of texture which

characterizes the three divisions sometimes leads drillers to report it under one item as "limestone" or "sandy limestone," and it may yet be questioned whether all three divisions may not be regarded as equivalents of the Lower Magnesian alone. Thirty miles farther south, where this rock measures 800 feet, drillers have found it so uniform in nature that they have described it all under one and the same designation as limestone.

Saint Peter.—This overlies the Oneota limestone, but it is usually separated from the latter by some greenish shale or clay, which in the waterworks well of 1902 is reported as having a thickness of ninety-two feet. Some shale generally also overlies this sandstone and in the above mentioned well this measures fourteen feet. In the other Clinton wells these shales are not reported, but the small development of the sandstone indicates that the shales probably exist, and that they may have been referred to the other formations above and below the sandstone. In Davenport, in Moline, and in Rock Island the shales are present in all wells where detailed records have been made. Probably they have also been penetrated by the deep wells in Clinton. The present writer is inclined to think that they should rather be classified with the Saint Peter, as the thickness of this formation usually varies inversely with the thickness of the shales; and as the combined measure of the three maintains a greater constancy than that of each of the three taken separately, they seem to replace each other.

Galena and Trenton.—These rest on the Saint Peter sediments and consist of dolomitic limestone above with a variable thickness of calcareous limestone below. The latter breaks into thin, flaky fragments under the drill. The measurements in the several wells range from two hundred and fifty to four hundred and fifty feet, owing apparently to differences in the identification of the several observers. The close correspondence between the two most accurate records suggests that these come nearest the facts, one making it 325 and the other 318 feet.

Maquoketa Shale.—The Maquoketa succeeds the Galena upward. Measurements in the different wells range from one hundred and forty to three hundred feet, but some of these measurements are clearly unreliable. In the well in Brook-

field township the drill, after penetrating the body of the shale, went through fifteen feet of limestone and then eight feet of a black shale. In Scott county, and south of the Mississippi, in Illinois, the base of this formation is often very dark and bituminous and this horizon may be the equivalent of the "black shale" under the limestone. It is evident that there may be alternations of shale and limestone between the main bodies of the two formations and this may account for some of the discrepancies in the measurements. The most reliable measurements agreed fairly well, viz: 180, 180, 227 and 223 feet.

Niagara Limestone.—This is the bed rock at Clinton and over almost the entire county. Its upper surface is quite uneven and this may partly account for the extreme differences in the measurements of its thickness in the several wells, which range from ninety to three hundred feet. Three of the wells agree very closely making it 120, 130 and 125 feet respectively at Clinton, and no doubt this is near the correct figure for the altitude of the land where the wells were bored.

In the absence of descriptive records for the most of the wells it seems safest in making a summary estimate of the nature and thickness of the several underlying terranes at Clinton, to average only such as corroborate each other by essential agreement. There is no evidence of faulting, and nothing short of this could account for some of the extreme differences which exist in records.

Summary of the Section.—It seems, then, that in making a deep well in Clinton one should encounter rock materials essentially as indicated below:

		FEET.
13.	Limestone (Niagara)	125
12.	Shale (Maquoketa)	202
11.	Limestone (Galena and Trenton)	321
10.	Shale (age not known)	10
9.	Sand (Saint Peter)	55
8.	Shale (age uncertain)	90
7.	Sandy limestone (Oneota)	304
6.	Sand, with little or no calcareous material (Jordan?)	50
5.	Sandy limestone (Cambrian, Saint Lawrence)	202
4.	Shale (Cambrian)	93
3.	Sandstone (Cambrian)	252
2.	Shale (Cambrian)	55
1.	Sandstone (Cambrian)	43

The Ordovician System.

THE MAQUOKETA SHALES.

Exposures.—The lowest, hence the oldest, rock which comes into view in this county is the Maquoketa shale. It does not cover a very large area, being confined to some places in the valleys of the Mississippi and of the Elk river, in Elk River and Spring Valley townships.

The most southern outcrop is seen in the base of the bluffs of the Mississippi river, just north of the city of Lyons, now included in Clinton. At this place there is seen nearly 100 feet of the yellow Niagara limestone in the cliff of the above mentioned bluff. This rests upon fifteen feet of Maquoketa shale. It is a greenish-gray shale with nodules of iron pyrites and with layers of impure dolomite. The shale is of uniformly fine texture. Under the microscope it was seen to contain occasional crystal-like grains of a bright green color, and also some very minute crystals of pyrites. The particles making up the shale range from .01 to .005 of a millimeter in diameter and fragments measuring as much as 0.1 of a millimeter in diameter are exceedingly rare.

About one-fourth of a mile north of the exposure above described there is another outcrop close to the tracks of the Chicago, Milwaukee & Saint Paul railroad. Here there is a thickness of forty feet exposed. The nature of the material is the same as at the first place, except that the pyrites nodules seem to be more frequent, though of small size. The shale is overlain by about forty feet of yellow limestone.

Another small exposure of the shale, only four feet in thickness, was found along the railroad track near the northeast corner of section 18, in the same township. No fossils were noted in any of these three localities.

In the northwest $\frac{1}{4}$ of section 20 in T. 83 N. and R. 7 E. some more of this shale was seen along the south side of Elk river. There were eight feet of bluish shale resting on two feet of greenish-yellow disintegrated limestone. In the shale were several bands of dolomitic, bluish limestone measuring from

one to three inches in thickness, and in these layers a few joints of crinoid stems were noted, and also numerous clusters of small cubical crystals of pyrites. The rock was quite impure and contained streaks of bluish clay. The limestone which lies under the clay partakes of the same nature, and exhibits some concretionary lumps of pyrites and other material. On its upper surface there occurs a Pleurotomaria, an Orthoceras, and a great number of poorly preserved fragments of brachiopods and bryozoa.

Along the highway in the southwest ¼ of section 13 in Elk River township, some of this shale is seen in a tributary of Elk river which comes in from the southwest. A thickness of only about four feet is exposed. The shale is greenish-gray in color, and in places it is somewhat indurated. There is some pyrite and a great number of dark, nodular grains of small size, ranging from one to three millimeters in diameter. The texture is variable but approximates the same as is found in other places. In this shale many fossils occur, representing forms like the following:

Pleurotomaria, sp.
Rhynchotrema capax.
Strophomena plicata.
Leptæna rhomboidalis.
Rafinesquina alternata.
Plectambonites sericea.
Orthis biforata.
O. biforata laticosta.
O. occidentalis.
Orthoceras, sp.
Chetetes, sp.
Dalmanites, sp.

On top of this shale there rest at this place two feet of a yellow or bluish-yellow, dolomitic limestone, in which were some pockets of crystalline calcite.

Thickness and Geographical Distribution.—The thickness of the Maquoketa can not be made out from these exposures, but from the data already given in the discussion of the wells it is apparent that this must be about two hundred feet. Its extent of outcrop as a bed rock, underlying the mantle rock, can to some extent be inferred from the topography. The steep bluffs on

the west side of the Mississippi bottoms which extend north from Lyons up to the north boundary of the county, indicate that the valley is now cut below the base of the Niagara limestone this entire distance, and that the shales constitute the bed rock under the flood plain north of Lyons on the west side of the river. In the Elk River valley the cutting has also reached the shale, and in all probability shale underlies the drift for three or four miles up this valley, although it has been laid bare at only a few scattered points.

The Silurian System.

THE NIAGARA LIMESTONE.

AREAL EXTENT.

Excepting the small area just described as underlain by the Maquoketa shale, and leaving out a few patches of still smaller extent of Carboniferous rock, the Niagara limestone is everywhere the bed rock in Clinton county. It underlies the drift over ninety-seven per cent of its entire surface, and there is only one township in which no outcrops of this rock have been noted—the township of Berlin. In the bluffs of the Mississippi rock is almost everywhere seen, and north of Clinton it frequently rises one hundred feet above the level of the river. Over the central and western part of the county the drift has not been so extensively eroded, and the bed rock appears mostly only in scattered places along the water courses. In order to present the details of the various exposures throughout the county the outcrops for the several townships may be described separately.

DESCRIPTION BY TOWNSHIPS.

Berlin.—This is the only township in the county where no outcrops of the Niagara limestone were observed. The land is low and drift covered, and although the rock probably lies at no very great depth, the drift has nowhere been entirely cut through by any of the drainage channels as far as is known to the writer.

Bloomfield.—A little to the northeast of the center of section 1 there are several exposures in the bluffs of Sugar creek. The rock is a much weathered and disintegrated, dolomitic limestone, which contains thin layers of gray chert and casts of *Pentamerus oblongus*, *Halysites catenulata* and some individuals of species of Favosites. On the north side of the creek and a short distance away from it, there are some towers of this limestone, with vertical walls, about thirty feet high. These towers are evidently erosion forms which have been buried under the drift, and are now again exposed by the more rapid removal of the latter. The Niagara limestone was also seen near the same creek one mile farther west, and near the Chicago, Milwaukee & Saint Paul railroad, in section 18.

Brookfield.—Over the central part of this township the drift is heavy and the bed rock is concealed, but it appears at the surface in a few places to the north. In the northwest $\frac{1}{4}$ of section 11 and in the southwest $\frac{1}{4}$ of section 12, ledges of weathered rock are seen rising on the slopes of some of the tributaries of Prairie creek. Other places where rock was noted are as follows: In the southwest $\frac{1}{4}$ of section 1, near the northwest corner of the southeast $\frac{1}{4}$ of section 2, in the northeast corner of the southeast $\frac{1}{4}$ of section 17, in the northwest corner of the southeast $\frac{1}{4}$ of section 5, and in the southeast $\frac{1}{4}$ of section 8. At the latter place the rock has been quarried by Mr. E. L. Cook. The face of this quarry is about six feet high with two feet of drift stripping above. The rock is a yellow, porous limestone, unevenly and indistinctly bedded. *Halysites catenulata*, *Pentamerus oblongus*, and fragments of an Orthoceras were noted. In the town of Elwood, rock has been found within thirty-six feet of the surface, but at a place in section 9, on J. W. Whilsell's farm, a well went down 250 feet before rock was reached.

Camanche.—On the lower uplands of this township rock is usually not deeply covered and outcrops are moderately common. In the bluffs bordering the lowlands limestone frequently crops out. Most of the surface rock is a porous, disintegrated limestone with frequent pockets of crystals of dolomite. Ledges which lie deeper down are apt to be more

fine-grained and compact. Some of the outcrops examined may be mentioned. In the west bank of Rock creek, in the southwest corner of the northwest ¼ of section 32, ledges of limestone rise to seven feet. In the northwest ¼ of section 25, at one place close to the Chicago & Northwestern railroad, and also on the farm belonging to J. H. Thiessen, irregularly bedded and mostly soft and porous, dolomitic limestone is exposed, and it has been quarried in the place last mentioned. A rock face ten feet in height shows no marked ledges and the rock, which is porous, has some of its cavities filled with a floury form of dolomite. Near the railroad a specimen of *Favosites niagarensis* was noted.

Centre.—The drift is thick in this township, and the bed rock is mostly covered. It comes up to the surface in the east bluffs of the Goose Lake valley, in sections 3 and 10, and is occasionally seen in the bed of a tributary to Brophys creek, which comes in from the west in section 28. On a farm belonging to Mr. C. Kearney there is a quarry near the northeast corner of the southwest ¼ of section 6. This exposes about nine feet of rock, the upper part of which is disintegrated and "shelly," while the lower part is more fine-grained and compact.

