GEOLOGY OF FAYETTE COUNTY.

BY

T. E. SAVAGE.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Fayette county was established in December, 1837, and was named in honor of the French Marquis de Lafayette. At that time it was the largest county in the United States.* It included the greater portion of what now comprises twenty-eight of the northern counties of Iowa, nearly all of the present state of Minnesota, and all of the Dakotas east of the White Earth and the Missouri rivers. It embraced a total area of nearly 140,000 square miles. Ten years later the county was reduced to its present boundaries.

Fayette county is situated in the second tier of counties west from the state of Wisconsin, and in the second row south from Minnesota. Winneshiek county lies to the north of the area, Clayton joins it on the east, Buchanan borders it on the south and Bremer and Chickasaw form its western boundary.

*Gue: History of Iowa, Vol. I, p. 183, and Vol. III, p. 344.

The eastern border of the county is only about twenty-two miles west of the Mississippi river, and the northern border thirty miles south from the state line. Fayette county forms a rectangle thirty miles in length from north to south, and twenty-four miles in width. It comprises twenty government townships—townships 91 to 95 north of the base line, and ranges VII to X west of the fifth principal meridian. It has an area of 720 square miles.

In the number of geological formations exposed, and in the favorable manner in which the relations of the different strata are exhibited, this region is surpassed by but few of the counties of the state. No other area of like size presents a richer variety of topographic forms expressed in widely extending prairies; forest mantled hills; deep, picturesque ravines which are bordered by high bluffs and precipitous ledges of limestone; and charming streams which are fed by scores of never failing springs.

EARLIER GEOLOGICAL WORK.

As early as 1839 Dr. D. D. Owen* collected and described a few fossils from the rocks exposed at various points along the Turkey river in or near Fayette county. In his report he calls attention to the symmetrical form of the hills which border the larger streams of the area. He also discussed in a general way some of the geological formations in the northeastern portion of the county.

In Hall's report on the Geology of Iowa† published in 1858, Prof. J. D. Whitney devotes three or four pages to a general discussion of the geology of the area under consideration. Mr. Whitney considered the Niagara limestone to have a much wider distribution and a much greater thickness in the county than the present studies seem to indicate. He also speaks of the Galena limestone appearing in the valley of the Turkey river throughout its entire length in the county.

*Owen: Geol. Surv. of Wisconsin, Iowa and Minnesota, pp. 74 and 577.

†Hall: Geology of Iowa, Vol. I, part I, pp. 302-305.

Fayette county is embraced within the region discussed by W J McGee in his Pleistocene History of Northeastern Iowa.* In that work several references are made to some of the topographic features, loess and drift deposits, and a few of the exposures of indurated rocks occurring within the limits of Fayette county.

In reducing the gradient of their road bed in 1896 the Chicago Great Western railway company made a deep cut a short distance southeast of the town of Oelwein. In this excavation an exceedingly instructive section of the Pleistocene deposits was exposed. In a paper before the Iowa Academy of Sciences in 1896 Mr. G. E. Finch† described the drift materials exposed at this place. The same drift exposure has been discussed by Prof. S. W. Beyer‡ who gave a section of the beds and referred the lower till, there to be seen, to the pre-Kansan age. At the meeting of the Iowa Academy of Sciences that same year Prof. T. H. Macbride§ described the Pre-Kansan Peat Bed that was exposed in the above mentioned cut, and discussed the conditions that must have obtained at the time the deposit was accumulating.

In a paper treating of The Galena and Maquoketa Series, Mr. F. W. Sardeson‖ refers to a number of places in Fayette county where there can be seen exposures of different beds that he mentions in his classification of the Maquoketa deposits.

Prof. G. E. Finch** has described an old terrace formation along the valley of the Turkey river in Fayette county. The same writer†† has discussed the significance of the position of individuals of *Nileus vigilans* that were found in strata near Elgin, in the county under consideration.

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* McGee: Eleventh Ann. Rept. U. S. Geol. Surv., Washington, 1890.

† Finch: Proceedings Iowa Academy of Sciences, Vol. IV, p. 54, *et seq.*, 1897.

‡ Beyer: Ibid., p. 58 *et seq.*

§ Macbride: Ibid., p. 63 *et seq.*

‖ Sardeson: American Geologist, Vol. XIX, pp. 30-33, 1897.

** Finch: Proceedings Iowa Acad. Sci., Vol. VIII, p. 204, *et seq* 1901.

†† Finch: Ibid., Vol. XI, pp. 179-191, 1904.

PHYSIOGRAPHY.

TOPOGRAPHY.

Over all the western and southern portions of Fayette county the surface is generally level or but gently undulating, except in close proximity to the larger streams. The topography of the northeastern part of the area is in striking contrast to that of the prairie portion. In this more hilly region the valleys and uplands are often separated by a difference in altitude of 300 to 400 feet. In many places high ramparts of Niagara limestone bound the valleys of the larger streams, and look down upon the tumultuous waters which flow in feverish haste past ancient crags, and weathered peaks, and gently rounded bluffs whose materials have been wasted through geologic ages by the slow processes of denudation.

The topography of each of the above mentioned areas, like that over the greater portion of our state, finds its explanation in the length of time since the leveling ice plow last withdrew from each particular region, and consequently in the length of time during which the streams of these areas have been uninterruptedly carving their channels.

It is possible that the extremely uneven surface of the northeastern portion of the area is partially due to the fact that only the edge of the Kansan glacier overspread the region. This marginal portion of the ice sheet was much less effective as an eroding or leveling agent than the thicker mass further from the periphery. On this account the preglacial topography here was not greatly obscured by the Kansan ice sheet. After the withdrawal of the ice the streams continued to follow the preglacial courses, and as a result of the but slightly interrupted erosion the action of the streams is much more marked here than over the general surface of the Kansan drift plain.

THE IOWAN-KANSAN BORDER.

In Fayette county, as in other counties that are crossed by the border of the Iowan drift, the margin of this drift area is

fringed by a line of irregular hills which are so deeply loess covered that their summits reach an altitude considerably greater than that of the general surface on either side.

This sinuous line of hills that marks the border of the Iowan drift plain enters Fayette county, from Clayton, near the northeast corner of section 36 of Fairfield township. It extends in a northwesterly direction up to about the middle of section 25, thence west for one mile, and continues with a trend a little north of west, about one-half mile north of the town of Arlington. It crosses the north end of section 27, the extreme southwest corner of section 22, the south end of section 21, and passes up to near the middle of section 20. It here bends more nearly northward across the southwest corner of section 17, and up to one-fourth of a mile east of the middle of section 18. It then swings to the northeast for one-half mile after which it bears once more to the northwest across the south half of section 7 of Fairfield township, and the north half of section 12 of Smithfield township, and on to the middle of the north line of section 11. Here it once more bends to the northeast, reaching the middle of the east line of section 2. Thence continuing towards the northwest it enters Westfield township about the middle of the south side of section 35. After crossing the southwest ¼ of the latter section and the north half of section 34, it loops to the northward across the extreme southwest corner of section 27 and the southeast corner of section 28, invading the corporate limits of the town of Fayette. It swings down a short distance below the north line of section 33 and again bears to the northwest, passing to the west and north of Fayette at a distance of one-half to one and one-half miles. It crosses the extreme southwest corner of section 28, the southeast corner of section 29 and the northwest corner of section 32. It again bears northward across the northern part of section 31 and the west side of section 30, whence it swings towards the east across the southeast corner of section 19, the middle of section 20 and on to near the northeast corner of section 21. It continues with many meanders in a general northerly direction for some six or seven miles. It takes a northwesterly trend across the southwest corner of section 16 and the northeast corner of section 17.

It then bears in a northeasterly direction across the extreme southeast corner of section 8 and on to the middle of the east half of section 9. From this point it swings again to the northwest and continues up to about the middle of the east half of section 5. Here it swings towards the northeast up to the extreme northeast corner of section 4. It then bears towards the northwest to near the middle of the west half of section 33 of Union township. Swinging eastward it continues up to the northeast corner of section 33 and across the north end of section 34. Bearing more to the northward it passes across the northwest corner of section 35, the southwest corner of section 26 and on to a short distance north of the middle of the west half of section 27. From this point it bears eastward to the northeast corner of section 27, and thence continues towards the northwest diagonally across the southwest $\frac{1}{4}$ of section 22, the northeast part of section 21, and the southwest $\frac{1}{4}$ of section 16, crossing the southeast corner of the town of West Union.

From a point near the middle of the east line of section 17 the hills extend southward for one mile, and thence continue towards the northwest, about one-half mile to the west of the city limits. This border crosses section 20 and the extreme southwest corner of section 17. It cuts diagonally across section 18 and enters Windsor township a little north of the southeast corner of section 12. It continues toward the northwest across section 12, the north part of section 11, the northeast corner of section 10, the southwest corner of section 3, across section 4, and enters Auburn township a short distance west of the southeast corner of section 32. These moraine-like hills continue up to the middle of the northwest $\frac{1}{4}$ of section 32, where they swing towards the southwest, reaching the southwest corner of section 31. Thence they bear a little west of north to a point a short distance north of the middle of section 25 of Eden township. They then trend due east for one mile and then north one-half mile, whence, after a slight curve to the south, they continue towards the northeast up to near the middle of the west side of section 21 of the township of Auburn. With an eastward trend having a gentle southward curve they cross the south half of section 21 and continue

nearly to the east side of section 22, within one mile of Auburn Mills. At this point they swing northward to the northeast corner of the same section 22. They continue to the northeast up to the middle of section 14, thence bear towards the northwest to the extreme northwest corner of section 14, across the south side of sections 10 and 9 and up to within a short distance east of the middle of the west side of section 8. Here they swing once more to the northeast, passing through the town of Saint Lucas, across the southeast corner of section 5, the northwest corner of section 4, and leave Fayette county about one-fourth of a mile east of the northwest corner of section 4 of Auburn township.

THE AREA OF IOWAN DRIFT.

The area lying to the south and west of the line of moraine-like hills traced above was covered by the Iowan glacier. Over all of Putnam and Scott townships, and the greater portion of Jefferson, Oran, Fremont, Harlan and Center, the south part of Fairfield, and all of Smithfield, with the exception of a small area in the northeast corner, the topography is that of a gently rolling, slightly dissected drift plain. This undulating prairie surface is interrupted only where marshy, concave depressions, which mark the initial drainage courses, meander with many devious curves and finally deliver their waters to some larger stream, which occupies a definite yet shallow channel. The bottoms of these trough-like depressions are only fifteen to thirty feet below the summits of the ridges between which they lie, and their gently sloping sides merge insensibly into the gentle swells of the upland plain.

To these major depressions numerous grassy swales owe allegiance, and their tortuous, digitating lobes separate the otherwise level prairie into a series of broad, sinuous swells which alternate with shallow, grassy sloughs.

In Oran and Fremont townships the Wapsipinicon river flows in a broad valley one and one-half to two miles in width. Ponds and marshes, some of them of large extent, are not infrequent over its flood plain. The channel is bounded by

low banks eighteen to twenty feet in height which are generally composed of moderately coarse gravel, and this is often covered with a mantle of sand. At a few places in Oran township low ledges of indurated rock appear in the banks of the streams, but such exposures are limited to the south part of the township.

In the east half of Harlan township, and the south part of Center, the generally level surface is broken by the erosion of the Volga river and its principal branches. The hills adjacent to these streams are low and the inclinations are gentle.

In the town of Maynard, and for a distance of about one mile both to the north and the south of the city limits, ledges of Devonian limestone are encountered at frequent intervals along the banks that border the river. Deposits of water laid gravels bound the bed of the stream as it courses through sections 10 and 2 of Center township. From the north side of section 2 of this township, down to where it leaves the county, the river is confined between walls of limestone or bluffs of shale.

In the northeast corner of Eden township, the central and northwestern portion of Auburn, and practically the whole of the townships of Banks and Bethel, the level surface resembles that of the southern townships described above. The topography of the southwest corner of Union township, the northwest portion of Westfield, and all but the extreme northeast corner of Windsor and the southeast portion of Center, is also that of a recent drift plain scarcely modified at all by stream erosion.

Contiguous to Crane creek and Little Turkey river, in Eden township, the surface is quite broken. These streams occupy broad, shallow valleys whose bordering banks are prevailingly of gravel. Erosion is limited to a narrow area adjacent to the major channels.

Remnants of a bluff that bordered a pre-Iowan stream are left as a series of disconnected mounds which crown the west bank of a branch of the Volga river in sections 20, 17 and 18 of Center township. A number of paha-like hills that appear to be the remains of pre-Iowan elevations occur over the Iowan plain between Arlington and Fayette. Another such ridge extends across the north side of section 14, in Windsor township.

These ridges stand at a distance of one-half to one and one-half miles from the Iowan margin, and their long axes are usually somewhat parallel with the Iowan border. The hills are forty to sixty feet in height and are usually loess covered. The cores of some of them are composed largely of gravel, while those of others are made up of Kansan drift materials. They doubtless represent more or less subdued hills which for some reason or other escaped complete destruction when the Iowan glacier overspread the region.

Notwithstanding the fact that over the area of Iowan drift in Fayette county the surface changes are so gradual and the slopes are so gentle that there appears to be but little relief to the landscape, the region presents a maximum topographic relief of nearly three hundred feet. The bed of Otter creek, south of Olewein is a little less than 1,000 feet above the level of the sea. That of the Wapsipinicon river, in Oran township, is of about the same altitude. The inconspicuous divide that separates these streams reaches a height of 1,100 feet. In the north central portion of Scott township, and the northwest corner of Putnam, the watershed between the Volga river and the branches of the Maquoketa rises 1,200 feet above the sea. In the eastern portion of Smithfield township the uplands have an altitude somewhat greater than 1,200 feet. Near the northwest corner of Harlan township, between the headwaters of Otter creek and those of the Volga river, the divide has an elevation of about one thousand two hundred feet. In Bethel township, west of Hawkeye, the uplands rise to a height of 1,220 feet, while in Windsor township the height of land between the basins of the Volga and the Turkey rivers reaches a maximum altitude of 1,280 feet.

Over all of the western and southern portions of the county granite bowlders are very numerous. They are usually found along the sloughs and on the flanks of the slopes. Many of these are so large that they constitute conspicuous topographic features, as in section 18 of Jefferson and section 19 of Oran township. Within a few miles of the Iowan border, the bowlders are not less abundant, but for some reason they become

much smaller in size so that their effect on the landscape is much less marked.

Near the southwest corner of section 26, Smithfield township, there are a number of low mounds that are probably the work of some prehistoric inhabitants of the region.

THE AREA OF KANSAN DRIFT.

All of that portion of Fayette county lying to the east and north of the Iowan border belongs to the Kansan drift plain. The drift materials here are, for the most part, covered deeply with loess and the surface is quite thoroughly dissected. The mantle of Kansan drift that underlies the loess is very thin. In many places it appears to have been entirely removed by the agents of denudation prior to the laying down of the loess. This area is, in fact, a part of a broad plateau that has a general altitude of about one thousand two hundred feet. The table land is determined by the resistant layers of Niagara limestone which here immediately underlie the superficial materials.

The topography of this region has been developed through the erosion of the streams which, during long geological ages, have cut through the floor of Niagara limestone and have carved their channels deeply into the underlying beds. This broad plateau has been profoundly trenched by the waters of the Turkey river and of its chief affluents, the Little Turkey and Otter creek, and, further south, by the Volga river.

In sections 30 and 31 of Westfield township the Volga river flows in a channel one-half mile in width. In some places, as at Eagle Point, the valley is bordered by cliffs of Devonian limestone sixty to seventy feet in height. See figure 33. Between Fayette and Albany the river is confined in rather a narrow channel between precipitous ledges of Niagara limestone. From this point onward in its course through the county the shales of the Maquoketa stage appear in the banks and become manifest in the topography. At Lima the channel has expanded to nearly one mile in width. The shales that appear in the immediate foot hills have a gentle slope for a distance of several

rods on either side of the flood plain, and to a height of fifty or sixty feet. Above this line the Niagara escarpment rises sheer fifty feet more. From the top of this ledge the incline is rather gradual to the level of the uplands above. Continuing down the river its channel grows constantly wider, the gentle gradient of the Maquoketa shales rises constantly higher in the bound-

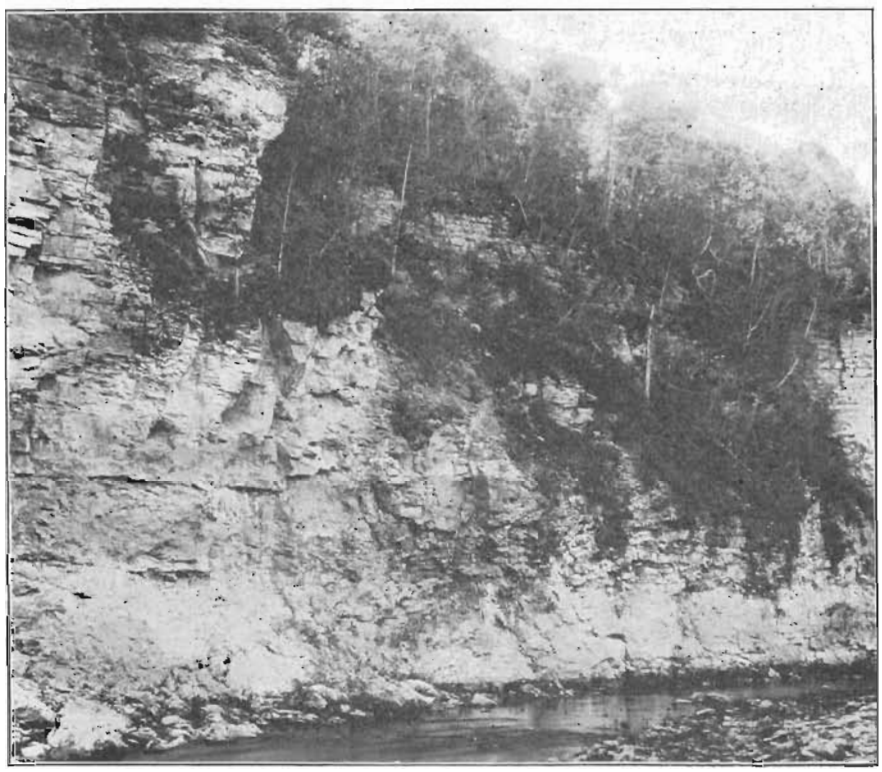

FIG. 33. Bluff of Devonian limestone in the south bank of the Volga river, near Eagle Point; one and one-half miles west of Fayette. The level of the water is about ten feet above the base of the Devonian.

ing bluffs, and the Niagara escarpment gradually recedes on either side of the valley. Below Wadena the flood plain is one and one-half miles in width. In the river banks the gentle erosion curves of the shale are conspicuous to a height of nearly one hundred feet and for a distance of one-half mile back on either side of the channel.

The shale at the upper part of the Maquoketa deposits yields much more rapidly to the agents of erosion than do the overlying layers of limestone. As a result there is left in many places a narrow shelf of the limestone somewhat overhanging a bed of shale. As portions of the Niagara materials become unsupported, large masses are detached from the parent ledge and creep slowly downward towards the river flat, making ever wider the gorge of the stream. Such talus blocks are prominent features of the landscape over the gently inclined surface of the Maquoketa shales, often having temporarily come to rest many feet below the mass from which they were separated. Above the Maquoketa shale interrupted ramparts of Niagara limestone face each other across the valley of the river, which is here nearly two miles in width. From the top of this scarp the slope rises to a height of 300 feet above the level of the water.

Trees of hard maple thrive well on the Niagara crest and over the adjacent slopes. During the autumn months the rich crimson and gold of the leaves of the maple and sumach, mellowed by the softer hues of the oak and the aspen, lend an indescribable charm to the picturesque crags and weathered towers and peaks that crown the river bluffs.

The waters of Otter creek, between West Union and Elgin, have cut a gorge to a maximum depth of about three hundred and thirty feet. From about three miles west of the town of Brainard to the confluence of Otter creek with the Turkey river, there have been developed topographic forms which resemble those seen along the Volga river in the eastern portion of the county. Passing down the stream east of West Union the gorge gradually widens and the gentle erosion curves of the Upper Maquoketa shales rise constantly higher in the banks.

The Maquoketa beds flank either side of the flood plain to a maximum height of about two hundred feet and for a maximum distance of about three-fourths of a mile from the bed of the stream. The precipitous and somewhat interrupted scarp of Niagara limestone crowns the bluffs on either side of the valley.

The tributaries of this creek are usually rather short, with a very steep gradient. They have formed conspicuous alluvial fans composed largely of blocks of Niagara limestone which have been brought down from the steeper portions of the channel and stranded where the velocity of the stream was checked by the change to a more gradual slope. Along the larger tributaries the landscape presents features very similar to those that are encountered in the channels of the streams to which they render tribute.

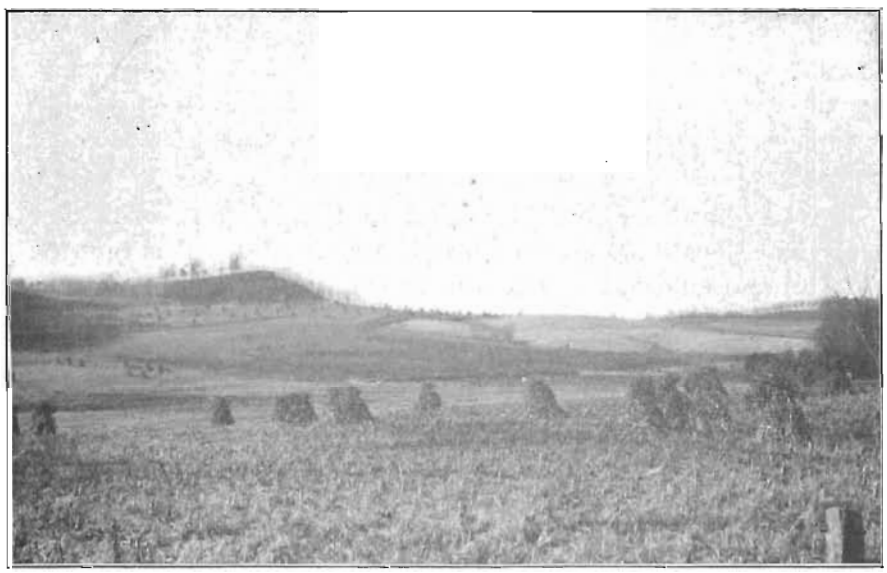

FIG. 31. View showing the gentle erosion curves of the Maquoketa shales and the scarp of Niagara crowning the slope. Along Otter creek in Pleasant Valley township.

The divide between the Volga river and Otter creek, and that between Otter creek and the Turkey river, are covered with a thick mantle of loess. Here, as elsewhere in the county, this material conforms in general to the inequalities of the preloessial surface. The regions have suffered extensive erosion and are thoroughly trenched by the lines of drainage. The topographic relief of these areas is unusually great owing to the proximity of the gorges occupied by the major streams.

The valley of the Turkey river is an excellent example of an old stream channel that has been developed through long continued ages of erosion. Throughout its course in the county the immediate banks which border the flood plain rise with a fairly abrupt slope to a height of from seventy-five to one hundred and fifty feet above the water. This bluff or terrace is determined by the presence of the indurated, cherty layers of the Middle Maquoketa deposits.

FIG. 35. View showing topography of the area over which the Upper Maquoketa shale underlies the superficial materials. Northeast ¼ of section 28, Clermont township.

With the exception of a small area in sections 2 and 3 of Auburn township, on the west, and a still more narrow strip about one mile in width bordering Clayton county, the region lying to the north of the river is a much trenched and thoroughly dissected plain. The surface is quite deeply loess covered. The tributaries of the second and the third order have carved deep channels in the comparatively soft shales of the Upper Maquoketa which immediately underlie the Pleistocene deposits over all of this area. The character of the topography of this portion of the county lying to the north of the Turkey river is shown in figure 35. The surface features are not

greatly unlike those of the typical loess-Kansan areas in other parts of the state, with the exception that here the superficial materials are underlain with nonresistant beds which have permitted even the smaller streams to develop more conspicuous trenches than is usual where the materials are more indurated.

On the south side of the river, for a distance of from one-half to one and one-half miles, the surface rises with a rather gradual slope to a height of about one hundred feet above the top of the terrace that bounds the flood plain. Over this region the loess is deep and the streams have developed topographic features similar to those encountered over the area north of the river. This gently sloping, much dissected strip, which borders the river on the south, is crowned by the more or less interrupted escarpment of Niagara limestone thirty to sixty feet in height. The resistant Niagara bed determines the skyline over all of that portion of the county lying to the east of Saint Lucas, Auburn Mills and West Union, and to the north of the town of Arlington and the Iowan drift border.

A double rampart or terrace—the upper formed by the Niagara and the lower by the indurated layers of the Middle Maquoketa, the two being separated by the softer erosion curves of the Upper Maquoketa beds—is a characteristic feature of the landscape, not only bordering the south side of the Turkey river and along all of the larger streams which render tribute thereto from the south, but also in the extreme eastern and the extreme western portions of the area north of the river where outliers of Niagara limestone cap the highest knobs.

