GEOLOGY OF DELAWARE COUNTY.

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INTRODUCTION.

Delaware county belongs to Northeastern Iowa, a region that has become noted the world over by reason of McGee's exhaustive memoir on its Pleistocene history.* Delaware lies directly west of Dubuque county and its northeast corner is only about eight or ten miles distant in a direct line from the Mississippi river. Its fertile lands early attracted the stream of settlers overflowing from the mining region around Dubuque. The main body of the county is included in the great Iowan drift plain, but in the extreme northeast it embraces some of the rugged irregularities of the Driftless Area. Delaware has Clayton county on the north, Buchanan on the west, and Jones and Linn bound it on the south. The eastern boundary of the county is twelve miles west of the Fifth Principal Meridian, the north-south line to which all the ranges of townships in the state are referred. The county is cut into approximately symmetrical north and south halves by the Second Correction line. Sixteen congressional townships are included in the area, the eight townships north of the correction line being severally somewhat larger than those south of it.

*Pleistocene History of Northeastern Iowa, Eleventh Ann. Rept. U. S. Geol. Surv., pp 189-577. Washington, 1891.

The area at present included in Delaware county was among the first regions west of the Mississippi to be studied by geologists. It was traversed in the autumn of 1839 by a party organized, under the direction of Dr. David Dale Owen, to explore the mineral lands of the United States. Each township was examined, quarter section by quarter section, and notes were made on the timber, soils and rock exposures. In the published report* of this exploration the detailed observations on the several townships are presented in short paragraphs under the following heading.

"*Description of the individual townships, showing the face of the country, proportion of prairie and timber, how watered, nature of the soil, and the kind of rocks and minerals.*"

Owen's work of that year began below Davenport and was carried, in Iowa, as far north as McGregor, and so Delaware county is only a small part of the area explored by the remarkable survey of the autumn of the year 1839. The soils are graded as first, second and third class—first class soils, in the judgment of the pioneer explorer, being rather rare, even in Delaware county. No minerals were noted in the area we are considering except some indications of iron ore. Under the head of "Fossils of the Coralline Beds of the Upper Magnesia Cliff Limestone of Iowa and Wisconsin," Dr. Owen, on plates xiii and xiv, gives excellent figures of a number of the common fossils of the Niagara limestone as it is developed in Delaware county. Many are described as new species, but for some reason Owen's specific names have not received the recognition from later students of Paleontology that they clearly deserve.

Mr. J. D. Whitney, Assistant Geologist on the Survey conducted by James Hall, notes very briefly some of the characteristic features of Delaware county.† No detailed investigations were made in the county, and the essential facts reported are embraced in the simple statements that the region is mostly

*Rept. of a Geological Exploration of Part of Iowa, Wis. and Ill., in the Autumn of the year 839. David Dale Owen, M. D. Ordered printed June 11, 1844.

†Rept. Geol. Surv. of Iowa, James Hall and J. D. Whitney, vol. I, part i, p. 295. 1858.

rolling prairie, it is drained by the Maquoketa river and its branches, the rock exposures are not satisfactory, and the rocks seen in place belong to the Niagara limestone.

The report of Dr. C. A. White* makes no reference specifically to Delaware county, but on the geological map accompanying the report the county is included in the area occupied by formations of the Upper Silurian period.

In McGee's memoir on northeastern Iowa† there are many references to geological phenomena in Delaware county. The indurated rocks and superficial deposits receive more or less attention. The Rockville conglomerate is noted for the first time in geological literature, and a new formation is thus added to the geological section of northeastern Iowa.

In Professor Norton's report‡ on the Artesian Wells of Iowa there is a detailed description of the deep well at Manchester.

Short papers relating more or less directly to the geology of Delaware county, have appeared in the *Geological Magazine*, the *American Journal of Science*, the *American Geologist* and the *Proceedings of the Iowa Academy of Sciences*, under the authorship respectively of McGee, Wilson and Calvin.

PHYSIOGRAPHY.

The topography of Delaware county includes a number of interesting and unique forms. About two-thirds of the surface is occupied by Iowan drift, and this area, with some exceptions to be noted later, presents the rather monotonous alternations of gently rounded eminences, and broad, irregularly disposed swales, or "sloughs," that, in the absence of more perfectly defined drainage channels, serve as water courses to carry the storm waters to the larger streams. In the typical Iowan drift plain the topography shows no erosional forms, the irregularities of the surface, such as they are, being

*Rept. on the Geol. Surv. of the State of Iowa, by Charles A. White, M. D., Des Moines, 1870.

†Op. Cit.

‡Artesian Wells of Iowa, by William Harmon Norton. Iowa Geol. Surv., vol. VI, pp. 113-428. Des Moines, 1897.

FIG. 1. Knob of limestone projecting through the Iowan drift plain in sw. qr. section 2, Delaware township, Delaware county.

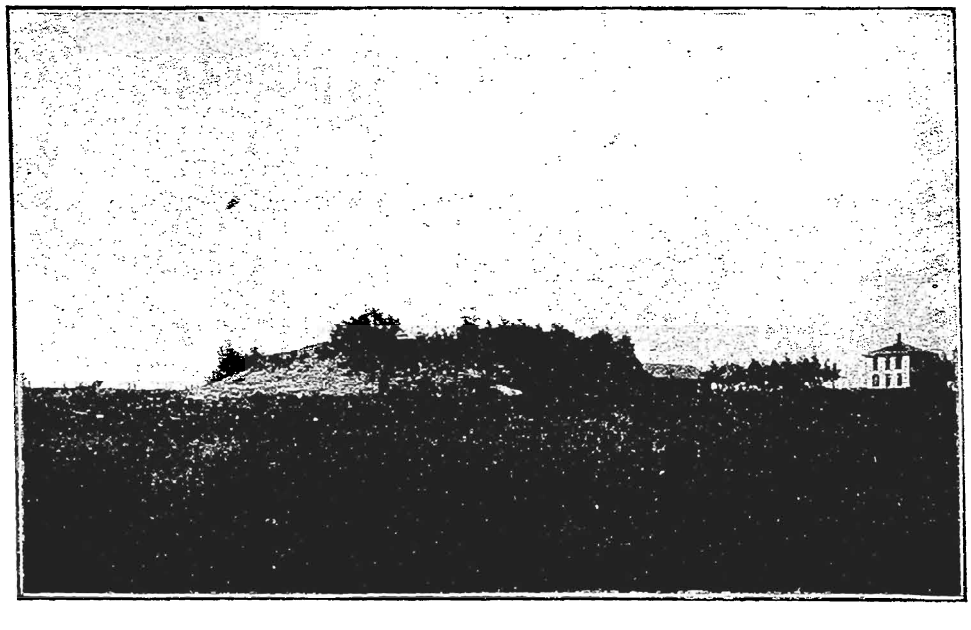


FIG 2. A very symmetrical rounded boss of Niagara limestone rising conspicuously above the Iowan drift plain in sw. qr. sec. 12, Oneida township, Delaware county.

due mainly to the eccentricities of ice molding. The Iowan drift plain is best developed southwest of the Maquoketa river, in Adams, Hazel Green, Prairie, Milo and Coffins Grove townships. Northeast of the river the best examples of the drift plain are found in Delaware, Honey Creek, Oneida and Bremen townships. The characteristic plain of Iowan drift was, at the time of settlement of the county, a gently undulating treeless expanse, covered in summer with a luxuriant growth of prairie grass, and dotted with numerous bowlders of grayish or reddish porphyritic granite. The low lands, or sloughs, were undrained, and, except in the neighborhood of the main streams, there were practically no indications of erosion as a factor in the genesis of the topography. Since the settlement of the county many of the sloughs have been artificially drained, and many more have been drained by ditches of varying depth cut in the rich, black loam by storm waters gathered from the higher grounds and flowing along the axes of the broad, shallow depressions.