Deep Creek.—Along Simmons creek in the northern part of the township there are a number of small outcrops of limestone, and also in the bluffs of Goose Lake channel further south. In the north bank of Simmons creek, in the northeast ¼ of section 15, the limestone forms two columns, which rise some twelve feet above the ground, and are only eight or ten feet wide. It is probable that these columns antedate the time of the deposition of the glacial drift, and their intact existence at the present time is evidence that the flow of the ice at this point must have been very slow and gentle, being too weak to tear down these towers. It is to be remembered that this part of the county lies near to the driftless area, which reaches down to within a few miles in this direction. Two quarries deserve separate mention. One is in section 28, about one-fourth of a mile north of the town of Goose Lake. This has a face of eighteen feet, which consists of a yellow and porous, magnesian limestone of a shattered appearance, without well-defined

ledges, and with streaks of white and powdery dolomite. The uppermost layer of the quarry, for a thickness of three inches, is literally filled with casts and moulds of fossils which are more or less distorted as from pressure. The most frequent forms were *Pentamerus oblongus* and *Halysites catenulata*. A Favosites, a Zaphrentis and a specimen of *Syringopora verticellata* were also noted. The other quarry is on the north bank of Simmons creek, in the northeast ¼ of section 14, and it shows the same kind of rock, which is honeycombed by small cavities set with small crystals of calcite. *Pentamerus oblongus* occurs in this quarry also; and in addition, *Halysites catenulata*, *Favosites niagarensis* and *Zaphrentis stokesi* were noted.

Dewitt.—In the east part of this township the bed rock is mostly covered. Two exposures were seen in section 12, T. 81 N. and R. 4 E. One of these is just to the north of where the east-west road crosses Cherry creek, and the other outcrop is north of the same road in the west part of the section. In section 12, T. 81 N. and R. 3 E., there are numerous small exposures along the bed of Silver creek. In all of these places the rock is porous and disintegrated, and fossils are scarce. Near the centre of the south half of section 2, to the northwest of the point last mentioned, a small pillar of the limestone rises above the drift. The following section seen on Silver creek, in the southwest ¼ of the southwest ¼ of section 2, T. 81 N. and R. 3 E., is the largest exposure of the Niagara limestone in this township:

		FEET.
7.	Drift	7
6.	Yellow, disintegrated dolomite, with irregular bedding	3½
5.	Fine-grained dolomite of yellow color	1½
4.	Dolomitic limestone in broken laminæ from 1 to 5 inches in thickness	5
3.	Concealed	4
2.	Disintegrated, dolomite rock	4
1.	Yellow, porous limestone forming one single ledge, without distinct bedding planes, and containing specimens of a Zaphrentis, *Halysites catenulata* and *Pentamerus oblongus*	6

In all of the ledges of this section there was evidence of crushing and brecciation, and most of the fossils were in broken fragments. The bedding planes had a dip of 5° to the southwest, evidently an oblique lamination.

Eden.—Most of the land in this township is low, and the bed rock is almost everywhere hidden. Some limestone was noted near the southwest corner of section 6, T. 80 N., near the Wapsipinicon river, also about one-half mile east of Malone, where a small quarry has been opened on the south side of the railroad, and likewise at a point near the railroad about three-fourths of a mile east of Brophys creek.

Elk River.—In sections 5, 8 and 17 in R. 7 E. the uplands terminate in a bluff, sometimes 150 feet high. The face of this bluff consists of the Niagara limestone with the overlying drift. The limestone rises in places as high as one hundred feet. The lower twenty-five feet consist of a dolomitic limestone, in which there are frequent bands of chert, varying in thickness from five to twelve inches. Above this cherty rock is the porous, yellow, often disintegrated dolomite with small cavities frequently lined with calcite crystals. This horizon occasionally contains abundant specimens of *Pentamerus oblongus*, *Halysites catenulata* and Favosites sp.. Along Elk river the rock sometimes rises in towers resembling those seen in Deep Creek and Dewitt townships, and exceeding these in size. On the farm belonging to Wood and Struve, the following section was noted near the southeast corner of the northeast $\frac{1}{4}$ of section 12, R. 6 E.

		FEET.
5.	Fine-grained, yellow, dolomitic limestone, unevenly bedded, with numerous bands of chert from two to eight inches in thickness, and frequently containing nodules of chert from one to three inches in diameter	20
4.	Layer of chert	⅔
3.	Thin bedded, dolomitic limestone, containing nodules of chert	4
2.	Brownish-gray, compact and fine-grained, dolomitic limestone; apparently in one single ledge without marks of stratification	10
1.	Dolomitic limestone, gradually changing in color from yellow above to bluish-gray below. The rock readily breaks up into small, angular blocks. Chert nodules measuring from three to four inches in diameter are found	30

At this place the face of the rock shows the effect of solution by water, which has opened crevices along some of the joints, extending into the rock. One of these was large enough to admit of entrance.

On the south side of the creek, near the centre of the north line of section 11, is another exposure of a single ledge of yellow rock, which measures fifteen feet in thickness. This rests on eight feet of laminated limestone. Near the center of the south ½ of section 18, R. 7 E., is a cherty limestone which contains the usual Halysites and Pentamerus together with a number of undetermined brachiopods. About one mile west from this point, in section 13, R. 6 E., there is a small quarry south of the road, on M. D. Shadduck's farm, which shows three ledges as follows:

		FEET.
3.	Yellow, disintegrated, dolomite limestone, with bands of chert.....	10
2.	Five layers, each a little more than one foot in thickness, and separated one from the other by thin bands of chert.....	7
1.	Fine-grained limestone, separated into thin layers and containing some chert nodules.....	15

Hampshire.—In this township a single exposure of limestone was noted on Mill creek in section 34, at a place where a branch comes in from the northwest. The rock was yellow and porous.

Liberty.—The only outcrops of bed rock in this township are in its west half, and near the Wapsipinicon river. The usual phase of the yellow limestone appears in the west bank of the river in section 17. A small quarry has been worked near the highway close to the southeast corner of the southwest ¼ of section 18, and some rock also appears near the southwest corner of section 29.

Lincoln.—In this township more quarries have been worked than in any other in the county. This, in the first place, is due to the local demand for building stone in Clinton. In the second place rock is plentiful in the bluffs of the Mississippi, and many exposures are also found along the creeks farther to the west. The stream beds are sometimes cut in ledges of the Niagara dolomite.

Near the Agatha hospital, in the city of Clinton, there is a quarry with a face about sixteen feet in height and about four feet of drift above. The uppermost three feet consist of a yellow, soft rock, which contains occasional heads and stem segments of crinoids, together with numerous moulds and casts of brachiopod shells. Below this there is more compact stone with small cavities containing crystals of dolomite. This is six feet thick and contains the usual fossils, such as *Zaphrentis*

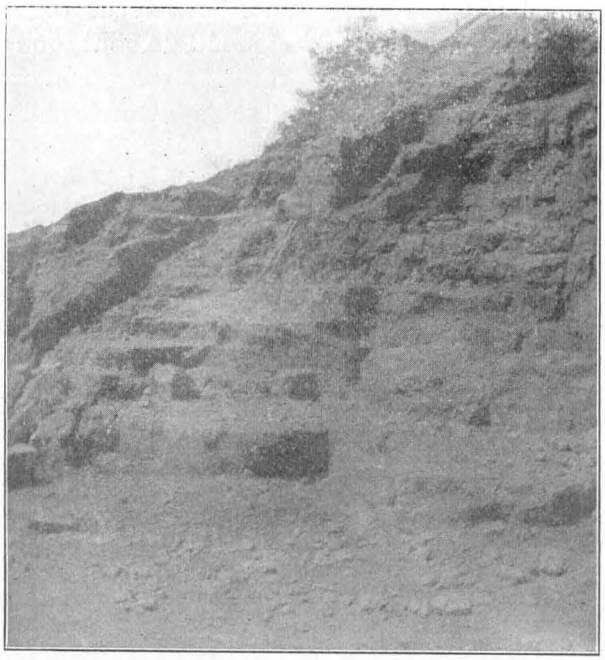


FIG. 31. View showing Niagara limestone in Mr. Peter Gypsum's quarry. Clinton, Iowa.

stokesi, *Halysites catenulata* and *Pentamerus oblongus*. The lower seven feet consist of more evenly bedded and compact, fine-grained ledges of a yellow or sometimes brown color. Several ancient caverns have been exposed by the excavation, one of which was four feet wide and at least five feet deep. All of these caverns are filled with shale of a later age. Ledges having the same appearance, and containing the same fossils as in the above quarry, appear at the foot of the bluff near Fourth

Avenue along the "bluff road", and also in Peter Gypsum's quarry farther to the northeast (Fig. 31). In both of the last two places specimens of an Orthoceras were noted. In D. T. Baldwin's quarry, which lies opposite the Springdale cemetery, the following section is exposed:

		FEET.
4.	Drift	4
3.	Geest	2
2.	Dolomitic limestone, porous and unevenly bedded	6
1.	Yellow and brownish dolomitic limestone, with compact texture and even bedding, containing a fossil resembling *Dawsonoceras annulatus* var. *americana*, an Orthoceras, a crinoid head and joints of crinoid stems, a Heliolites, *Pentamerus oblongus*, and *Halysites catenulata*	5

Olive.—A single small exposure of limestone was noted along Calamus creek; this was in the southeast ¼ of section 2. In the south part of the township rock occurs near the bluffs of the Wapsipinicon river, and has been encountered near the surface in some wells which have been made there.

Orange.—Rock appears in the bed of Barber creek in the southeast ¼ of section 19. The exposure is small, and the ledges are yellow and disintegrated.

Sharon.—This township is covered with a thick deposit of drift, and exposures of the bed rock are not numerous. Nevertheless, a considerable thickness of beds is exposed. An old quarry in the northeast corner of section 18 shows some heavy ledges of the common, yellow dolomite which dip about 7° to the west. Some brownish ledges of the same rock appear along the ravines near the west line of section 18. Rock has been quarried on Henry Kiel's farm, one-half mile northeast of Lost Nation. The ledges are porous, rather unevenly bedded, and contain some chert. Several fossils were noted, such as *Halysites catenulata*, *Pentamerus oblongus*, *Caryocrinus ornatus*, Bumastus sp., and an Orthoceras. The face exposed is only five feet high.

Another quarry from which much rock has been taken is located one-fourth of a mile east of the center of section 15. The rock exposed is as follows:

		FEET.
10.	Drift	5
9.	Geest	4
8.	Fine-grained and laminated rock, breaking along the horizontal seams into slabs from one to three inches in thickness	4
7.	More coarse-grained and porous, evenly bedded, yellow dolomitic rock, without well marked lamination	3
6.	Fine-grained dolomitic limestone, in places with very distinct crystalline texture, and weathering into slabs about four inches in thickness	3
5.	Yellow rock with occasional pockets set with crystals of calcite	4
4.	A single layer of fine-grained, dolomitic rock	3
3.	Brownish, dolomitic limestone of compact texture, breaking much in quarrying, and having occasional crystals of calcite	3
2.	Laminated, fine-grained and compact, dolomitic limestone, breaking into layers one inch in thickness, occasionally bearing chert	1
1.	Solid and compact ledge of gray, dolomitic limestone, with some empty crevices lined with a thin coating of crystals of calcite	2

It is possible that the rock in this section belongs to an outlier of what has been called the Anamosa phase of the Niagara. It is apparently destitute of fossils, and in this respect as well as in its even bedding it differs markedly from the rock in other outcrops in this county.