This double scarp is very conspicuous in the bluffs that border the Little Turkey river between Auburn Mills and Eldorado. Further west in the southwest ¼ of section 30, Auburn township, the low banks of the Little Turkey are composed of Niagara limestone. Large talus blocks of this material are abundant along the foothills but the bluffs are not conspicuously high. Indeed, the Niagara here does not form prominent topographic features until quite a depth of the underlying shale is cut through by the streams, at which time the resistant cap of Niagara stands out in strong relief. On this account the

materials of the Niagara formation determine topographic forms to an extent out of all proportion to the thickness of the beds.

Flood Plains and River Terraces.—In the vicinity of the town of Fayette and further eastward, from the little village of Albany to the Fayette-Clayton county line, the Volga river flows in a broad flood plain from one-half mile to more than one mile in width. Just north of Albany, where the river is joined by a creek from the north, the river swamp expands into a wide plain which embraces about six hundred acres. Between Brainard and Elgin the waters of Otter creek have developed a river swamp from one-fourth to one-half mile in width.

The alluvial flats that border the above mentioned streams are insignificant, however, when compared with the flood plain that has been developed by the waters of the Turkey river. The latter stream meanders in a river marsh which has an average width of more than one mile. At Eldorado, where the river receives the water of the Little Turkey, the streams have carved out a broad amphitheater nearly two miles in diameter. Another such expansion of the flood plain has been formed at Dover Mills where the width is not much less than that at Eldorado.

Within the Iowan drift plain the Little Turkey and the Wapsipinicon rivers occupy broad depressions that are not true flood plains. These channels are remnants of preglacial valleys that were successively almost filled with detritus during the invasions of the Kansan and the Iowan glaciers.

Remnants of an old terrace eighteen to twenty feet in height are encountered at several points along the Turkey river. In the expansion of the flood plain at Eldorado these gravels cover an area of more than three hundred acres just east of the business portion of the town. In the angle of the valley west of the village the terrace is also conspicuous.

About two and one-half miles east of Eldorado, in the vicinity of the Huntsinger bridge, this old terrace is continuously exposed for a distance of nearly one-half mile. At this place the top is twenty feet above the level of the present flood plain. See figure 36. Near Dover Mills remnants of the terrace again

become conspicuous. The greater portion of the town of Clermont stands upon this gravel train. The gravels of the pit worked by the Chicago, Rock Island & Pacific Railway Company near Clermont are a part of this old fluvial deposit. Beds of gravel, somewhat modified by the more recent action of wind and water, are encountered along the river between Clermont and Elgin. The cemetery at Elgin is located upon a bench of this material, and the wagon road follows on such a terrace for some distance east of Elgin, to near the county line.

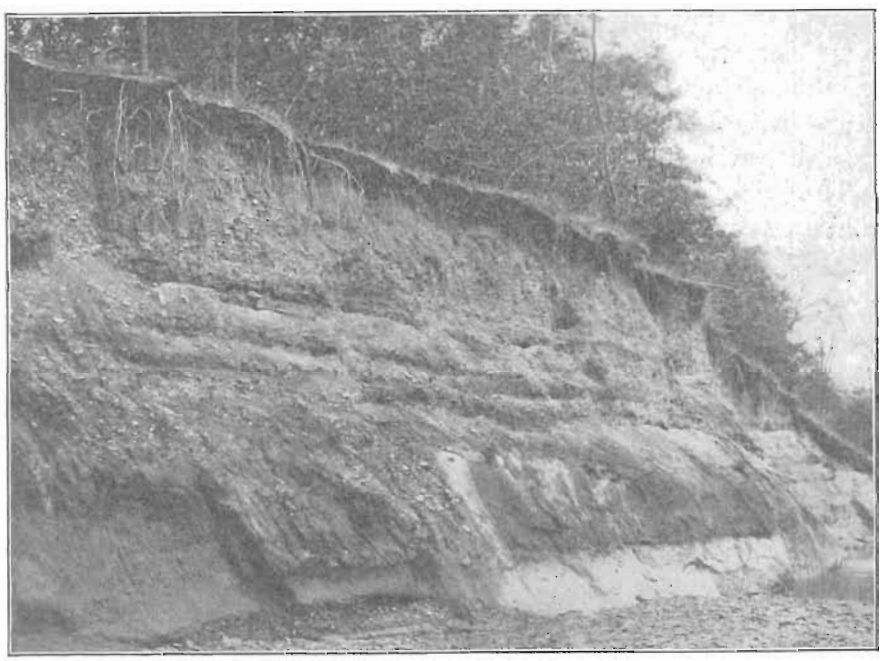

FIG. 56. View of the gravel terrace along the Turkey river, near the old Huntsinger bridge, two and one-half miles east of Eldorado. The gravel bench is twenty feet in height. The top of the very rusty, iron-stained zone appears a little below the middle.

In the vicinity of Waucoma these coarse, water-laid materials form a bench fifteen to eighteen feet in height, bordering the channel of the Little Turkey river. They are also encountered at the bridge near the south side of section 30 of Auburn township, and at other points along this stream.

To a height of a few feet in the lower part of the terrace the materials are highly ferruginous and profoundly oxidized, as shown in figure 36. The gravels in the upper portion are more fresh and but slightly stained with iron.

All of the facts seem to indicate that during the melting of the ice of the Kansan glacier the Turkey river was the line of discharge of a much larger volume of water than it carries at present. During this period of high water and excessive transportation, the river deposited a thick bed of gravel over the surface of the pre-Kansan flood plain. During the long interval between the Kansan and the Iowan ages the meanders of the river carved out this bed of gravel and lowered the flood plain to nearly its present level, leaving only disconnected patches of the former stream deposit in the form of a low terrace along the sides of its channel. Once again, when the Iowan ice was melting, there was a long period when the stream was flooded. During this interval a large river poured its torrents along this channel and formed wide embayments at the mouths of the tributary streams. At this time another blanket of river gravels was spread over the flooded plain, burying the alluvium of the bottom lands and the remnants of the Kansan terrace and building a flood plain deposit some feet higher even than that formed during the retreat of the Kansan ice.

After the melting of the Iowan ice, and the recession of the waters, the stream developed a flood plain at a new level which was determined by the mean volume of water that it has carried in recent years. Its meanders have removed all but a few scattered fragments of the materials it earlier deposited, which remnants reveal some of the chapters in the history of the changes that the stream has wrought, and in which it has had a share.

The elevation of the following places will give a general idea of the height above sea level of representative points in the county. The figures were taken from Gannett's Dictionary of Altitudes in the United States, from data furnished by the United States topographic sheets and from aneroid readings.

TABLE OF ALTITUDES.

	FEET.
Arlington	1113
Auburn	970
Brainard	919
Clermont, at station	866
Donnan	1151
Dover Mills, level of flood plain	863
Eldorado	924
Elgin	843
Fairbank	1000
Fayette	1003
Hawkeye	1173
Lima	935
Maynard	1106
Oelwein, Chicago, Rock Island & Pacific Railroad	1049
Oelwein, Chicago Great Western Railroad	1036
Postville Junction	1062
Putnam township, middle	1113
Randalia	1106
Saint Lucas	1060
Scott township, middle	1143
Smithfield township, middle	1168
Stanley	1098
Sumner	1060
Wadena	877
Waucoma	1045
Westgate	1091
West Union, Chicago, Rock Island & Pacific Railroad	1155
West Union, Chicago, Milwaukee & Saint Paul Railroad	1109

The lowest point in the county is where the channel of the Turkey river crosses the Fayette-Clayton county line at an elevation of 775 feet above the sea. The highest known point is in the northwest $\frac{1}{4}$ of section 14 of Windsor township, which reaches an altitude of 1,285 feet. The maximum topographic relief in the county is not less than 500 feet.

DRAINAGE.

The streams of Fayette county contribute to three principal drainage systems, whose master streams are the Wapsipinicon, the Maquoketa and the Turkey rivers. The main lines of discharge were outlined in preglacial times, but the cycle of erosion and the development of the respective basins were interrupted at least twice, and in some cases a third time, by the incursion of an ice sheet from the north. Each successive invasion of the ice choked the river valleys with glacial detritus, and more or less completely obliterated the channels of the smaller tributaries, and the minor inequalities of the pre-existing surface.

The Wapsipinicon River.—The Wapsipinicon river receives the run off from an area of about one hundred and sixty square miles in the southwest part of Fayette county. Its tributaries drain practically the whole of Jefferson, Oran and Fremont townships, and the west half of Banks, Harlan and Scott. The chief streams of this system in the county are the Little Wapsipinicon river and Otter creek. The former flows in a general southerly direction for a distance of about fifteen miles, in the south part of the western portion of the county.

The headwaters of the Otter creek that renders tribute to the Wapsipinicon river drain the larger portion of Harlan and Jefferson townships. These small streams, like the ultimate branches of all of the streams that gather water for the Wapsipinicon river, are fed by springs which issue in the form of marshes over the Iowan drift plain. They follow shallow depressions that were formed by the irregular heaping of the drift materials as the Iowan ice melted. Channels of erosion have been but slightly developed over this area, except in close proximity to the larger streams. Even these larger valleys owe their present features almost as much to the deposition of the drift in a preglacial channel as to the normal processes of water action.

The Maquoketa River.—Small streams which owe allegiance to the Maquoketa river drain about fifty square miles of the townships of Putnam and Scott. These small creeks are typical Iowan water courses. Like the branches which constitute the

headwaters of Otter creek and the Little Wapsipinicon river, they rise in marshy swales and follow swamp-like depressions which wind around the swells with many tortuous meanders and finally discharge their waters into another series of marshes whose channels are scarcely more distinct than those whose waters they receive.

The Turkey River.—The Turkey river includes in its basin nearly three-fourths of the surface of Fayette county. Its water flows in an old valley which, with an exceedingly sinuous course, crosses the northeast corner of Auburn township, the middle portion of Dover, the southwest corner of the township of Clermont and the northeast corner of Pleasant Valley.

The largest tributaries of the Turkey river in the region under consideration are the Little Turkey river and Otter creek. The former stream enters the county near the northeast corner of section 5 of Eden township. It follows a southeasterly course down to the northwest corner of section 31 of Auburn township. It then bears eastward to the village of Auburn, whence it trends towards the northeast for a few miles, its waters meeting those of the Turkey river near the town of Eldorado, in Dover township.

The Otter creek that owes allegiance to Turkey river takes its rise in the springs and swales of the Iowan plain near the east side of Windsor township. It follows a generally eastward course for a dozen miles, draining the greater portion of Union and the southern part of Pleasant Valley township, and joins the river near the town of Elgin. Numerous other streams of smaller size pay tribute to the Turkey river both from the north and from the south. Those from the north, which have worked in the beds of the Maquoketa shale, have developed longer channels and a more widely branching series of tributaries than those from the south, whose waters have acted upon the resistant ledges of the Niagara limestone.

Crane Creek.—Crane creek is the principal affluent of the Little Turkey river in Fayette county. It flows eastward across the southern portion of Eden township, and joins its major stream near the northwest corner of section 31 of Auburn township. It drains the north half of Bethel township and the south and west portions of Eden.

The Post-Glacial Gorge.—A small, southward flowing creek drains the western portion of section 24 of Dover township. Not far from the middle of section 24 this stream debouches in a broad valley which is a northward extension of the Turkey river flood plain. At this point the creek receives tribute of a small stream from the east. Here its waters have been deflected against the bluffs which border the west side of the valley, along which the stream follows closely for about seventy rods. Without any assignable cause it then swings quite

FIG 37. Looking up the post-glacial gorge carved in the Galena-Trenton limestone. Immediately after emerging from the gorge the stream crosses a drift-filled channel which may be seen to the left, in the picture. *Murchisonia major* appears in the bed of the stream. Southeast ¼ of section 24, Dover township.

abruptly eastward. From a point not far above this elbow, for a distance of thirty rods below the bend, the stream is bordered by fresh ledges of Trenton limestone, twelve to fourteen feet in height, and its waters are at present carving constantly deeper the youthful gorge. About ten rods above the wagon bridge that crosses this creek in the southeast ¼ of section 24, the

stream emerges from the gorge, but crosses a drift-filled valley, as shown in figure 37. After continuing to the east for a few rods it makes a detour towards the south following a preglacial channel for a distance of fifty rods. At this place, instead of swinging westward in the ancient valley, the present stream persists in its southward course, and it has carved another narrow gorge, to a depth of about fifteen feet in the resistant beds of the Galena-Trenton stage. This lower gorge is about twenty-five rods in length. From it the waters emerge upon the flood plain of the river and reach the major stream through a broad gravel-filled channel near the southwest corner of section 19, Dover township.

STRATIGRAPHY.

General Relations of Strata.

In the indurated rocks that are exposed in Fayette county there are represented three different systems of the Paleozoic group, the Ordovician, the Silurian and the Devonian. Of the Ordovician system there are encountered deposits of the Galena-Trenton and the Maquoketa stages, which belong to the Trenton series. All of the Silurian rocks of Iowa belong to the Niagara series, and of these there outcrop over our area deposits of the Delaware stage. The Devonian rocks of Fayette county belong to the Wapsipinicon and the Cedar Valley stages of the Middle Devonian series.

During the many geological ages that intervened between the laying down of the last of the Cedar Valley sediments and the invasion of the glaciers, the surface of Fayette county stood above the sea and was the theater of erosion rather than of deposition. We find the history of a portion of this long interval inscribed in the rocks further west in our own state, and a part of the records must be sought in other portions of our continent. During all of this time the agents of weathering and erosion were ceaselessly at work. Doubtless the cycle of erosion was more or less nearly completed again and yet

again, only to be as often interrupted by some slight shifting of the level of the land. There is every reason to suppose that the region was denuded of many hundreds of feet of strata that once overlay the uppermost Devonian rocks that now appear in the county.

The records of this immensely long period, that have here been preserved, are exceedingly slight when compared with the great length of the time. They consist of deep gorges and wide valleys that were carved by the streams out of the indurated beds. Some of these channels have since become partially filled with drift and many of them are completely buried beneath the mantle of superficial materials. Even over the deeply drift-covered portion of the area, where the surface is comparatively level, well borings and artificial excavations reveal the exceedingly rugged character of the surface over which the mantle of glacial detritus was spread.

The Pleistocene period is represented in Fayette county by three different sheets of drift, together with beds of loess and deposits of gravel, sand, and alluvium. The respective till sheets were deposited during the invasion of the pre-Kansan, the Kansan and the Iowan glaciers.

The successive stages of glaciation were separated by a long period of temperate climatic conditions during which the surface of the land was mantled with vegetation and peopled with animal life very much as it was before the natural faunal and floral relations of recent times were disturbed by the advent of civilized man.

The following table shows the relations of the different geological formations that are known to be exposed in the county:

TABLE OF FORMATIONS.

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Cenozoic.	Pleistocene.	Recent.		Alluvium and loess.
		Glacial.	Iowan.	
			Yarmouth.	
			Kansan.	
			Aftonian.	
			Pre-Kansan.	
Paleozoic.	Devonian.	Meso-Devonian.	Cedar Valley.	
			Wapsipinicon.	Upper Davenport.
				Lower Davenport.
	Silurian.	Niagara.	Delaware.	
	Ordovician.	Trenton.	Maquoketa.	Upper Maquoketa.
				Middle Maquoketa.
				Lower Maquoketa.
			Galena-Trenton	

Ordovician System.

GALENA-TRENTON STAGE.

The assemblage of strata in Iowa that are included in the Galena-Trenton stage is bounded below by the sandstone formation known as the Saint Peter, and above by the beds of shale and shaly limestones which constitute the Maquoketa stage. The deposits of the Galena-Trenton were originally distributed between two stages, the Trenton and the Galena. The lower group of strata, in which limestones and shales predominate, was called the Trenton. The upper beds, which further south are prevailingly dolomitic, were designated as the Galena.

Professor Calvin * has shown that these two groups of strata constitute one geological unit; that there is no stratigraphic or biologic line of separation between them. In certain places the materials have suffered local alteration which resulted in the dolomitization of the upper beds to a variable depth. The term Galena-Trenton is now applied to the entire aggregate of layers which are embraced between the limits mentioned above.

It will be observed from the foregoing table that the oldest rocks exposed in Fayette county belong to the Galena-Trenton stage. The materials are quite pure limestones, light gray in color, fairly fine-grained in texture, and very hard. The fragments break with a rough fracture and the weathered surfaces present a characteristic chipped and hackled appearance. The ledges are cut into rhomboidal blocks of variable size by numerous joints. The dolomite phase that is developed in the rocks near the top of this stage in Dubuque county is entirely wanting in our area.

An aggregate thickness of about thirty feet of the rocks of this stage is all that is exposed in the county. Outcrops appear at intervals to a height of ten to fifteen feet above low water in the banks of the Turkey river, from a point some distance above Dover Mills down to a short distance below the town of Clermont. Excellent exposures are encountered in the lower

* Calvin: Iowa Geol. Surv., Vol. X, pp. 406 *et seq.*, Des Moines.

portion of the channels of many of the streams that render tribute to the Turkey river between the points above mentioned. The rocks can be well studied in the post-glacial gorge near Dover Mills. They can be seen in the east bank of the river in sections 32 and 29 of Clermont township. They are well exposed along the bed and in the banks of a small creek that joins the Turkey river from the north, in section 28. They border the river for some rods both above and below the mill-dam at Clermont, and they appear in the banks of a dry run where it enters the corporate limits of the town of Clermont, near the northwest corner. At the latter place, where the stream is crossed by a wagon bridge, the upper layers of the rocks of this stage are well exposed.

Usually the planes of sedimentation can scarcely be distinguished in the weathered ledges, but along unweathered joint planes the materials appear to be disposed in quite regular layers which vary from four inches to more than one foot in thickness.

In a zone about fifteen feet below the top of the Galena-Trenton deposits there occur very numerous individuals of *Murchisonia major* Hall and *Fusispira ventricosa* Meek and Worthen. Associated with these there are found in lesser numbers Lophospira sp., *Trochonema umbilicatum* Hall. *T. robbinsi* Ulrich and Scofield, and *Fusispira nobilis* U. and S. From the rocks lying between this horizon and the top of the Trenton stage were collected *Zittelella lobata* U. and E., a second species of sponge that was undetermined, *Receptaculites oweni* Hall, *Ischadites iowensis* Owen, *Lingula iowensis* Owen, *Rafinesquina minnesotensis* N. H. Winchell, *Leptaena rhomboidalis* Wilckens, *Lophospira fillmorensis*? U. and S., Orthoceras sp. and an undetermined species of Illaenus. Near the top the materials of this stage grade up into a bed about nine feet in thickness, made up of layers of gray, crinoidal limestone which alternate with bands of calcareous shale. Both the shale and the indurated layers are from three to six inches in thickness, and both contain numerous fossils, among which were found *Streptelasma corniculum* Hall, *Rafinesquina alternata* Conrad, *R. deltoidea* Conrad, *Plectambonites sericea* Sowerby, *Strophomena*

incurvata Shepard, *Orthis* (*Dalmanella*) *testudinaria* Dalman, and a variety of this species of Orthis. The above bed is well exposed in a railroad cut a short distance northwest of Clermont. These layers can also be seen in the banks of a small ravine that discharges from the east into the lower post-glacial gorge, in section 24 of Dover township. They represent the transition from the Galena-Trenton to the Maquoketa deposits.

MAQUOKETA STAGE.

The strata of the Maquoketa stage constitute the uppermost deposits of the Ordovician system found in the state. The name Maquoketa was applied to the rocks of this stage by Dr. Charles A. White from the fact that these deposits are well developed along the Little Maquoketa river in Dubuque county. The term is synonymous with the Hudson River Shales* as used by Hall†, in his report on the Geology of Iowa. Dr. D. D. Owen‡ did not differentiate this group of strata when he discussed the geology of eastern Iowa, but included them in the deposits of the Upper Magnesian limestone.

In Fayette county the Maquoketa materials immediately underlie the Pleistocene deposits over nearly the whole of the area north of the Turkey river. They border that stream on the south over a strip one-fourth to one and one-half miles in width. They are seen in the bed of Otter creek, and appear in its banks to a constantly increasing height from the point where they are first encountered, about one and one-half miles east, and one-half mile south of West Union, to the junction of this creek with the Turkey river. In like manner the Maquoketa shale fringes the channel of the Little Turkey river from Auburn Mills to Eldorado. Near the bridge across the Little Turkey river, about the middle of the south side of section 30 of Auburn township, the Maquoketa shale appears in the north bank of the river to the height of nearly six feet above low water. As far as known this point is the most westerly exposure of the Maquoketa deposits that occurs in the county.

* White: Geology of Iowa, Vol, I, p. 180, *et seq.* 1870.
† Hall: Geology of Iowa, Vol. I, part 1, p. 64, *et seq.*
‡ Owen: Geology of Wisconsin, Iowa and Minnesota.

The shales of this age appear along the channel of the Volga river from a point some distance southwest of Albany to the eastern border of the county. These materials are also encountered in the banks of all of the larger tributaries of these streams between the points above mentioned.

The strata of the Maquoketa stage over this area fall naturally into three divisions. As a convenient means of referring to these divisions they will be designated respectively as the Lower, Middle, and Upper Maquoketa beds.

The basal portion of the Maquoketa beds consists of alternating layers of shale and argillaceous limestone. In the indurated layers near the bottom there occur very numerous fragments of *Isotelus maximus* Locke (*Asaphus iowensis* Owen). Towards the middle of the Lower Maquoketa beds the calcareous materials become predominant and the layers contain abundant remains of *Nileus vigilans*, and other species of trilobites. Towards the upper part of the lower Maquoketa the proportion of shale gradually increases and the deposit blends into a bed of blue colored, tenaceous clay. The maximum thickness of the Lower Maquoketa strata is about ninety-five feet.

The Middle member of the Maquoketa deposits is made up of a bed of cherty limestone which in some places is strongly magnesian. Where the materials are of limestone, they are arranged in layers three to six or eight inches in thickness. The chert masses are usually somewhat segregated along the lines of bedding, but there are also numerous concretions enclosed in the limestone of the various layers. Where the rocks are the most nearly dolomitic, as at Clermont, the chert nodules are very abundant, often appearing in conspicuous bands. The thickness of this member varies from forty to sixty feet. It impresses itself strongly upon the topography of the region over which it outcrops on account of the indurated character of the layers, and because of the fact that immediately above and below this phase the materials are of rather soft, incoherent shale.

The upper division of the Maquoketa deposits is made up of a body of quite plastic, bluish-gray shale. This bed carries numerous crystals of selenite but it is practically barren of

fossils, with the exception of a zone eight to twelve feet in thickness, near the top, where there are harder, calcareous bands intercalated between layers of shale. This member has a thickness, in some places, of not less than one hundred and twenty-five feet.

The rocks of the respective divisions of the Maquoketa stage are quite constant in their lithological characters, and quite uniformly developed over all of the area of Fayette county in which they are exposed. A continuous section of the Maquoketa beds, from the base of the *Nileus vigilans* zone to the contact of the Maquoketa with the overlying Niagara limestone, can be seen on passing up the channel of Cascade gulch, a small stream which joins the Turkey river about one mile southeast of the town of Eldorado.

A consideration of a number of exposures will make clear the characteristics of the rocks of the Maquoketa stage as a whole, as well as those that distinguish the strata of each of the three divisions.

TYPICAL EXPOSURES.

The Lower Maquoketa Division.—Just below the old milldam at Dover Mills the Trenton limestone appears in the south bank of the Turkey river to a height of eight or ten feet above the water. A few rods west from this point a small stream joins the river from the south. In walking up the bed of this stream the following succession of layers is passed over, the lowest of which is about eight feet above the top of the Trenton limestone exposed at the milldam.

		FEET.
6.	Bed of bluish colored, plastic shale, not indurated; containing the fossils *Rafinesquina alternata*, *Plectambonites sericea*, *Strophomena incurvata*, *Orthis* (*Dalmanella*) *testudinaria*, and *Rhynchotrema capax*.....	15
5.	Bed of yellowish colored shale, in places somewhat arenaceous, the lower portion containing fragments of yellowish, impure limestone imbedded in a matrix of shale. The following fossils are characteristic of this member: *Strophomena planumbona*, *Orthis* (*Hebertella*) *insculpla*, and *O.* (*Plectorthis*) *whitfieldi*.....	13

FEET.