Within the area properly belonging to the Iowan drift there are a number of exceptional topographic features. One group of these is due to the fact that near the margin of the Iowan ice the materials of the drift were too scant wholly to conceal the irregularities of the pre-Iowan surface. Accordingly some of the pre-Iowan knobs and prominences project above the mantle of drift. Some of these are symmetrically rounded rocky knolls that, viewed from a short distance, bear a very striking resemblance to the tumuli of the mound builders. A very characteristic example of these pseudo-tumuli is seen in the Nw. ¼ of Sw. ¼ of section 2, Delaware township (Plate vii, Fig. 1). This stony knob rises twelve feet above the level of the drift immediately surrounding it. It is composed of very much weathered Niagara dolomite which contains silicified specimens of *Favosites favosus*, *Alveolites undosus*, Syringopora, *Amplexus shumardi*, Zaphrentis and some very obscure Stromatoporoids. Another similar knob, very striking on account of its symmetrically rounded form rising above the drift

mantled plain, occurs in the Nw. ¼ of Sw. ¼ of section 12, Oneida township. The rock here is thin bedded, and much decayed on the outside (Plate vii, Fig. 2). It has been quarried to some extent for road material, and amongst the debris there occur imperfect specimens of *Favosites favosus*. These knobs bear no constant relation to surrounding altitudes. They may occur in any situation, from tops of hills of moderate height to low grounds bordering the prairie streams. The first example given above is found on a hill top, the second occurs on the border of a low plain, through which flows a branch of Plum creek.

Another feature, which is after all but a modification of the preceding, is found in the form of weathered crags and irregular rock masses that, in certain cases, occupy spaces covering some hundreds of acres. The deeply pitted, weather-beaten rocks and the absence of till suggest that some of these areas never were invaded by Iowan ice. The topography within such areas is usually very irregular and is in fact due to pre-Iowan erosion and weathering of massive Niagara dolomite. An example of the topography under consideration occurs in the region immediately adjoining the town of Earlville, particularly on the west and south. In the east half of section 21, Oneida township, is a small, nearly driftless valley bounded by weather-beaten crags. The topography is plainly pre-Iowan. The crags show effects of prolonged weathering, and the relief is wholly inconsistent with known effects of erosion since the close of the Iowan stage. Another very typical example of the same type of topography occurs in the Sw. ¼ of section 2 and Se. ¼ of section 3 in Delhi township. Drift is practically absent and the scant surface materials are wholly insufficient to cover up the jagged, weathered ledges of Niagara limestone, or to fill up the small gulches and crevices between the prominent projecting masses (Plate viii, Fig. 1). The rock here, as in all cases of the same kind elsewhere, has weathered into fantastic shapes. The surface is deeply pitted, and everything betokens exposure to the atmosphere

FIG. 1. View of a portion of the stony knob projecting through the drift in se. qr. section 3, Delhi township, Delaware county, showing the weathered, fissured and pitted condition of the limestone.

FIG. 2. Valley of Elk creek bounded by hills 220 feet high. The topography is that of the driftless area, view taken in section 10, Elk township, Delaware county.

for a much longer period than post-Iowan time. At this point the rocks are quite barren of fossils. *Favosites favosus* and a large celled variety of *Halysites catenulatus* occur very sparingly. A number of areas of the same type are scattered through North Fork township, being especially prominent in sections 10, 22 and 27, and driftless rocky ridges occur in section 36 of Bremen township. In this last case the rock ledges are rendered very conspicuous by the fact that they rise somewhat abruptly above a low and very level plain covered with a thin mantle of Iowan drift. The low plain referred to is a part of the wide preglacial valley of Bear creek. In sections 15, 16 and 22 of the last named township, there is a somewhat rounded rocky hill projecting abruptly above the plain of Iowan drift. There are some rocky points in a plain of Iowan drift near Sand Spring in South Fork township. There are also similar rocky points in sections 6, 7 and 18 of Milo township and in section 12 of Prairie.

With the exception of the cases cited in Milo and Prairie townships, all the remnants of pre-Iowan topography within the proper limits of the area belonging to the Iowan drift are found near the line which marks the extreme eastern border of the Iowan glaciers. That the Iowan ice invaded some of the areas referred to is indicated by typical bowlders lying on bare rock surfaces or on residual clays and cherts; but finer materials, such as ordinarily make up the main body of the drift sheet, seem to have been locally absent.

Other exceptional topographic forms, similarly limited to the marginal zone of Iowan drift, are found in the peculiar ridges called paha by McGee.* The typical paha are isolated, elongated hills rising above the Iowan drift plain. Superficially they are composed of loess, a fine, yellow, pebbleless clay, but the loess usually forms a relatively thin mantle over a core of rock or of Kansan drift. The paha ridges are not always isolated. A chain or series of such ridges, more or

*Pleistocene History of Northeastern Iowa, Eleventh Ann. Rept. U. S. Geol. Surv., p. 220. Washington, 1891.

less intimately connected one with another, may extend across the country for miles; and in many cases the paha are simply lobes or digit-like extensions projecting into the relatively low, drift-covered plain from a larger body of loess that may cover continuously an area of many square miles in extent. Good examples of isolated paha are seen in sections 3, 4 and 12 of Honey Creek township, and in 6, 7 and 18 of Elk. There is a very beautiful cluster of these loess-covered ridges in sections 23, 24, 25 and 26 of Oneida township, and there is another group in 9, 10 and 15 of South Fork.

Of the paha ridges connected with continuous areas of loess, mention may be made of the chain of loess hills extending from section 6 to section 10 of North Fork township. In sections 27 and 28 of Union township there is another very prominent ridge of the same type. Others are found in the northwestern sections of Union and at other points around the margins of the extensive loess-covered areas presently to be noted.

A third exceptional topographic form within the area properly belonging to the Iowan drift occurs in the form of sand ridges, or dunes, of æolian origin. While on the whole these ridges are inconspicuous features of the landscape, they occur in certain localities in such numbers as to force themselves upon the attention. One of the most definitely marked ridges of wind-blown sand is found at the "Sand corners," at and around the southeast corner of section 1, Delaware township. Wind drift sand, in places occurring in ridges and in places spread out on a comparatively level surface, is very abundant in the southeast half of North Fork township, and a moderately conspicuous sand ridge, with a definitely northwest-southeast trend similar to that of the isolated paha, occupies parts of sections 17 and 18 in South Fork township.

Besides the paha already described, there are in Delaware county continuous areas of considerable extent covered with loess. Within these larger loess-covered regions no Iowan drift was observed, and it is quite certain that, in some cases

at least, they were never invaded by Iowan ice. In all these regions erosional topography prevails. The surface, as a rule, is carved into ridges and narrow valleys. There are no undrained sloughs, but everywhere the drainage is perfect and the water courses well defined. The margins of these regions, where the loess hills begin and the Iowan drift ends, are always higher than the adjacent drift plains, a fact very fully and very graphically described by McGee in the work on northeastern Iowa already cited. One of the areas in question embraces all of Colony township and parts of Elk, Oneida and Bremen. This region contains Kansan drift, covered very generally with loess. The Iowan ice seems to have reached its extreme eastern margin along a very sinuous line drawn from the northwest corner of Elk township to near the southeast corner of section 25, Bremen township. On one side of that line is a relatively low plain, on the other side are loess ridges rising from twenty to forty, or even sixty, feet higher. On one side a gently undulating plain, without trace of erosional topographic forms; on the other side sharply rounded hills and V-shaped valleys, the whole surface deeply trenched and molded by erosion. On one side Iowan drift, Iowan bowlders and black, loamy soil; on the other side nothing but Kansan drift occasionally revealed in the water-worn gullies under a heavy mantle of loess, and uneven, rough, hilly farms with a soil composed of yellow loess clay. The transition is so abrupt as to create surprise even in the mind of the experienced student of Pleistocene deposits and their attendant topographic forms.