Spring Rock.—A porous and dolomitic, gray or yellow limestone underlies most of this township and comes into view in several places over the uplands. In the bluffs of Rock Run and east of Big Rock, limestone cliffs measuring ten feet or more in height are not infrequent. Nearly all of the deep wells enter this rock, which is porous and yields water. The elevation of the surface often varies quite considerable in wells that are near together.

Spring Valley.—The Niagara limestone is exposed almost everywhere in the bluffs of the Mississippi river, throughout the entire length of the township from north to south. In the main the same ledges are to be seen, and these belong in the lower part of the formation. The best section is seen where the front of the bluff lies close to the railway grade near the river in the northeast corner of section 30. At this point the following succession of layers was observed.

		FEET.
6.	Drift	5
5.	Geest	3
4.	Porous and yellow, dolomitic limestone, irregularly bedded, full of small crevices lined with calcareous incrustations. This is known as "shell rock" among the quarrymen. In these ledges *Halysites catenulata* and *Pentamerus oblongus* were found.	40
3.	Finely granular, yellow, dolomitic limestone with numerous small cavities, often lined with a coating of crystalline calcite. Bands of chert occur at intervals of from two to four feet. Seven of these were each about five inches in thickness	30
2.	Buff-brown, dolomitic limestone of fine-grained texture, with many bands of chert, also scattered nodules of chert. The chert is most abundant below. Some of the chert bands have a thickness of one foot. These thicker bands occur above and the thinner lie below. Thirteen bands in all were counted. The lowermost, of which some were no more than an inch in thickness, lie close together	25
1.	Blue shale (Maquoketa)	15

Washington.—The bed rock is mostly concealed in this region, and there are no extensive outcrops. At two points the usual kind of limestone was noted. One of these was in the northeast $\frac{1}{4}$ of section 19, near John Tray's place, where the rock comes to the surface on a hillside in the wagon road; and the other was on Cherry creek near the center of section 36.

Waterford.—In the north part of this township, along Sugar creek and its tributaries, there are several exposures of the usual dolomitic limestone, and there are also some outcrops along the minor streams on the uplands. The rock is mostly free from chert, and resembles that commonly found in Lincoln township. Some appears in the railroad cuts near Riggs post office. In the south part of the township the drift is heavier and the bed rock is more generally concealed. There is a small quarry one-half mile east of Quigley post office in section 30, and another near Charlotte. At the latter place about twenty feet of rock are seen. The upper five feet is a coarse-grained, yellow rock, and the lower fifteen feet consists of an almost brown, porous and disintegrated limestone carrying *Pentamerus oblongus*, *Halysites catenulata*, *Syringopora verticellata*, a Favosites, and a Zaphrentis.

Welton.—Most of the exposures in this township are to be seen along Silver creek. In the southeast ¼ of section 26, the drift is very thin and the bed rock occasionally crops out at the surface of the low uplands. Near the center of section 22, a bank of soft and porous limestone, about ten feet high, is exposed in the base of the east bluffs of Silver creek. The rock exhibits no bedding planes, and it has the appearance of having been somewhat crushed and disturbed. Fossils are numerous but many are distorted into almost unrecognizable shapes The following fossils, or forms like them, were noted:

Atrypa reticularis (?) Lin.
Spirifer niagarensis Conrad.
Platystoma niagarensis Hall.
Orthis hybrida (?) Sowerby.
Rhynchotreta cuneata americana Hall.
Streptelasma patula Rominger.
Favosites niagarensis Hall.
Siphonocrinus armosus McChesney.
Saccocrinus christyi Hall.
Ichthyocrinus laevis Conrad.
Orthoceras, sp.
Zaphrentis. sp.

DIVISIONS OF THE NIAGARA.

The limestone of the Niagara series has been separated into several subdivisions by different authors. The stages recognized by the present survey are, taken in ascending order, the Delaware, the Gower and the Bertram. Of these the Delaware, and probably the Gower, are represented in exposures in this county. The Delaware is by far the most common.

Prof. A. G. Wilson* has separated the Niagara into five subdivisions, as follows:

(1) *The basal member*, directly overlying the Maquoketa shale. This ranges in thickness from thirty to fifty feet and contains the "Lower Quarry Beds" of the Delaware and Dubuque county reports. (2) *The lower coralline beds*, with a thickness of from twenty to twenty-five feet, the "*Syringopora tenella* beds" of Calvin. (3) *The Pentamerus beds*, from seventy to eighty feet in thickness. (4) *The upper coralline beds*, some

* Am. Geol., Nov., 1895, p. 275.

fifty feet in thickness. (5) *The Niagara building stones*, also about fifty feet in thickness. In his report of Jones county, Calvin correlates the four lower divisions of Wilson with the Delaware.* In the report on Dubuque county, Iowa Geological Survey, Vol. X, Calvin and Bain give the results of later studies of the rocks of the Delaware stage.

From the present study of the outcrops in Clinton county it does not seem practicable to apply Professor Wilson's classification to this region, except as to the basal member. The lower fifty feet or more of the Niagara is here characterized by the occurrence of gray chert and by a comparative scarcity of fossils. The rock belonging to this horizon is exposed best in the bluffs of the Mississippi river north from Clinton, and all the way up to Jackson county. It is also seen at some scattered places westward. But the succession of the two coralline beds and the intervening Pentamerus beds could not be made out. In fact it appears likely that these phases of the Niagara may here replace each other horizontally. Most of the exposures, especially in the western, the central and the southern townships, belong in the upper part of the Delaware stage. There are also some ledges which partake of the appearance of the LeClaire limestone, sometimes exhibiting slightly oblique bedding. In a quarry in section 15, Sharon township, a rock is worked that in every way resembles the Anamosa limestone. As it lies in a line with the Anamosa outcrops observed by Calvin in Jones county, it is perhaps the eastermost instance of this phase of the Niagara known in the state. As no ledges of the typical LeClaire limestone are known in the county surrounding this quarry, we may suppose that the LeClaire horizon loses its characteristic features as we follow it northwestward and becomes indistinguishable from the coralline and the Pentamerus horizon. The highly pitched, oblique bedding noted in Scott county is not known anywhere in Clinton county. But the coralline beds and the Pentamerus ledges are sometimes tilted, the highest inclination seen being about twelve degrees from the horizontal.

* Iowa Geological Survey, Vol. V p. 49.

THICKNESS OF THE NIAGARA.

The surface of the bed rock apparently keeps pace with the dip of the terranes to the south, and the general thickness of the Niagara at the north boundary of the county probably does not fall much short of that along the Wapsipinicon river to the south. In an east and west direction there is a greater difference. In Elk River township the Mississippi river bluffs show nearly one hundred and fifty feet of rock, and at Clinton the limestone extends 120 feet below the bottom land. At DeWitt a well made for the Chicago & Northwestern railroad went into the Maquoketa shale after penetrating 220 feet of limestone. On section 1, in Brookfield township, the Maquoketa shale was entered 160 feet below the upper surface of the overlying limestone. Apparently the greatest thickness of the Niagara formation is in Sharon and Spring Rock townships, and it may here average nearly three hundred feet. The formation gradually thins to about one-half that measure when followed to the east near the Mississippi, as already shown.

The Carboniferous System.

THE DES MOINES STAGE.

After the deposition of the Niagara limestone and of some later sediments of the Devonian age, which latter in all probability once covered the upper Silurian in this region, the bottom of the sea was elevated and became land, which was for some considerable time subjected to general erosion. The elevation was greatest to the north, and it left the terranes with a slight dip to the south. Near the middle of the Carboniferous period this land was again submerged and covered by a new series of sediments. This submergence was greatest to the south, but it is quite clear that it extended north beyond the limits of this county, for Carboniferous sediments are known even in Jackson county. However, nearly all of the Carboniferous deposits have been carried away by later erosion, and there remain only a few outliers of the very base of the rocks of this age, and occasional pockets of clay and sand that fill caverns in the

Niagara limestone. In his paper on the Pleistocene History of Northeastern Iowa, McGee* has mapped a small outlier of the Coal Measures on sections 7 and 18 in Sharon township. The present writer was unable to locate any such outcrop near that point, but several blocks of Coal Measure sandstone were found close together in the base of the drift, near a ravine about one mile farther to the east. There is no doubt an outlier of this rock lies hidden somewhere on these two sections. The sandstone was rather fine-grained.

Near the center of section 2, in Bloomfield township, there appear on the west side of the wagon road running north and south, and in the base of the south bluff of Sugar creek, a thin ledge of white sandstone and some shale. The sandstone is dark and ferruginous in some places. Some blocks of the same sandstone were noted in the east side of the road, close to an outcrop of a highly ferruginous dolomite of the Niagara series. The sandstone on the west side of the road lies some ten feet lower down than this limestone, and this is evidently due to the unconformity between the two formations.

About one-third of a mile east of the northwest corner of section 1 in the same township, the east and west wagon road crosses a small ravine in the east bank of which a sandstone is exposed which measures at least fifteen feet in thickness. This sandstone is rather coarse in texture, of a faintly yellowish-white color, and exhibits some oblique bedding in straight ledges which are mostly about one foot in thickness. A few acres of land appear to be underlain by this rock, and it extends across the line into Jackson county to the north; it evidently belongs to the Coal Measures.

In his paper on the "Carboniferous Deposits of Eastern Iowa," Keyes† makes mention of a small outcrop of Carboniferous rock "on a small branch of Deep creek, in the north-central part of the county, near Charlotte." This locality was not found by the present writer, but no doubt exists as to its presence. Fragments of Coal Measure sandstone are frequently seen in the drift in the north tier of townships west of the Goose Lake channel.

* 11th Annual Report U. S. Geol. Surv., Part 1, p. 305.
† Iowa Geol. Surv., Vol. II, p. 469.

One undoubted outlier of the Carboniferous was explored in a well on section 33 in Welton township. This well was made by Mr. J. J. Dickman, at a point about one-third of a mile south of the northwest corner of the section. The materials penetrated were as follows:

		FEET.
6.	Yellow clay	30
5.	Blue clay	20
4.	Quicksand	20
3.	Slate, with seams of coal in the lower part	17
2.	White sand	12
1.	Yellow limestone	4

Number 1 was without doubt the Niagara limestone. Number 2 appears to have been a disintegrated, soft sandstone of the Coal Measures, which changed upward into a shale that contained thin seams of bituminous coal.

As deposits of the Carboniferous age we must also classify certain clays, silts, and sands which have been noted in caverns in the Niagara limestone, especially in the quarries at Clinton. Some of these have already been noted in the descriptions of these quarries, and other instances have been reported and described by Dr. J. P. Farnsworth * and James Hall.† The latter, who was quite familiar with the geology of this entire region, referred these clays to the Carboniferous, and this view is unhesitatingly concurred in by the present writer. Pockets of this kind are frequent in the older limestones in Scott and Muscatine counties. They quite often contain imprints of leaves of Carboniferous ferns, and the clay is often mixed with carbonaceous material such as has been noted in the clays at Clinton.