4. Bed composed of alternating layers of yellowish-gray shale and of yellowish colored, impure limestone, each two to three inches in thickness; argillaceous materials predominate in the upper part. The indurated bands contain numerous nodules of chert and carry the following fossils: *Hindia parva?*, *Plectambonites sericea*, *Orthis (Dalmanella) testudinaria*, *Rhynchotrema inaequivalvis*, *Murchisonia gracilis* and two or three species of Orthoceras..... 16

3. Bed of gray limestone in layers one to three inches in thickness, with thin seams of yellowish colored shale separating the successive bands of limestone; the proportion of shale increases towards the top; the following fossils are not rare: *Nileus vigilans*, *Calymene senaria* and *Pterygometopus calliccphalus*.—*Nileus vigilans* zone 15

2. Bed consisting of layers of lean, yellowish colored, indurated shale, two to three inches in thickness, with some irregular layers of limestone and bands of chert nodules of about equal thickness with the seams of shale. Fossils rare. 18

1. Bed made up of layers of bluish colored, fine-grained, argillaceous, limestone, three to eight inches in thickness, between which are intercalated bands of blue colored shale of about the same thickness. The indurated layers of this bed contain very numerous remains of *Isotelus maximus* and a few other fossils..... 14

The foregoing will be designated as the Dover Mills section. The entire aggregate of layers which constitute the Lower Maquoketa beds are here represented. The materials of the successive members do not change abruptly, but the ratio of the shale to the calcareous constituents increases or diminishes gradually in passing from one member to another.

The lower layers of number 1 represent the basal portion of the Maquoketa deposits. This member will be referred to as the *Isotelus maximus* horizon on account of the fact that the remains of this trilobite are exceedingly abundant in the indurated layers. So numerous are the fragments of these individuals that not infrequently a score of pygidia, glabellæ and cheeks are found on the surface of a slab two feet square. Notwithstanding the abundance of the fragments of this species,

entire individuals are exceedingly rare. Mr. A. G. Becker, of Clermont, has collected a few almost perfect specimens of this species, and he has also found associated with these, an entire individual of a related species in which the cephalon is prolonged anteriorly into a peculiar snout-like projection, somewhat similar to that of the *Asaphus extenuata* Ang.* The equivalent of the rocks of number 1 are exposed below the bridge in the roadside, near the middle of section 21, Clermont township, and also along a ravine near the wagon road about the middle of the east half of section 33. They are conspicuous in the north bank of a small creek for several rods before it joins the Turkey river, near the middle of the south side of section 3 of Pleasant Valley township. They appear in a bluff just above the wagon bridge a short distance west of the middle of section 35 of the township of Clermont. The beds at the latter place are shown in figure 38. They are here overlain by the layers of the succeeding member. These beds are also well exposed, near the wagon road, in the bed and banks of a small stream about three miles east of Elgin, a short distance beyond the Fayette-Clayton county line. In all of the above mentioned exposures the remains of the characteristic fossil, *Isotelus maximus* Locke, occur in great abundance.

A bed which corresponds with number 2 of the Dover Mills section outcrops along Otter creek within the limits of the town of Elgin. The rocks of this member here form the bed of the stream, and appear in the south bank to a height of twelve or fourteen feet, underlying the zone of *Nileus vigilans*. The wagon road passing up the hill north of Clermont has been cut through the rocks of this horizon, exposing on either side a height of about eighteen feet. These materials may also be seen near the wagon road in the southeast corner of section 12 of Pleasant Valley township, and they outcrop in the south bank of a small stream in the northeast ¼ of section 11 of the township of Clermont. The rocks of this member consist of quite hard, yellowish colored shale, in layers from one to two or three inches in thickness. The shale is in places calcareous, and in others it contains an admixture of sand. Between the bands of

* See figure 1303. Zittell's Text-Book of Palæontology. Trans. by C. R. Eastman, Vol. I, p. 630.

shale are intercalated irregular layers of limestone which carry a large number of chert nodules. The limestone layers are about equal in thickness to the bands of shale. The materials furnish but few fossils, *Lophospira quadrisulcata* U. and S., *Bellerophon bilobatus* Sowerby, Trochonema sp., fragments of two other species of gastropods, *Orthoceras bilineatum* Hall and an undetermined species of Orthoceras being all that were collected from this horizon.

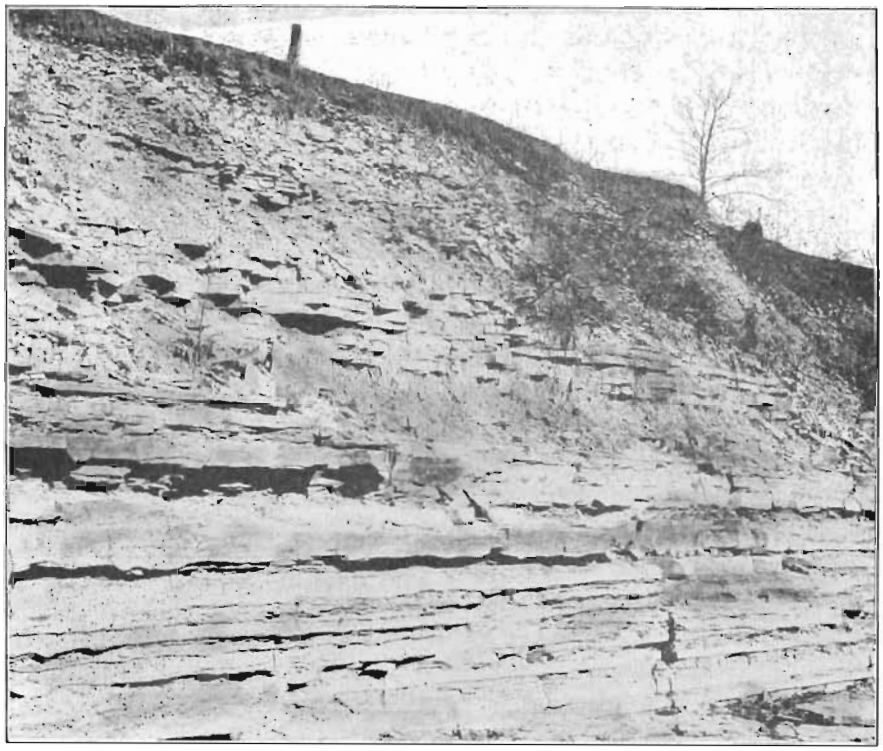

FIG 38. Beds of *Isotelus maximus* which constitute the basal deposits of the Maquoketa shales; north of the bridge in section 35, Clermont township.

Number 3 of the Dover Mills section will be known as the *Nileus vigilans* zone. The limestone layers are prevailingly thicker than the bands of shale that lie between them. The materials are gray or yellowish-gray in color and the indurated layers are quite hard. The characteristic fossil is *Nileus*

vigilans Meek and Worthen, which is most abundant near the middle of the member, but the species ranges in lesser numbers throughout the bed. Associated with the above are found several other species of trilobites, among which are *Bumastus orbicaudatus* Billings, *Ceraurus icarus* Billings, *C. pleurexanthemus* Green, *Calymene senaria* Conrad, *Pterygometopus callicephalus* Hall, and a species of Dalmanites. Besides the above trilobites the rocks of this horizon have furnished *Hindia parva* Ulrich,

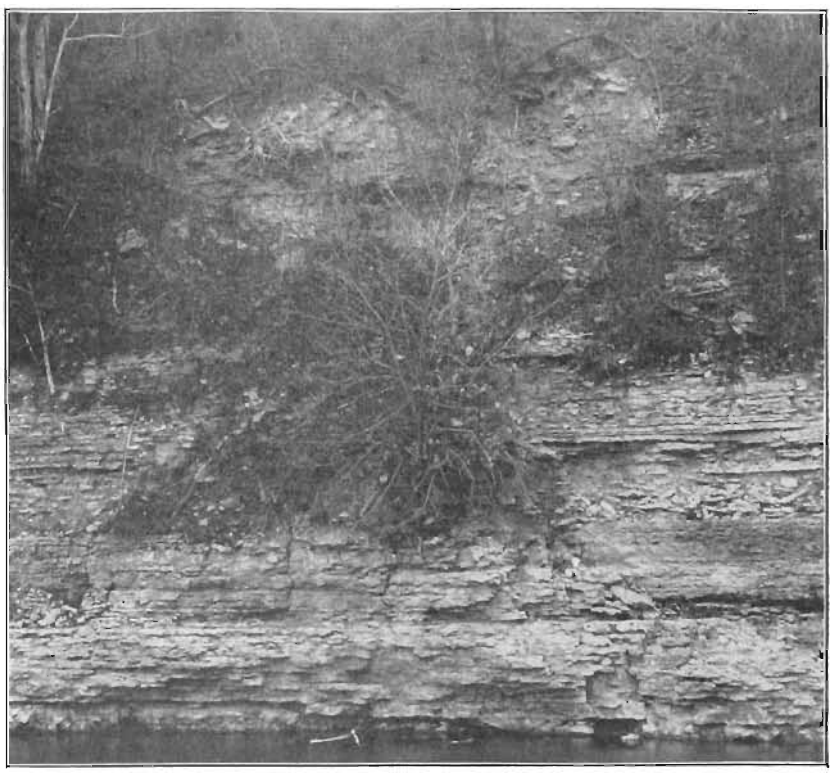

FIG. 39. Exposure of the Lower Maquoketa shale in the south bank of Otter creek at Elgin, Iowa. The *Niteus vigilans* zone appears in the upper part.

Rafinesquina minnesotensis N. H. Winchell, *Plectambonites sericea* Sowerby, *Strophomena fluctuosa* Billings, *Orthis* (*Dalmanella*) *testudinaria* Dalman, *O.* (*Hebertella*) *insculpta* Hall, *Rhynchotrema capax* Conrad, Trochonema sp., two undetermined species of Orthoceras and a species of Trochoceras.

The layers of the *Nileus vigilans* horizon are well exposed in the south bank, of the Turkey river, near the west side of section 17 and the east side of section 18 of Dover township. They can be studied in the hill just north of Postville junction, in section 2 of Clermont township. They appear in the bed and banks of a small stream a short distance north of the middle of the east side of section 13, Pleasant Valley township. Perhaps the best known exposure is in the south bank of Otter creek, in the town of Elgin, where they appear near the top of the bluff in an almost continuous exposure for several rods before the creek joins the river. The materials of this member can be well studied in the south bank of the Turkey river in the vicinity of Cascade gulch, about one mile southeast of Eldorado, where they are exposed continuously for a distance of several rods.

Number 4 of the foregoing section consists of alternating layers, about equal in thickness, of yellowish-gray, arenaceous limestone and bands of impure, yellow colored shale. Towards the top of the bed the shaly materials become predominant. When they have been long exposed to the atmosphere, these layers weather down into a lean, somewhat sandy and slightly calcareous clay.

The characteristic fossils of this member are shells resembling *Clitambonites diversa* Shaler, *Rhynchotrema inaequivalvis* Castlenau, *Murchisonia gracilis* Hall, and *Orthoceras sociale* Hall. Besides these the layers contain numerous other fossils among which are *Hindia parva?* Ulrich, *Rafinesquina alternata* Conrad, *R. minnesotensis* N. H. Winchell, *Strophomena planumbona* Hall, *Plectambonites sericea* Sowerby, *Leptæna unicostata* M. & W., *Orthis (Dalmanella) testudinaria* Dalman, *O. (Hebertella) insculpta* Hall, *O. (Plectorthis) whitfieldi* N. H. Winchell, *O. (Plectorthis) plicatella* Hall, *Rhynchotrema capax* Conrad, *Bellerophon bilobatus* Hall, *Gyronema* cf. *pulchellum* U. & S., an undetermined species of Orthoceras, *Cyrtoceras camarum?* Hall, *Calymene senaria* Conrad, and *Pterygometopus callicephalus* Hall.

The materials of this member can be well studied along the bed of Cascade gulch, near the southwest corner of section 17 of Dover township. They form a low bluff bordering the river a

few rods above the mill at Eldorado. They outcrop towards the top of a hill a short distance west of Postville Junction, and they are also to be seen, above the beds of number 3, in the bluff just north of the latter place. They are well exposed near the middle of the north side of section 25 of Dover township. A bed composed of the weathered materials of these layers is encountered in the roadway, about the middle of the southwest ¼ of section 4 in Dover township. At the latter exposure there were collected *Hindia parva?* Ulrich, *Rafinesquina alternata* Conrad, Leptaena sp., *Plectambonites sericea* Sowerby, *Clitambonites diversa?* Shaler, *Orthis* (*Dalmanella*) *testudinaria* Dalman, *O.* (*Hebertella*) *insculpta* Hall, *O.* (*Plectorthis*) *whitfieldi*, N. H. W., *O.* (*Plectorthis*) *plicatella* Hall, *Rhynchotrema capax* Conrad, *R. inaequivalvis* Castlenau, Bellerophon sp., and a large Orthoceras resembling *Camaroceras proteiforme* Hall.

Number 5 of the Dover Mills section consists of about fourteen feet of yellowish-gray shale which in some places is quite plastic. Crystals of selenite are not rare and, in the lower portion of the bed, there are occasional layers of impure limestone two to four inches in thickness. In a zone a short distance below the middle of this member there occurs in great abundance well preserved shells of *Orthis* (*Plectorthis*) *whitfieldi*, N. H. Winchell. Mr. Winchell* states that this species is nearly related to *Orthis kankakensis* McChesney, but that the former species is less elongated along the hinge line, is more nearly square in outline, and bears a less number of plications. The individuals, which are very abundant at this horizon in Fayette county, possess characters which ally them very closely indeed with *Orthis kankakensis* McChesney.

The layers of this member constitute the typical horizon for *Orthis* (*Plectorthis*) *whitfieldi*, although this fossil makes its earliest appearance in layers considerably lower down, and it is occasionally encountered well towards the top of this division. *Orthis* (*Hebertella*) *insculpta* Hall, also occurs the most abundantly in the layers of this member. Associated with these fossils there were found at the Dover Mills exposure *Hindia parva?* Ulrich, *Streptelasma corniculum* Hall, *Rafinesquina alternata* Conrad, *R. minnesotensis* N. H. W., *Plectambonites sericea*

*Winchell: Geol. and Nat. Hist. Surv., of Minn. Vol. III. Part I, p. 438.

Sowerby, *Strophomena fluctuosa* Billings, *Orthis* (*Dinorthis*) *subquadrata* Hall, *O.* (*Dalmanella*) *testudinaria* Dalman, and *Rhynchotrema capax* Conrad. Materials which are the equivalent of number 5 of the section appear along the road-side a short distance north of the schoolhouse, and in the banks of a small stream a few rods still further north, near the middle of the east side of section 19 of Clermont township. The layers in the east bank of this stream are in places slightly crumpled, as ap-

FIG. 40. A small fold in the Lower Maquoketa shale, at the horizon of *Orthis whitfieldi*. In a ravine a short distance west of the middle of section 19, Clermont township.

pears in figure 40, but the flexures are probably due to the creeping of the shales under the pressure from the hill above. At the latter place the *Orthis* (*Plectorthis*) *whitfieldi* horizon is well exposed. From these exposures the following fossils were collected: *Hindia parva?* Ulrich, *Rafinesquina alternata* Conrad, *R. minnesotensis* N. H. W., *Plectambonites sericea* Sowerby,

Strophomena planumbona Hall, *S. fluctuosa* Billings, *Orthis (Dinorthis) subquadrata* Hall, *O. (Dalmanella) testudinaria* Dalman, *O. (Hebertella) insculpta* Hall, *O. (Plectorthis) whitfieldi*, N. H. W., *Rhynchotrema capax* Conrad, *R. inaequivalvis* Castlenau, *Murchisonia gracilis* Hall but much less abundant than in number 4, *Bellerophon bilobatus* Hall, Trochonema sp., Conularia sp., Orthoceras sp., and *Pterygometopus callicephalus* Hall.

In passing up Cascade gulch, near Eldorado, the layers of number 5 succeed those of the fourth member of the section in their normal order, and they may also be seen overlying the layers of number 4, in the north bank of the Turkey river, a short distance above the mill in the same town. A weathered shale bed of this horizon appears in the wagon road along the south bank of the Little Turkey river about one mile west of Eldorado, near the middle of the east side of section 13, Auburn township. From this exposure a number of interesting fossils were collected, among which were *Streptelasma corniculum* Hall, an undescribed species of Streptelasma in which the septa unite at the center in such a manner as to form a columella-like elevation on the floor of the calyx, *Plectambonites sericea* Sowerby, *Strophomena planumbona* Hall, *Orthis (Dalmanella) testudinaria* Dalman, *O. (Dalmanella) hamburgensis?* Walcott, *O. (Hebertella) insculpta* Hall, *Rhynchotrema capax* Conrad, *Rhynchonella neenah* Whitfield, *Zygospira modesta* Say, *Z. recurvirostra* Hall, Ctenodonta? sp., Parastrophia sp., and Orthoceras sp.

Number 6 of the Dover Mills section represents the uppermost deposits of the Lower Maquoketa division. It consists of a bed of blue or bluish-gray, plastic shale about fifteen feet in thickness. At some points the shale carries numerous fossils, while at others not far distant it is almost barren of organic remains. This upper phase of the Lower Maquoketa deposits is well exposed in the abandoned clay pit of the Clermont Brick and Tile Company, in the hill north of Clermont. At this place the shale bed is overlain by the indurated, chert-bearing layers of the Middle Maquoketa division. The pit from which the clay for the above mentioned plant is taken at present is worked in the same horizon, a short distance below the top of the member. At none of these exposures were fossils abundant.

Just south of a small wagon bridge near the line between sections 19 and 20 of Clermont township, the hard, cherty layers of the Middle Maquoketa division can be seen overlying a bed of tenaceous, blue colored shale which corresponds with number 6 of the section at Dover Mills. The transition from the shale to the limestone is abrupt, as is usually the case wherever the contact between these two divisions is seen. The shale at this place is about fourteen feet in thickness and carries the following fossils: Crania? sp., *Rafinesquina minnesotensis* N. H. Winchell, *R. alternata* Conrad, *Plectambonites sericea* Sowerby, *Strophomena fluctuosa* Billings, *Orthis* (*Dalmanella*) *testudinaria* Dalman, *O.* (*Hebertella*) *insculpta* Hall, *O.* (*Plectorthis*) *whitfieldi*, N. H. W., *Rhynchotrema capax* Conrad, Orthoceras sp. and a fragment of a species of Bumastus.

About two and one-half miles down the Little Turkey river from the village of Auburn, just below the wagon road near the middle of section 24 of Auburn township, a small stream has cut through the cherty layers of the Middle Maquoketa beds. From near the base of this zone the water falls about fifteen feet, down to the level of the river. In this gorge there is exposed a bed of blue colored shale immediately underlying the indurated layers of the Middle Maquoketa. This shale deposit is also the equivalent of number 6 in the Dover Mills section, and it has furnished the fossils, *Rafinesquina minnesotensis*, N. H. W., *Plectambonites sericea* Sowerby, *Strophomena incurvata* Shepard, *Orthis* (*Dinorthis*) *pectinella* (Emmons) Hall, *O.* (*Dalmanella*) *testudinaria* Dalman, *O.* (*Hebertella*) *insculpta* Hall, *O.* (*Plectorthis*) *whitfieldi*, N. H. W., *Rhynchotrema capax* Conrad, Orthoceras sp., *Trochoceras baeri* Meek, Bumastus sp. and a species of Pterygometopus.

The shale deposit of this same horizon is also well exposed, and attains a similar development, in the bed of Cascade gulch just below the hard, cherty layers of the Middle Maquoketa beds.

The Middle Maquoketa Division.—The entire thickness of the indurated, chert-bearing layers of the Middle Maquoketa deposit

is well exposed in the banks of Cascade gulch, about fifty rods above the point where this stream meets the river. The section here is as follows:

		FEET.
4.	Heavy layer of impure limestone, yellowish-gray in color and rather fine-grained in texture; containing a few chert nodules, but these are less abundant than in the preceding members; showing imperfect planes of bedding	5
3.	Bed of impure limestone in rather even layers two to six inches in thickness. The layers are largely composed of crowded masses of chert imbedded in the limestone matrix, or segregated along the lines of stratification; bearing *Streptelasma corniculum*, very large individuals of *Rafinesquina alternata* and of *Rhynchotrema capax* together with *Orthis* (*Dalmanella*) *lesludinaria* and a second species of Orthis	13
2.	Bed made up of quite regular layers of fine-grained, impure limestone, six to eight or ten inches in thickness; containing very numerous concretions of chert, and having chert bands intercalated between the layers of limestone; the fossils *Rafinesquina alternata*, *Orthis* (*Dalmanella*) *testudinaria*, *O.* (*Hebertella*) *insculpta* and *Rhynchotrema capax* are present	20
1.	Thin layers of yellow colored, fine-grained, magnesian limestone, which breaks with a smooth fracture and appears homogeneous throughout; bearing few chert masses, and containing *Lingula iowensis*, and several individuals of one or more species of Orthoceras	7

These resistant layers stand in vertical cliffs in the banks on either side of the stream, and they appear in the channel as an abrupt declivity over which the water flows in steep cascades.

A bluff, the materials of which belong to this same horizon, is exposed in the east bank of a small stream about one-half mile south of the village of Auburn, near the middle of section 35 of Auburn township. At this place the limestone is less magnesian than that described in the foregoing section. The ledge is made up of even layers which contain a large proportion of chert in the form of imbedded nodules and irregular bands. Along the banks of the Little Turkey river this phase is exposed at a number of points between Auburn and Eldorado. The en-

during character of the materials is manifest in the conspicuous bluff or terrace that flanks the valley a short distance back on either side of the flood plain. Occasionally a small stream has cut a narrow gorge through this ledge and has built a conspicuous alluvial fan of chert fragments where it debouches on the flood plain of the river. About three miles down the Little Turkey river from Auburn a cliff of these chert-bearing layers of the Middle Maquoketa phase borders the east side of the flood plain for a distance of twenty-five rods and to a height of about thirty-five feet.

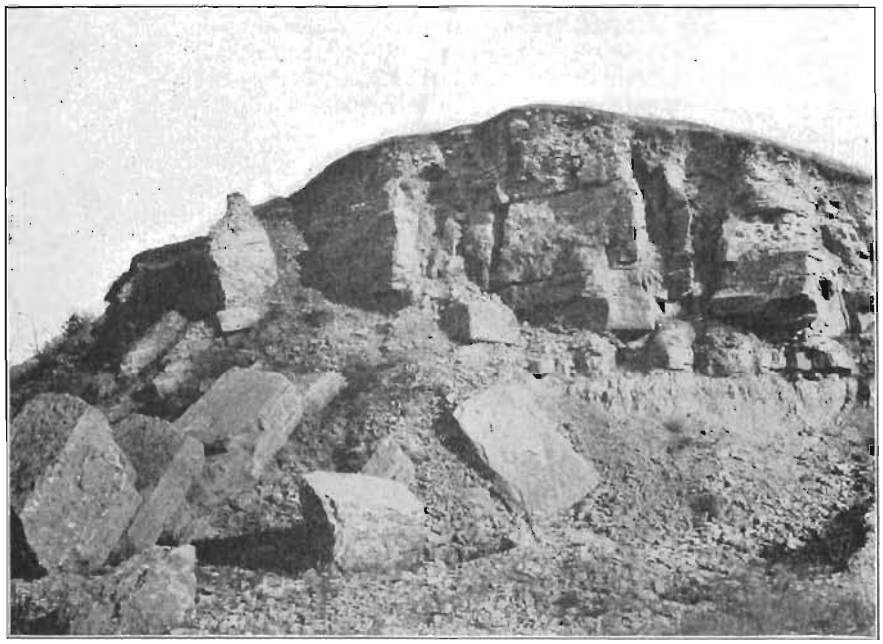

FIG. 41. View in the abandoned clay pit of the Clermont Brick and Tile Company, showing the cherty, indurated layers of the Middle Maquoketa beds overlying the uppermost zone of the Lower Maquoketa shale. Clermont, Iowa.

Near the extreme northwest corner of section 6 of Dover township, the cherty limestone of this same horizon is well exposed in the banks of a small creek. The layers here are fairly pure carbonate of lime, with the exception of the great number of chert nodules which they carry. They are very hard, and break with a hackly fracture In a zone correspond-

ing with number 3, of the last section *Rafinesquina alternata* Conrad, was very abundant. The following fossils were also collected here: *Streptelasma corniculum* Hall, *Lingula iowensis* Owen, *Rafinesquina minnesotensis* N. H. W., *R. alternata* var. *loxorhytis* Meek, *Leptæna unicostata* N. & W., *Strophomena incurvata* Shepard, Strophomena sp., *Orthis* (*Dalmanites*) *testudinaria* Dalman, *O.* (*Hebertella*) *insculpta* Hall, *O.* (*Plectorthis*) *whitfieldi* N. H. W., *O.* (*Dinorthis*) *subquadrata* Hall, very large individuals of *Rhynchotrema capax* Conrad, *R. perlamellosa* Whitfield, and a species of Trochonema somewhat resembling *T. umbilicatum* Hall.