Northeast of the line which marks the limit of the Iowan drift, two types of topography are clearly recognizable. Apart from the valleys of the main drainage streams, the loess, in general, forms a mantle resting upon an eroded surface of Kansan drift, and the loess itself has suffered much erosion since it was deposited. The present surface configuration is due, therefore, to effects produced during two periods of erosion, both post-Kansan. The first erosion period extended

over the very long interval between the deposition of the Kansan drift and the deposition of the loess. During this period the drift surface was deeply carved, and when later the loess was molded over the irregularities of this surface the old pre-loessial lines of drainage were not so completely obliterated but that they controlled to a large extent the lines along which erosion attacked the new deposit. The fine silt-like loess is easily cut by surface drainage, and post-loessial erosion has in most cases tended to accentuate the irregularities of the surface on which this deposit of fine yellow clay was laid down. The particular surface configuration developed in the manner just described has sufficient individuality to deserve a distinctive name, and may be called loess-Kansan topography.

In the south-central part of Colony township, about the headwaters of the numerous branches of Bear creek, the loess-Kansan surface is more than usually level and at first sight suggests a gently undulating plain of Iowa drift. The surface, however, is covered with loess, and it requires no very close inspection to see that the irregularities, though not very pronounced, are erosional in type. The characteristics of this rather level loess-Kansan plain, embracing the initial branches of Bear creek, and differing so sharply from the rest of the loess-Kansan area, are probably related to the fact that the Iowan ice, at the time the loess was depositing, filled the valley of Bear creek as far north as sections 10 and 11 of Bremen township. During all the time the Iowan ice occupied the valley there was no drainage of the basin embracing the head water branches of the creek, except by overflow toward the northeast into the Little Turkey river. There was, therefore, no erosion of the surface of the basin so long as the Iowan ice remained stationary, and even after the retreat of this ice the flow of water down Bear creek valley was not very energetic. On the other hand, the rest of the loess-Kansan area in northeastern Delaware is drained toward the northeast, the surface waters flowing with great energy toward the

deep stream channels of the Driftless area. This drainage was not checked by the Iowan ice. Erosion proceeded uninterruptedly during the whole period of the ice invasion, and the swollen streams flowing away from the margin of the ice served to intensify the effects of the erosive processes.

While loess-Kansan topography is the prevailing type in that part of Delaware county which lies beyond the margin of the Iowan drift, there is yet another type well expressed along Elk creek and its tributaries in the northern part of Elk township, and along Little Turkey river and some of its branches in the northeastern part of Colony. Here the stream valleys are from 200 to 280 feet in depth. They are not limited to erosion in drift or loess. They are gorges or canyons cut through ledge after ledge of Niagara limestone and down into the underlying Maquoketa shales. Drift and loess are absent in these deeper valleys. The work of carving them was nearly all accomplished in preglacial time. They illustrate the Driftless area topography.

Driftless area topography is illustrated along the whole course of Elk creek and its branches from sections 16 and 23 of Elk township to the north line of the county. Steep, rocky walls bound the valleys of the streams (Plate viii, Fig. 2), and for some distance on both sides of the valleys the surface materials consist of a thin mantle of loess overlying residual clays and cherts. In the Se. ¼ of the Ne. ¼ of section 10 the nearly vertical rocky bluffs rise to a height of 220 feet above the level of the stream. From the hilltop overlooking the valley in section 1 of Elk township, to the bottom of the gorge, the difference in level is 275 feet. The Little Turkey river flows in a deep, picturesque valley which traverses sections 1, 2, 11, 14 and 15 of Colony township. A small tributary of Little Turkey which begins in the northeast quarter of section 3 of the same township, has a valley characterized by even wilder grandeur than that of the main stream. Weathered cliffs, tumbled crags, and precipices over which the waters plunge when set in motion by melting snows, or following

heavy rains, are some of the striking features of this charming bit of Driftless topography. The maximum depth of the driftless valleys in Colony township is 280 feet.

Inside the Iowan area, and surrounded on all sides by Iowan drift, are two anomalous regions that seem not to have been invaded by Iowan ice. One of the regions occupies the central part of Richland township and may be called the Richland highlands. The other embraces three-fourths of Delhi township and parts of Milo, North Fork, South Fork and Union townships, and may for convenience of reference be named the Delhi plateau. The regions in question seem to have been islands in the midst of the Iowan glacial sea. At all events they contain no Iowan drift. The togography is erosional, partly resembling the loess-Kansan type, partly that of the Driftless area. Except in the stream valleys the surface is on the average higher than that of the Iowan drift plain, the difference in elevation ranging from forty to more than a hundred feet. Both areas are traversed by the Maquoketa river. In each there are heavy bodies of loess exhibiting the rounded hills, steep slopes and sharp valleys that result from erosion of this peculiar deposit. In each there are spaces, free from both loess and drift, in which steep rocky cliffs, isolated towers, and all other features of Driftless area topography are characteristically developed.

The region in Richland township includes the somewhat noted locality known as the "Backbone." The "Backbone" is a high rocky ridge around which the Maquoketa forms a loop. The summit of the ridge rises from 90 to 140 feet above the stream. Its sides are in places precipitous, the rocky cliffs rising sheer for more than 80 feet. Erosion and secular decay have carved the rocks into picturesque columns, towers, castles, battlements and flying buttresses. The exposed surfaces are deeply pitted and weather worn (Plate ix, Fig. 1). Crevices, widened by protracted chemical action of air and water, are wholly or partly filled with dark-brown residual clay or geest. The stream, on each side of the ridge, flows in

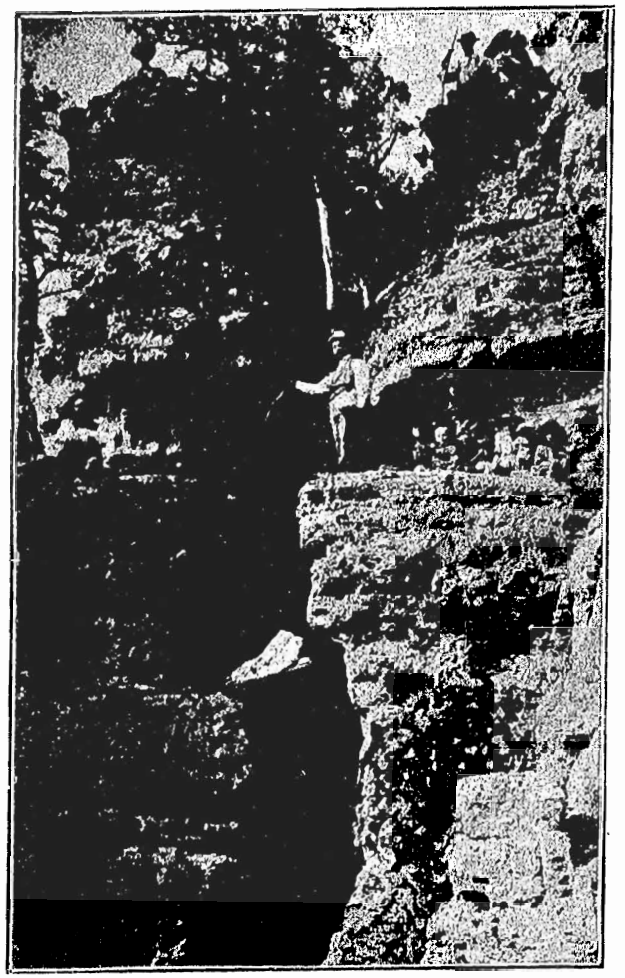


FIG. 1. The "Stairway" at the Backbone in section 16, Richland township, Delaware county. The view shows a portion of the vertical, weather beaten cliffs.