From the nature of the scattered remnants of the deposits of the Carboniferous age in this region it appears that the geographic conditions were quite uniform. The deposits are such as would result from sedimentation along a low coast. There are no conglomerates, but mainly shales of the finest texture, and sandstones. There can be no doubt, as already stated, that the Coal Measures once covered the entire county,

* American Geologist, Vol. II, pp. 331-334, Fire Clay Pockets at Clinton.
†Geological Survey of Iowa, Vol. I, part I, pp. 130-131, 1858.

and extended a considerable distance beyond its northern boundary. All of the outcrops belong to the Des Moines stage.

EROSION INTERVAL—THE GEEST.

After the Carboniferous had been deposited, the sea once more receded, and the land was slowly raised and tilted again a little more to the south. During the greater portion of the Mesozoic era and the Tertiary period which followed, this land was subjected to erosion which no doubt resulted in the removal of several hundred feet of rocks, of the previous age, and which left the surface of the bed rock essentially in the condition in which we now find it under the drift, although the occurrence of the Cretaceous deposits farther to the west and to the north indicate the very remote possibility of a temporary submergence in Cretaceous times. The topography of this old land probably had quite as high relief as does the present land surface. The altitudes reached by the bed rock are known to range from four hundred and fifty to seven hundred and seventy feet above sea level, giving a relief of about three hundred feet. But it is clear that this does not represent the extreme relief of the buried land surface. The general slope of this old surface was like that of the present land; from the northwest to the southeast, descending from an average elevation of some seven hundred feet, in Sharon and Brookfield townships, to about five hundred and seventy-five feet in Eden and Camanche townships. The old land surface must have been quite broken and rough, for the elevations at which the bed rock is encountered in wells frequently varies greatly in short distances.

The superficial residual deposits from this erosion interval—called "geest" by McGee—has not always been removed but may sometimes be seen under the drift, resting on the bed rock. The old geest mantle, which resulted from weathering and decay of the Carboniferous and Silurian sediments, is usually a tough, highly ferruginous and red clay, in which pebbles of quartz and chert are imbedded, and also small nodules of oxide of iron. The greatest thickness seen in this county does not exceed four feet. While it is chiefly a residual product, resulting

from the decay of the local rocks, it may be mixed more or less with materials washed from higher slopes by the ancient drainage. The principal localities where it has been noted are given below: Henry Kiel's quarry on the southeast ¼ of section 26 in Sharon township; Anthony Ale's quarry in the southeast ¼ of the northeast ¼ of section 15 in Sharon township; on a slope near the northeast corner of section 30 in Spring Valley township; and in Peter Gypsum's quarry in the city of Clinton. No doubt the geest is exposed also in many other localities in the north part of the county. In many of the deeper wells which have been made, a "red clay" has been reported a few feet thick, directly overlying the limestone. This no doubt also is the "geest." In other wells gravel and sand replace the clay and probably represent deposits contemporaneous with the "red clay." A number of records of the materials explored in such wells are given in the table below. This table likewise contains data on the elevation of the surface of the bed rock in the different townships, and on the nature of the drift deposits:

TABLE OF WELL RECORDS.

Berlin Township.

Number.	LOCATION.	SITUATION.	Elevation of curb (estimated).	Depth.	MATERIALS EXPLORED.	Elevation of bed rock.
1	Pat Connors. S. ½ Sec. 7.	High upland.	780	172	Sandy soil 30, blue clay 20, sand 120, limestone 2.	610
2	Bowman Bros. Sec 27.	Upland.	720	122	Loess 2, quicksand 100, limestone 10.	618
3	Daugherty Estate. Sec. 4.	High upland.	820	175	Yellow clay 30, blue clay 50, limestone 95.	740
4	Wm. Rock. N. E. ¼ Sec. 23.	Upland.	720	130	Yellow clay 25, blue clay 60, limestone 45.	635
5	Wm. Betts. S. E. ¼ Sec. 28	Upland.	720	70	Sandy soil 30, limestone 40.	650
6	Mary Hassett. S. W. ¼ Sec. 2.	High upland.	760	129	Yellow clay 30, blue clay 95, gravel 4.	631
7	A. Gallaway. Sec. 3.	High upland.	840	326	Black soil 3, yellow clay 30, blue clay 288, red clay 3, limestone 2.	516

Berlin Township—Continued.

Number.	LOCATION.	SITUATION.	Elevation of curb (estimated)	Depth.	MATERIALS EXPLORED.	Elevation of bed rock.
8	John Foedt. Sec. 24.	Upland.	740	86	Black soil 2, yellow clay 20, blue clay 60, sand 2, limestone 2.	656
9	Peter Peterson. Sec. 13, S. E. ¼.	High upland.	780	210	Black soil 3, yellow clay with sand 40, blue clay 30, quicksand 15, blue clay 110, limestone 5.	575
10	Kohler Bros. Sec. 36, center S. ½.	High upland.	760	180	Black soil 2, sandy, yellow clay 30, blue clay 40, sand 10, blue clay 96, gravel 2.	580
11	J. M. Wolfe. Sec. 36, S. E. cor.	Upland.	740	85	Black soil 3, yellow clay 10, sand 2, blue clay 30, limestone 40.	691
12	J. B. Wolfe. Sec. 6, N. W. cor.	High upland.	760	169	Black soil 4, black gumbo 40, blue clay 100, sand 10, limestone 15.	606
13	H. Schocker. Sec. 8, S. E. cor. S. ½.	High upland.	300	117	Black soil 2, hard pan with coarse gravel 20, blue clay 83, limestone 15.	688
14	P. Twogood. Sec. 26, N. E. ¼, S. E. cor.	Upland.	740	100	Black soil 2, yellow clay 30, blue clay 67, limestone 1.	641
15	M. J. Pinter. Sec. 12, S. E. cor. S ½.	High upland.	840	252	Black soil 2, yellow clay 30, blue clay 190, limestone 20.	608

Bloomfield Township.

16	Jerry Dennis. Sec. 31, S. ½ of N. W. ¼	Upland.	740	170	Black soil 2, yellow clay 40, blue clay 30, limestone 98.	668
17	E. A. Fitch. Sec. 32, N. W. ¼.	Upland.	745	175	Alluvium 2, yellow clay 25, quicksand 144, limestone 4.	574
18	Marvin Fenton. Sec. 19.	Bluffs.	800	150	Yellow clay 30, blue clay 90, limestone 20.	670
19	Alex Narrin. Sec. 29.	High bluff.	840	172	Black soil 2, yellow clay 30, blue clay 90, limestone 50.	713

Brookfield Township.

Number.	LOCATION.	SITUATION.	Elevation of curb (estimated).	Depth.	MATERIALS EXPLORED.	Elevation of bed rock.
20	Doctor McKinze. Elwood.	Upland.	736	72	Alluvium 6, yellow joint clay 20, gravel and sand 8, hard, black clay 15, blue quicksand, very fine 15, black hardpan, 4 gravel 3, limestone 2.	666
21	George Tesky. Elwood.	Upland.	736	77	Alluvium 7, blue clay 25, black hardpan 20, sandy coarse gravel 1-20, limestone 5.	664
22	W. Webster. Elwood.	Upland.	736	87	Alluvium 5, yellow clay 20, blue clay 25, black clay 20, gravel 10, limestone 7.	656
23	Geo. Benton. Elwood.	Upland.	736	72	Alluvium 2, yellow clay 10, blue clay 20, limestone 40.	704
24	H. G. Scott. Sec. 25, S. E. cor. S. E. ¼.	Upland.	740	110	Alluvium 2, yellow clay 15-20, blue clay 30, limestone 58.	688
25	M. P. Kroozgaard. Sec. 36, N. E. cor. N. E. ¼.	Upland.	740	70	Alluvium 2, yellow clay 27, red clay 3, limestone 38.	708
26	H. P. Christenson. Sec. 30. S. E. cor. S. E. ¼.	High upland.	820	450	Alluvium 2, yellow clay 30, blue clay 400, then a bowlder of iron pyrites 7, blue clay 11.	
27	John Wirths. Sec. 29, S. W. ¼.	Upland.	820	613	First 100 feet unknown, blue clay 100, sand 60, blue clay 300, gravel and blue clay 50, limestone 3.	210
28	Hans Christenson. Sec. 30, S. E. ¼.	Upland.	820	501	Black soil 4, yellow clay 35, blue clay 136, river sand 25, blue clay 100, soapstone 100, blue shale 101.	
29	Wm. Pitch. Sec. 1, S. W. ¼.	Bluff.	780	412	Yellow clay 10, limestone 160, blue shale 200, gray limestone 15, black soft shale 8, gray limestone to bottom 18.	770
30	J. Toskey. Sec. 28, N. ½ of N, E. ¼.	Base of bluff.	800	329	Black soil 2, yellow clay containing bowlders 35, blue clay 100, quicksand 115, blue clay 75, coarse gravel 2.	471
31	C. Ketelsen. Sec. 34.	Bluff.	840	150	Black soil 2, yellow clay 35, blue clay 100, limestone 13.	703
32	J. W. Whitsell. Sec. 9.	Upland.	740	277	Black soil 2, yellow clay 40, blue clay 215, limestone 20.	483

Brookfield Township—Continued.

Number.	LOCATION.	SITUATION.	Elevation of curb (estimated).	Depth.	MATERIALS EXPLORED.	Elevation of bed rock.
33	J. A. Anderson. Sec. 14, S. W. ¼.	High upland	820	315	Black soil 3, yellow clay 30, blue clay 190, quicksand 72, limestone 20.	525
34	H. C. Atzen. Sec. 36.	High upland	820	183	Black soil 3, yellow clay 40, blue clay 100, limestone 40.	677
35	J. D. Limbaugh. Sec. 32.	High upland	820	212	Black soil 2, yellow clay 45, blue clay 161, limestone 10.	618

Center Township.

36	Elvira City Well.	Upland.	710	118	Alluvium 5, yellow clay with sandy streaks 50, sandy blue clay 60, sand 3.	
37	Tom McQuire. Sec. 31, S. E. cor. S. W. ¼.	Upland.	715	103	Alluvium 4, yellow clay 20, sand 50, yellow limestone 8, red gravelly sand 20.	
38	Tom McQuire. Sec. 31, S. E. cor. S. W. ¼.	Upland.	715	110	Alluvium 4, yellow clay 30, blue clay 25, rock 10, red gravelly sand 6.	

DeWitt Township.

39	H. E. Vickery. Sec. 36, S. W. ¼ of N. E. ¼.	Upland.	720	47	Sandy soil 7, yellow limestone 40.	713
40	W. E. McKinney & Co. Sec. 12, N. E. cor. of N. E. ¼.	Upland.	720	60	Yellow clay 12, sand 20, limestone 5, blue clay with sand 23.	
41	Alex. Works. Sec. 19, N.E.¼ S. W.¼	Bottom land.	660	26	Alluvium 3, gravel 23.	
42	DeWitt, C. & N. W. R. R. Depot.	Low upland	687	267	Soil and sand 40, limestone 220, shale 7.	647

Eden Township.