A bed of the Middle Maquoketa materials, which is the equivalent of numbers 1 and 2 of the foregoing section, is well shown overlying the upper portion of the Lower Maquoketa division in the abandoned clay pit of the Clermont Brick and Tile Company, a short distance north of Clermont. See figure 41. At this place the following section is exposed:

		FEET
5.	Bed of yellow colored dolomite, in layers one to three inches in thickness; nearly one-half of the material of these layers is composed of chert nodules and masses of about one inch in thickness	8
4.	Massive bed of yellow colored, magnesian limestone which shows indistinct lines of bedding, and contains a large amount of chert in the form of irregular nodules and more or less interrupted bands. The following fossils were found here: *Rafinesquina alternata*, Strophomena sp., *Orthis* (*Dalmanella*) *testudinaria*, *O.* (*Hebertella*) *insculpta*, *Rhynchotrema capax* and fragments of individuals of two species of Orthoceras	5
3.	Bed composed of two layers of yellow colored dolomite, which are respectively two and one-fourth and one and three-fourths feet in thickness. The exposed surfaces show numerous cavities from which small concretions have weathered. Small nodules of chert are quite numerous; the layers contain *Rafinesquina alternata*, *Orthis* (*Dalmanella*) *testudinaria* and *Rhynchotrema capax*	4
2.	Bed of arenaceo-magnesian limestone, rather homogeneous, yellowish in color, containing but few concretions of chert	3
1.	Bed of yellowish-gray shale, quite hard, without evident planes of stratification, and carrying no fossils	14

In the section given above, number 1 is the equivalent of number 6 of the section at Dover Mills. It represents the upper portion of the Lower Maquoketa deposits. Numbers 2 and 3 together correspond with number 1 of the section of the cherty beds exposed in Cascade gulch, and represent the basal materials of the Middle Maquoketa. Numbers 4 and 5 combined are readily correlated with number 2 of the section in Cascade gulch. The even and indurated character of the layers of this division, and the very large amount of chert which they carry, make it an easy matter to distinguish the Middle Maquoketa beds from the shale deposits either above or below this chert-bearing phase. In our area the fossil *Rafinesquina alternata* var. *loxorhytis* Meek was found only at this horizon.

About one and one-half miles east of Brainard the Middle Maquoketa cherts appear to a height of twenty-five feet in the north bank of Otter creek.

At a point eighty rods southwest of the station at Brainard, near the middle of section 30 of Pleasant Valley township, a small quarry is worked in the south bank of Otter creek which shows the following succession of layers:

		FEET.
4.	Reddish colored clay, for the most part residual; barren of organic remains	2½
3.	Bed of yellow to gray colored, arenaceous shale, becoming blue in color towards the top, without fossils	3½
2.	Bed composed of narrow layers of arenaceo-magnesian limestone, yellowish-gray in color, and quite hard; containing a large admixture of shale, but no fossils	5
1.	Bed consisting of two layers of yellowish, impure limestone, each about two feet in thickness; containing small masses of calcite and an occasional nodule of chert	4

In the foregoing section, number 1 represents the uppermost deposits of the Middle Maquoketa beds, and corresponds with number 4 of the section of this horizon in Cascade gulch. Number 2 represents the transition materials from the Middle to the Upper Maquoketa deposits. These materials consist of five or six feet of alternating layers of arenaceo-magnesian

limestone, and lean, somewhat sandy, impure shale. The layers are four to eight inches in thickness and contain no fossils. At this place the transition to the shales of the Upper Maquoketa beds is much less abrupt than it appears in the channel of Cascade gulch. Numbers 3 and 4 of the section represent the basal portion of the Upper Maquoketa beds.

The Upper Maquoketa Division.—The Upper Maquoketa deposits can be well studied along the banks of Otter creek, and in the channels of the tributary streams, in the vicinity of the village of Brainard. Near the middle of the north side of section 24, Union township, the creek swings to the south and has exposed in its west bank a thickness of about fifty feet of blue, tenaceous shale. The bed here shows no trace of stratification, nor does it contain any fossils. Large, compound crystals of selenite are quite abundant in the clay. From the top of this bluff the inclination is rather gentle for about fifty feet more, up to the foot of the scarp of Niagara limestone. The base of the exposure is about twenty feet above the top of the Middle Maquoketa beds. The outcrop represents the middle and lower portion of the Upper Maquoketa.

At Patterson's spring, about one mile north of Brainard, the contact of the Maquoketa with the Niagara is well exposed. At this point, a short distance west of the middle of section 20 of Pleasant Valley township, the following section may be studied in a small ravine:

		FEET.
7.	Bed composed of yellow colored, rather coarse-grained dolomite, in layers four to twelve inches in thickness; containing a few small nodules of chert, and occasional fossils.....	6
6.	Bed of rather fine-grained, yellow colored, magnesian limestone, homogeneous in texture, evenly bedded, and breaks with clean fracture; containing no fossils or chert concretions.....	2
5.	Bed composed of indurated layers of very fossiliferous, gray limestone, one to four inches in thickness, which are separated by narrow, softer seams of blue shale which also contain numerous fossils	2½

		FEET.
4.	Bed in which the calcareous layers are less indurated and thinner than in number 5 above, separated by narrow bands of blue shale. The material is very fossiliferous throughout, containing *Leptaena unicostata, Orthis occidentalis, Tentaculites sterlingensis* and other forms.....	1½
3.	Layer of rather incoherent shale, blue or bluish-gray, or in places reddish-brown, in color; containing very numerous fossils, among which are a branching monticuliporoid, *Leptaena unicostata*, *Orthis occidentalis* and *O.* (*Platystrophia*) *biforata* var. *acutilirata*.....	2
2.	Layer of hard, bluish-gray shale; without fossils..	⅝
1.	Homogeneous, blue colored shale, very soft and plastic where soaked with water; containing small concretions of iron pyrites, and but few fossils.....	14

The foregoing will be designated as the Patterson's Spring section. Upon following down the channel of this small stream, a vertical thickness of nearly one hundred feet of plastic, blue colored shale, quite similar to number 1 of the section, is passed over. Number 2 is a band of shale much more indurated than the great body of the shale seen at this place.

Numbers 3, 4 and 5 are exceedingly fossiliferous. Some of the calcareous layers are composed almost wholly of ramose colonies of a monticuliporoid, together with *Leptaena unicostata* Meek and Worthen, and a lesser number of detached valves of *Orthis occidentalis* Hall. *Leptaena unicostata* is exceedingly abundant at this horizon. The individuals are exceptionally large and well preserved, but it is very rarely that a ventral valve shows any trace of the median costa. Besides the above, the following fossils were collected from these uppermost members of the Maquoketa stage at Patterson's spring. Crania sp., *Streptelasma corniculum* Hall, *Rafinesquina minnesotensis* N. H. W., Leptaena sp., *Plectambonites sericea* Sowerby, *Strophomena trilobata* Owen, *Orthis* (*Platystrophia*) *biforata* var. *lynx* Eichwald, *O.* (*Platystrophia*) *biforata* var. *acutilirata* James, *Rhynchotrema capax* Conrad, *Zygospira modesta* Say., Bellerophon sp., *Cyclonema bilix* Conrad, *Tentaculites sterlingensis* Meek and Worthen, *Pterinea demissa* Conrad, *Ambonychia radiata* Hall, *A. intermedia* Meek and Worthen and *Calymene senaria* Conrad.

At the old Rawson's mill, a short distance north of the middle of the west side of section 3, Fairfield township, the following beds are exposed in the bluff that borders Bear creek on the east:

		FEET.
4.	Ledge of heavy layers of Niagara dolomite.....	16
3.	Bed of grayish-blue shale, near the top of which there are a few thin, indurated bands; fossiliferous throughout, containing *Streptelasma corniculum*, *Leptaena unicostata*, *Plectambonites sericea*, *Orthis occidentalis* and *Rhynchotrema capax*.....	14
2.	Weathered bed of gray shale, with somewhat indurated bands two to eight inches in thickness. The following fossils are abundant: *Plectambonites sericea*, *Orthis occidentalis*, *O.* (*Platystrophia*) *biforata* var., and *Rhynchotrema capax*...	18
1.	Bed of blue colored, plastic shale, carrying fine crystals of selenite, but containing no fossils ..	35

In the above exposure the depth of the fossiliferous zone near the top of the Maquoketa is much greater than that of the corresponding phase at Patterson's spring, ten miles further north. It is possible that a portion of the materials that are exposed in number 2 of the Rawson's Mill section may have crept down the slope from a higher position, and that in reality they are a duplicate of number 3. There was no way of satisfactorily determining whether this is the case or not, but at no other place in the county, where the materials of this horizon are clearly exposed, does the fossiliferous zone attain a thickness of more than eight to twelve feet. About one mile west of Rawson's mill a shale bed corresponding with number 1 of the last section may be seen in the north bank of Bear creek. The materials here are blue in color and quite plastic. They contain numerous crystals of gypsum but no fossils.

Near the center of the north side of section 35 of Auburn township a small affluent joins the Little Turkey river from the east. A few rods north of the point where this stream discharges into the river the cherty, indurated layers at the top of the Middle Maquoketa beds are exposed to a height of eight feet above low water. Upon walking up the channel of the above mentioned stream the entire thickness of the Upper

Maquoketa beds is passed over. At this place the deposit has a depth of not less than one hundred feet. The material is bluish-gray in color, is quite plastic and, near the top, it contains the fossils *Streptelasma corniculum* Hall, *Leptaena unicostata* Meek and Worthen, *Plectambonites sericea* Sowerby, *Orthis occidentalis* Hall, *O. (Platystrophia) biforata* var. *acutilirata* James, *O. (Dalmanella) testudinaria* Dalman, and *Rhynchotrema capax*. Conrad. The transition to the overlying Niagara beds is well shown and the materials are not unlike those seen at Patterson's spring, although the number and variety of fossils is not so great as at the latter exposure.

Near the middle of the south side of section 21 of Illyria township, a short distance northwest of Wadena, the following succession of layers may be seen in the banks of a small ravine:

		FEET.
6.	Bed composed of layers of Niagara dolomite, six to eighteen inches in thickness, yellow in color; containing few fossils	8
5.	Layer of yellowish-brown shale, strongly stained with iron	1
4.	Gray colored shale in which are present iron-stained, indurated bands, three-fourths to one inch in thickness, which are crowded with poorly preserved fragments of shells. *Plectambonites sericea* and *Orthis occidentalis* were recognized	3½
3.	Indurated layers of limestone, two to seven inches in thickness, which are crowded with broken fragments of brachiopod shells, and separated one from another by bands of shale.	4
2.	Gray colored shale, containing small concretions of iron pyrites, and thin bands of iron-stained materials; no fossils	3
1.	Blue colored, plastic shale which breaks into irregular fragments, and contains no fossils...	21

In the above section numbers 1 and 2 are the equivalents of numbers 1 and 2 of the section at Patterson's spring. Numbers 3 to 5 inclusive of the foregoing section correspond with the horizon represented by numbers 3 to 5 inclusive of the Patterson's Spring exposure. Number 6 above represents the basal portion of the Niagara limestone at this place, and it is the correlative of numbers 6 and 7 inclusive of the Patterson's Spring section.

Another exposure very similar to the last appears in the bed of a ravine near the southeast corner of section 1, Fairfield township. At this place the ledge of Niagara dolomite is eight feet in thickness, and is composed of quite regular, nonfossiliferous layers, six to eighteen inches in thickness. Below this dolomite there appears about ten feet of the uppermost layers of the Maquoketa, consisting of narrow, indurated, calcareous bands, separated one from another by seams of shale. Both the shale and the limestone layers carry numerous individuals of *Plectambonites sericea*, *Orthis occidentalis* and other fossils characteristic of this horizon. Below the transition beds there may be seen about thirty feet of blue colored nonfossiliferous shale, containing small concretions of iron pyrites.

The materials of the Upper Maquoketa beds are also well exposed in the town of Saint Lucas, near the northern limits of the county. They outcrop along the wagon road in the hill upon the summit of which the large Catholic church is built. The materials at this place do not differ in any special way from those of the Upper Maquoketa beds at Auburn and at Patterson's spring. In the upper part there were found the fossils that are characteristic of this zone at other places in the county.

The deposits of the Upper Maquoketa beds, and the contact of these with the overlying Niagara limestone, appear in the channel of a number of the smaller tributaries of the Volga river, Otter creek, the Little Turkey and the Turkey rivers. As a general thing the contact of the Niagara with the Maquoketa shale is well exposed in the beds of these streams, if no great thickness of the Niagara is present at the point where the water cuts through the limestone and into the underlying shale. When the depth of the Niagara materials is great, such contact is usually concealed by the large limestone masses that have fallen down from above, and which the waters are unable to transport further down the channels.

From the foregoing descriptions it will have been noticed that the lithological characters of the Upper Maquoketa beds in Fayette county are quite unlike those of the Middle and the Lower Maquoketa deposits. They are very similar, however, to those of the Upper Maquoketa materials in the county of

Dubuque. In our area the assemblage of fossils that occurs in the zone near the top of the Upper Maquoketa is also quite different from the fauna of the Middle or the Lower Maquoketa beds, but it is practically identical with that of the corresponding horizon further south, in Dubuque county. Professor Calvin* has called attention to the fact that the fauna that is found in the materials near the top of the Upper Maquoketa, in Dubuque county, is practically the same as that which is encountered in the Cincinnati shales of southwestern Ohio. The fossils of the Upper Maquoketa beds in Fayette county make still more complete the correspondence of the biologic contents of the Upper Maquoketa of Iowa with those of the Cincinnati shales in Ohio and Indiana.

From a comparison of the foregoing sections a general section of the Maquoketa strata of Fayette county may be constructed as follows:

GENERAL SECTION OF THE MAQUOKETA SHALES.

		FEET.
13.	Bed composed of bands of soft, bluish-gray shale, two to four inches in thickness, which alternate with thin layers of limestone one to three inches in thickness, having a band of reddish shale two feet in thickness at the base. The materials are fossiliferous throughout, containing numerous colonies of a branching Monticuliporoid, *Leptaena unicostata*, *Plectambonites sericea*, *Strophomena trilobata*, *Orthis occidentalis*, *O.* (*Platystrophia*) *biforata* var., *Rhynchotrema capax*, *Cyclonema bilix* and *Ambonychia radiata*.....	8-12
12.	Bed of blue colored, plastic shale, without distinct planes of bedding; containing small concretions of iron pyrites in the upper part and numerous large crystals of selenite below; bearing no fossils.....	95-110
11.	Transition beds from the Middle to the Upper Maquoketa; consisting of layers of yellowish arenaceo-magnesian limestone, three to eight inches in thickness alternating with bands of dry, indurated, impure shale; without fossils	3-5

*Calvin: Geology of Dubuque County, Iowa, Geol. Surv., Vol. X, p. 444.

FEET.

10. Massive bed of yellow colored limestone, which in some places is dolomitic, sometimes showing indistinct planes of bedding that separate the ledge into imperfect layers, six to twelve inches in thickness; bearing few fossils, and occasional concretions of chert..... 5

9. Bed of impure limestone (in places dolomitic) made up of quite regular layers, two to six inches in thickness; containing a large quantity of chert in the form of nodules and imperfect bands; bearing the fossils *Streptelasma corniculum, Rafinesquina alternata, R. alternata*, var. *loxorhytis, Leptaena unicostata* and *Rhynchotrema capax*..... 12-14

8. Bed of fine-grained, impure limestone, in even layers six to ten inches in thickness, consisting largely of chert nodules imbedded in the layers or of chert bands segregated along the planes of bedding; containing large individuals of *Rafinesquina alternata, Strophomena incurvata, Orthis* (*Dalmanella*) *testudinaria, O.* (*Hebertella*) *insculpta*, and *Rhynchotrema capax*.... 18-21

7. Massive bed of yellow colored, fine-grained dolomite, which in some places is divided into thin layers; containing a number of chert nodules, and bearing *Lingula iowensis* and Orthoceras sp..... 5 7

6. Bed of bluish colored, plastic, rather fine-grained shale; in places containing numerous fossils among them *Rafinesquina alternata, R. minnesotensis, Plectambonites sericea, Strophomena incurvata, Orthis* (*Dalmanella*) *testudinaria, Rhynchotrema capax*, and *Trochoceras baeri?*..10-14

5. Bed of lean, yellowish-gray shale, in places somewhat arenaceous; containing, in the lower part, thin bands of impure limestone, three to six inches in thickness; bearing *Strophomena planumbona, Orthis* (*Dinorthis*) *subquadrata, O.* (*Hebertella*) *insculpta* and *O.* (*Plectorthis*) *whitfieldi*.....10-13

4. Bed composed of layers of yellowish-gray shale, three to six inches in thickness, separated by bands of impure limestone about equal in thickness to the seams of shale, becoming more calcareous below; bearing numerous nodules of chert, and containing *Plectambonites sericea, Orthis* (*Hebertella*) *insculpta, Rhynchotrema inaequivalvis, Murchisonia gracilis, Pterygometopus callicephalus* and *Ceraurus pleurexanthemus*.....14-16

FEET.

3. *Nileus vigilans* zone: consisting of a bed of gray colored limestone in layers one to four inches in thickness, which are separated from one another by thin bands of gray shale; containing *Nileus vigilans*, *Calymene senaria*, *Pterygometopus callicephalus* and *Ceraurus icarus*.....13–16
2. Bed of bluish or yellowish colored shale, usually dry and indurated, in layers two or three inches in thickness, between which thin bands of limestone or irregular seams of chert nodules are intercalated; among the fossils are *Lophospira quadrisulcata* and *Orthoceras bilineatum*.....15–18
1. *Isolelus maximus* zone: composed of layers of bluish, fine-grained, argillaceous limestone, four to eight inches in thickness, alternating with bands of bluish-gray shale of about the same thickness as the calcareous layers. The indurated materials break with a smooth fracture and contain very abundant fragments of the trilobite *Isolelus maximus*..... .14–16

A study of the above section will show that the strata of the Maquoketa stage in Fayette county attain a maximum thickness of about two hundred and sixty feet. Numbers 1 to 6 inclusive constitute the Lower Maquoketa beds which have a thickness of more than ninety feet. Numbers 7 to 11 inclusive belong to the Middle Maquoketa division, with a thickness of about fifty feet. Numbers 12 and 13 represent the deposits of the Upper Maquoketa which have a maximum thickness of about one hundred and twenty feet.

The fossils of the Maquoketa are of more than usual interest both on account of the number and variety of the forms and from the fact that the fauna of the Upper Maquoketa beds presents such a marked contrast with that of the Middle and Lower Maquoketa divisions. Below is given a list of the more common species that occur in Fayette county. These will furnish a general idea of the forms of life that flourished in this portion of that old Ordovician sea.

FOSSILS OF THE MAQUOKETA SHALES.

Astylospongia? sp.†
Hindia parva Ulrich.†
Streptelasma corniculum Hall.* ‡ †
Streptelasma sp.†
Lingula iowensis Owen.‡ †
Crania sp.*
Rafinesquina alternata Conrad.* ‡ †
R. alternata var. *loxorhytis* Meek.‡
R. minnesotensis N. H. Winchell.* ‡ †
Leptæna unicostata Meek and Worthen.* †
Plectambonites sericea Sowerby.* ‡ †
Strophomena planumbona Hall.†
S. fluctuosa Billings.†
S. incurvata Shepard.‡ †
S. trilobata Owen.*
Strophomena sp. †
Clitambonites diversa ? Shaler.†
Parastrophia sp.†
Orthis (*Dinorthis*) *subquadrata* Hall.†
O. (*Dinorthis*) *pectinella* (Emmons) Hall.†
O occidentalis Hall.*
O. (*Hebertella*) *insculpta* Hall.‡ †
O. (*Plectorthis*) *whitfieldi* N. H. Winchell.†
O. (*Plectorthis*) *plicatella* Hall.†
O. (*Plectorthis*) *fissicosta* Hall.†
O (*Dalmanella*) *testudinaria* Dalman.* ‡ †
O (*Dalmanella*) *hamburgensis* Walcott.†
O. (*Platystrophia*) *biforata* var. *lynx* Eichwald.* †
O. (*Platystrophia*) *biforata* var. *acutilirata* James *
Rhynchotrema capax Conrad.* ‡ †
R. perlamellosa Whitfield.†
R. inæquivalvis Castlenau.†
Rhynchonella neenah Whitfield.†
Zygospira modesta (Say) Hall.* †
Z. recurvirostra Hall.†
Murchisonia gracilis Hall.†
Lophospira cf. *conoidea* U.*
L. quadrisulcata U. & S.†
Bellerophon bilobatus Sowerby †
Bellerophon sp.†
Helicotoma sp.*
Trochonema umbilicatum Hall.†
Trochonema sp.†
Gyronema pulchellum ? W. and S.†
Cyclonema bilix Conrad.*

* Collected from the Upper Maquoketa beds.
‡ Found in the Middle Maquoketa.
† Occur in the Lower Maquoketa.

Holopea cf. *concinnula* U. & S.†
Tentaculites sterlingensis Meek and Worthen.*
Conularia sp.†
Pterinea demissa Conrad.*
Ambonychia radiata Hall.*
A. intermedia Meek and Worthen.*
Ambonychia sp.*
Orthoceras sociale Hall.†
O. bilineatum Hall.†
Orthoceras sp.†
Cameroceras proteiforme Hall.†
Cyrtoceras camarum? Hall.†
Trochoceras? baeri M. & W.*
Gyroceras sp.†
Isotelus maximus Locke.†
Isotelus sp.†
Bumastus orbicaudatus Billings.†
Nileus vigilans Meek and Worthen.†
Calymene senaria Conrad.* †
Ceraurus icarus Billings.†
C. pleurexanthemus Green.†
Pterygometopus callicephalus Hall.†
Dalmanites sp.†

The presence of an impervious body of shale beneath the porous, and more or less jointed beds of Niagara limestone determines a zone of springs along the line of contact of the Niagara with the Maquoketa shale. Occasionally as at the Falling Spring, shown in figure 42, the water issues a few feet above the base of the Niagara. In such places it would seem probable that a large mass of the limestone had slipped downward from its original position, owing to the more rapid weathering of the shales upon which it rested. In that event the water, which further back in the bank follows near the line of contact, would find a ready outlet along the planes of bedding when it encountered the ledge of Niagara limestone.

*Collected from the Upper Maquoketa beds.
| Found in the Middle Maquoketa.
†Occur in the Lower Maquoketa.

Niagara Series.

DELAWARE STAGE.

The rocks of the Delaware stage immediately underlie the superficial materials over an exceedingly irregular area in the northern, eastern and southern portions of Fayette county. By referring to the Geological map it will be seen that they are

FIG. 42. Falling Spring near the middle of the south side of section 35, Auburn township. The water issues a few feet above the top of the Maquoketa shales.

present over the greater portion of Auburn township, except where they have been eroded in the development of the gorges occupied by the Turkey and Little Turkey rivers. The most westerly appearance of the Niagara limestone, in the northern

portion of the county, is in the bed and banks of Crane creek near the middle of section 34, Eden township, where it outcrops to a height of a few feet. Following down the creek from this point the Niagara disappears for a distance of a mile and one-half, after which it is again seen in the banks more or less continuously down to the junction of this stream with the Little Turkey river.

The Delaware deposits appear in the extreme northeast corner of Windsor township, and in section 25 of Eden. They are present over the area south of the Turkey river, in the townships of Dover, Clermont and Pleasant Valley. They cap a few disconnected knobs in sections 24, 25 and 26 of Clermont township, and sections 1 and 12 of Pleasant Valley. They are the uppermost indurated rocks in the northern and eastern portions of Union township, the eastern portion of Westfield and Smithfield, and the whole of the townships of Illyria and Fairfield. The unconsolidated, mantle materials that appear at the surface over all of the southern tier of townships, with the exception of the extreme southwest corner of Oran, probably rest upon these enduring layers of the Delaware stage. The strata of the Niagara do not attain anything like the thickness in Fayette county that they do further to the southeast in the county of Delaware, where they reach a thickness of more than two hundred feet. It seems certain that the aggregate thickness of the Niagara limestone constantly decreases towards the northwest, from the southern border of Fayette county. At the "Devil's Backbone," about two miles southeast of West Union, the complete section of the Niagara may be seen within a distance of fifty rods. At this place the entire thickness of the beds does not exceed seventy feet.

In the wagon road a short distance east of the middle of section 33 of Auburn township, the Devonian limestone appears in the top of the hill as one approaches the Little Turkey river from the south. At a distance of eight rods from this place the Maquoketa shale is exposed in a small ravine to a height of twenty feet above the level of the river, and it is succeeded by a cliff of Niagara limestone. The thickness of the Niagara beds at this place does not exceed forty feet.

A few rods east of the wagon bridge, near the middle of the south side of section 30, Auburn township, about six feet of the Maquoketa shale outcrop in the north bank of the river. The flood plain here is bounded by low bluffs of Niagara limestone to a height of thirty feet above the bed of the stream. One mile to the southwest from this place the top of a ledge of Niagara appears in the north bank of Crane creek fifteen feet above the water and it is overlain by about twenty feet of Devonian limestone. It would seem probable that in this vicinity the Niagara strata are not more than twenty-five feet in thickness. Still further towards the northwest, in Winneshiek and Howard counties, the Niagara limestone has in places entirely faded out, and the Maquoketa shales are immediately succeeded by strata of Devonian age.*

Over the southern portion of the county the Niagara limestone is a rather coarse-grained, yellowish-brown dolomite. In some places it contains an admixture of sand, and it usually carries a large number of chert nodules. In the vicinity of West Union the material is often a fine-grained, very hard limestone, light gray in color, and contains a very large amount of chert concretions. Near the small town of Auburn the Niagara is prevailingly a gray limestone which reacts vigorously with cold hydrochloric acid. The layers are two to six feet in thickness. They are somewhat vesicular, and show no traces of lamination planes. They are very hard and, when broken, they cleave as readily in one direction as another into fragments of irregular shape.