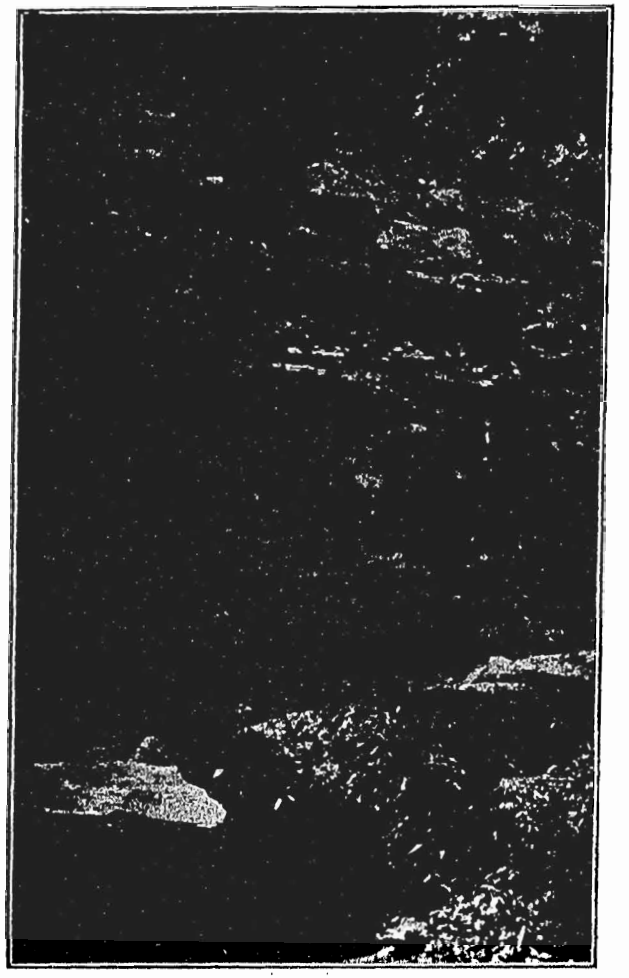


FIG. 2. Beds of passage from Maquoketa shales to Niagara limestone. The heavy ledges at the top of the view are Niagara. The thiner layers belong to the transition phase of the Maquoketa. Ne. qr. section 15, Elk township, Delaware county.

a deep valley. The "Backbone" with its valleys on the east and west is a bit of Driftless area, and the sections north of the "Backbone," namely, 3, 4, 5, 8, 9 and 10, as well as the region to the southeast between the center of section 16 and Forestville, and southward along the river to section 34, constitute a region of loess-Kansan topography.

Between the south end of the area just described and the southeast quarter of section 4 of Milo township, the Maquoketa flows through the Iowan drift plain, in a valley but little depressed below the general level of the country. In the northern part of Milo township, the river enters the second of the anomalous areas, and in doing so it turns away from a low drift-plain to cleave its way through an area that rises from 80 to 100 feet higher than that from which it turned aside. These areas of anomalous topography afford illustrations of McGee's anomalous rivers. In section 5, where the stream crosses the north line of Milo township, the river channel is but a shallow trough in Iowan drift, and the drift plain, with little change of level, extends for many miles towards the south. In the east part of section 9 of the same township the stream flows in an old rock-walled valley of erosion approximately 200 feet in depth. The gradient of the stream is not perceptibly changed, the greater depth of the valley being due to the increase in altitude of the general surface in passing from the first to the second point mentioned.

With one or two unimportant exceptions, the Maquoketa flows in a comparatively deep canyon all the way from section 9 of Milo township to the south line of Delaware county. At Hartwick, in section 30 of Delhi township, the valley is 190 feet in depth, and at Fleming's mill, a mile east of Hartwick, the depth is 215 feet. In Delhi township and in the northern part of Union the stream valley is cut through a plateau and not through a ridge, as is usual with other anomalous rivers. The plateau has an extreme width of about ten miles, extending from section 23 of Milo township to section 21 of North Fork, and embracing in its eastern margin the valley of Plum

creek. Loess hills all around its border rise sixty or eighty feet above the adjacent drift plain, and throughout its entire area of about sixty-five square miles the topography is erosional. Loess hills predominate, but there are some areas covered with sand, and in some places weathered crags of Niagara limestone control the character of the topographic forms.

At Hopkinton the Maquoketa emerges from its canyon and skirts for a short distance the eastern edge of the loess-covered highlands; but, although the low plain followed by the railway to Monticello might have been traversed with a very slight amount of channel cutting, the stream turns abruptly into the hills, and has excavated a gorge 165 feet in depth in ledges of limestone. This gorge cuts longitudinally through a ridge that overlooks plains of Iowan drift both on the east and west.

The North Maquoketa flows through a high, loess-covered ridge, free from Iowan drift, in sections 1 and 12 of South Fork township, and the Iowan drift plain between this ridge and the loess hills bordering Plum creek, looking like a much depressed valley, affords an impressive illustration of McGee's paradoxical divides.*

Even the cores of the paha that are distributed near the margin of the loess-covered areas appear to have been islands in the Iowan glacial sea, for they consist usually of rock masses, or of ridges of Kansan drift, and bear no evidence of having been overtopped by Iowan ice.

Finally, there are some striking topographic forms due to the unequal distribution of Iowan drift within the limits of the Iowan drift plain. The gentler undulations, due to ice molding, which in general express the difference between the uplands and the sloughs, give place at one or two points to pronounced hills or ridges of drift resembling moraines. The

*This valley-like divide west of the ridge through which flows the North Maquoketa is very graphically described by McGee in his *Pleistocene History of Northeastern Iowa*. Eleventh Ann. Rept. U. S. Geol. Surv., pp. 218-219. Other divides of the same paradoxical type are described on other pages of the work cited.

best examples of the ridges referred to occur in the southern part of Milo township and in the southern part of Hazel Green. A ridge of Iowan drift, without loess, extends in a nearly east-west direction through the southern half of sections 21 and 22 of Milo township. Another ridge, with a southeast-northwest trend, more pronounced and more moraine-like, is found in sections 33 and 34 of the same township. This ridge is broken into many knobs and rounded hills. Its height above the plain on the north and south is ninety feet. Even more moraine-like is a complicated series of knobs and ridges occurring in sections 27 and 28 of Hazel Green township. The general trend is not well defined. The area is more than half a mile wide, and in length extends beyond the limits of the sections named. The aspect is identical with that of a terminal moraine. Areas of low, wet ground alternate with irregularly distributed knobs and ridges. The higher points rise eighty feet above the ordinary level. On the summit of some of the knobs there is a thin veneer of loess, thus forming a sort of pseudo-paha; but the main body of the ridges in question seems to be composed of Iowan drift.

DRAINAGE.

One system controls nearly all the drainage of Delaware county. The Maquoketa river enters the county in Richland township and flows nearly southeast, leaving the county finally in South Fork township. Above Forestville, in Richland township, the valley, for some distance, is a rock-walled gorge cut in Niagara limestone, and for two or three miles below Forestville the valley retains the gorge-like character as it passes through loess-covered highlands. In the southern part of Richland township, however, the stream enters the Iowan drift plain through which it flows until it passes Manchester. Two miles below Manchester it leaves the low plain of Iowan drift to follow a canyon cut in the highlands that extend from that point to the southern limits of the county. As already noted, the valley, at certain points in

the highlands, is more than 200 feet in depth. The singular habit, first fully described by McGee, of streams avoiding low plains and cutting deep chasms through rocky highlands, is well illustrated at many points along the Maquoketa in Delaware and Jones counties. This puzzling behavior has not yet been fully explained.