43	C. Van Epps. Sec. 3, N. W. ¼.	Terrace.	640	172	Sand 40, blue clay 130, gravel 2.	
44	E. B. Wilkes. Tolletts P. O.	Terrace.	620	51	Black clay 2, sandy soil 35, yellow limestone 14.	583

Liberty Township.

Number.	LOCATION.	SITUATION.	Elevation of curb (estimated).	Depth.	MATERIALS EXPLORED.	Elevation of bed rock.
45	M. Yale Sec. 21, N. E. cor. N. E. ¼.	... .	.....	...	Alluvium 5, yellow clay 23, yellow limestone 30, fine-grained limestone 20, flinty limestone 20, soft, yellow limestone 12.	
46	P. J. Quade. Sec. 13, S. ½ N. W. ¼.	Upland.	740	60	Alluvium 4, blue clay 30, black hardpan 15, blue clay 4, a large bowlder of lead under which was blue clay 3.	680
47	M. Yale. Sec. 17, S. E. ¼.	Upland.	700	107	Sand 40, limestone 67.	640
48	Ed. Hart. Sec. 34, N. E. ¼.	Upland.	700	48	Sand 3, limestone 45.	697
49	E. Kloidt. Sec. 4.	Upland.	720	100	Black soil 2, yellow clay 30, sand and yellow clay 63, limestone 5.	625
50	J. Figley. Sec. 5.	Upland.	700	100	Sand 70, limestone 30.	630
51	Peter Kulp. Sec. 6.	Upland.	740	80	Black soil 2, yellow clay 35, blue clay 30, limestone 13.	673
52	T. Horstman. Sec. 27.	Wapsipinicon river.	700	175	Black soil 2, yellow clay 35, blue clay 118, limestone 20.	545
53	J. E. Wolfe. Sec. 14, S. E. ¼.	Wapsipinicon river.	700	140	Sand 110, limestone 30.	590
54	Creamery. Sec. 14, S. E. ¼.	Upland.	720	140	Sand 120, limestone 20,	600

Olive Township.

55	A. Tumpani. Sec. 11, S. E. ¼, S. ½.	Upland.	700	55	Sandy soil 3, yellow clay 45, soft, porous limestone 7.	652
56	O. F. Ludwigson. Sec. 20.	Upland.	700	230	Sandy soil 100, blue clay 20, sand 108, limestone 2	472
57	N. O. Olson. Sec. 20.	Upland.	700	175	Limestone at 175.	525
58	Bruce Walker. Calamus.	Upland.	700	137	Black soil 2, yellow clay 20, blue clay 98, limestone 17.	600
59	C. Reming. Sec. 3.	Upland.	720	117	Black soil 2, sand 100, limestone 15.	618

Orange Township.

Number.	LOCATION.	SITUATION.	Elevation of curb (estimated.)	Depth.	MATERIALS EXPLORED.	Elevation of bed rock.
60	Grand Mound. City Waterworks.	Upland.	700	88	Alluvium 1, gravel 40, limestone 47.	659
61	C. Munts. Sec. 19.	Upland.	680	60	Sand 60.	
62	P Peterson. Grand Mound.	Upland.	700	67	Sand 45, red clay 2, gravel 20.	

Sharon Township.

63	C., M. & St. P. R. R. Station. Lost Nation.	Upland.	744	95	Alluvium 7, yellow joint clay 40, yellow limestone becoming harder and lighter in color at bottom, also flinty at bottom 48.	697
64	P. Ahrens. Sec. 10, E. ½ of N. E. ¼.	Upland.	800	183	Alluvium 2-3, yellow clay 30, blue clay 50, limestone 100.	717
65	Chas. W. Comstock. Lost Nation.	Upland.	750	73	Alluvium 2, yellow clay 10, blue clay 20, red clay 2, limestone 40.	726
66	H Dickman, Sec. 9, S. E. cor. S. E. ¼.	Upland.	800	130	Alluvium 2, yellow clay 30, blue clay 100, limestone 8.	768
67	Mrs. H. Lockmer. Sec. 17.	High bluff.	840	210	Black soil 2, yellow clay 20, blue clay 78, limestone 100, about 50 feet down in this limestone a pocket containing blue muck was encountered 2-3.	730
68	Henry Dickman. Lost Nation.	Upland.	740	89	Black soil 2, yellow clay 30, blue clay 36, limestone 20.	670
69	W. Jaronsen. Lost Nation.	Upland.	740	135	Black soil 3, yellow clay 30, blue clay 97, limestone 5.	610
70	J. G. Gardner. Sec. 34, N. E. ¼ N. E ¼.	Creek bottom.	700	137	Black soil 4, yellow clay 4, very fine sand 125, coarse gravel 3.	
71	Jerry Mulverhill. Sec 6, S. E. ¼.	High bluff.	840	140	Black soil 2, yellow clay 35, blue clay 36, limestone 68.	768
72	Wm. Tinnefeld. Sec. 15, S. ½ N. W. ¼.	Upland.	780	137	Black soil 2, yellow clay 30, blue clay 35, limestone 55, chert (hard, white marble) 15.	713
73	Mrs. P. Pitch, Sec. 31, S. W. cor. S. W. ¼.	Upland.	740	140	Sand, fine red 80, limestone 60.	660
74	Wm. Kuehen. Sec. 1, N. W. ¼.	High bluff.	900	140	Yellow clay 40, yellow sand 100, gravel at bottom.	

Spring Rock Township.

Number.	LOCATION.	SITUATION,	Elevation of curb (estimated).	Depth.	MATERIALS EXPLORED.	Elevation of bed rock.
75	Fred Benk's brickyard, Wheatland.	Upland.	700	87	Alluvium 3, yellow clay 16, blue clay, some places white 48.	
76	Wheatland City Waterworks.	Upland.	700	171	Alluvium 5, yellow clay 43, blue clay 39, limestone 4, yellow hardpan and limestone alternating 50, white, flinty limestone 30.	613
77	Louis Homrighausen. Sec. 28, S. E ¼ of N. E. ¼.	Bluffs.	800	287	Alluvium 80, quicksand 20, blue clay 85, limestone 60.	615
78	Knudt Jergenson. Sec. 25, N. E. cor. N. E. ½.	Wapsipinicon bottom		245	River sand 60, blue clay 80, black, hard clay 40, blue shale 40, limestone 9.	2
79	City school well. Wheatland.	Upland.	700	177	Alluvial soil 7, yellow clay 44, blue clay 40, limestone alternating with yellow hardpan 60, limestone 26.	549
80	M. Pingel. Sec. 4, S. W. ¼.	High bluff.	800	130	Black soil 1, sand 120, hardpan 2.	
81	D. Pingel. Sec. 4, S. W. ¼ of N. ½.	?		237	Limestone at bottom.	
82	M. Hoffman. Sec. 3, N. E. ¼ in S. W. cor.	?		55	Limestone at 55.	
83	Geo. Buchsel. Sec. 10, N. ½ N. W. ¼.			112	Limestone 22.	
84	G. H. Leffingwell. Sec. 15, S. E. ¼.	?		237	Limestone at bottom.	
85	J. Wohlinberg. Sec. 3, N. W. ¼ in S. E. cor.	?		90	Limestone 20.	

Waterford Township

86	M. Omara. Sec. 18.	Bluff.	840	140	Soil 20, limestone 120.	820
87	W. Ward. Sec. 7.	High bluff.	880	120	Soil 20, limestone 100.	860

Waterford Township—Continued.

Number.	LOCATION.	SITUATION.	Elevation of curb (estimated).	Depth.	MATERIALS EXPLORED.	Elevation of bed rock.
88	J. Reife. Sec. 8.	Bluff.	780	190	Yellow clay, limestone 40, blue, mucky shale 40, limestone 80.	750
89	Anton Tur. Sec. 8.	Bluff.	800	160	Yellow clay 6, limestone 154, about 17 feet down in the limestone a a large cavern was encountered.	794
			Welton Township.			
90	L. A. Loofboro. Sec. 17, S. E. ¼, S. E. ¼.	Upland.	700	180	Yellow clay 30, blue clay 50, limestone 100.	620
91	W. Rilley. Sec. 16, N. W. ¼.	Upland.	700	130	Black soil 2, yellow clay 20, sand 80, limestone 28.	598
92	P. H. Ryan. Sec. 11, N. E. cor. N. E. ¼, R. 3 E. T. 82 N.	Upland.	780	136	Black soil 3, yellow clay 33, blue clay 30, limestone 40.	764
93	Wm. Betts. Sec. 6.	Upland.	860	140	Drift (?) 100, limestone 40.	760

The Pleistocene System.

The long period of erosion during which the Coal Measure sediments were removed, was brought to an end by the approach of extensive ice fields from the north in the Quaternary age. During this age continental glaciers covered this entire region, probably more than once, and once or twice during that time they overran a part of the area of Clinton county. Each of these incursions deposited a sheet of drift.

PRE-KANSAN STAGE.

Sub-Aftonian or pre-Kansan Drift.—The earliest drift which is known in this state has been called the sub-Aftonian or pre-Kansan. For descriptions of this drift the reader is referred to the reports on several of the counties in the south part of the state, where it is best exposed. It is usually of a dark color and frequently contains fragments of coal and wood, and it lies

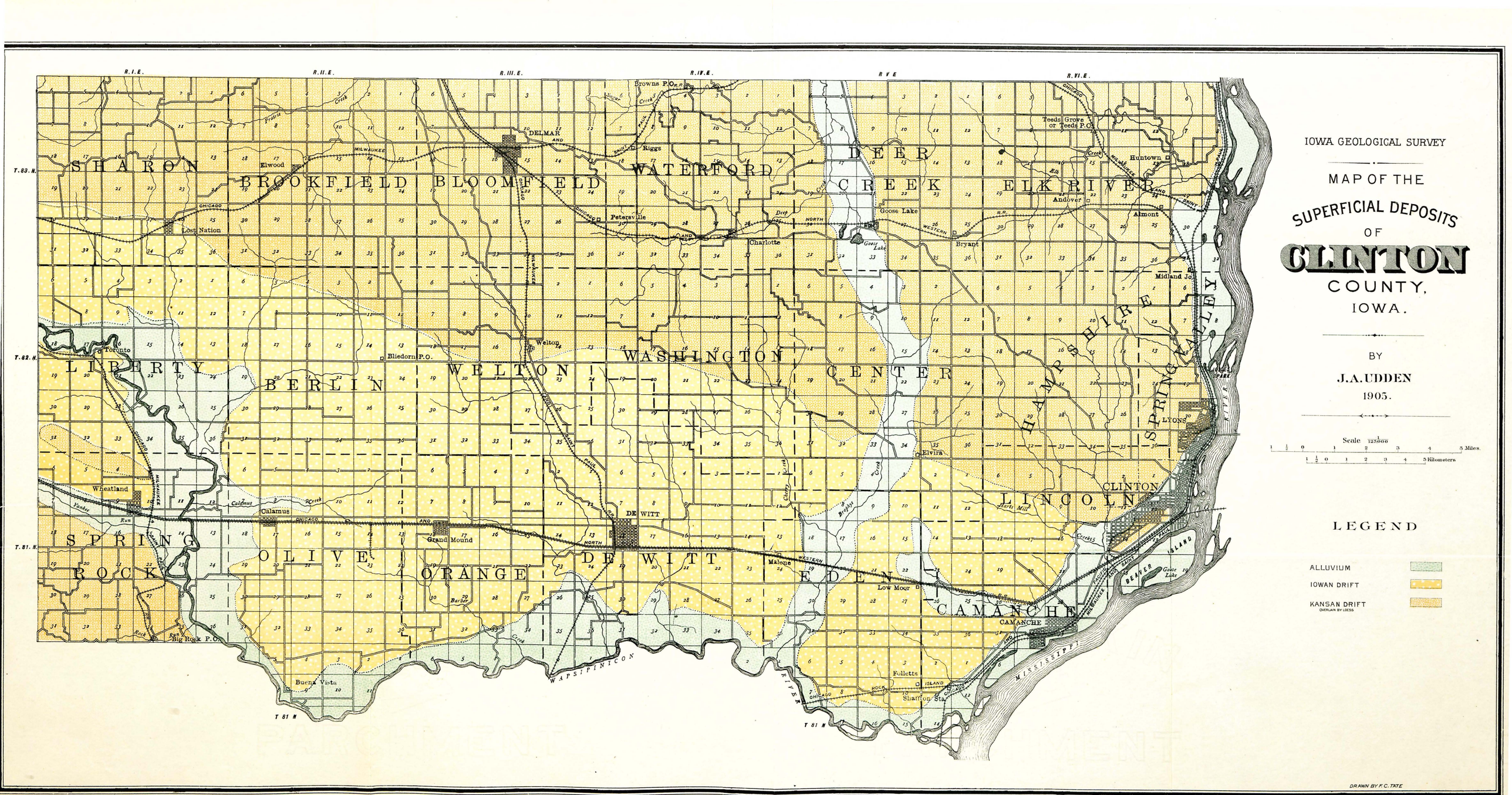
under the Kansan bowlder clay. Whether or not it is found in Clinton county must be left an open question. No characteristic outcrops have been observed. The thickness of the drift along a line running west-northwest from Lyons suggests the presence of a morainic belt along that line, and from its location such a moraine can not very well belong to the Kansan, since the ridge does not follow the margin of this drift. It may mark the course of a moraine of an earlier drift,* such as the sub-Aftonian.