The absence of dolomitization and the remarkable purity of the Niagara limestone in this vicinity will appear from an analysis of representative samples taken from the blocks of Niagara that overlook the village of Auburn from the east. The analysis was made by the Survey Chemist, Prof. L. G. Michael, and shows the following:

Calcium carbonate, $CaCO_3$	98.52
Silica, SiO_2	.68
Alumina and iron, Al_2O_3, Fe_2O_3	.50

*Calvin: Iowa Geol. Surv., Vol. XIII, pp. 47 and 48.

Here, as everywhere, the enduring ledges are cliff-forming to a remarkable degree. Where a region has suffered extensive erosion they impress themselves upon the topography to an extent out of all proportion to the thickness of the beds.

Exposures.—In the northeast ¼ of section 24, Clermont township, Mr. Wilkes Williams operates a quarry in the lower layers of the Niagara limestone. The section at this place is as follows:

		FEET.
8.	Bed of reddish colored clay, largely residual, but containing occasional pebbles and small bowlders of greenstone and granite	3
7.	Bed of much decayed, yellow colored dolomite, containing very abundant nodules of chert; long exposed surfaces present numerous cavities from which chert masses have weathered; lamination planes irregular, and imperfectly developed, indicated by bands of chert	14
6.	Layer of coarse-grained, yellow colored dolomite, which contains a large amount of chert in the upper part	2
5.	Heavy ledge of dolomite, yellow in color and rather coarsely granular in texture, without chert	3½
4.	Layer of coarse-grained dolomite, yellow in color, containing no chert	1
3.	Regular layer of rather fine-grained dolomite, without chert	1⅝
2.	Layer of yellow colored dolomite, resembling number 1 in texture; two and one-half feet in thickness at the south end of the quarry, increasing to four feet in thickness at the north end	4
1.	Heavy ledge of homogeneous, fine-grained dolomite, with no tendency to split along planes of lamination, and containing no fossils or chert nodules; increasing in thickness toward the north	4

The first member of the foregoing section rests upon the top of the Maquoketa shale, and represents the basal layer of the Niagara limestone. This layer together with numbers 2 and 3 have an even texture, and carry no fossils or chert masses. They furnish excellent materials for sills, water tables and general range work. The stone is quarried in large blocks, and

then sawed into any dimensions desired. These members supply all of the material for dressed stone and sawed work that the quarry produces. Numbers 4 and 5 are also free from chert, and furnish stone suitable for bridge copings and general masonry. No use is made of the upper layers in which chert masses are numerous and cavities abundant.

Number 8 consists of a tough red clay in which are mingled chert fragments and occasional pebbles and small

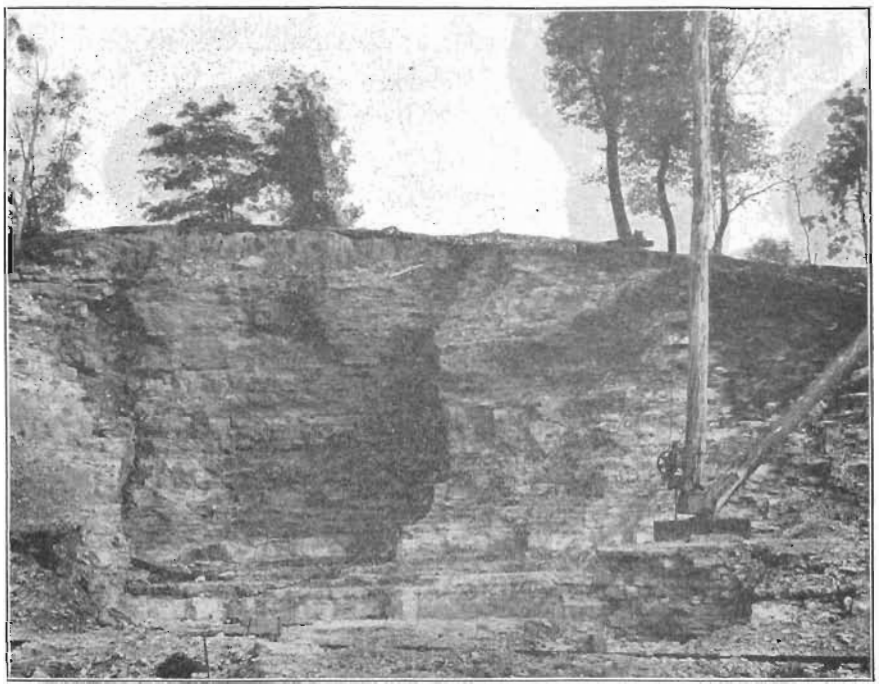

FIG. 43. View of the Niagara limestone in the old Williams and Davis quarry, southeast ¼ of section 15, Union township. The stone here represents the upper portion of the Niagara in Fayette county.

bowlders. The clay is largely a product of rock decay in situ, to which the name "geest" has been applied. Such residual products are frequently exposed along the hillslopes over the Niagara area.

If the lower, fine-grained, quarry-stone layers persist to the southward, they thin out quite rapidly. In the Patterson's Spring section number 6, which consists of layers of fine-grained, homogeneous materials having an aggregate thickness of two feet, seems to be all that corresponds with the lower fourteen feet of quarry stone in Williams' quarry.

A large amount of chert is usually present throughout the middle portion of the Niagara beds in Fayette county. This characteristic is conspicuous at the old Williams and Davis quarry, which has been opened in the north bank of Otter creek, near the northeast corner of section 22 of Union township. The characters of the strata appear in figure 43. The following succession of layers is exposed here:

		FEET.
8.	Layer of impure limestone, yellowish gray in color, and fine-grained; no chert	1½
7.	Ledge of gray colored, very hard limestone, in places showing a tendency to separate into layers eight, three, two, four and eight inches in thickness respectively; without fossils, and containing no chert	2
6.	Much shattered layer of gray limestone, containing a very large amount of chert in the form of nodules and irregular masses	1½
5.	Layer of dense, fine-grained limestone, gray in color, without fossils, almost free from chert in the middle portion	1
4.	Bed of gray limestone consisting of layers two to four inches in thickness, which are separated from one another by bands of chert	4
3.	Bed of fine-grained, gray limestone, in two layers one and one-third feet and one foot in thickness; containing much chert and separated by a chert seam	2½
2.	Massive layer of gray limestone, containing a very large amount of chert in the form of bands and imbedded nodules	3½
1.	Bed of gray, cherty limestone, in layers three to six inches in thickness	4

In the above section the horizon of number 1 is very near that of the top of number 7 in the Williams' Quarry section. The very great amount of chert which the layers contain renders them unfit for use except as riprap, ballast or macadam.

The materials in this quarry are not dolomitized with the exception of a zone a few feet in thickness near the top. The rock is very fine-grained and sub-crystalline in texture. In the first member there is a zone in which indistinct traces of a coral having very small tubes, or of a Stromatoporoid, are very abundant, but in the process of alteration which the rocks have undergone the structure of the fossils has been largely obliterated.

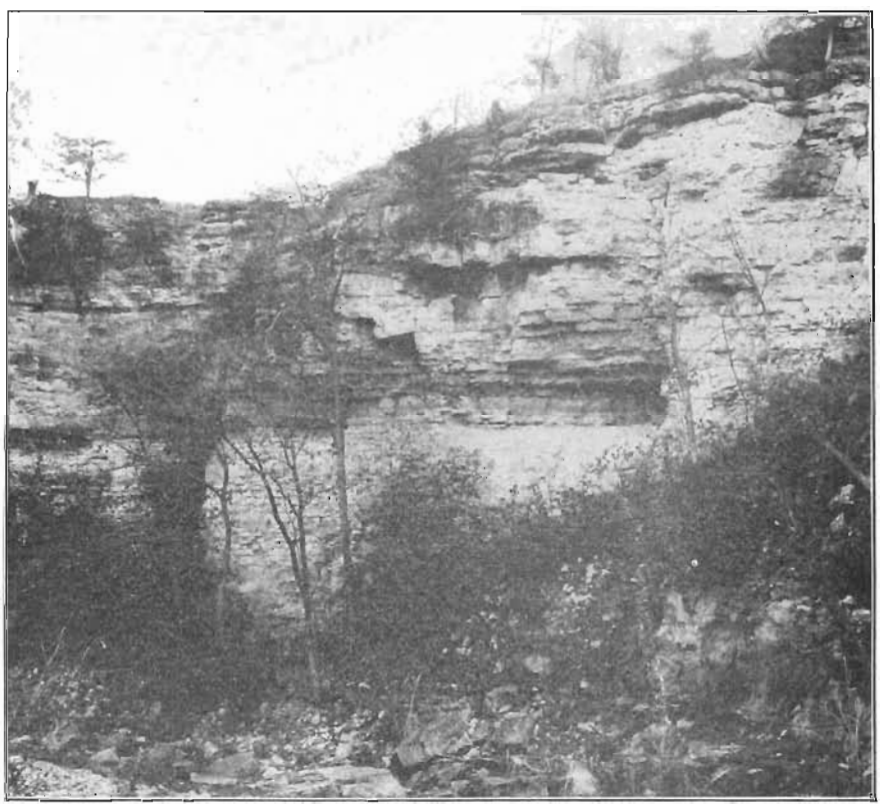

FIG. 44. Section of the Niagara limestone at the "Devil's Backbone", two and one-half miles southeast of West Union. Nearly the entire thickness of the Niagara in the county is here exposed.

An abandoned quarry in the northeast ¼ of section 21 of Fairfield township shows a ledge of chert-bearing, nonfossiliferous layers which belong to the upper portion of the Niagara

deposits, and which are probably the equivalent of the layers seen in the Williams and Davis quarry. Materials similar to the above are also encountered along a stream a short distance north of Arlington.

A few rods west of the Williams and Davis quarry, a cliff of Niagara limestone, sixty feet in height, is exposed in the north bank of the creek, see figure 44. That the basal layer in this bluff is but a very few feet above the Maquoketa shale, if indeed it does not rest upon the Maquoketa, is shown by the fact that fifteen rods down the creek from this point the shale appears in the bank to a height of eight feet above the water. That the uppermost layer of the bluff is only a very few feet below the base of the Devonian, if its horizon is not immediately below the Devonian, appears from the fact that in the railroad cut, about thirty rods southwest of this point, the top of the Niagara is well exposed at no greater altitude than the top of the bluff. In the cut, the Niagara is succeeded by a bed of fine-grained, finely laminated Devonian limestone, four and one-half feet in thickness. It seems certain that the aggregate thickness of the Niagara strata in this region is not more than seventy feet.

Few fossils were found in any of the above mentioned exposures of the Niagara, and none of these were sufficiently well preserved for identification. Where the layers outcrop in a nearly east and west direction, in the bluff, they appear horizontal, as is shown in figure 44. Where these layers are seen in a north and south direction, in the railroad cut, their position is also nearly horizontal, but they present gentle undulations six inches to one foot in vertical height. That portion of the Niagara immediately underlying the Devonian in this cut could not be satisfactorily studied, on account of the steepness of the face of the ledge.

The uppermost layers of Niagara limestone, and the succeeding Devonian strata, can be observed under more favorable conditions about three and one-half miles south, and one and one-half miles west of this cut. There is a continuous outcrop for several rods, in the south bank of a small creek, a short distance east of the center of section 5, Westfield township. The layers are as follows:

		FEET.
7.	Bed composed of fragments of drab colored, fine-grained limestone, imbedded in a matrix of calcareous material which is also fine-grained in texture but lighter in color, without fossils; the layers show slight undulations. Lower Davenport breccia	12
6.	Bed composed of fine-grained, yellowish colored limestone which is very finely laminated; upon weathering the material splits along the lamination planes into thin, fissile fragments; without fossils. A few feet at the top somewhat talus-covered	9
5.	Irregular band of yellow colored dolomite, coarse-grained in texture, in places appearing somewhat arenaceous; nonfossiliferous	1½
4.	Bed of yellow, impure dolomite, in layers four to eight inches thick; bearing some chert, and containing *Favosites favosus* and *Halysites catenulatus*	3
3.	Bed of vesicular dolomite, coarsely granular in texture, and yellow in color, made up of layers two to six inches in thickness, which contain *Favosites favosus* and *Halysites catenulatus* besides a number of brachiopods; nodules of chert are not rare	5
2.	Layer of porous, yellowish-brown dolomite, containing many concretions of chert, and bearing the fossils *Favosites favosus*, *Halysites catenulatus* and a species of Orthoceras	1⅙
1.	Layer of yellowish-brown dolomite, somewhat sandy in places, containing chert concretions; to level of the water	1½

In the above, which will be referred to as the Niagara-Devonian Contact section, numbers 6 and 7 represent Devonian limestone. The line of separation of the Niagara from the Devonian would be drawn between numbers 5 and 6. The change in the lithology of the materials above and below this line is very marked. The Niagara layers embrace numbers 1 to 5 inclusive. The material is coarsely granular, and in some parts of the exposure it is distinctly arenaceous. The rock is a yellowish-brown dolomite and contains such characteristic Niagara fossils as *Streptelasma spongaxis* Rominger, *Favosites favosus* Goldfuss, *F. niagarensis* Hall, *Halysites catenulatus* Linn., *Orthothetes subplana* Conrad, *Orthis flabellites* Hall, *Uncinulus stricklandi* Sowerby, *Homœospira apriniformis* Hall, and *Camarotœchia neglecta* Hall.

Niagara layers belonging to the same horizon as numbers 1 to 5 of the foregoing section, are well exposed at the Westfield bridge, in the northwest ¼ of section 29, Westfield township. At this place there is a thickness of twenty-two feet of yellow, vesicular dolomite which carries numerous chert nodules, and contains *Favosites favosus* Goldfuss, *Halysites catenulatus* Linn. and other characteristic fossils of the Delaware stage. The Niagara is here succeeded by a ledge of Devonian limestone, fifty feet in height. On account of the excellent exposure of Devonian strata overlying the Niagara at this place, a detailed description of the outcrop will be given under the discussion of the Devonian deposits.

A bed of impure dolomite, ten feet in thickness, is exposed along the banks of Otter creek, near Oelwein, in the northeast ¼ of section 29, Jefferson township. The ledge shows imperfect lines of bedding. It is quite vesicular. In places it contains an admixture of sand and carries a number of small calcite geodes. The following fossils were collected from these layers, *Zaphrentis stokesi* Ed. & H., *Favosites favosus* Goldfuss, *Halysites catenulatus* Linn., Syringopora sp., and casts of small individuals of *Pentamerus oblongus* Sowerby.

Two miles north of the town of Fairbank, near the southwest corner of section 20, Oran Township, a bluff of dolomite borders the east bank of a branch of the Wapsipinicon river for a distance of several rods. The exposure here shows the following layers:

		FEET.
5.	Bed of moderately coarse sand.....	4½
4.	Gravels, which are in places much iron-stained...	3½
3.	Residual material of a much weathered bed of dolomite, containing *Favosites favosus*, *Halysites catenulatus*, *Lyellia americana* and *Alveolites undosus*	2
2.	Ledge of coarse-grained, yellowish-brown dolomite, which weathers into layers three to six inches in thickness, and contains fossils similar to number 3 above.....	7
1.	Massive ledge of yellow dolomite, coarse-grained in texture, carrying nodules of chert, and containing *Favosites favosus*, *Halysites catenulatus*, Syringopora sp. and *Lyellia americana*	8

Materials which correspond with those of the above section outcrop along the south bank of a small stream, about one mile northeast of Fairbank, on land owned by Mr. Oscar Constantine. Imperfect exposures of weathered Niagara materials of this same horizon are encountered at a number of points along the streams in sections 16, 20 and 21 of Oran township.

The rocks in the above mentioned exposures, near Fairbank, are quite similar in their lithological characters and their contained fossils to those of the exposure near Oelwein. They also resemble quite closely those of members 1 to 5 of the Niagara-Devonian Contact exposure in section 5 of Westfield township, and those of the upper Niagara layers at Westfield bridge. It seems probable that the materials in each of these exposures belong to horizons that are separated by no great thickness of strata; and that they represent deposits near the top of the Delaware stage, as the rocks of that stage are developed near the western margin of the Niagara area in Fayette county.

The Niagara outcrop north of Fairbank is especially interesting from the fact that in the town of Fairbank Devonian strata that lie just below the zone of *Acervularia profunda* Hall and *Newberria johannis* Hall, nearly sixty feet above the base of the Devonian, are quarried at an altitude forty feet lower than the top of the Niagara bluff two miles further north. The presence of a fold of no mean proportions would seem to be indicated in this portion of the Niagara strata.

Near the middle of the east side of section 13, Smithfield township, the slopes and crest of a hill are strewn with masses of quartz which contain silicified coralla of *Favosites favosus* Goldfuss, and numerous casts and moulds of very large individuals of *Pentamerus oblongus* Sowerby. The immediate banks of this stream are bordered by low ledges of yellow dolomite which contain *Favosites favosus*, *Halysites catenulatus* and casts of a few small individuals of *Pentamerus oblongus*.

In the northeast $\frac{1}{4}$ of section 13 and the southeast $\frac{1}{4}$ of section 12 of the same township, a bed of buff colored dolomite outcrops to a height of twelve feet along the banks of a small creek. The ledge is massive and vesicular. It carries chert nodules, and contains *Favosites favosus*, *Halysites catenulatus* and

Syringopora tenella. In the residual chert masses scattered over the slope, above the ledge, there also occur numerous very large casts of *Pentamerus oblongus.*

The Niagara strata of our area probably attain their greatest thickness in the southeastern portion of the county. The presence in abundance, of casts of large individuals of *Pentamerus oblongus* in the residual chert masses that are scattered over the slopes, in Smithfield township, and the absence of such remains in the Niagara deposits of the central and northern portions of the county, would indicate that the Niagara strata of Fayette county belong to a horizon below the true *Pentamerus oblongus* zone. It seems probable that the materials of the *Pentamerus oblongus* horizon were once the uppermost deposits over only the southeastern portion of the area, and that they have subsequently been removed by the agents of denudation. If this inference is correct, the uppermost deposits of the Delaware stage in Fayette county belong to a horizon more than one hundred feet below the latest of the Niagara deposits that appear in the county of Delaware. There are indications, too, that the lower layers of the Niagara in our area correspond with layers which, in Delaware county, occupy a position several feet above the base of the Delaware stage. In short, it is probable that both the uppermost strata and the lowermost members of the Niagara beds, which are encountered in Delaware county, fade out towards the northwest, in the county of Fayette.

Devonian System.

WAPSIPINICON STAGE.

Deposits representing the Middle Devonian series immediately underlie the superficial materials over the central and western portions of our area, covering nearly one-half of the surface of Fayette county. These rocks belong to the two lowermost stages of the series, the Wapsipinicon and the Cedar

Valley. The strata range from the base of the fine-grained, delicately laminated bed, underlying the Lower Davenport phase of the Fayette breccia, to the layers containing very numerous individuals of *Dielasma iowensis* and *Athyris vittata*, which occur in a zone a few feet above the Acervularia coral reef.

Devonian rocks outcrop in the towns of Fayette and West Union, and they may be seen at several points between these places. They are exposed at a distance of two and one-half miles northeast of West Union. They are encountered in the banks of the streams along the north side of Windsor township. They appear at different points along Crane creek, down to within less than one mile of its junction with the Little Turkey river. Layers which belong to a horizon a few feet below the *Acervularia profunda* zone are exposed at a number of places in the vicinity of Waucoma.

Over the greater portion of the western tier of townships the mantle of drift is so deep that the indurated rocks appear at the surface at but a few points in Eden township in the extreme north, and Oran township in the south. Devonian strata belonging to a zone immediately below that of *Newberria johannis* are quarried in the town of Fairbank. Corresponding layers outcrop near the cemetery about three-fourths of a mile northwest of this point. Rocks belonging to the horizon of *Acervularia profunda* and *Newberria johannis* may be studied along the banks of the Volga river in the town of Maynard, and for a distance of more than one mile both north and south of this place. The Lower Davenport beds of the Wapsipinicon stage outcrop in the banks of Alexander creek, near the northeast corner of section 5, Smithfield township, and this phase is exceptionally well exposed in the vicinity of the town of Fayette.

Just north of Westfield bridge, in the northeast $\frac{1}{4}$ of section 29, the lower members of the Devonian can be well studied in their relation to the underlying strata of the Delaware stage. The section below the surface materials is as follows:

		FEET.
9.	Decayed zone composed of thin fragments, which in places are crowded with valves of *Newberria johannis*, weathered individuals of *Acervularia profunda*, *Cystiphyllum americanum*, *Cladopora iowensis* and Favosites sp. occur in the upper part	1
8.	Bed consisting of yellow, fine-grained, impure limestone, in layers two to six or eight inches in thickness. The layers are somewhat broken, and contain the fossils *Atrypa reticularis* and *A. aspera* var. *occidentalis*. Small cavities lined with crystals of calcite are not rare	5½
7.	Bed of yellow colored, impure limestone, in three layers respectively two and three-fourths, two and one-fourth and two feet in thickness. Besides the fossils of number 8, *Pentamerella dubia* and *Spirifer pennatus* occur in the lower layer	7
6.	Bed of rather massive, yellowish-gray limestone, less magnesian than the layers of number 7 above, somewhat broken, but the large fragments lie in the general plane of the original layers; containing in the upper portion Favosites sp., *Pentamerella dubia*, *Gypidula comis*, *Spirifer pennatus*, *Atrypa reticularis*, *A. aspera* var. *occidentalis* and *Hypothyris intermedia*	8
5.	Bed of light colored, argillaceous limestone, with few fossils; consisting of brecciated material in which small limestone fragments are imbedded in an abundant matrix of clayey shale	7
4.	Bed of Lower Davenport breccia; composed of dense, fine-grained, drab colored fragments of limestone, surrounded with lighter colored cementing material; without fossils	10
3.	Bed of yellowish-gray limestone, very fine-grained; exposed surfaces showing numerous, delicate lines of lamination; weathering in thin fragments which are characteristic of this zone; no fossils	11
2.	Bed consisting of two imperfect layers of yellow, magnesian limestone, one foot and two feet in thickness; the upper one dense and rather fine-grained, the lower vesicular and somewhat softer; without fossils	3
1.	Bed of yellowish, magnesian limestone, in layers which are respectively two, four, two and one-third, one, two, four, two and one-half, and five feet in thickness. Small cavities are numerous, and nodules of chert abundant; containing *Lyellia americana*, *Favosites favosus*, *Halysites catenulatus* and other fossils	22

This exceedingly instructive section may be designated as that of the Westfield Bridge. Not only is the contact of the Niagara and the Devonian well shown at this place, but there is also exposed an almost complete section of the Devonian strata as those deposits are developed in this portion of the state. See figure 45.

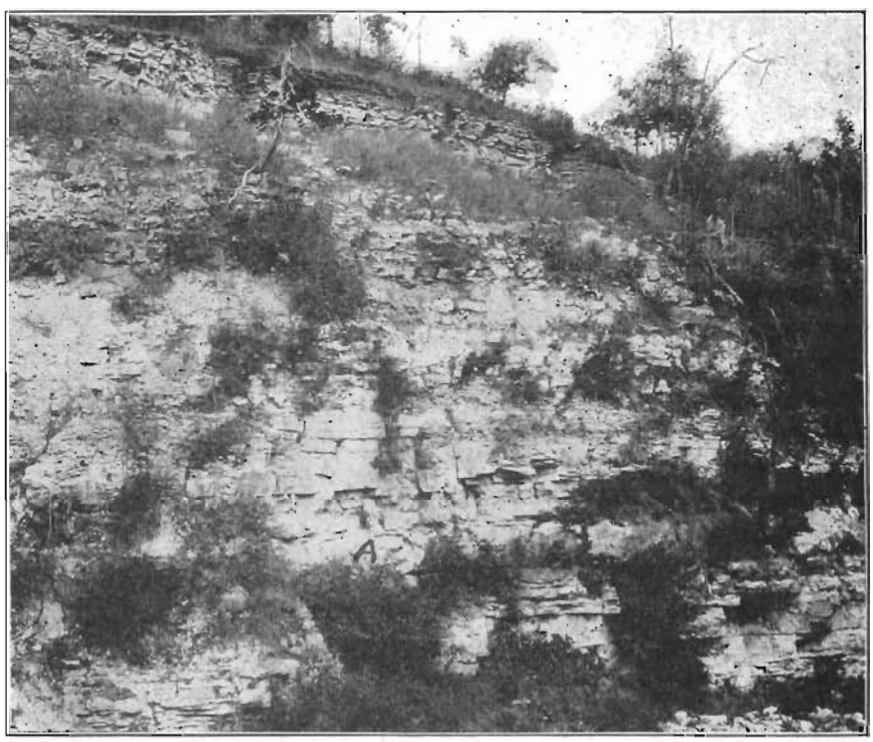

FIG. 45. Exposure at Westfield bridge in the town of Fayette, showing the contact of the Niagara and Devonian limestones. The layer marked A, a short distance below the middle of the picture, is the uppermost layer of the Niagara at this place.