Contrary to the view sometimes entertained, these deep valleys dissecting uplands are much older than the age of the loess, older than the Iowan drift, older than the Kansan. Undisturbed loess comes down on the side of the deep valley to the level of the water at Flemming's mill, south of Delhi. The reddish-brown Buchanan gravels, in beds undisturbed since the close of the Kansan age of the glacial epoch, lie in the lowest parts of the valley at Hartwick and Hopkinton. The erosion in the bottom of this valley, like the erosion on the drift plain itself, has been inappreciable since the disappearance of the Iowan ice.

The tributaries of the Maquoketa from the west are mostly small, unimportant prairie streams that have their headwaters in the sloughs of the Iowan drift plain. Prairie creek, or Coffins Grove creek, as it is sometimes called, begins in slough lands in the eastern part of Buchanan county and flows eastward through the southern part of Coffins Grove township to join the Maquoketa a mile above Manchester. In section 28 of Coffins Grove the channel of Prairie creek is cut through a rocky hill, timbered and covered with some loess, but elsewhere the channel of the stream is a shallow depression cut but little below the general level of the adjacent prairie.

Buck creek and its branches drain the undulating prairie land of Hazel Green township and part of Milo and Adams. The upper branches of the stream have no definitely marked channels, the drainage waters being conducted along the sags or sloughs. Near the center of Hazel Green township the channel has better definition, but is a mere shallow ditch in the prairie. In the western part of Union township Buck creek enters a gap in the loess-covered plateau and flows

thence to its junction with the Maquoketa in a deep valley, sometimes between rocky walls that rise 125 feet above the level of the stream. The walls are developed into picturesque, rugged, fissured, weather beaten cliffs in section 9 of Union township.

A few streams flow into the Maquoketa from the east. Honey creek, with its principal tributary, Lindsey creek, drains the larger part of Honey creek township and the northern part of Delaware. It joins the Maquoketa above Manchester. Honey creek, together with its branches, is throughout most of its course a simple prairie stream flowing in a shallow channel through the ordinary drift plain; but in the west half of section 35, Honey creek township, the stream wanders in a broad valley bounded by rocky cliffs twenty-five feet high. The region contains some deposits of loess, but there are no signs of Iowan drift. All the drift exposed below the loess or at the surface is of Kansan type.

Plum creek is the largest affluent of the Maquoketa in Delaware county. Its ramifying branches extend to the northern part of Oneida and Bremen townships, and the southwest part of Elk township pays tribute to this stream through a system of undefined channels or sloughs. The initial branches and upper reaches of Plum creek conform to the usual type of streams flowing in an uneroded drift plain; but east of Earlville the creek enters the region of the Delhi plateau, flowing through rock gorges and among loess hills that overlook the drift plain throughout most of the remainder of its course, to its junction with the Maquoketa in section 11 of Union township. For a short distance, in sections 20, 28 and 29 of North Fork township, Plum creek follows the western margin of the low drift plain from which the Delhi plateau rises abruptly to the westward, but in section 33 of the township named it turns away from the drift plain to follow a rock-walled chasm cut through a portion of the plateau. At the top of the chasm the rock ledges are overlain by residual chert and Kansan drift, but the Iowan drift does not rise above the plain which

constitutes the paradoxical divide between Plum creek and North Maquoketa river.

The North Maquoketa river flows through the eastern part of North Fork township, and through sections 1 and 12 of South Fork. The area draining into the North Maquoketa is unimportant. Above Rockville in North Fork township and in its short course in South Fork this stream flows in a deep valley, the borders of which rise conspicuously above the general level of the neighboring plains. For a few miles below Rockville the North Maquoketa has a channel in the Iowan plain, a condition that affords a feasible crossing for the Farley and Cedar Rapids branch of the Chicago, Milwaukee & St. Paul railway.

Bear creek has its origin in a number of small branches draining the central part of Colony township. It flows southward through sections 2 and 10 of Bremen, emerging from the loess-Kansan area and passing out upon the Iowan drift near the southwest corner of the last named section. During the occupation of the county by Iowan glaciers the lower part of the valley of Bear creek was choked with ice, and the valley was undrained except by overflow to the north into the valley of Little Turkey river. As a result of the conditions noted Bear creek was robbed of part of its drainage area, the waters from the northern part of this area being permanently turned into the Little Turkey. From section 10 of Bremen township, Bear creek flows near the margin of the Iowan drift, in an ancient valley that was only partially filled by glacial debris, and enters the North Maquoketa at Dyersville.

The northeastern part of Elk township and the northern part of Colony are drained by branches of Turkey river. The main drainage channels in the locations named trend toward the north. Elk creek flows in a rock bound valley that is more than 200 feet in depth, and the valley of Little Turkey river, before crossing the north line of Colony township, attains a depth of nearly 300 feet. The valleys of Elk creek and Little Turkey properly belong to the Driftless area.

Buffalo creek receives the drainage from the greater part of Adams township and from part of Prairie. With the exception of Robinson creek its affluents in Delaware county are without definite channels. Buffalo creek is a prairie stream flowing in a broad concave depression in the drift, all the erosion it has accomplished being represented by the channel a few feet in depth. The difference between the amount of erosion represented by the valley of Little Turkey river in the northeast corner of the county and the inconsiderable channel of Buffalo creek in the southwest is well nigh immeasurable.

The greater part of the surface of Prairie township does not reveal a single well-defined water course. Over most of the drift plain, indeed, there has been practically no erosion since the withdrawal of the Iowan glaciers, and even in the beds of the larger streams the post-Iowan deepening of the channels has been at most only a few feet. The deep valleys of the Richland and Delhi highlands, as well as the similar valley of the North Maquoketa, resemble canyons of preglacial origin. The highly oxidized, reddish-brown Buchanan gravels near Hopkinton and Hartwick demonstrate that, at all events, they are older than the Kansan stage of the Pleistocene.

STRATIGRAPHY.

The geological formations of Delaware county embrace representatives of at least two groups, namely, the Paleozoic and the Cenozoic. A somewhat problematic deposit near Rockville, the Rockville conglomerate, has with some doubt been referred by McGee* to the Cretaceous system, and so may represent the Mesozoic group. Keyes† thinks that the Rockville conglomerate, and other ferruginous conglomerates in northeastern Iowa are probably Carboniferous instead of Cretaceous, but the most recent evidence at hand tends to

*Pleistocene History of Northeastern Iowa, by W. J. McGee, p. 231 and pp. 304-308.
†Iowa Geol. Surv., vol. I, p. 125. Des Moines, 1893.

support McGee's conclusion, and so in the present report this deposit will be retained in the taxonomic position to which it was first assigned.

The stratigraphic relations of the several formations of this county are expressed in the following

Synoptical Table of Formations in Delaware County.

GROUP.	SYSTEM.	SERIES.	STAGE.
Cenozoic.	Pleistocene.	Recent?	Alluvial.
		Glacial.	Iowan (including Loess and Iowan drift).
			Buchanan.
			Kansan.
In process of forming during all the ages since the post-Silurian elevation of the region above sea level.			(Residual clays and chert, Geest.)
Mesozoic?	Cretaceous?	Upper Cretaceous?	Dakota? (Rockville conglomerate).
Paleozoic.	Devonian.	Middle Devonian.	Wapsipinicon.
	Silurian, or Upper Silurian.	Niagara.	Delaware.
	Ordovician, or Lower Silurian.	Trenton.	Maquoketa.

Ordovician.

MAQUOKETA SHALES.