KANSAN STAGE.

The Kansan Drift.—In the north part of the county the surface of the drift presents an old appearance. It has suffered extensive degradation by erosion, and the drainage lines have invaded the drift plain until less than one-fourth of its original surface is now intact. Under the loess which lies uppermost there is a yellow or gray till, or bowlder clay, which in all respects resembles the Kansan in other parts of the state. Its upper surface is mostly leached and oxidized to a depth of several feet below the base of the overlying loess. Its most reliable distinctive characteristic for this county is probably to be found in the nature of the rocks represented, in its pebbles and larger erratics. These are the same that characterize the Kansan drift farther south. Dolomite limestone is less frequent than calcareous limestone. Among the pebbles measuring one-third of an inch in diameter the latter outnumber the former by nearly two to one. Among the pebbles and bowlders which are less than one foot in diameter, diabase, greenstone and granite are present with nearly equal frequency, and together constitute from fifty to eighty per cent of all the erratics of this size. Among the pebbles which are less than one-half inch in diameter there is usually from five to ten per cent of an arenaceous and calcareous rock of the Cretaceous age. These pebbles contain scales of fishes, and have a tendency to break into flaky chips.

Some details of a rather hurried examination of the erratics in this drift are given in the table below:

*See "The Illinois Glacial Lobe," Mon. XXXVIII, U. S. Geol. Surv., by Frank Leverett, p. 144 *et seq.*


IOWA GEOLOGICAL SURVEY
MAP OF THE
SUPERFICIAL DEPOSITS
OF
CLINTON
COUNTY,
IOWA.
BY
J.A.UDDEN
1905.
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
IOWAN DRIFT
KANSAN DRIFT
OVERLAIN BY LOESS
DRAWN BY F.C. TATE
IOWA LITHO. CO.
R.I.E.
R.II.E.
R.III.E.
R.IV.E.
R V E
R.VI.E.
T.83.N.
T.82.N.
T.81.N.
T 81 N
SHARON
BROOKFIELD
BLOOMFIELD
WATERFORD
DEER CREEK
ELK RIVER
LIBERTY
BERLIN
WELTON
WASHINGTON
CENTER
HAMPSHIRE
SPRING VALLEY
SPRING ROCK
OLIVE
ORANGE
DE WITT
EDEN
LINCOLN
CAMANCHE
Elwood
Lost Nation
Toronto
Bliedorn P.O.
Welton
Petersville
Charlotte
Browns P.O.
Riggs
DELMAR
Teeds Grove or Teeds P.O.
Huntown
Andover
Almont
Goose Lake
Bryant
Midland Jc.
LYONS
Elvira
CLINTON
Wheatland
Calamus
DE WITT
Grand Mound
Malone
Low Moor
CAMANCHE
Big Rock P.O.
Buena Vista
Folletts
Shanton Sta.
Beaver Island
Goose Lake
Wapsipinicon River
Mississippi River

COMPOSITION OF THE ERRATICS IN THE KANSAN DRIFT IN EASTERN IOWA.

(*The table gives the per cent of erratics of each kind of rock among the different sizes.*)

KINDS OF ROCKS.	DIAMETER OF PEBBLES IN INCHES.						
	ONE MILE NORTH OF RIGG'S STATION, CLINTON COUNTY.				One-half mile north of Delmar.		North of Lowden
	9	3	1	⅓	1	⅓	⅓
Limestone	2	14	32	22	17	15	11
Dolomite				14		7	5
Sandstone	1	....	3	....	1	....	2
Shale	....	....	1	....	....	....	1
Ferruginous concretions	....	....	....	3	4	....	....
Cretaceous rock	....	....	....	9	5	4	7
Chert	1	2	6	4	2	2	11
Schist	3	3	1	2	1	1	4
Quartzite	5	5	10	3	2	....	11
Diabase, gabbro, etc	15	17	10	30	24	20	19
Greenstone	36	30	23	8	23	23	9
Granite	36	27	9	9	20	23	12
Vein quartz	....	2	4	6	1	5	8

The Kansan drift was laid down over the entire area of the county, for we find it not only on the north side but also on the south side of a later drift. The Kansan drift is known to have come in with an extensive ice field from the northwest, and this accounts for the frequency of pebbles of Cretaceous material. It seems likely that these may have come from some part of the plains several hundred miles farther north.

ILLINOIAN STAGE.

The Illinoian Drift.—Some time after the deposition of the Kansan drift, a lobe of an extensive ice field, coming from the northeast, is known to have advanced westward across the present course of the Mississippi river to the south of this region. The drift left by this ice is known as the Illinoian, and it covers parts of Scott, Muscatine, Louisa and Des Moines counties. It is believed that this drift has been recognized as far north in Scott county as to within a few miles of Clinton county.* In

*Geology of Scott county. W. H. Norton, Iowa Geol. Surv., Vol. IX, p. 480. The Illinois Glacial Lobe, Frank Leverett, U. S. Geol. Surv., Monograph XXXVIII, p. 34.

Clinton county it is probable that this drift also exists, but its presence has been obscured by the later deposits. The Illinoian drift is characterized throughout western Illinois and in eastern Iowa by a high percentage of dolomitic material among its smaller erratics. Of the pebbles which measure less than one inch in diameter, from fifty to eighty per cent are of this kind of rock. If the Illinoian drift occurs in this county at all, it should be found in the townships bordering on the Wapsipinicon and the Mississippi rivers. No certain evidence of the presence of this till has been noted.

IOWAN STAGE.

The Iowan Drift.—Long after the Illinoian ice had disappeared there was an incursion of glacial drift from the west along the lowlands of the Wapsipinicon. This was brought by a tongue of the Iowan ice field which apparently reached as far out as to the present course of the Mississippi river, or perhaps even beyond this some distance into Illinois.* The topographic character of this drift has already been described. Its average elevation is from fifty to one hundred feet less than that of the Kansan drift plain, it has suffered much less from erosion, and fully two-thirds of the original surface of the plain is yet intact and uninvaded by the drainage channels. Occasionally low ridges rise from its surface and run in a northwest-southeast direction. North and west of DeWitt some of these ridges form belts with a broken topography that is almost morainic in character. Elongated and irregular knolls hem in some small and undrained basins.

Another feature of this belt of drift is the quite frequent absence of loess, which elsewhere covers the bowlder clay. In some places, especially near the ridges just described, and also near the margins of the belt, the loess is present, but it is seldom heavy. Quite frequently it is entirely absent. In such cases the drift forms the soil, and this may be calcareous almost up to the surface, and bowlders appear in the fields. Such bowlders are especially frequent immediately west of DeWitt, and also in Olive, Orange, Eden and Camanche townships. They

*See the Illinois Glacial Lobe, by Frank Leverett, Mon. U. S. Geol. Surv., XXXVIII. p. 151.

were also noted in the southern part of Center, Welton, Berlin, and Sharon townships. The percentages of different kinds of rocks represented among 200 of these bowlders were as follows

	PER CENT
Gabbro and diorite	47
Granite and gneiss	35
Quartzite	6
Dolomite	6
Greenstone	3
Coarse, red granulite	3

These bowlders had an average diameter of about two feet, but they ranged in size from one-half to twice this measure. Such very large blocks as have been noted on this drift in other counties are not frequent, only two having been noted. One of these lies on the east side of the wagon road in the northwest $\frac{1}{4}$ of section 6 in Orange township. It is of granite, and it is broken into several parts some of which measure ten feet in diameter. Another block of coarse granite was noted in the southwest $\frac{1}{4}$ of section 30 in Sharon township. This measured about 10 by 12 by 15 feet.

The limits of the Iowan drift are by no means clearly or sharply marked. The boundary on the north side may be said to consist of an ill defined belt from one-half mile to two miles in width, where the distinctive features of the earlier and the later drifts gradually merge, or frequently alternate, without apparent order. The belt is marked by dome-like ridges, called paha, which extend more or less parallel with its course, from the west-northwest to the south-southeast. On the south side west of the Wapsipinicon river some Iowan drift appears to have come down along the valley of Yankee creek, while undoubted Kansan drift was noted on the uplands northwest of Wheatland. Small isolated areas of the earlier drift have also been noted to the west, in Cedar county, by Professor Norton.* They seem to be entirely surrounded by Iowan drift.

*Iowa Geol. Surv., Vol. XI, Geology of Cedar County, by Wm. Harmon Norton, p 313 *et seq.*

GRAVELS.