The dolomite layers of number 1, containing *Lyellia americana*, *Favosites favosus*, *F. niagarensis*, *Halysites catenulatus*, *Leptæna rhomboidalis* and a species of Orthis, are readily recognized as belonging to the Delaware stage. Number 2 also belongs with this Niagara bed. These layers are the equivalent of numbers 1 to 5 inclusive of the Niagara-Devonian Contact section, three and one-half miles further north.

Number 3 represents the basal member of the Wapsipinicon stage, and corresponds with number 6 of the Niagara-Devonian Contact section above mentioned. This bed of yellow colored, fine-grained material, in which very numerous, delicate lines of lamination are preserved, and which weathers into thin, fissile fragments, is uniformly present as the lowermost member of the Devonian in Fayette county. The line between numbers 2 and 3 of the Westfield Bridge section, which separates the Devonian strata from the Niagara beds, is well exposed for a distance of several rods but there is shown no decided evidence of unconformity between these deposits. Number 4 is a bed of the typical Lower Davenport phase of Fayette breccia, and it is the equivalent of number 7 of the Contact exposure in section 5. The fragments are slate colored, fine-grained and very hard. They are usually small, rarely more than six inches in diameter. The lighter colored cementing material or matrix composes about one-half of the constituents of the bed. No fossils were found in this member. It is probable that number 5 represents a slightly unusual phase of development of the Lower Davenport beds in which light colored, indurated, clay-like shale predominates over the general brecciated materials. Number 6 is composed of a massive, slightly fractured ledge of gray, fossiliferous limestone, rather similar throughout. It shows lines of bedding which separate the ledge into indistinct layers two to two and one-half feet in thickness. This member contains *Pentamerella dubia* Hall, *Gypidula comis* Owen, *Hypothyris intermedia* Barris, *Spirifer pennatus* Owen, *Atrypa reticularis* Linn. and *A. aspera* var. *occidentalis* Hall. These fossils are characteristic of the Gyroceras beds, as defined by Professor Calvin* in Buchanan county, and of the Upper Davenport beds of Professor Norton,† as described in the Linn county report.

The materials of number 7 and 8 are quite similar in color and lithology to those of number 6, but the thickness of the layers constantly decreases towards the top. In number 8 the layers are considerably shattered although the fragments are not displaced. Small veins and geodes of calcite are abundant.

* Calvin: Iowa Geol. Surv., Vol. VIII, pp. 225 *et seq.*

†Norton: Iowa Geol, Surv., Vol. IV, pp. 157 *et seq.*

Number 9 is composed largely of calcareous layers that are filled with more or less broken valves of *Newberria johannis*, and which are overlain by residual fragments and weathered coralla from the zone of *Acervularia profunda*. A few rods further down the river there is exposed at the top of the bluff a thickness of four feet above the *Newberria johannis* horizon. These layers contain coralla of *Acervularia profunda* Hall in place, together with Cyathophyllum sp., *Cladopora iowensis* Hall and

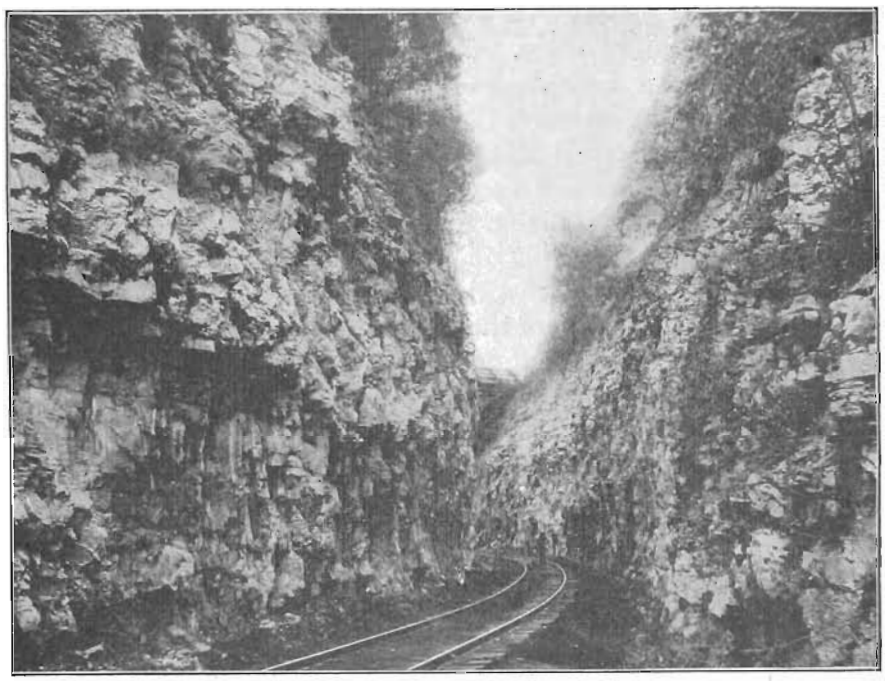

FIG. 46. Cut along the Chicago, Milwaukee & Saint Paul railroad, a short distance west of station, Fayette, Iowa. The walls of the cut are Devonian limestone and the track is laid on the Niagara.

colonies of Favosites resembling *F. placenta* Rominger. This is the typical *Acervularia profunda* zone in its normal position, only a very short distance above that of *Newberria johannis*.

An exposure which is almost a duplicate of that at Westfield bridge appears in the south bank of the Volga river, near the middle of the south side of section 21, Westfield township. At

this place a quarry is worked in the yellow, somewhat disturbed layers corresponding with the upper part of number 6 and numbers 7 and 8 of the Westfield Bridge section. Several small quarries are worked in the layers of this horizon within the limits of the town of Fayette.

The contact of the Niagara and Devonian strata is again well shown in the northwest ¼ of section 17, Union township. A quarry has been opened in this ledge, within the corporate limits of West Union, which is operated by the city for crushed stone. At this place a thickness of about one and one-half feet of Niagara dolomite appears at the base of the exposure. This is succeeded by a bed of yellowish, fine-grained material, ten feet in thickness, which shows very numerous, fine lines of lamination, and which weathers into thin fragments. This latter bed corresponds with number 3 of the Westfield Bridge section. Above this fine-grained, delicately laminated bed there occurs a thickness of about six feet of the typical Lower Davenport breccia.

An interesting section of the Wapsipinicon strata of our area is exposed in the deep cut along the Chicago, Milwaukee & Saint Paul railway, a few rods west of the station at Fayette. The strata at this place are shown in figure 46. The cut is fifty feet in depth and six hundred feet long. There appears in either wall the following succession of layers:

		FEET.
6.	Bed consisting of somewhat shattered layers of fine-grained, yellow colored, impure limestone, three to nine inches in thickness; containing *Atrypa reticularis* and *A. aspera* var. *occidentalis*	11½
5.	Bed composed of yellow colored, magnesian limestone, similar in lithology to number 6 above, in imperfect layers one and one-half to three feet in thickness; containing *Gypidula comis*, *Spirifer pennatus* and the Atrypas	8½

		FEET.
4.	Thick layers of gray limestone, somewhat fractured, yet not so thoroughly brecciated but that the original layers can be recognized. The large fragments contain *Favosites placenta*, *Stropheodonta demissa*, *Pholidostrophia nacrea*, *Productella subalata*, *Orthis iowensis*, *Gypidula comis*, *Spirifer pennatus*, *Atrypa reticularis*, *A. aspera* var. *occidentalis*, *Athyris vittata* and tritors of *Ptyctodus calceolus*.....	10
3.	Bed of yellowish colored, calcareous shale; quite indurated; showing scant traces of brecciation; without fossils	6
2.	Bed composed of slate-colored fragments of very hard, fine-grained limestone, imbedded in a matrix of fine-grained calcareous material which is lighter in color. Many of the fragments show delicate, closely crowded lines of lamination; no fossils.....	11
1.	Ledge of yellow colored, fine-grained limestone, on the face of which delicate, closely placed laminæ weather out in faint relief. Small fragments of the material present this characteristic laminated appearance. When long exposed to weathering the rock splits along these lines into thin bits.....	10

Number 1 of the foregoing section represents the basal member of the Wapsipinicon deposits, and corresponds with number 3 of the Westfield Bridge section. The rock is homogeneous, and fine-grained in texture. In some places it has been more or less brecciated as appears in the fact that there are occasional areas in which groups of closely crowded, delicate laminæ, which are usually parallel with the planes of bedding, lie at various angles with respect to one another and to the larger planes of stratification. In other places the fine lines of lamination are gently undulating or slightly faulted. Numerous thin veins of calcite indicate the position of the original lines of fracture. Aside from such calcite veins there appears no other cementing material. The upper portion of this bed shows slight flexures, the arches of the folds having, in some places, a height of one to one and one-half feet. The material appears to have been of a slaty color before it was acted upon by the atmosphere. Upon weathering it is changed to a yellow color, and breaks along the lamination planes into charac-

teristic thin, fissile bits. The materials of this member are less resistant than those of the overlying Lower Davenport breccia, number 2 of the section, as appears in the relative amount of the fragments of each member in the talus heap at the foot of the ledge. This is also indicated by the fact that the rock of the first member has crumbled down to such an extent as to leave a shelf of the materials of number 2 projecting beyond the lower member for a distance of one and one-half feet.

The lithological characters and general appearance of the material of this basal member of the Devonian limestone in Fayette county, number 1 of the last section, would ally it very closely with the Otis beds as described by Norton.* Because of the thinness of the formation in our area, and on account of the fact that it presents occasional brecciated masses this member will be included as the basal portion of the Fayette breccia.

At a few places in the cut there is exposed below number 1 a thickness of one to one and one-half feet of yellowish-colored dolomite. This material represents the Niagara limestone, and corresponds with the uppermost layer of the Niagara at Westfield bridge, less than one mile to the north. Both in the cut and at the Westfield Bridge exposure such dolomite is succeeded by a bed of fine-grained, closely laminated limestone, as number 1 described above. In the railroad cut, the top of the Niagara limestone forms the floor upon which the track is laid.

The respective beds that succeed number 1 in the last section are readily correlated with, and their development is not unlike, those that lie above number 3 in the Westfield Bridge section. Numbers 4 and 5 consist of limestone that shows no trace of dolomitization. It is somewhat fractured, but the thick layers have not been greatly disturbed. The fossils found in this member include *Pholidostrophia nacrea* Hall, *Productella subalata* Hall, *Orthis macfarlanei* Meek, *Pentamerella dubia* Hall, *Gypidula laeviuscula* Hall, *Gypidula comis* Owen, *Hypothyris intermedia* Barris. *Atrypa reticularis* Linn., *A. aspera* var., *occidentalis* Hall, *Spirifer pennatus* Owen, and *Athyris vittata* Hall.

*Norton: Iowa Geol. Surv., Vol. IV, p. 138, *et seq.* 1894.

An exposure of brecciated limestone which corresponds with numbers 2 to 4 inclusive of the section of the Railroad Cut can be seen in the east bank of Alexander creek, near the southeast corner of section 32, Westfield township. In walking up the bed of a ravine that crosses the wagon road a few rods west of this point the breccia of this same horizon is passed over, and the succeeding beds of less shattered, thicker limestone layers are encountered which contain *Orthis iowensis* Hall, *Gypidula comis* Owen, *Atrypa reticularis* Linn. and *A. aspera* var. *occidentalis* Hall, and which belong to the Upper Davenport phase of the breccia.

In the northwest ¼ of section 6, Windsor township, the following succession of layers is exposed in the east bank of a small stream:

		FEET.
6.	Bed of residual materials, containing weathered remains of Cyathophyllum sp., *Acervularia profunda*, *Cystiphyllum americanum*, Favosites sp., *Spirifer pennatus* and *Atrypa reticularis*...	1
5.	Bed composed of layers of yellow, magnesian limestone, two to six inches in thickness. The layers are much checked and broken, and contain few traces of fossils.....	6
4.	Bed of yellow, fine-grained, earthy limestone, in layers six to twenty-four inches in thickness. The materials are more or less shattered, and show numerous small spherical patches in which iron-stained lines are concentrically arranged about a common center.....	3½
3.	Ledge of yellow, impure limestone, resembling that of number 4 above, in layers eight to thirty inches in thickness; containing imperfectly preserved fragments of brachiopod shells.....	6
2.	Bed of yellowish-gray limestone, in rather indistinct layers which are checked with numerous joints; containing *Productella subalata*, *Pentamerella dubia*, *Gypidula comis*, *Spirifer pennatus*, *Atrypa reticularis* and *A. aspera* var. *occidentalis*	8
1.	Bed composed largely of light colored shale, in which a few irregular fragments of limestone are imbedded. Such fragments become more abundant in the lower part; talus covered to bed of stream.....	7

In the above, which may be known as the Windsor section, number 1 corresponds with number 3 of the Railroad Cut section and with number 5 of that of Westfield Bridge. Number 2 above is a well marked zone which is characterized by the fossils *Productella subalata* Hall, *Pentamerella dubia* Hall, *Gypidula comis* Owen, *Atrypa reticularis* Linn., *A. aspera* var. *occidentalis* Hall, and *Spirifer pennatus* Owen. This bed is the equivalent of number 4 of the Cut, and of number 6 of the

FIG. 47. Ledge of Cedar Valley limestone near the northwest corner of section 2, Bethel township. The horizon of *Acervularia profunda* occurs at the top, and *Spirifer pennatus* is found in the heavy layers at the base. The stone is magnesian throughout.

Westfield Bridge section. Number 6 of the last section represents the horizon of number 9 at Westfield bridge.

Rocks which correspond with those of numbers 2 to 5 inclusive of the last section outcrop about forty rods southwest of this exposure, and they may be seen on either side of the wagon road as it turns east in the southwest $\frac{1}{4}$ of section 6 of Windsor township.

Near the middle of the west side of section 35 of Eden township, there outcrops in the north bank of Crane creek a cliff of Devonian limestone thirty-five feet in height. The beds exposed here are embraced between the *Acervularia profunda* zone at the top and the Lower Davenport breccia at the base.

In the extreme northwest corner of section 2 of Bethel township, a representative section of the uppermost Devonian beds appears in the east bank of a small affluent about one-half mile above its junction with Crane creek. The rocks in this exposure are shown in figure 47, and the section is as follows:

		FEET.
5.	Bed of yellow colored, fine-grained, dolomite in broken layers three to eight inches in thickness. In the upper part the fossils *Acervularia profunda*, *Cystiphyllum americanum*, Favosites sp. and *Cladopora iowensis* are not rare	8
4.	Bed of fine-grained, yellow dolomite, in two layers which are somewhat broken, and contain no fossils	1
3.	Ledge consisting of two layers of fine-grained, magnesian limestone, each about eight inches in thickness. The material is yellow in color and quite durable. Small cavities lined with crystals of calcite are abundant	1⅓
2.	Bed of dense, yellow colored, fine-grained, earthy limestone, in three layers which are respectively twenty-four, twenty and twenty-five inches in thickness; containing the fossils *Spirifer pennatus*, *S. bimesialis*, *Atrypa reticularis* and *A. aspera* var. *occidentalis*	5⅔
1.	In the bed of the stream, a few rods below the exposure of the members 2 to 5 inclusive, there are encountered heavy layers of yellow dolomite which underlie the base of number 2, and contain *Stropheodonta demissa*, *Productella subalata*, *Pentamerella dubia*, *Gypidula comis*, *Spirifer pennatus*, *Cyrtina hamiltonensis*, *Atrypa reticularis* and *A. aspera* var *occidentalis*	6

In the foregoing section number 1 corresponds with number 2 of the Windsor section, with number 4 in that of the Railroad Cut at Fayette, and with number 6 of the Westfield Bridge section. This member is well developed in the northwestern portion of the county where the materials of the Devonian are almost universally dolomitized. This bed is the lowermost of the Devonian deposits that was seen in Eden township, with the exception of a single exposure near the southeast corner. It contains *Stropheodonta demissa* Conrad, *Productella subalata* Hall, *Pentamerella dubia* Hall, *Gypidula comis* Owen, *Spirifer pennatus* Owen, *Cyrtina hamiltonensis* Hall, *Atrypa reticularis* Linn. and *A. aspera* var. *occidentalis* Hall. The assemblage of fossils is characteristic of the Upper Davenport beds, which constitute the uppermost deposits of the Wapsipinicon stage. Number 2 above is the equivalent of number 5 of the Fayette Cut section and with number 7 of the section at Westfield bridge. The rocks of the members 3 to 5 of the foregoing section succeed those of number 2 in the normal order in which they appear above the correlative of that member in the sections of the Fayette Cut and Westfield Bridge.

In Howard county, beds that are the equivalent of numbers 1 to 3 of the above section are the lowermost strata of the Devonian that are present,* and they rest directly upon the shales of the Maquoketa stage. All of the Lower Davenport phase of the Fayette breccia, as well as the bed of fine-grained, finely laminated material that underlies it in the central portion of Fayette county, fade out completely a few miles further towards the northwest.

The materials of the first three members of the last section may probably be correlated with the lowermost strata that appear in Chickasaw county.† They correspond with the layers that are exposed in the quarries near Independence, in Buchanan county, and they are the equivalent of the beds that appear in the railroad cut three miles northwest of Vinton, in Benton county. At the latter place the deposits of this horizon have a thickness very much greater than they attain in the county of Fayette.

*Calvin: Iowa Geol. Surv., Vol. XIII, p. 50. *et seq.*

†Calvin: Iowa Geol. Surv., XIII, p. 268. *et seq.*

Layers of yellow, impure dolomite, which correspond with numbers 2 to 4 of the last section, are quarried about one-half mile north of the village of Alpha, in Eden township, on land owned by Mr. Seth Clark. They also outcrop a short distance west of this place, on land belonging to Mr. Hilton.

About one-half mile northwest of Waucoma, a quarry is operated in a body of massive, earthy dolomite which is overlain by somewhat broken layers, four to eight inches in thickness. The rock is yellow and quite vesicular. In the thick ledge at the base the bedding planes have been so completely destroyed in the process of dolomitization that masses are quarried out without any regard to the original lines of stratification. *Acervularia profunda* was found in the upper layers, and casts of *Productella subalata* Hall, *Gypidula comis* Owen, *Spirifer pennatus* Owen, a species of Spirifer resembling *S. bimesialis* Hall, *Atrypa reticularis* Linn. and *A. aspera* var. *occidentalis* Hall were collected from the massive bed at the base. The rocks that are exposed in this quarry correspond with the layers that are worked in the vicinity of Alpha.

Broken layers which contain colonies of *Acervularia profunda* and shells of *Atrypa reticularis* outcrop in the wagon road, near the middle of the north side of section 5 of Eden township, and they appear again in the banks of a small stream some rods further east.

CEDAR VALLEY STAGE.

The line which separates the deposits of the Wapsipinicon stage from those of the Cedar Valley has been somewhat arbitrarily drawn between the *Spirifer pennatus* beds and the overlying layers which contain *Acervularia profunda* and several other species of corals. In Fayette county the *Spirifer pennatus* horizon can not be perfectly differentiated from that of the Gyroceras beds which precede it. The Cedar Valley strata will be considered to start with the undisturbed layers a short distance below the *Acervularia profunda* and *Newberria johannis* zone. At no place in the county have these beds been involved in the brecciation or disturbance that so profoundly affected the most of the strata of the Wapsipinicon stage.

As thus delimited, the uppermost layers that appear at Westfield bridge, which contain many corals and numerous detached valves of *Newberria johannis*, represent the basal portion of the Cedar Valley deposits.

In the town of Fairbank a quarry is worked in the west bank of the river, just south of the Catholic school. The following layers are here shown:

		FEET
5.	Iron-stained gravels with a dark colored soil zone at the top; containing numerous weathered coralla of *Acervularia davidsoni*, *Cystiphyllum americanum*, *Favosites alpenensis* and other species of corals	5
4.	Bed of yellow, much decayed limestone, in thin layers, which contain species of Cyathophyllum, Cystiphyllum and Favosites, and a few individuals of *Newberria johannis* that have weathered out entire	2½
3.	Bed composed of thin layers of hard, gray limestone which in places are crowded with detached valves of *Newberria johannis*	2
2.	Yellowish-gray limestone in rather even layers with occasional bands of softer, shaly material; showing numerous spots of concentrically arranged lines of iron stains; containing Cyathophyllum, Cystiphyllum, Favosites, and occasional shells of *Stropheodonta demissa*.	6
1.	Massive bed of gray limestone; containing numerous geodes of calcite, and bearing but few fossils	3

The above section represents a slightly greater development of the *Newberria johannis* beds than appears in the exposures further north. *Acervularia profunda* is usually found in the layers which correspond with those of 2 to 4 of the foregoing section. The spherical, iron-stained concretions are generally abundant in the zone immediately preceding that of *Newberria johannis*, and cavities lined with crystals of calcite are abundant in layers corresponding with number 1 of the last section.

About one-half mile northwest of Fairbank a quarry was formerly worked near the Catholic cemetery. The layers that are seen at this place are the equivalent of numbers 1 to 3 of the Fairbank section. At the top there appear thin layers that are

largely composed of broken or detached valves of *Newberria johannis*. Below this zone are seen the yellow layers with concentric iron stains. This lower bed contains occasional remains of *Cystiphyllum americanum*, *Stropheodonta demissa* and *Atrypa reticularis;* and carries small geodes of calcite. These layers show no traces of brecciation or dolomitization, and they represent a horizon at the base of the Cedar Valley deposits.

Along the Volga river in the east part of Maynard, the following layers are exposed:

		FEET.
4.	Reddish-brown sand and fine gravel	1½
3.	Zone of decayed limestone, in which occur numerous coralla of Cyathophyllum sp., *Acervularia profunda*, *Cystiphyllum americanum*, *Heliophyllum halli*, Favosites sp. and Syringopora sp	2
2.	Bed consisting of thin layers of gray limestone, some of which are composed almost wholly of valves of *Newberria johannis*. *Acervularia profunda*, *Cystiphyllum americanum* and other corals are present	4
1.	Bed of gray limestone in layers three to eight inches in thickness; containing *Acervularia profunda*, *Alveolites goldfussi*, Stromatopora sp., *Stropheodonta demissa*, *Spirifer pennatus*, *S. fimbriatus*, and finely-striated, Independence forms of *Atrypa reticularis*	6

In the above section number 3 is distinctly a coral zone that succeeds the horizon of *Newberria johannis*. The Newberria layers also contain a few corals. The first member contains numerous brachiopod shells which are usually associated with the corals in the layers below the Newberria zone.

Some rods south of the Maynard exposure there may be seen, in the bed of the river, undisturbed masses of gray limestone in which both large and small individuals of *Gypidula comis* are exceedingly abundant. These rocks also contain occasional colonies of *Acervularia profunda* Hall, *Favosites placenta* Rom., *Productella subalata* Hall, *Orthis iowensis* Hall, *Dielasma roemingeri* Hall, *Spirifer pennatus* Owen, *S. bimesialis* Hall, *Cyrtina hamiltonensis* Hall, Independence forms of *Atrypa reticularis*, Linn., *A. aspera* var. *occidentalis* Hall, and *Phacops rana* Green.

The layers of the Maynard section belong to a horizon that corresponds very closely with that of the Devonian beds exposed in the vicinity of Fairbank. The fauna seen in the layers along the bed of the river some distance south of Maynard would indicate a zone just below the base of the Cedar Valley stage.

For a distance of one mile north of Maynard there are exposed, in every bend of the river, limestone layers that are included between the Newberria zone at the top and the horizon of very abundant shells of *Gypidula comis* at the base. Beautiful coralla of *Acervularia profunda* have weathered out along this portion of the river's channel. Beds which belong to this horizon appear again at the iron bridge, three miles north of Maynard. About four miles still further down the Volga river, at Eagle Point, the equivalents of these layers appear near the top of the bluff sixty feet above the water, and almost the entire section of the Wapsipinicon strata is exposed below them. See figure 33 on page 446.

Near the extreme southwest corner of section 18 of Westfield township, there outcrops a low, weathered ledge of limestone that contains *Acervularia profunda* Hall, *Stropheodonta demissa* Conrad, *Orthis iowensis* Hall, *Dielasma ramingeri* Hall, *Spirifer pennatus* Owen, *Atrypa reticularis* Linn. and *A. aspera* var. *occidentalis* Hall. Continuing north up the hill, layers representing a horizon twelve to fifteen feet above this ledge are passed over. In these upper layers the form of *Atrypa reticularis* becomes more robust and more coarsely striated. *Spirifer pennatus* is still frequent, while *Dielasma iowensis* Calvin, and *Spirifer subvaricosus* H. & W. make their appearance. *Acervularia profunda* Hall, *A. davidsoni* Ed. & H., and *Favosites alpenensis* Winchell, are occasionally encountered. These fossils indicate a horizon near the base of the Cedar Valley deposits.