The Maquoketa shales are the oldest of the geological formations naturally exposed in Delaware county. They are best seen in the deep, driftless valleys of Elk creek and Little Turkey river, as well as in the lateral ravines opening into the valleys mentioned. There is, however, a very interesting occurrence of these shales at the mill dam at Rockville. The

east end of the dam abuts against thin beds of soft, yellowish, argillaceous limestone that, for the most part, is rather free from fossils, but contains impressions of *Orthis testudinaria* down near the level of the water. The plunge of the water over the mill dam has scooped out a deep pit on the lower side. Out of this pit there has been carried, and strewn along down the stream, a great number of very fossiliferous slabs of shaly limestone. These have all the characteristics of the fossiliferous beds of the true Hudson river or Cincinnati shales. They are very rich in monticuliporoid bryoza. *Plectambonites sericea* is exceedingly common, and *Strophomena planumbona* Hall,* *S. nutans* James, *Orthis testudinaria* Dalman, as usually recognized in this country, and *Orthis occidentalis* Hall, are not rare. Less common are *Strophomena filitexta* Hall, *Zygospira modesta* Say and *Calymene senaria* Conrad. These fossil-bearing shales, both lithologically and faunally, are identical with typical horizons of the Hudson river shales as developed in southwestern Ohio and eastern Indiana.

The thin-bedded, shaly limestone, above the level of the river, has a thickness of twenty-five feet, and is overlain by heavy ledges of dolomitic limestone that are unquestionably of the age of the Niagara. The shaly limestones, however, probably all belong to the Maquoketa stage. At least the lower layers are of this age, for they contain such typical species as *Orthis testudinaria;* and the upper portion, destitute of fossils and becoming rather more calcareous, is made up of transition beds that record the passage from the conditions of deposition which gave rise to blue shales, to those represented by the Niagara dolomite. The following section was taken at this point.

*In recent years, Professor Hall and some other authors have referred this species to *Strophomena rugosa* Rafinesque. See Pal. N. Y., vol. VIII, part i, and Geology of Minnesota, Final Report, vol. III, part i.

		FEET.
6.	Loess, resting on residual clays and cherts, without intervening drift	0 to 6
5.	Rather evenly bedded layers of fairly good quarry stone	30
4.	Thin bedded limestone, with much chert	20
3.	Heavy ledge of dolomite	3
2.	Argillaceous, yellow limestone, with fossils of Maquoketa stage at base, and becoming more calcareous towards the top; transition beds	25
1.	Blue and gray shales, with thin, calcareous, very fossiliferous layers below level of water. Not measured.	

The base of No. 3 in the above section may conveniently be taken as the line of junction between the Maquoketa shales and the Niagara limestone. Below that line the beds grade downward into true Ordovician or Lower Silurian; above the line the cherts and dolomites are typical of the Niagara limestone.

At the point where Elk creek crosses the north line of the county the bottom of the valley is forty feet below the top of the Maquoketa formation. In this valley the exposures of the more shaly, clayey phase of the deposit are, however, neither very numerous nor very satisfactory. In general the shale is concealed by talus material, and this in turn may be overgrown by rank vegetation, so that it is only where recent landslides have occurred that the beds are seen with any success. Even then one is not always certain that the material is in place.

Numerous good exposures of the argillaceous limestone corresponding to the transition beds, No. 2 of the Rockville section, occur at intervals along Odell's branch of Elk creek in sections 10 and 15 of Elk township. These transition beds are invariably capped with heavy ledges of Niagara limestone (Plate ix, Fig. 2.) Near the confluence of the two branches of Elk creek in the Se. ¼ of Se. ¼ of section 10 there are some exposures of the shaly beds of the Maquoketa stage, and at intervals along the valley to the north line of the county the shales are seen in the banks

of the creek. Just below the calcareous transition beds, which are uniformly about twenty-five feet in thickness, there are four feet of indurated blue shale, below which the beds weather into smooth, plastic potters clay. Considering the great abundance of fossils in the bluish calcareous bands beneath the transition beds at Rockville, it is a singular fact that no fossils of any kind were seen either in the shales proper or in the yellow calcareous beds above them, at any of the exposures in Elk creek valley. The definite localization of faunas is one of the most striking facts encountered by the geologist in studying this formation in Iowa.

The best exposures of Maquoketa shales in Delaware county occur along Little Turkey river and its branches in sections 2 and 3 of Colony township. A deep lateral gorge, eroded by a small tributary of the Little Turkey in sections 2 and 3, cuts through nearly the whole thickness of the formation and affords a number of fairly satisfactory sections. At what is known as the "big spring" in the Se. ¼ of Ne. ¼ of section 3 the bottom of the gorge coincides with the base of the transition beds and the spring issues on top of the shaly portion. The section taken a few yards below the spring shows:

		FEET.
5.	Steep slopes sodded over; not measured	...
4.	Niagara limestone in thick heavy ledges	10
3.	Transition beds; soft, yellowish argillaceous limestone, more shaly below, becoming firmer and more calcareous above, in thin layers	25
2.	Hardened shale, in layers two to four inches thick, some of the layers containing segments of crinoid stems	1
1.	Bluish shale, indurated, composed of thin laminæ, no organic remains	4

The spring is 230 feet lower than the level of the plateau on which Colesburg is built. One-fourth of a mile below the spring there is a clay pit from which a large amount of clay to supply the pottery at Colesburg has been taken. The altitude is sixty feet lower than the spring, and between the spring and clay pit there is almost a continuous section of the

shales exposed. Following down the stream a short distance farther, just beyond the Delaware line, in Clayton county, the massive dolomitic beds of the Galena limestone are reached. The Maquoketa shales in this particular locality are very uniform throughout their entire thickness. Excepting the transition beds occupying the upper twenty-five feet of the formation the whole body is argillaceous. The usual calcareous fossiliferous bands are absent. If there are any fossil remains below No. 2 of the big spring section, they escaped observation. The only differences noted between different horizons had reference only to varying shades of the blues and drabs that control the color tones of the formation.

At West Dubuque, Graf and other points in Dubuque county there are very fossiliferous beds, containing a unique fauna, near the base of the Maquoketa shales. Near Wadena, in Fayette county, there are beds, rich in fossils, belonging to the Cincinnati shales fauna, in the upper part of the formation. The Cincinnati fauna, with a different proportional representation of species, occurs just below the transition beds at Rockville, Delaware county. But in Elk and Colony townships, of Delaware county, and in some ravines in Clayton county, a few miles northeast of Edgewood, the exposures of the Maquoketa shales, some of them showing the entire thickness from top to bottom, are absolutely destitute of organic remains. This peculiar localization of faunas record conditions of late Ordovican sea bottom not yet explained.

Silurian.

NIAGARA LIMESTONE.

DELAWARE STAGE.

The formation following the Maquoketa shales in ascending order was designated by Hall* the Niagara limestone; and in this correlation of a western dolomite, containing a mixed Clinton and Niagara fauna, with the Niagara shale and lime-

*Rept. on the Geol. Surv. of Iowa, by James Hall and J. D. Whitney, vol. I, part i, p. 71. 1858.

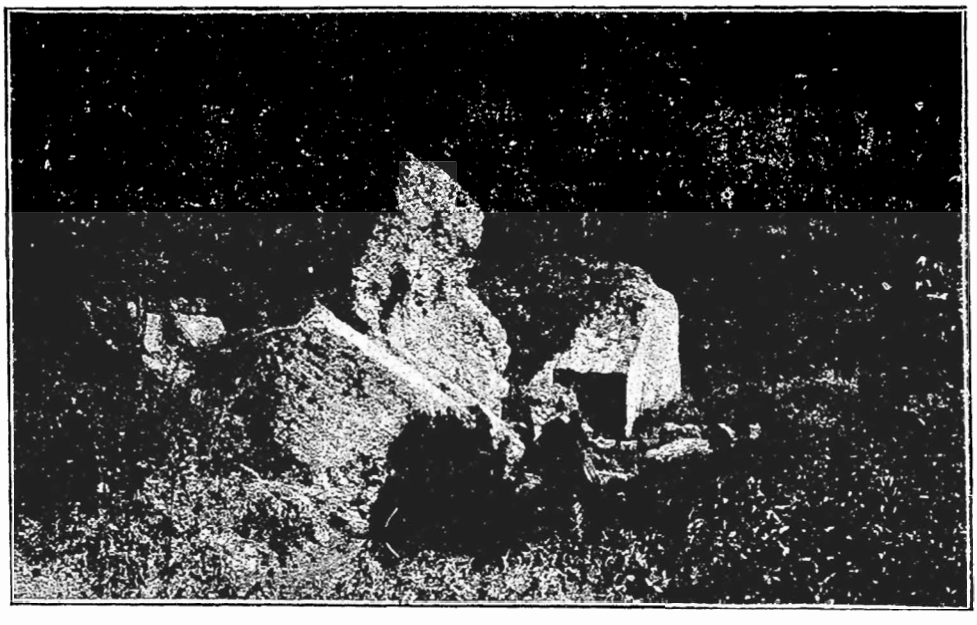


FIG. 1. Fallen masses from the basal ledges of the Niagara limestone, showing the tendency to split along parallel planes of lamination. Southwest qr. section 14, Elk township, Delaware county.