Gravels of Uncertain Age.—Some gravels which occur in ridges on the Iowan area merit special notice. These are the gravels in the pits worked in the northwest ¼ of section 19, just south of DeWitt, and in the northwest ¼ of section 16, a short distance east of Grand Mound, along the Chicago & Northwestern railway. In the pit which lies nearest the railroad south of DeWitt, the lowest part of the material seen in the south end of the excavation consists of sand and gravel about fifteen feet in depth. This exhibited an obscure but still clearly perceptible bedding or assortment of materials of different degrees of coarseness, into layers which had the very unusual attitude of extending in directions varying from the

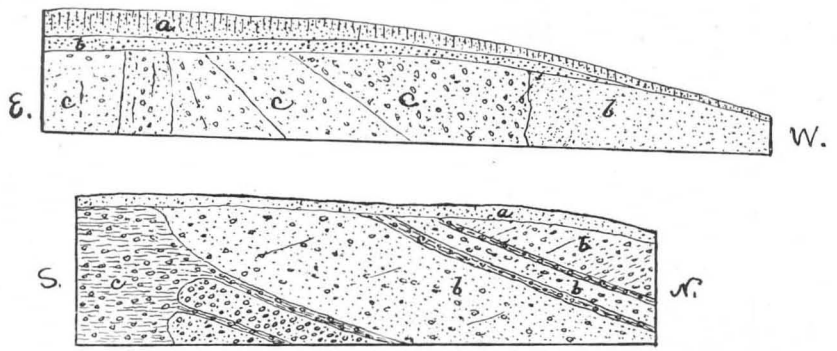


FIG. 32. a. Upper section shows bedding of the drift in the Scott county gravel pit near DeWitt. (a) Sandy loess, (b) ferruginous sand, (c) gravel and sand.
b. Lower section shows bedding in the drift in a gravel pit near Grand Mound. (a) Soil, (b) gravel and sand, (c) bowlder clay.

vertical to inclinations of forty-five degrees. Above this was a two-foot stratum of ferruginous sand, which changed upward into a sandy loess some three feet in depth. The structure is represented in figure 32a. In the pit east of Grand Mound a gently sloping stratification in the gravel seen in the north end of the exposure abuts against an irregular wall of bowlder clay at the south end. From this till some thin layers of bowlder clay run out and are interbedded with the sand and gravel, as indicated in figure 32b. The character of the bedding in both of these instances shows that the gravels are of a glacial origin and were deposited in the presence of ice. The

vertical bedding can have been produced only by disturbances connected with the melting of the ice. In the pit farthest south, near DeWitt, the gravel and sand is overlain by a fine and calcareous silt such as settles in glacial waters. The gravel itself bears clear evidence of being a glacial product, for quite a considerable percentage of the pebbles bear glacial scoring and planing. The question arises as to which age the gravel belongs. The overlying sandy material is, of course, Iowan, and though there is an unconformity between this and the underlying beds, both may very well be derived from the same drift. The ridges are no doubt to be regarded as eskers or kame deposits built up by glacial streams. Were these streams on the Iowan ice or on the Illinoian? This question must be left undecided. Their intimate association with the Iowan drift and their general relation with the Iowan topography render presumptive their identity with this drift. But the material itself very much resembles that found in the Illinoian drift, and in an esker of that drift found in Whiteside county, directly east of the Mississippi. The bulk of the gravel is dolomitic limestone. The results of some observations on the rocks represented in the two principal occurrences of this gravel are given in the table below:

COMPOSITION OF THE GRAVEL IN THE ESKERS SOUTH OF DEWITT.

(*Expressed in percentages of fragments of different sizes.*)

GRAVEL.	SIZES OF DIAMETERS OF FRAGMENTS IN INCHES.									
	NEAR DEWITT.					NEAR GRAND MOUND.				
	27	9	3	1	⅓	27	9	3	1	⅓
Dolomitic limestone	4	37	77	78	73	18	63	75	75	59
Sandstone and conglomerate	....	..	3	2	...	1	....	....	1	..
Limonitic nodules	....	....	....	....	..	....	....	....	1	1
Chert	..	....	....	5	9	...	....	2	4	18
Schist	.	1	....	2	....	..	....	1	1	....
Greenstone	4	8	2	..	3	1	5	3	4	4
Granite	20	32	5	2	4	14	7	8	4	6
Granulite (red)		1	1	....	...	2	....	1	2	....
Diabase and gabbro	56	9	10	7	8	62	23	10	8	7
Hornblende rock	....	....	1	....	....	....	....	....	....	....
Quartz (vein)	....	....	....	1	3	....	....	....	....	....
Quartzite	16	12	1	3	....	1	2	1	....	3

LOESS.

The Loess.—The loess is the latest deposit on the uplands. It is a yellow or gray, porous material of uniformly fine texture, usually known to well drillers as yellow clay. In the uppermost part it changes into dark soil, which is the universal material seen in the roadbeds on all uplands. When dry it is readily crushed into dust that is easily borne by the wind. It is free from pebbles and coarse sand, but frequently contains calcareous nodules or concretions of most varied forms and sizes. In this county such concretions are not very common. Calcareous material is rather less abundant as an ingredient in the deposit here than elsewhere in the state. North of Clinton the loess occasionally has a purplish tint which is a rather exceptional feature. In the bluffs west of the city of Clinton the writer, some years ago, found a small block of Niagara limestone in the lower part of a freshly exposed wall of the loess in a stone quarry. The block was quite angular and evidently not worn, and as the Niagara limestone rises considerably higher in the hills close by, the suggestion was near at hand that the block might have crept down into its present position. Pulmonate gastropods, which often are frequent in the loess elsewhere, are rare in this county, but not unknown. A few brittle and disintegrated fossils of this kind were seen in the lower part of the loess in the clay pit of the brickyard in the north part of Lyons. The only form indentified with certainty was *Succinea avara* Say.

The loess is universally present on the uplands of the Kansan drift plain, north as well as south of the belt of Iowan drift. It probably averages fifteen or twenty feet in thickness. But in the bluffs of the Mississippi it is heavier than this at some places. In Brookfield and Berlin townships it appears to increase slightly in thickness toward the boundary of the Iowan drift, but this can not be said to be the case along the same boundary east of Welton. The material which forms the upper part of the paha is invariably loess, but it usually changes downward into yellow sand, and even into gravel. Such an instance was noted in a paha in the northwest ¼ of section 29 in Sharon township.

Over the Iowan drift plain the loess is patchy and its tendency is to be absent on the lower parts of the land and to appear in greatest thickness on the higher tracts and on the paha, as already explained. It is believed to be present as a thin mantle in most places, but it probably averages less than one-half the thickness observed on the Kansan drift. A loess-like material was also noted on the alluvial plain of the Goose Lake channel.

ALLUVIUM.

Exposures for the study of the fluviatile deposits are not very frequent. The materials on the surface of the lowest flood plains are almost invariably a silt, largely made up of redeposited loess in the smaller streams. In the Wapsipinicon and the Mississippi bottoms it is occasionally coarser and sandy. Below this silt wells usually penetrate stream sand or quicksand. In the terraces which rise above the flood plain the materials are usually coarser. Such is the case in the terrace near Camanche. In a remnant of a terrace near the Milwaukee railroad at Midland, the bank consists of sand above and gravel below. The composition of the gravel resembles that of the gravels in the Wisconsin terraces, and it seems probable that this is a remnant of the same deposits. The following table shows the nature of the pebbles averaging about one-half inch in diameter in this gravel:

Granite	41
Quartz (one carnelian)	4
Serpentine rock	3
Magnetic iron ore	1
Felsite	1
Diabase	17
Other Keweenawan eruptives	16
Red quartzite (Kew. ?)	4
Gray quartzite	4
Chert	6
Limestone	3
Clay ironstone concretion	1

Section of the Rocks Underlying Clinton County
Along the Mississippi River.

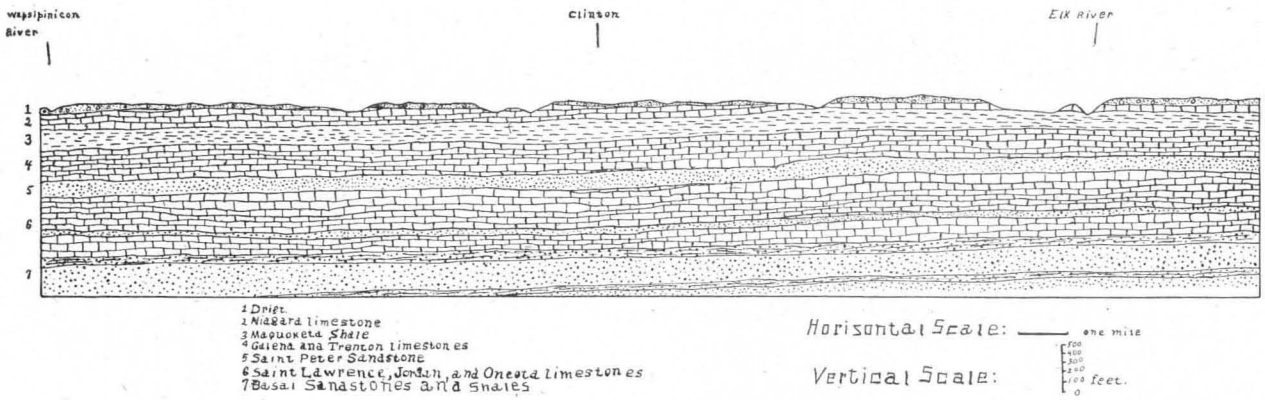


Plate VII. Section of the rocks underlying Clinton county, along the Mississippi river.

Geological Structure.

The Paleozoic terranes in Clinton county have a dip toward the south of about twelve feet per mile, as near as can be made out from measurements within the county. The above statement is based upon data which fixes the elevation of the base of the Niagara at four points lying at the corners of a quadrangle which nearly includes the east two-thirds of the county. In the northeast corner of Elk River township the division between the Niagara and the Maquoketa is known from outcrops, and it averages 600 feet above the sea level. In Mr. Wm. Pitch's well the Maquoketa shale was encountered at an elevation of 610 feet above sea level, practically at the same height as it occurs on the Mississippi twenty-six miles to the east. Again at DeWitt a well entered the Maquoketa at 427 feet above sea level and at Clinton the top of the same shale lies 468 feet above the sea. As DeWitt lies two miles south of the Clinton wells the greater depth of the shale at the former place must be regarded as in part, if not altogether, due to the southward dip, and thus it is clear that in the east and west direction these formations are nearly horizontal. From the north line of the county south to the Clinton wells we may take the distance as twelve miles. The difference in elevation being 132 feet, there must be an average descent of eleven feet per mile. The north and south distance from Mr. Pitch's well to the well at DeWitt being fourteen miles and the difference in elevation of the base of the Niagara being 191 feet, there is an average descent of about thirteen and one-half feet to the mile. The close correspondence of the two figures corroborate their accuracy.

From the exposures in the bluffs of the Mississippi river it appears that this general dip is not uniform. North of Lyons the top of the Maquoketa maintains nearly the same level up to the Jackson county line, so that the strata must lie almost horizontal. Then in the next three and one-half miles to the Clinton wells, the Maquoketa descends 132 feet, or nearly thirty-eight feet to the mile. This comparatively steep dip evidently soon gives place to a more gentle descent of about ten feet to

the mile, for this is required to give to the Niagara the thickness it is known to have twenty miles farther south. See section shown in plate VII.

Minerals.

Some galena and some nuggets of copper have been found in the drift. A specimen of galena was taken up on the farm belonging to Mr. C. Schoff, on section 18 in Brookfield township. Another, which was found on a farm belonging to Mr. A. Evers, weighed ten pounds. Mr. J. W. Hover of Wheatland states that while drilling a well on the farm belonging to Mr. P. J. Quacke in the south half of the northwest $\frac{1}{4}$ of section 13 in Liberty township, a bowlder of galena was struck at a depth of fifty-three feet. These erratics of lead ore have evidently been picked up by the ice sheet in the lead bearing Galena limestone fifty or a hundred miles to the north, and have been brought here with the drift.