In the southwest $\frac{1}{4}$ of section 17 of Union township, the following layers are exposed in a small quarry on the north side of the railroad track:

		FEET.
4.	Bed of sand or sandy loess, with a dark colored soil band at the top	5
3.	Reddish-brown clay, containing gravel and small bowlders	3
2.	Ledge of gray, weathered limestone, in rather irregular layers, which contain *Acervularia profunda*, *Phillipsastrea billingsi*, *Craspedophyllum strictum*, *Favosites alpenensis* and *Cladopora magna*	3
1.	Bed consisting of layers of gray limestone three to twelve inches in thickness; containing *Stropheodonta demissa*, *Spirifer pennatus*, *S. subvaricosus*, *Atrypa reticularis* and *A. aspera* var. *occidentalis*	5

About thirty rods to the east of this exposure limestone layers corresponding with those of the above section are worked. There is here seen, below the horizon of number 1, a massive layer of gray limestone which contains numerous geodes of calcite and carries, in the middle portion, abundant shells of *Gypidula comis* and *Atrypa reticularis*.

In the foregoing section, numbers 1 and 2 doubtless represent the lowermost of the Cedar Valley strata, and they probably correspond with the Devonian layers exposed near Maynard and Fairbank. They contain a rich fauna which include Cyathophyllum sp., *Acervularia profunda* Hall, *Phillipsastrea billingsi* Calvin, *Craspedophyllum strictum* Ed. & H., *Heliophyllum halli* Ed. & H., *Cystiphyllum americanum* Ed. & H., *Cladopora magna* Hall, *Favosites placenta* Rominger, Favosites sp., Syringopora sp., *Stropheodonta demissa* Conrad, Stropheodonta sp., *Spirifer pennatus* Owen, *S. fimbriata* Morton, *S. subvaricosus* H. & W., *Cyrtina hamiltonensis* Hall, *Atrypa reticularis* Linn. and *A. aspera* var. *occidentalis* Hall.

At the top of the ledge in the upper railroad cut, in the northwest ¼ of section 30 of Westfield township, there occur numerous remains of corals which are distinctive of the *Acervularia profunda* horizon. In layers below the coral zone were collected *Pholidostrophia nacrea* Hall, Productella sp., *Orthis macfarlanei* Meek., *Gypidula lævisucula* Hall, *Gypidula comis* Owen, *Hypothyris intermedia* Barris, the Atrypas usually associated with these fossils and *Athyris vittata* Hall. Layers

of the coral zone are again encountered in the northeast ¼ of section 17, Westfield township, and they appear at other points in this and the adjoining township of Center.

Probably the uppermost Devonian layers that are exposed in Fayette county appear in an unused grade for a railroad that was projected some years ago between the towns of Lima and Sumner. This abandoned grade is crossed by the Chicago, Milwaukee & Saint Paul railway, in the southeast ¼ of section 13 of Center township. At this place the grade is about twelve feet in height. The materials of which it was built were taken from shallow excavations on either side of, and adjacent to, the ridge. The rock fragments that appear over the top and the sides of this grade are very fossiliferous. Many of the pieces of yellow limestone are crowded with shells of *Athyris vittata* Hall, and contain numerous individuals of *Dielasma iowenis* Calvin. At no other point in the state are these two species known to occur in such abundance.

Besides the above fossils there were found here *Favosites alpenensis* Winchell, Favosites sp., Syringopora sp., large individuals of *Stropheodonta demissa* Conrad, the large, coarse-ribbed form of *Atrypa reticularis* Linn., a species of Spirifer related to *S. pennatus* Owen, *S. subvaricosus* H. & W., *Cyrtina hamiltonensis* Hall, Gomphoceras sp. and individuals of a curved cephalopod resembling a species of Gyroceras.

The point where the old grade is crossed by the Milwaukee railway is about one and one-half miles northwest of the second railroad cut, referred to above, near the top of which the *Acervularia profunda* and the *Newberria johannis* zones are to be seen. It seems probable that the horizon of the very abundant *Athyris vittata* and *Dielasma iowensis* found on the abandoned grade is ten to fifteen feet above the zone of *Acervularia profunda*, and that the fragments which contain those fossils represent the uppermost layers of Cedar Valley limestone that occur in Fayette county.

A general section of the Devonian strata known to be exposed in Fayette county may be arranged as follows:

GENERAL DEVONIAN SECTION.

		FEET.
11.	Layers represented by the fragments which are found on the unused railroad grade, in the southeast ¼ of section 13 of Center township; containing rock masses crowded with shells of *Athyris vittata* and bearing numerous individuals of *Dielasma iowensis*, besides large individuals of *Stropheodonta demissa* and of the coarse-ribbed form of *Atrypa reticularis*.	12
10.	Coral zone made up of gray limestone which contains Cyathophyllum sp., *Acervularia profunda*, *Cystiphyllum americanum*, *Heliophyllum halli*, *Favosites alpenensis* and other species of corals	2½
9.	Bed consisting of thin layers of gray limestone, some of which are composed almost wholly of detached valves of *Newberria johannis*, also containing *Acervularia profunda*, *Cystiphyllum americanum* and *Cladopora magna*.....	4
8.	Bed of gray limestone, in layers three to twelve inches in thickness; containing *Acervularia profunda*, *Alveolites goldfussi*, *Stropheodonta demissa*, *Spirifer pennatus*, *S. subvaricosus*, *S. fimbriatus*, *Atrypa aspera* var. *occidentalis* and *A. reticularis*	6
7.	Bed of limestone, in places dolomitic, in some places gray and in others yellow in color; containing very numerous individuals of *Gypidula comis*, also *Productella subalata*, *Orthis iowensis*, *Dielasma roemingeri*, *Spirifer pennatus*, *S. bimesialis*, *Cyrtina hamiltonensis*, Independence forms of *Atrypa reticularis* and *Phacops rana*.....	4½
6.	Bed made up of somewhat shattered layers of yellow colored, fine-grained, earthy limestone, three to nine inches in thickness; containing the species of Atrypa found in number 5. Small cavities lined with crystals of calcite are abundant in the upper portion.....	11½
5.	Bed of yellow, impure, magnesian limestone, rather fine-grained, in imperfect layers one and one-half to three feet in thickness; containing *Gypidula comis*, *Spirifer pennatus Atrypa reticularis* and *A. aspera* var. *occidentalis*....	8½

		FEET.
4.	Bed of gray limestone, consisting of layers two to two and one-half feet in thickness; somewhat fractured but the masses not displaced to such an extent but that the layers can be recognized. The large fragments contain *Favosites placenta*, *Stropheodonta demissa*, *Pholidostrophia nacrea*, *Productella subalata*, *Orthis iowensis*, *Gypidula comis*, *Spirifer pennatus*, two species of Atrypa, *Athyris vittata* and tritors of *Ptyctodus calceolus*.....	10
3.	Bed of gray or yellowish colored, calcareous, shale; quite indurated and non-fossiliferous; showing but scant traces of brecciation.....	6
2.	Brecciated bed, composed of slate colored frag ments of very hard, fine-grained limestone imbedded in a matrix of fine-grained, calcareous material that is lighter in color. Many of the fragments show delicate, closely crowded lines of lamination; no fossils.....	11
1.	Ledge of yellow colored, fine-grained limestone, which is finely laminated, and weathers into thin fragments. In places this bed shows small brecciated areas, without fossils.....	10

Residual Materials.

Geest or residual materials that have been derived from the decay of the native rocks of the county are conspicuous at numerous points over the area of the Niagara outcrop. They present two phases, one of which consists of yellowish, incoherent grains of dolomite sand, and the other is composed of angular chert fragments imbedded in a small amount of tough, reddish colored clay. Both of these phases are a product of the secular decay of the Niagara dolomite.

The sandy phase of the geest is encountered over the the foothills and along the wagon road near the east side of section 3, and between sections 10 and 11 of Smithfield township. Such sands are also abundant at the base of the Niagara escarpment and along the wagon road across the center of section 36, Illyria township. They are present at several other points where the cutting of the streams has long exposed ledges of the more granular dolomite to the action of weathering.

Residual cherts underlie the loess and drift over the greater portion of the townships of Fairfield and Smithfield. They are mingled with the ferruginous clay and gravel that are exposed in the roadside in the southwest ¼ of section 29, Illyria township, and near the middle of section 12 of Fairfield township. They appear at the top of a bluff near the south side of section 19, Pleasant Valley township. Red colored, residual products, containing occasional pebbles and bowlders, overlie the Niagara limestone at Williams' quarry, and they are present in the roadside near the middle of section 15, Westfield township. Such materials are usually to be seen overlying the dolomite in the northeastern portion of Fayette county.

PLEISTOCENE SYSTEM.

All of the deposits of the Pleistocene system in Iowa consist of unconsolidated materials. They rest unconformably upon, and are separated by an enormous time interval from, the rocks of the Paleozoic and Mesozoic groups.

The Pleistocene materials are composed of sheets of glacial drift and beds of fluvial and wind deposits. Of the Glacial series there are represented in Fayette county the deposits of the pre-Kansan, the Kansan and the Iowan ice ages. The known aggregate thickness of the glacial deposits of our area varies from zero to more than one hundred and fifty feet.

PRE-KANSAN STAGE.

Some years ago the Chicago Great Western Railroad Company made a cut thirty feet in depth through a ridge of Pleistocene materials a short distance southeast of the town of Oelwein. The sides of this cut have since slipped down to some extent, and they are at present somewhat sodded over. The following section of this exposure is taken from a report that was given of the same, at a meeting of the Iowa Academy of Sciences* soon after the excavation was made.

* Beyer: Proc. Iowa Acad. Sciences, Vol. IV, p. 59.

		FEET.
5.	Bowlder clay, rather dull yellow in color; the upper portion modified into a thin soil layer. Large bowlders, mainly of granite, are present often resting on or partially imbedded in the deposits lower in the series. (Iowan)	0–10
4.	Sand and gravel, not a continuous deposit; often showing water action expressed in parallel stratification lines and false bedding. The gravels are usually rather fine and highly oxidized. (Buchanan)	0–2
3.	Till, usually bright yellow above, grading into a gray-blue when dry or a dull-blue when wet, below. This deposit is massive and exhibits a tendency to joint when exposed. Decayed granite bowlders are common. (Kansan)	3–20
2.	(a) Fine-grained, white sand, much waterworn; often with a slight admixture of silt and clay...	0–½
	(b) Vegetable layer and soil, from two to four inches of almost pure carbonaceous matter, with one to three feet highly charged with humus. The peaty layer often affords specimens of moss (Hypnum) in a perfect state of preservation. (Aftonian)	0–4
1.	Drift, greenish blue when wet or gray-blue with a greenish cast when dry. Greenstones and vein quartz pebbles predominate. (Pre-Kansan)..	10

In the foregoing section the first member represents a bed of pre-Kansan drift which exhibits this material in its typical bluish color and with its characteristic constituents of greenstone and quartz pebbles and small bowlders. While the sides of the excavation were fresh and unweathered this cut furnished one of the most satisfactory exposures of the pre-Kansan drift that has been found in the state. Owing to the fact that the succeeding Kansan ice sheet carried an exceedingly large amount of glacial detritus, and that it was even more widely extended than the pre-Kansan, the latter drift can be observed in our state only at rare intervals where excavations or erosion have cut through the deep mantle of Kansan materials at such fortunate points as to reveal a bed of older drift underlying it.

IOWA GEOLOGICAL SURVEY

MAP OF THE SUPERFICIAL DEPOSITS OF FAYETTE COUNTY, IOWA.

BY

T. E. SAVAGE.

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

- ALLUVIAL DEPOSITS
- IOWAN DRIFT
- KANSAN DRIFT. OVERLAIN BY LOESS

EDEN
AUBURN
DOVER
CLERMONT
BETHEL
WINDSOR
WEST UNION
PLEASANT VALLEY
UNION
BANKS
CENTER
WESTFIELD
ILLYRIA
FREMONT
HARLAN
SMITHFIELD
FAIRFIELD
ORAN
JEFFERSON
SCOTT
PUTNAM

WAUCOMA, St. Lucas, Postville Jc, El Dorado, Eden, Auburn or Douglas, Dover Mills, CLERMONT, Alpha, Richfield, HAWKEYE, Elgin, Brainard, Donnan, LIMA, Randalia, ALTOONA, Watkins, FAYETTE, Corn Hill, MAYNARD, West Gate, Taylorsville, ARLINGTON, Scott, OELWEIN, Fairbank

T. 95 N. T. 94 N. T. 93 N. T. 92 N. T. 91 N.

R. X W. R. IX W. R. VIII W. R. VII W.

DRAWN BY F. C. TATE

IOWA LITHO CO.

AFTONIAN STAGE

The second member of the Oelwein section represents a layer of carbonaceous matter which was derived from the products of plant decay through a long series of years. In the lower portion of this member there occurred a compact bed of moss which contained no admixture of foreign matter. A large proportion of this moss bed was made up of the well preserved remains of a single species, *Hypnum (Harpidium) fluitans* Linn. Besides the above species Professor Holzinger and Dr. G. N. Best* have found occasional stems of two other aquatic forms, *Hypnum (Harpidium) revolvens* Swartz, and *Hypnum (Calliergon) richardsoni* Lesq. and James. Numerous fragments of the wood, branches and roots of some coniferous trees were found in the lower portion of the till immediately overlying number 2. These are probably the remains of trees that flourished over the Aftonian surface, and which were overwhelmed by the advance of the Kansan glacier. Professor Macbride† has considered these wood fragments to be identical with that of *Larix americana* Mx.

It is worthy of note that the moss species, whose remains were found in the second member of the section, as well as the pieces of larch wood that came from the horizon of the old Aftonian surface, are forms that thrive at present in more northern latitudes. It is probable that the climatic conditions of the Aftonian interglacial age were, at least toward the close of the interval, less mild and genial in this portion of our country than those which the region has enjoyed in recent times.

KANSAN STAGE.

Kansan Drift.—A very large proportion of all the Pleistocene deposits that occur in Fayette county is composed of Kansan drift. Over all but the northeastern portion of the area the mantle of the Kansan material is deep. A well put down in the southwest ¼ of section 26, Smithfield township, on land owned by W. B. Stevenson, penetrated 114 feet of superficial

*The Bryologist, November, 1903.
†Macbride: Proc. Iowa Acad. Sciences, Vol. IV, p. 65.

materials before the indurated rock was encountered. In drilling a well, one mile west and one-half mile north of this place, a thickness of 130 feet of these deposits was passed through. A well put down one-half mile east of Mr. Stevenson's, on the farm of William Gordon, penetrated 112 feet of drift. In each of the above wells, much the greater part of the depth was through drift of Kansan age.

Over a large portion of the surface of the county the Kansan till is buried beneath the more recent deposit of Iowan drift, or is covered by a blanket of loess or sand that was laid down over the extra-Iowan areas. Here, as elsewhere in the state, the top of the Kansan drift shows evidence of having been very long exposed to erosion and to the leaching and oxidizing action of the atmosphere before it was covered by the later deposits. On the slopes and along the ravines where recent erosion has exposed this till, the upper portion of the material has been leached of its lime constituent for some depth. The small amount of iron which this part of the drift contained has been so completely oxidized that it imparts a reddish-brown color to a depth of two or three feet. This red, ferretto zone grades downward to a less perfectly oxidized, yellow colored bowlder clay which, at a depth of ten to fifteen feet, merges gradually through gray into bluish colored till of the unchanged Kansan deposit.

The upper, leached and oxidized portion of the Kansan drift sheet is very uneven. The later drift and the beds of loess and sand were spread over a surface that was deeply furrowed by erosion.

The crystalline pebbles and bowlders of the Kansan till in Fayette county are such as are characteristic of this deposit in other portions of the state. The bowlders are seldom of large size. Many of them show beautifully polished and striated surfaces. Masses of dark colored, microcrystalline trap or greenstone predominate. Quartz fragments are common, and granite bowlders are not rare. Many of the latter are in an advanced stage of disintegration.

In the extreme northeastern portion of the county the greater part of the drift material has been removed by erosion, yet it

seems probable that the Kansan ice sheet overspread the entire area, and left its mantle of glacial detritus over all of the surface. At numerous points in the townships of Fairfield and Westfield the soil band is underlain by residual cherts, which are mingled with crystalline pebbles and small bowlders and imbedded in a matrix of highly ferruginous clay. Exposures of such materials are common along the roadsides. They may be seen near the middle of the east half of section 15 of Westfield township, and near the southwest corner of section 29, Illyria township.

Highly oxidized Kansan drift, overlain by loess, may be seen in the northeast ¼ of section 2, and near the southeast corner of section 10 of Union township. Such materials are exposed a short distance north of the middle of the south side of section 10, and about the middle of the line between sections 5 and 6 of Dover township. They also appear near the middle of the south side of section 36, in the same township.

Granite and greenstone pebbles and bowlders, mingled with clay, may be seen in the wagon road a short distance east of the middle of the line between sections 1 and 12 of Clermont township, and near the middle of the line between sections 13 and 24 of the same township. Such drift materials also appear near the middle of section 8, and of section 17, Clermont township. The superficial materials that overlie the Niagara limestone at Williams' quarry contain occasional pebbles and small bowlders, and seem to consist, in part, of glacial till. Along the top of the bluff northeast of the town of Clermont bowlders of crystalline rock two to three feet in diameter are not rare. It seems probable that the margin of the Kansan glacier extended but a short distance east of this portion of Fayette county.

Buchanan Gravels.—The Buchanan gravels are derived from the Kansan drift. They were separated from the finer constituents of the drift by the sorting action of water, and were deposited along the channels of the turbulent streams which carried off the water that resulted from the melting of the Kansan glacier. Thus, in point of age, the Buchanan gravels were contemporaneous with the withdrawal of the Kansan ice

sheet. They belong to the very latest portion of the Kansan stage and the very beginning of the Yarmouth.

The deposits of Buchanan gravel present two phases. Sometimes they consist of very coarse materials in which bowlders ranging in size from a few inches to one foot in diameter are not rare. Such deposits are known as the upland phase. Other

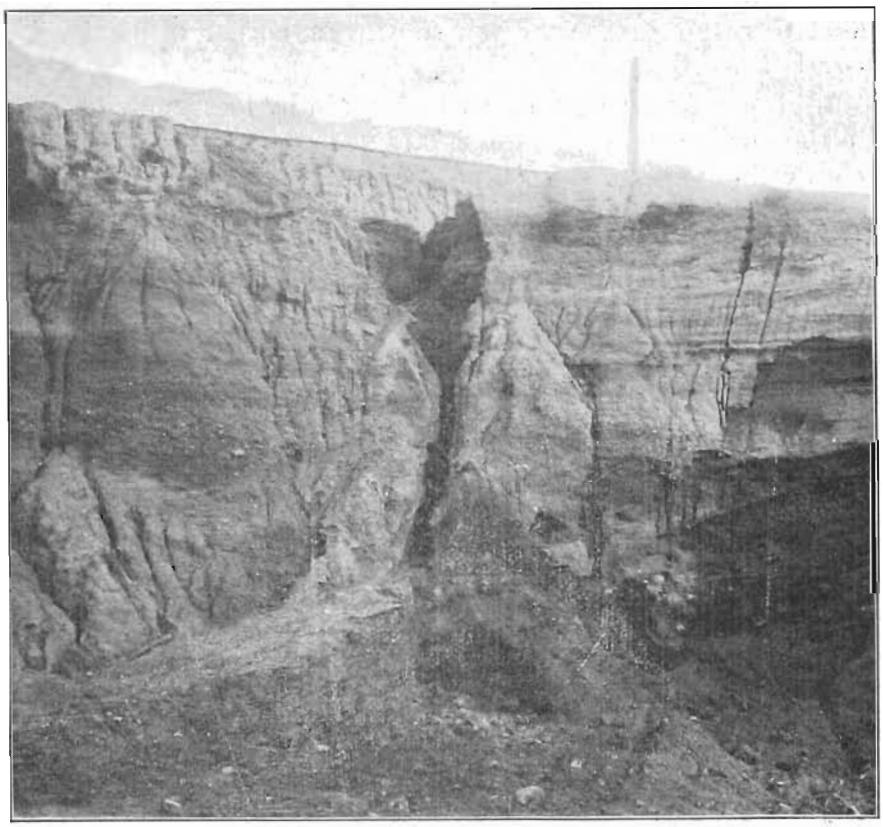

FIG. 48.—Buchanan gravels in a pit at West Union. Cross-bedding is conspicuous at the right in the picture.

beds are composed of sand and small pebbles, a large proportion of which are less than one inch in diameter. These deposits constitute the valley phase.*

* NOTE.—For a discussion of the genesis of these phases of Buchanan gravel, see Iowa Geol. Surv. Vol. VIII, p. 241, *et. seq.*, and Vol. XIII, p. 67.

All of the beds of the Buchanan gravel that were seen in Fayette county belong to the valley phase. That they were laid down by streams whose currents were exceedingly variable is indicated by the lack of uniformity in the size of the constituent materials, and in the cross-bedding which is a very common and conspicuous feature of these deposits. This will appear in figure 48. The materials are usually much weathered and very strongly stained with iron. The beds vary from three or four feet to more than twenty feet in thickness. Sometimes they occur in broad belts along the lowlands as if the streams which carried them initiated drainage lines that have since been followed. They are sometimes found over the uplands; occasionally forming ridges or elevations which rise some feet above the general level of the surrounding surface. In such cases it would seem probable that they were laid down while the ice still occupied the areas that now appear as the lower lands. Beds of Buchanan gravel are exposed at a number of points in Fayette county. Their distribution is indicated on the accompanying map of the Superficial Materials of the area.

IOWAN STAGE.

Iowan Drift.—During the greater part of the Yarmouth interglacial interval, and all of the Illinoian glacial, and the Sangamon interglacial ages the surface of the Kansan drift in Fayette county was subjected to the erosive action of the rains and streams, and to the chemical action of the amosphere and of the products of plant decay. It was during these ages that the profound leaching and oxidation and erosion of the upper portion of the Kansan drift were largely accomplished.

The Iowan ice sheet covered nearly two-thirds of the area of Fayette county. Its limits have been traced under the discussion of Topography. The drift of this age is thin. In many places over the Iowan plain very slight erosion has exposed the oxidized surface of the Kansan. Where the Iowan drift can be well seen, as in the southeast $\frac{1}{4}$ of section 27, Jefferson township, it consists of yellow clay which carries numerous bowlders

of coarse-grained, gray or pink granite. The Iowan surface is practically uneroded, unleached and unoxidized, and its bowlders of granite show but slight signs of decay.

A very conspicuous and characteristic feature of the Iowan drift area is the very numerous bowlders of large size that are strewn over the surface. Such large granite masses are conspicuous in the townships of Jefferson, Oran, Fremont, Banks and Bethel. Near the eastern border of the Iowan drift plain the bowlders are even more abundant, but they are usually much smaller in size. At several points in the townships of Putnam, Smithfield and Windsor they have been gathered from the fields and thrown in great piles, or heaped in long windrows along the roadsides.

There seems to be little order or regularity in the distribution of the bowlders. Over some portions of the Iowan area they are sparsely scattered, while over others they are strewn so thickly as to be serious obstacles to the cultivation of the land. They are decidedly more abundant over the marshy depressions and along the flanks of the swells. The causes which resulted in leaving much the greater number of Iowan bowlders over the lower lands seem somewhat obscure. They could hardly have been exposed in the depressions through the action of erosion in removing the finer constituents of the drift, for the surface over these portions of the Iowan plain seems to have suffered almost no erosion, and exists today practically as it was left when the Iowan glacier melted from the region.

Professor Calvin* has shown that the bowlders that were carried by the Iowan glacier were imbedded in the lower surface of the ice. As the ice sheet moved over slight and relatively narrow concavities the pressure upon these sub-glacial bowlders would be partially relieved, and there would be a tendency for some of them to become permanently lodged in the depressions.

The Iowan ice sheet was comparatively thin and it carried but a small amount of glacial debris. Owing to the wide extension of such a thin ice sheet, it is probable that the line of ice movement, within some miles of the margin, fluctuated

*Calvin: Iowa Geol. Surv., Vol. XIII, pp. 285 and 286.

with the climatic variations during successive series of years. There may have been periods during which, toward the glaciers' margin, the movement ceased and the ice became dead and melted where it came to rest. Then again there would probably return conditions that would favor the advance of the line of ice movement. During the periods of slackened movement of the glacier, as the dead ice melted the bowlders which it bore would be left irregularly distributed upon the drift surface. They could not have been buried to any great extent on account of the small amount of fine detritus that the Iowan ice sheet carried. With another advance of the ice movement the loose bowlders that were left over the surface would be pushed forward by the ice for a short distance until they became stranded in the depressions which, then as now, were abundant over the Iowan surface. It would seem probable that the distance the bowlders were moved, in this final shifting of their position, would be too short, and the ice mass at such points would be too thin to result in abrasion to an extent that would leave permanent marks of glaciation upon them.

The Iowan Loess.—The homogeneous, fine-grained, yellow colored, superficial material, called loess, forms a thick mantle over all of the Kansan drift area, except where it has been removed in the development of the channels of the streams. While the deposit of loess is deep over all of the Kansan drift plain, it shows the greatest depth over a belt adjacent to the Iowan border. As is usual around the immediate margin of the Iowan area, the deposit of loess is so thick over the hills that their summits stand several feet higher than those at some distance from the Iowan plain. A few knobs and ridges that lie within the Iowan drift area are also crowned with loess.