FIG. 2. Reglarly bedded prentamerus-bearing limestone in section 31, Bremen township, one mile east of Earlville.

stone of western New York, he has been followed by all geologists who subsequently have studied the formations in this part of the Mississippi valley.

The Niagara limestone begins as heavy ledges at the top of the argillaceous limestone which marks the close of the Maquoketa stage. There is much local variation in the details when sections in different parts of the county are compared, but in general the beds near the base of the formation are heavy, compact, non-fossiliferous dolomite. In some instances they are massive ledges, four to six feet in thickness, showing no indications of lamination planes. In other cases they are very distinctly laminated, and readily split along the horizontal planes of lamination into great blocks with parallel faces. This laminated condition of the lower beds is best seen in Elk and Colony townships. A typical concrete illustration of the structure described is seen in the vertical faces of cliffs of Niagara limestone that overhang the more rapidly weathering transition beds of the Maquoketa shales in the southwest quarter of section 14, Elk township. Near the southwest corner of the section named the recession of the transition beds has undermined the basal ledges of the Niagara and allowed blocks fifteen to thirty feet in diameter and ten to fifteen feet in thickness to fall down into the channel of the creek. In falling the blocks have been pitched at all angles, and some stand on edge (Plate x, Fig. 1). All have been split along some of the lamination planes so as to demonstrate very forcibly the nature of the structure that is only suggested by the weathered edges of the masses yet in place. The same structure is equally well illustrated at the big spring in section 3 of Colony township. The weathered edges of the undisturbed beds indicate horizontal lamination. Fallen blocks of great size, cleft by the force of the fall into relative thin slabs with smooth, parallel surfaces, afford a very impressive demonstration.

The laminated condition of the basal ledges of the Niagara in the northeastern part of Delaware county is the more note-

worthy for the reason that at Rockville, in North Fork township, the corresponding beds are not laminated; and in the opposite direction, in Fayette and Clayton counties, the beds immediately above the Maquoketa shales are massive, homogeneous, with no more tendency to split horizontally than vertically. The Williams quarry, near the northeast corner of Fayette county, is worked in basal ledges of Niagara, which are four to six feet in thickness; and dimension stone is obtained by sawing the great blocks, after they are quarried, to the size desired. The laminated condition of the stone in Elk and Colony townships will have great economic importance if the demand for heavy dimension stone should ever make it an object to operate quarries in these localities.

The laminated basal ledges of Niagara limestone in Elk creek valley have an aggregate thickness of about twenty-five feet, and are followed by some definitely bedded dolomite, which in some places consists of thin layers with considerable chert. Along Elk creek this second member is ten feet in thickness. This is followed by a bed of quarry stone in very definite layers, which range from three to thirty inches in thickness. The stone is fine-grained, and light yellow to light drab in color. The individual layers are homogeneous, without laminæ, and sharply separated one from the other by clayey partings. Exposures of the quarry stone horizon occur at a number of points in section 16 of Elk township, and quarries are worked on the land of B. A. Baker, George Boehm and Job Odell. The quarry operated by O. Wilcox on land of Mr. Odell shows a section thirty feet in thickness. The heavier layers are toward the top of the exposure, and some of these contain numerous cherty concretions. Near the base of the quarry the stone lies in thinner layers and is free from chert. The quarry is capable of yielding good material for cut dimension stone, all kinds of ashlar work, rubble and heavy dimension stone for bridge piers. A great number of joints trending southwest-northeast cut vertically through the strata. The best material for cut stone lies about the middle of the quarry

section. Here the beds are free from chert, and the surfaces of the individual layers are comparatively parallel planes. Near the base of the quarry the layers present uneven surfaces, the irregularities resembling the effects of wave action.

The Wilcox quarry is situated on the north side of a triangular ridge separating two converging valleys. Around the point of the hill, and almost opposite the exposure operated by Wilcox, another opening has been made in layers corresponding to those in the upper part of the Wilcox quarry. The stone is weathered at the top, and is overlain by dark-brown residual clay, residual chert and a thin layer of loess. There are no signs of drift. If the Kansan drift was ever laid down in this locality it was entirely removed by erosion before the deposition of the loess. All the other quarries opened at this horizon show essentially the same details as those described.

Regularly bedded limestone, apparently the same as the beds worked, continue below the base of the Wilcox quarry for at least fifteen feet, and hence there is a total thickness of forty-five feet of beds that might be quarried. Between the quarry stone and the horizontally laminated beds at the base of the Niagara there is a rather gradual transition through strata intermediate in character. No fossils were noted either in the basal beds or in the quarry stone.

Above the quarry stone in Elk creek valley the section is not very satisfactorily exposed. Forty feet higher than the top of the quarry there appears in the hillside some massive, vesicular, coarse-grained, crystalline ledges that exhibit the usual lithological characters of certain fossiliferous beds that elsewhere are known to lie at the same distance above the base of the Niagara. Here, however, the beds, so far as could be observed, are barren. In other localties they contain a fauna embracing a number of corals, the most common and most characteristic species being *Syringopora tenella* Rominger.

A short distance northeast of the center of section 20, Elk township, the roadway cuts through ledges crowded with casts of *Pentamerus oblongus* Sowerby. Altogether about

thirty feet of the Pentamerus-bearing beds are exposed. The elevation is 100 feet above the top of the Wilcox quarry.

There are two gaps in the Elk creek section of the Niagara limestone. The first is forty feet in extent and occurs between the top of the Wilcox quarry and the massive crystalline ledges that represent the horizon of *Syringopora tenella*. The second, forty or fifty feet, lies between the ledges last named and the first exposures of the Pentamerus beds seen in coming up the valley. The exposures containing Pentamerus near the center of section 20, represent the top of the Pentamerus-bearing horizon. At least they are overlain by a few feet of limestone free from Pentamerus and evidently representing the next higher horizon. From what is known elsewhere of the thickness attained by the several portions of the Niagara limestone in this part of Iowa, the Elk creek section may be determined with a fair degree of approximation; and this particular section, notwithstanding certain unfilled gaps, is presented first for the reason that it affords the best and practically the only available opportunity for study of the lower members, down to contact with the Maquoketa shales. The succession of strata seen along the valley from the southeast quarter of section 10 to near the center of section 20 is as follows.