Some small copper nuggets a quarter of an inch in diameter were found in blue bowlder clay sixty feet from the surface, on a farm belonging to Mr. Leonard Clapp, in the west half of the northwest $\frac{1}{4}$ of section 28 in Sharon township. Such nuggets occur in the drift in other parts of the state and they have probably been transported by the ice from the region of Lake Superior.

A white rock flour is sometimes to be seen in small crevices in the Niagara limestone. It is a form of dolomite. Cubical crystals of iron pyrites are also common in the Maquoketa shale.

ECONOMIC PRODUCTS.

Clay Industries.

The largest brick making establishment in Clinton county is located in the city of Clinton, near First avenue and Fifth street and belongs to Mr. Thomas Price. The clay used is loess, and this is taken from a bluff near by. The brick is hand made

and the clay is prepared in two pug mills. The brick is sun dried, and burned in open kilns. The usual output in one season is 1,500,000 brick. About twenty men are employed. The average price received is $7.00 per thousand. The total output is consumed by the home market.

The Lyons brickyard is located at the foot of the bluffs in the northwest part of the former city of Lyons (now a part of Clinton). The clay used is a yellow loess. There is one pug mill, and the brick are sun dried and burnt in open kilns. From five to ten men are employed, and the output for each season varies from 200,000 to 500,000 bricks, which are sold in the home market at prices varying from $6.00 to $8.00 per thousand.

The tile and brick works near DeWitt belong to W. E. McKinney & Co. The plant is located along the Chicago, Milwaukee & Saint Paul railroad about one-fourth of a mile northwest of the town. Tile as well as brick is made from a yellow, sandy, loess-like material, which rests on drift in a paha ridge. A Brewer and Tiffany, stiff mud machine is run with steam power. From eight to ten men are employed. About 200,000 bricks and 400,000 tiles of two sizes (three and eight inches in diameter) are made in a season. The product is dried in sheds and is burnt in down draft kilns. Part of the output is shipped to outside points and part is sold in the home market. Prices are about as follows: brick, $8.00; three inch tile, $12.00; eight inch tile, $65.

Mr. Fred Rink owns a brickyard in Wheatland, and uses a yellow loess clay. The brick is made with a Leander machine. It is dried in sheds and burnt in a down draft kiln. Four men are employed. About 700,000 bricks are made in a season and sold at $7.00 per thousand in the home market. Some tile is also made, as the market demands.

Sand and Gravel.

Mortar sand is obtained in many places from the drift and also along some of the streams. Near Toronto large quantities are taken each year from the bed of the Wapsipinicon river and hauled away to supply the country to the north.

In the northwest ¼ of section 31 in Elk River township the Chicago & Northwestern railroad operates a large gravel pit. The top layer consists of a moderately fine sand which is partly used for engine sand. Underneath this sand there is from twelve to fifteen feet of gravel, which is coarse enough to be used for road ballast. About five hundred car loads are taken out each year. This gravel is in an old terrace of the Mississippi river.

Gravel suitable for ballast and for building of highways has been found in esker-like ridges in four places over the area of the Iowan drift. Two of these are on the west ½ of section 19, south of the city of DeWitt. The larger of these two is owned and worked by Scott county for road building. This pit is close to the Chicago, Milwaukee & Saint Paul railroad, and the gravel is hauled by this road. About six thousand cubic yards were taken out last season and from three to six men were employed. The other pit on this section lies a quarter of a mile farther south. It is owned by the city of DeWitt and supplies material for gravelling the roads in DeWitt township.

The Chicago & Northwestern railroad once worked a gravel bank on the north side of the road in the northwest ¼ of section 16 in Orange township. This pit at present supplies some road material for the neighborhood of Grand Mound.

Another old gravel pit was formerly worked by the same road near the center of section 23 in Olive township.

The material in all of these places on the area of the Iowan drift consists mainly of dolomitic limestone. There are several other ridges which contain the same kind of gravel, in the region near the Wapsipinicon river. These will no doubt be utilized when the supply in the present pits has been exhausted.

Building Stone.

There are a great number of small stone quarries throughout this county. None are worked on a large scale. No building stone is exported, and such quarries as these, merely supply the local demand for curbing, riprap, road making and flagging stone. All the rock quarried comes from the Niagara formation. While this in many places can be taken out in blocks suitable for building stone, it is not suitable for dimension work. One reason for this is the fact that in nearly all of the quarries the several layers vary in thickness as they are followed horizontally. Quite often the rock is too porous and too soft to stand weathering. The largest quarries are in Clinton, but even these are not worked during all of the year. Openings have been made in many places in the bluffs where no work is now going on. Throughout the county, openings for small quarries are so generally distributed in every neighborhood that there has been no centralization of the industry in any particular place. The value of the entire output probably does not exceed $7,000 a year, and no more than a dozen men are employed in the work.

Water Supply.

On the alluvial or "bottom" lands along the rivers and larger creeks water is obtained in wells which go down into sand. Usually this is encountered within forty feet of the surface. On the uplands the most of the wells are deeper than this. Water is sometimes obtained in sandy or gravelly beds either in the glacial till or immediately below it, but the best wells draw their supply from the Niagara limestone. This latter horizon lies at depths usually ranging from fifty to two hundred feet below the surface. The waterworks in DeWitt, Grand Mound and Wheatland obtain their supply from this rock. The water supply in the city of Clinton is partly from deep wells which tap the Saint Peter sandstone of the Ordovician, and also the Saint Croix sandstone of the Cambrian. Part of the city supply is pumped from the Mississippi river.

Soils.

The soils in Clinton county do not differ essentially from those in the surrounding country. The alluvial plains are covered with a very rich and black soil, but during wet seasons much of the land suffers from insufficient drainage. On the uplands there is less of humus and the soil is not always so black, but it is nevertheless of good quality. Along the north border of the Iowan drift, and near the paha on this drift, there are occasional small patches of sandy soil. Along Elk river, in the northeast part of the county, the land is too hilly for general cultivation, but it furnishes excellent pasturage.

Quicklime.

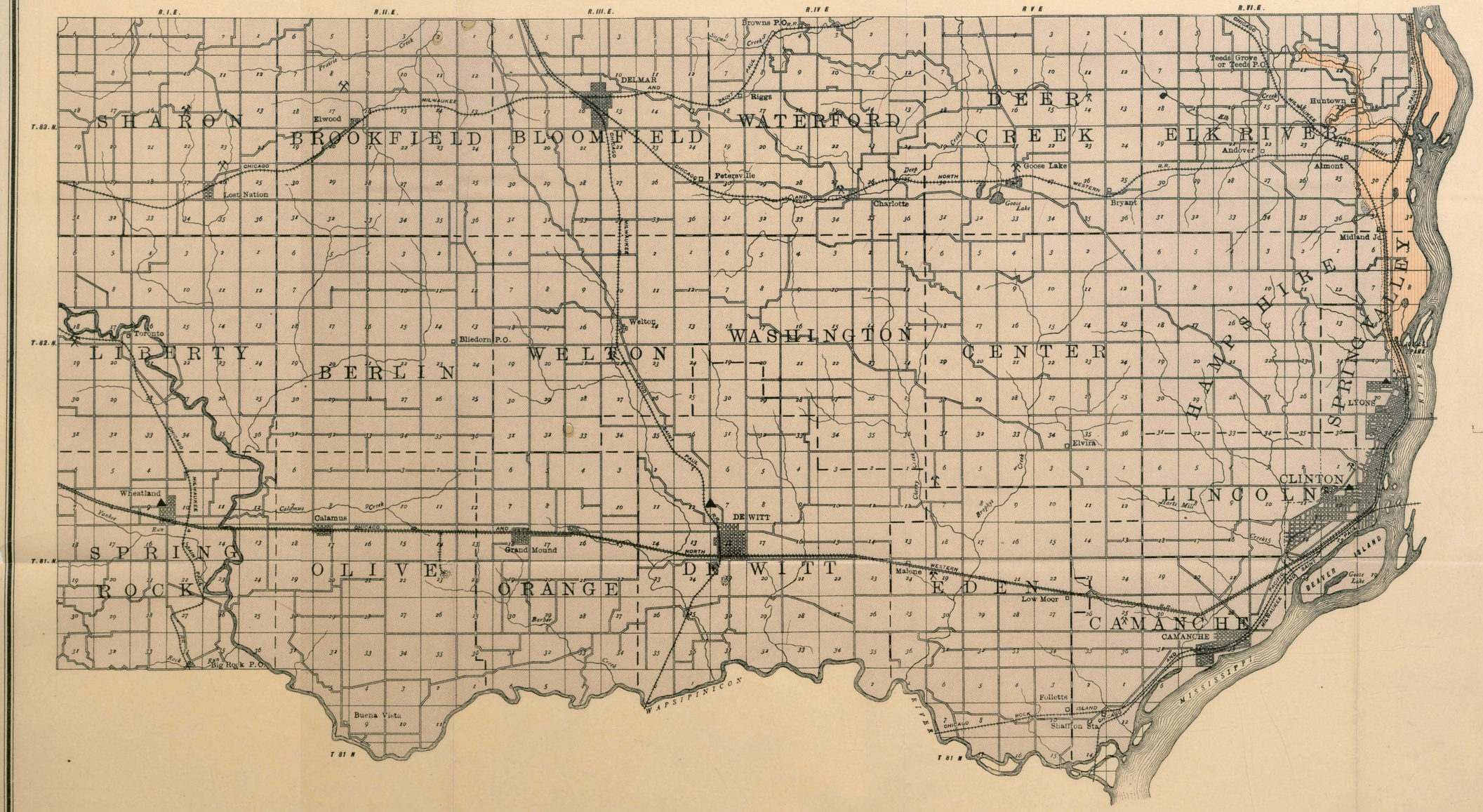
In earlier years lime was burnt for some time at Lyons and near Camanche, but this industry has now been abandoned. Rock suitable for such purposes is common throughout the county.

Coal.

While there is no doubt that the Coal Measures once covered the Niagara limestone everywhere in this region, it is no less evident that during later ages the rocks of the Des Moines stage have been almost entirely removed, and that the few remaining outliers are altogether too insignificant to contain any workable seams of coal. A coal bearing shale has been reported from a well on section 33 of Welton township, but the seam was thin and no doubt of very limited extent, as the Silurian rocks are known to come up around it on all sides. Money spent in prospecting for coal in this county is certain to bring no returns.

Lead and Copper.

The fragments of galena and copper which have been discovered in this county are erratics from other regions, and do



IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF CLINTON COUNTY, IOWA.

BY

J.A. UDDEN

1905.

Scale 1/125000

1 ½ 0 1 2 3 4 5 Miles.

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

DES MOINES (Coal Measures)

NIAGARA

MAQUOKETA

INDUSTRIES

QUARRIES

CLAY WORKS

GRAVEL PITS.

DRAWN BY F.C. TATE

IOWA LITHO. CO.

not signify that such minerals can be found by prospecting. The bed rock is known to be barren and will never yield either base or precious metals.

ACKNOWLEDGMENTS.

The writer, who is responsible for nearly all of the field work in this county, desires to state that the above report has been edited and in part written by his father, Dr. J. A. Udden, who also aided in the field work on the study of the drift.