The Iowan loess, like the Iowan drift, is a very recent deposit as compared with the Kansan till upon which it rests. It is largely unleached of its lime constituent and seldom shows more signs of oxidation in one portion than in another.

Professor Calvin has shown that the loess which forms a thick deposit for a width of some miles around the margin of the Iowan plain was probably derived from the Iowan drift by some process of transportation outward from the Iowan gla-

ciers*. Such origin is suggested from the geographical relation which this body of loess sustains to the Iowan margin, from its color and its composition, and from its general position, like the Iowan drift, overlying the old, eroded, leached and oxidized Kansan surface. The fact that this loess is occasionally found covering the highest elevations over the Iowan plain, or that it sometimes occurs as a thin mantle lying above Iowan drift, is not inconsistent with the reference of its age to the Iowan, and

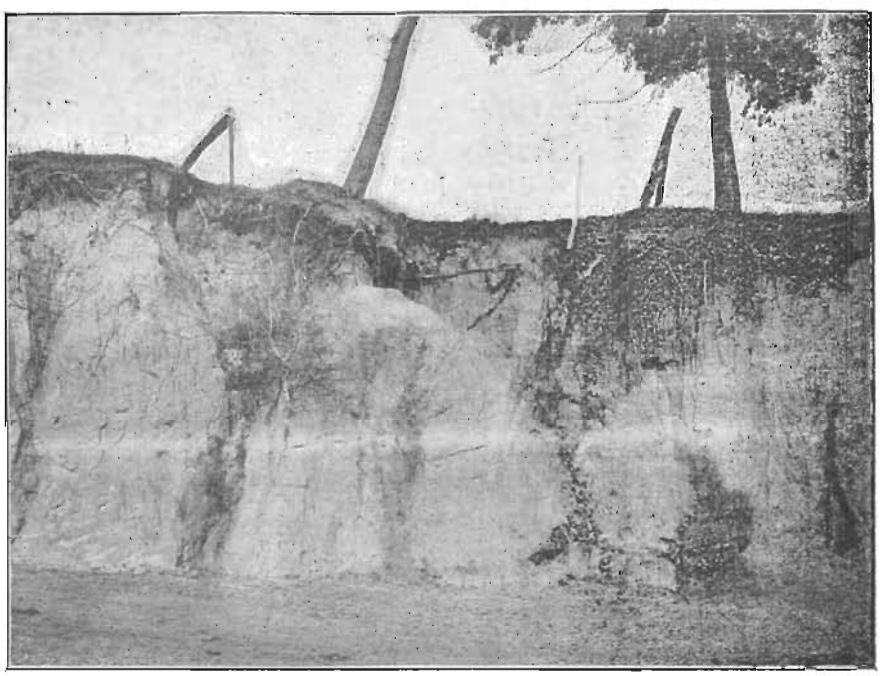

FIG. 49. Bluff of fossil-bearing loess in the west bank of Turkey river; near the middle of the south side of section 30, Clermont township.

its origin to the Iowan glaciers. Here as in other portions of the state, the loess carries fragile shells of air-breathing, herbivorous gastropods. Such an exposure, in the west bank of the Turkey river, is shown in figure 49. This material does not tend to level up the surface, but conforms to the inequalities of the underlying drift. It is not generally a stratified deposit.

*Calvin: Iowa Geol. Surv., Vol. XIII, p. 70, and Vol. VII, p. 89.

All of the facts that are presented by the loess in Fayette county are consistent with, and are best explained by, the assumption that it was transported and deposited by currents of air; and that the greater portion of the material was laid down contemporaneous with the invasion of the Iowan glaciers and immediately succeeding their withdrawal. There seems no doubt but that wind deposits somewhat resembling the Iowan loess materials are taking place at the present time. It is not unlikely that a portion of this fine-grained material in Fayette county has been shifted, worked over, and redeposited since the Iowan age.

In the southern and western portions of the state, the thicker beds of loess are found in such a relation to the channels of the larger streams as to indicate that this material might have been gathered by the winds from the flood plains and alluvial bars, and deposited on the bluffs or slopes of the uplands, in places where the air currents were obstructed or where the dust-like material was caught and retained by vegetation. It seems certain, too, that at several other points in the state there are areas in which the loess can not be referred to the Iowan age, and in which beds of loess are exposed within relatively short distances which are not contemporaneous deposits.* However, in this portion of the state, and further south in the counties of Tama, Benton and Johnson, the much more intimate relation which the thickest deposits of loess sustains to the Iowan border than to the valleys of the larger streams makes the impression in the field overwhelmingly in favor of the greater portion of this accumulation having taken place during, and immediately following, the stage of Iowan glaciation.

Iowan Gravels.—Deposits of unweathered gravels of Iowan age appear in the upper part of the gravel terrace that is exposed at various points along the Turkey and Little Turkey rivers. The fresh character of the upper gravels as compared with the very ferruginous and decayed materials at the base is well shown at the exposure near the Huntsinger bridge, two and one-half miles east of Eldorado. See figure 36 on page 452. At this place there are seen occasional lens-shaped masses of loess imbedded in the coarser terrace material. One such

*See Iowa Geol. Survey, Vol. XIII, pp. 328-330.

body of loess, buried beneath eight feet of gravels measured fourteen feet in length and had a maximum height of three feet. It contained a number of fossils among which several individuals of two or three of the more common loess species were collected. This loess mass was underlain with a depth of two or three feet of fresh looking gravel, below which there was exposed a thickness of about eight feet of old and much iron-stained terrace material.

There is no place in the immediate locality from which it seems probable that these lenses of loess could have slipped down to their present position. Possibly such masses are fragments of pre-Iowan loess bodies; or it may be that they became detached from beds that were deposited on the slopes beyond the Iowan margin, while this ice sheet occupied the area a short distance to the west. During the time of melting of the Iowan glacier, and while the flooded streams were carrying ice floes and coarse material, such masses may have been dislodged from the place of their deposition, and having slid down upon cakes of ice they could be carried without disturbance, while frozen, and imbedded with the accumulating terrace deposit.

DEFORMATIONS AND UNCONFORMITIES.

A slight folding of the strata may be seen in the east bank of a small stream near the middle of the east side of section 19, Clermont township. See figure 40 on page 472. The horizon of *Orthis whitfieldi*, in the Lower Maquoketa beds, is involved in this flexure. It seems probable that the deformation here is due to a local creeping of the shales under pressure from the hill above, rather than to a widespread crumpling of the layers.

Where the Niagara strata are exposed in the railroad cut, at the "Backbone", about two and one-half miles southeast of West Union, the layers show undulations in which the low anticlines are one to one and one-half feet in height. A fold in the Niagara limestone, eighty to one hundred feet in vertical height, is indicated by the outcrop of layers of the *Newberria*

johannis zone of the Devonian strata, in the town of Fairbank, at an altitude forty feet lower than the top of the Niagara ledge that is exposed two miles to the northward, in the east bank of a branch of the Wapsipinicon river. In the deep railroad cut, at Fayette, small undulations appear in the layers of the Wapsipinicon stage at the base of the Lower Davenport breccia. The crushed and shattered materials near the top of the Wapsipinicon deposits form another example of deformation in the Devonian strata.

The most conspicuous unconformity that was encountered in this area is that between the Pleistocene deposits and the indurated beds upon which they rest. The loess and the Iowan drift were also spread unconformably over the eroded surface of the Kansan till.

Soils.

A considerable variety of soils is represented in Fayette county. The most productive type, and the one most widely distributed, is that which has been developed upon the Iowan drift. This soil is dark colored and usually deep. It is generally rich in humus and in all of the plant foods that result from the decay of organic matter. In this soil the mineral constituents are unleached and undecayed. It contains an abundance of lime and other inorganic substances that contribute to the growth of plants. This soil is so granular and porous that it does not run together or bake from the effects of excessive rains. It is light and warm, and easily worked. It responds most generously to intelligent methods of cultivation, and is altogether one of the most fertile, satisfactory and important soil types found in the state.

There are occasional areas over the Iowan plain in which the drift has been modified by a more recent deposit of windblown sand. Such tracts are more common in the vicinity of the larger streams over the townships of Jefferson, Oran, Fremont, Center and Eden. Such soil is warm and mellow. It is favorable for maturing early crops, but it is less productive and more sensitive to drouth than the soil on the more typical Iowan drift.

Over the greater portion of the Kansan drift area the soil has been developed upon a deep mantle of loess. This loess soil is fine-grained, is quite porous, and contains an abundance of lime. Where the slopes are not so steep as to cause rapid rainwash, and thus prevent an accumulation of humus in the superficial portion, this loess soil ranks with the best in its endurance and productiveness. Areas of exceptionally fertile loess soil occur north of West Union, and east of the village of Taylorsville. Too often, however, the loess areas are very hilly, and unless great care is exercised in their cultivation, the rains furrow the fields with gullies and soon remove the humus and other plant foods that may have accumulated previous to the attempts at tillage. When this soil has never been disturbed by the plow it produces the best of crops of blue grass. Even the steeper slopes furnish excellent pasturage which grows constantly better with the passing years.

Along the flood plains of the streams there has been developed an alluvial type of soil of superior quality. Over these level areas leaching and washing are at the minimum. This alluvium usually consists of the very cream of the superficial materials that has been washed from the slopes of the basin which is drained by the respective streams. The subsoil is usually sufficiently porous to insure good underdrainage. Where these soils are not too sandy, they are prevailingly productive and rank among the best in endurance.

The most important alluvial areas are found over the flood plain of the Turkey river, and along the Little Turkey river and the Volga. Small tracts also occur along Otter creek in Pleasant Valley township. A belt of Iowan drift, slightly modified by alluvial materials, borders the Wapsipinicon river in Oran and Fremont townships, and Crane creek in the township of Eden.

ECONOMIC PRODUCTS.

Building Stone.

In Fayette county small quarries that can furnish stone suitable for ordinary building purposes are numerous and well distributed. At a number of points in Clermont township an inferior quality of stone is obtained from the more calcareous

FIG. 50. Williams' quarry near the east side of section 24, Clermont township. The thick layers in the lower portion furnish the good stone.

portions of the Lower Maquoketa beds. In a few places the less cherty layers of the Middle Maquoketa division yield a suitable material for cellar walls and rough foundation work.

Niagara Limestone.—The Niagara limestone is the most important quarry stone in the county, from a commercial point of view. The quarry of Wilkes Williams, on the east half of section 24 of Clermont township, produces practically all of the

dressed stone and range material that is marketed in this area. A view of the ledge worked is presented in figure 50. The bed consists of thick, homogeneous layers at the base of the Niagara. The stone is quarried in large blocks by the "plug and feather" method. These masses are then sawed to the desired dimensions, by means of large steel blades which work back and forth horizontally and are constantly supplied with water and sand. The distance between the saws can be adjusted to cut slabs of any desired thickness. The sand used for cutting is rather angular, coarse-grained and very ferruginous. It is taken from a hill in the edge of Clayton county, and represents an exceptionally fine-grained bed of the valley phase of the Buchanan gravels. The quarry furnishes sawed stone for sills, water tables, side walk crossings and range work. The greatest demand is for trimmings for buildings.

Crushing tests were made at the University of Wisconsin on five two-inch cubes of this stone with an average result of 5,280 pounds per square inch. The dimension stone is hauled on wagons and loaded for shipment at the stations of Clermont and Postville. A market for the products is found in many of the larger towns of northern Iowa, and west into South Dakota.

The Williams and Davis quarry, about two and one-half miles southeast of West Union, is worked in the cherty phase of the Niagara limestone. No stone suitable for shipment is produced at this place. At a number of points in the townships of Fairfield and Auburn small quantities of stone are taken from Niagara layers to supply a local demand.

Devonian Limestone.—Layers of Devonian limestone, from a zone between the horizon of very abundant *Gypidula comis* and that of *Acervularia profunda*, are worked at a greater number of more widely separated points than any other rocks of the county. Stone of this horizon is quarried at a number of places, near the top of the bluffs, in the town of Fayette. The layers here are more or less broken and furnish a yellow, earthy, magnesian stone of excellent quality. Materials which correspond in color, lithology, and geological position with those worked at Fayette are quarried in the northwest $\frac{1}{4}$ of

section 6, Windsor township, and also in the extreme northwest corner of section 2 of the township of Bethel. Small quarries are also operated in the rocks of this horizon near Alpha and Waucoma, in Eden township.

In the vicinity of Maynard and Fairbank the stone that supplies the local demand is taken from beds that are the equivalent of those worked at Fayette, but the material is much less magnesian. Blocks of desirable size are not so readily obtained from these non-magnesian layers, and the materials are much less durable.

Lime.

There is no lime burned in commercial quantities in Fayette county. In the vicinity of Auburn a small amount of the Niagara limestone is burned each year in rude, inexpensive kilns. The stone is here a remarkably pure carbonate of calcium, and the quality of the lime that is produced is equal to the best grades that are made from lime carbonate. At a few other points over the Niagara area the immediate neighborhood needs are supplied by burning an occasional small kiln of stone.

Clay.

The clay resources of this area are for the most part undeveloped. A large amount of the clay products that are used in the county are imported. Clay goods are manufactured at two points, near Oelwein and at Clermont.

Oelwein.—The plant of the Oelwein Pressed Brick Company is located one mile north and one mile west of Oelwein. It is owned and operated by Mr. J. C. Knapp. The clay is taken from a pit in the Kansan drift which shows the following section:

		FEET.
3.	Moderately coarse sand	2
2.	Deposit resembling the valley phase of Buchanan gravel	1
1.	Bed of clay in which pebbles and small bowlders are not abundant. Upper ten feet yellow in color, blending into bluish-gray at the base.	14

In this pit the materials of the second and third members are stripped away as waste. The entire thickness of number 1 is utilized. The clay is passed through a crusher which consists of double rolls, one with pins and one with perforations. These work in such a manner as to sort the most of the pebbles from the clay and to pulverize those that remain. The plant is equipped with one stiff mud, and one dry press brick machine. One large Scove kiln and one Eudaly kiln are used in burning

FIG. 51. Shale pit of the Clermont Brick and Tile Company. The horizon is immediately below the base of the Middle Maquoketa beds. Clermont, Iowa.

the wares. Construction brick is the only class of goods produced, and a market for all of the output is found in the town of Oelwein.

Clermont.—The Clermont Brick and Tile Company operates a clay plant in the north part of Clermont. They work a body

of shale from a zone in the upper part of the Lower Maquoketa beds. The pit is located about one-half mile east of the plant, and the shale is conveyed to the works on wagons. There is exposed in the pit about twenty feet of shale which is overlain with much decayed residual products of the Middle Maquoketa beds. See figure 51. The shale is quite hard, and becomes plastic after weathering or soaking in water.

Results of the rational and ultimate chemical analyses of this shale are given below.*

Silica	28.82
Alumina	10.37
Combined water	16.24
Clay and sand	55.43
Iron oxide	3.76
Lime	19.14
Magnesia	5.40
Potash	5.38
Soda	7.41
Total fluxes	41.09
Moisture	0.43
Sulphur trioxide	3.01

RATIONAL ANALYSIS.

Clay substance	73.32
Feldspar	4.93
Quartz	21.76
Total	100.01

The wares made from the shale alone shrink but little in burning and are almost white in color. Loess is mixed with the shale in varying proportions to impart a richer color to the products. Construction brick, drain tile, hollow block and sidewalk blocks are manufactured in white, mottled and red colors.

*Iowa Geol. Surv., Vol. XIV, p. 393.

In recent years common brick have been made at Hawkeye by Mr. L. A. Book, but during the past year the plant has not been in operation.

The Upper Maquoketa beds consist of a body of plastic shale in no way inferior to that used by the Clermont Brick and Tile Company. Shale of this horizon is favorably exposed at the towns of Saint Lucas, Auburn, Brainard, Lima and Wadena. Deposits of loess are also accessible near each of these points, if it might seem desirable to mix this material with the shale, as is done at Clermont. So far as the abundant supply of excellent raw material is concerned, all of the more common clay wares might be successfully manufactured at any one, or all, of the above mentioned towns in Fayette county.

Sand.

There are no deposits of merchantable sand found in the area under consideration. Gravel and finer material suitable for use in cement walks may be found along the beds of the most of the larger streams. Such materials occasionally occur in deposits of the valley phase of the Buchanan gravels. The river laid materials, when screened, furnish sand adapted for making common lime plaster and mortar. They supply practically all of the sand used in the county for these purposes.

Road Materials.

Deposits of the Middle Maquoketa rocks, and beds of the Niagara and the Devonian limestone furnish material that would make very serviceable macadam. Outcrops of such beds are fortunately distributed so that nearly every township of the county is accessible to a supply of such stone within easy hauling distance.

However great may be the desirability of macadamizing the country roads, its great cost will make such a proposition im-

practicable over a large portion of the county for many years to come. There are about seventy miles of public roads in each township, and at present the average sum of money that is annually expended on the roads of each township is less than one thousand dollars. If this entire amount could be applied towards macadamizing the roads there would be only a fraction of one mile covered each year. Under the present conditions the greater portion of the road tax in each township is required to keep all of the roads in a passable condition, without any attempt being made at permanent road building.

At the present time it would seem wiser to work along cheaper lines of road improvement. All of the country roads could be gradually graded up in such a manner that the water that falls upon them could quickly escape at the sides. A line of drain tile could be placed down the middle of the road or at the roadsides, where the subsoil demands underdrainage, and further away at points where it may be required to divert the water of a porous soil stratum from entering the roadbed. When the roads are prepared in this manner, and then a top dressing of gravel, a few inches in thickness, is applied, a very excellent and permanent roadbed is secured. The cheapness of such a plan of road improvement makes the method feasible under present conditions. Fortunately for the people of Fayette county, the beds of Buchanan gravel are abundant and well distributed over the area, as is shown on the map of Superficial Materials. The constituent particles of these deposits are of such size that without further preparation they are ready to be hauled out and applied to the road. A start has already been made in building gravel roads over this area, the success of which justifies the much more extended use of these fine gravels in building excellent, cheap and durable country roads.

Cement Materials.

In recent years the expansion of the uses to which Portland cement is applied has been extremely rapid. In some of the adjoining states the manufacture of cement has become a very important industry, but as yet there is no cement producing plant in Iowa. On this account the location in our state of deposits suitable for the manufacture of Portland cement is of more than casual interest. With this purpose in view samples were collected from the most promising localities in Fayette county, and submitted to the Survey Chemist for analysis. The samples, numbers 1 and 2, were collected from near the village of Auburn. Number 1 represents the Upper Maquoketa shale, and number 2 came from the non-dolomitized Niagara limestone that overlies the shale at this place. The results of the analyses of these two samples were reported by Professor Michael as follows:

Sample Number 1. Shale.

	PER CENT.
Silica, SiO_2	49.60
Alumina Al_2O_3	6.36
Iron oxide, Fe_2O_3	6.25
Lime, CaO	22.45
Magnesia, MgO	0.20
Soda, Na_2O	0.35
Potash, K_2O	0.90
Loss on ignition	13.56
Sulphur trioxide	0.37

Sample Number 2. Limestone.

Silica	0.68
Alumina and iron oxide	0.50
Calcium carbonate	98.52

A calculated mixture consisting of 4,049 pounds of raw shale used with 9,946 pounds of the limestone would yield, upon calcining, about 9,105 pounds of cement having a composition of silica 20.08 per cent, and calcium oxide 64.00 per cent. The purity of the limestone, sample number 2, is remarkable and

the per cent of the magnesian ingredient is extremely low. The materials here are almost unlimited in quantity, and are readily accessible. There seems little doubt that from some combination of the above shale and limestone materials a very excellent grade of Portland cement could be produced. The apparent serious drawback to the profitable working of these beds lies in the fact that the nearest railroad point is West Union, five miles distant.

Near Clermont a sample for analysis was taken from the limestone layers of the *Isotelus maximus* beds, and from the bands of shale which lie between these calcareous layers. The following are the results of these analyses:

	Limestone PER CENT	*Shale* PER CENT
Silica	11.95	33.82
Alumina and iron oxide	2.80	9.75
Calcium carbonate	84.80	56.66
Magnesium carbonate	0.45	3.17
Soda	.00	1.82
Potash	.00	4.25
Loss on ignition	.00	15.60
Sulphur trioxide	.00	1.62

A calculated mixture consisting of 11,086 pounds of the limestone with 4,147 pounds of the shale would give, after calcining, about 10,400 pounds of cement of the composition silica 27.24 per cent and calcium oxide 65.79 per cent. The proportion of silica above is larger than would be desired. It might be possible to lower the percentage of silica in other combinations of these materials without appreciably affecting the lime.

Mixtures of the limestone and shale from the *Isotelus maximus* horizon do not promise such satisfactory results as do those of the limestone and shale deposits near Auburn. However, the greater accessibility of the former deposits to railroad facilities would make it desirable for prospective cement producers to test the combinations of these materials more fully before pronouncing the beds unsuitable for cement manufacture.

Water Supplies.

The larger streams of the area furnish an unfailing supply of water. Even their smaller affluents which rise in the seapy sloughs over the Iowan drift plain have a constant flow throughout the year. Over the greater portion of the area wells in the Pleistocene deposits furnish an abundance of water at a depth varying from twenty or thirty, to one hundred and forty feet. In the northeastern portion of the county, the top of the Maquoketa shale determines a line of springs. many of which have a perennial flow, and furnish an excellent supply of water.

Water Powers.

The large streams of the county furnish ideal conditions for developing strong water power. Along the Turkey river a well kept and well furnished mill is operated at Eldorado, and further south there is another at Clermont and still another at Elgin. Until recent years a mill has been kept up at Dover Mills, but at present the dam is out of repair. At Auburn, on the Little Turkey river, there is a well equipped mill with excellent power. Another such mill is operated at Waucoma. At the village of Alpha a mill on Crane creek does a flourishing business in flour and feed. Water power is also utilized at Fairbank on the Wapsipinicon river.

Lead.

Persistent rumors of the finding of deposits of lead reached the writer during the prosecution of the field work in this area, although careful search revealed no grounds for such reports. There are men who relate in all seriousness how in the early days lead mines were secretly worked by the Indians in this region. What is even worse they seem to expect credence to be placed in their word. The lead that is mined in Dubuque

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF FAYETTE COUNTY, IOWA.

BY

T. E. SAVAGE.

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

DEVONIAN
WAPSIPINICON AND CEDAR VALLEY

NIAGARA
DELAWARE

ORDOVICIAN
MAQUOKETA

GALENA—TRENTON

INDUSTRIES

QUARRIES

CLAY WORKS

GRAVEL PITS.

DRAWN BY F. C. TATE

IOWA LITHO. CO.

county comes from dolomitized rocks of the Galena-Trenton stage. So far as the Galena-Trenton rocks are exposed in Fayette county they consist of unaltered limestones. The great body of dolomite that occurs in this area is a later deposit and has not been known to yield any quantity of lead or zinc in this portion of the country. It is possible that small quantities of these minerals may be found in the rocks of our area, but the probability of finding workable deposits in Fayette county is too remote for serious consideration.

Copper.

Some years ago a piece of copper was found in the surface materials near Elgin. Under the stimulus of this discovery there has been considerable time and money expended in sinking a shaft in search for copper near that place. The strata penetrated include the greater portion of the Lower Maquoketa beds.

Masses of native copper have been found in the drift at various points in the state.* Such fragments were brought down by the glaciers from the north at the same time that the crystalline bowlders, found in the Kansan drift, were transported to their present position. It is needless to say that the presence in the drift of occasional fragments of copper furnishes absolutely no indication of deposits of this mineral in the underlying rocks of the state.

Gold.

In the early years of the settlement of Fayette county gold was panned in small quantities from the gravel and sand along the channels of a number of the streams. Mr. C. E. Allen of West Union is authority for the statement that the gravels in the bed of Otter creek, a short distance southwest of West Union, have yielded to the patient washer from one dollar to a

*Geology of Benton County, Iowa Geol. Surv., Vol. XV. p. 223.

dollar and twenty-five cents per day. Doctor Parker, of Fayette, has panned gold out of the sands of Alexander creek, south of Fayette. Responsible parties state that gold was exploited with small returns in the gravels and sands of Bear creek a short distance east of Cornhill, in Fairfield township.

In each of the above cases, as with all the gold found in our state, the minute particles of the precious metal were disseminated in the drift, with which material they were brought down by the ice sheets from the northern ledges. These particles have become segregated in the sands and gravels along the streams by the sorting action of the water. The presence of minute grains or scales of gold along the beds of the drift streams is quite common in Iowa, and in other states.* Like the finding of copper, the presence of such gold particles in the sands that have washed out of the drift is no indication that such materials occur in the native rocks of our state.

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*Annual Rept. Geol. and Nat. Hist., Resources of Indiana, 1901-02, pp. 20-28. See also, Iowa Geol. Surv. Vol. XI, p. 18. *et seq.*