6. Barren beds of massive dolomite much weathered.... 10
5. Pentamerus beds, with casts of the ordinary *Pentamerus oblongus* Sowerby..... 60
4. *Syringopora tenella* beds in heavy non-laminated ledges, usually vesicular and crystalline..... 70
3. Quarry stone beds of the Wilcox quarry and other quarries in same neighborhood..... 45
2. Intermediate beds, somewhat regularly stratified..... 10
1. Basal ledges, horizontally laminated, with definite partings at intervals of four to eight or ten feet, resting on the thin-bedded, argillaceous limestone at top of the Maquoketa shales..... 25

Near Hopkinton, in the southern part of the county, there are many picturesque cliffs of Niagara limestone affording opportunity for study of other portions of the complete

Niagara section. Along the Maquoketa river in sections 24, 25 and 36 of township 87, north, range 4, west of the fifth principal meridian, the cliffs rise vertically almost from the margin of the stream, to a height of 165 feet above the water. The cliffs consist at the base of massive dolomitic ledges, ranging from 6 to 15 feet in thickness, with no lamination, breaking when quarried for any purpose into shapeless blocks containing many vesicular cavities, and very coarse and granular in texture. These coarse massive ledges rise in places to the summit of the cliffs, 165 above the water, but at the Loop quarry, in Sw. ¼ of Nw. ¼ of section 25, Tp. 87, N., R. IV, W., they are capped with evenly bedded quarry stone varying from 12 to 20 feet in thickness. The section here gives the following details.

		FEET.
7.	Rock ledges, presumably of quarry stone, hidden under slope covered with loess and dark colored ferruginous residual clays; from summit of hill to uppermost beds exposed in Loop quarry	38
6.	Quarrystone in definite beds which are arched as if the quarry were located at the summit of a small anticline	12
5.	Massive beds, no definite bedding planes; fossils rare, and consisting of casts of Orthoceras and related Cephalopods, with casts of Caryocrinus and Eucalyptocrinus	20
4.	Beds similar to 2 and 4 containing *Cerionites dactylioides* and *Pentamerus pergibbosus*	10
3.	Massive bed of the usual coarse, vesicular dolomite. No fossils detected	15
2.	Massive dolomite with numerous casts of *Pentamerus oblongus*. In the lower part of this member the casts of Pentamerus are small and rather scarce; in the upper part the individuals are larger and much crowded together	25
1.	Unexposed to level of water in river	45

Near the Williamson lime kiln in the southern part of section 24, the rock ledges are exposed down to the water's edge; and at this point *Pentamerus oblongus* occurs, even in the lowest beds, in considerable numbers. The total thickness

of the *Pentamerus oblongus* beds is not less than sixty feet. In general this horizon is a coarse massive dolomite that breaks up into pieces of irregular shape, but near the center of section 27, Colony township, there is an exposure of evenly bedded Pentamerus limestone in which the layers vary from eight to ten inches in thickness. The beds have been quarried for building stone, and blocks of fairly regular shape are obtained. Another exception to the general statement respecting the Pentamerus beds is seen in some quarries east of Earlville, (Plate x, Fig. 2,) where beds rich in casts of Pentamerus are separated by shaly partings into layers varying from six to thirty-six inches in thickness. In general, however, the Pentamerus beds show no very definite bedding planes. The ledges below Hopkinton may be regarded as their typical phase. The same massive phase of the Pentamerus limestone is seen near the opposite corner of the county at the Backbone in Richland township. It occurs also at the mill in Forestville. It is this phase that is exhibited in section 20 of Elk township near Greeley. It is seen again along the headwaters of Lindsey creek northeast of York. It is this same phase that occurs in the bed of Honey creek near Millheim as well as in the low cliffs along Sand creek where it traverses the Ne. ¼ of Se. ¼ of section 8, Milo township. Besides *Pentamerus oblongus* the beds of this horizon contain, locally, colonies of corals among which *Halysites catenulatus* and *Syringopora tenella* are the most characteristic. The two species named range, however, from the base of No. 4 of Elk creek valley section to the top of No. 5 of the Loop quarry section. They are most common in the horizon below the Pentamerus beds.

The presence of Cerionites at the horizon represented by No. 4 of the section at the Loop quarry is quite constant throughout this part of Iowa; and the crinoid and cephalopod fauna of the next higher member, No. 5, is also well represented over an area embracing the southeastern part of Delaware county and adjacent portions of Dubuque, Jones and

Jackson. The fauna characteristic of this horizon seems to be best developed in Cedar county.

The stone at the Loop quarry, No. 6 of the preceding section, is a fine quality of light gray to light buff dolomite, regularly bedded, easily quarried and capable of being worked into forms suitable for almost any structural purposes. The individual layers in the part now exposed range from three to ten inches in thickness. In the upper part of the quarry some of the layers include cherty concretions, but in general the stone is of excellent quality for all ordinary masonry. The lower layers contain casts of a variety of *Pentamerus oblongus* that differs from the usual form in being thin and wide, and in having the spondylium of the pedicel valve and the septal laminæ of both valves very feebly developed. The presence of these casts does not, however, impair the value of the stone for ordinary range work.

The beds represented at the Loop quarry were first worked in this neighborhood along the ravine known as Whittaker hollow, in the southeast quarter of section 23, Tp. 87 N., R. IV, W. The Merriam quarry, located a short distance southeast of the center of the section, has been operated intermittently for a great many years. The quality of the stone is the same as at the Loop quarry. A second quarry on the Merriam property has recently been opened a few rods east of the original one. It shows nothing different from those already described. The layers in both are thin at the top, and are badly shattered and weathered. Residual clays and cherts, with some loess, overlie the limestone beds, but drift is practically absent. In the bottom of these quarries are ledges two feet in thickness suitable for bridge stone.

The regularly stratified beds belonging to the horizon of the Loop and Merriam quarries is found in the Davis quarry, east of the center of section 17, in South Fork township, and at the McGlade quarry and other quarries in the same neighborhood, though here the layers are thinner than in the quarries west of the river. These exposures would produce

excellent flagging stone. Among the few fossils which they have furnished are *Calymene niagarensis* Hall, *Illœnus imperator* Hall and the peculiar siphuncle that has been described as *Huronia vertebrale.* An exposure of the thin-bedded quarry stone of the Davis and McGlade quarries occurs near the center of section 27, North Fork township. There are other outcrops in this same township, but they have not been quarried. In Delhi township, within the town of Delhi, are some small quarries worked in these beds, and on the south side of the river at Fleming's mill, in Sw. ¼ of Nw. ¼ of section 29, Delhi township, this upper quarry stone horizon is exposed at an elevation of ninety feet above the level of the water. One of the best quarries worked at this horizon is located near the center of section 24 of Milo township. It has layers ranging from flagging stone two or three inches in thickness up to heavy dimension stone with a thickness of two feet.

Exposures showing some departures from the typical phase of the quarry stone horizon are seen in the east part of section 9, Milo township. The beds have been quarried at a few points. The stratification is mostly regular, but the quality of the stone is much inferior to that usually seen in this position. The layers are more broken and shattered than usual, and some of them evidently yield rapidly to the effects of weather. A large amount of the rock is bluish in color; and some beds, quite worthless for ordinary uses, seem to be made up to a great extent of crystalline calcite. The face of the exposures is about twenty-five feet in height; but the stone is overlain by a heavy bed of loess resting on residual clays and chert, and the upper layers are thin, much shattered and badly weathered, necessitating a large amount of stripping.

There is no drift, at least there is none of Iowan age. The exposures occur on hills through which the Maquoketa flows in a gorge 200 feet in depth. The hills rise eighty to 100 feet above the adjacent portions of the Iowan drift plain, and the region is one of many that give very positive indications of the fact that in Delaware county the Iowan ice did not over-

flow eminences that rose a few score of feet above the general level.

The building stone beds noted as belonging to the horizon of the Merriam and Loop quarry stone represent the same zone as the building stone beds of the Delaware stage noted in the report on Jones county.*

At the Backbone, in section 16 of Richland township, the vertical cliffs, eighty to ninety feet in height, show the following section:

		FEET.
4.	Pentamerus beds, massive and weathering irregularly	25
3.	Band of chert, with casts of Pentamerus	1
2.	Pentamerus beds, like No. 4	43
1.	Massive beds, without Pentamerus, but containing colonies of *Halysites catenulatus* and *Syringopora tenella*.	20

Cliff-forming Beds.—The part of the Niagara limestone lying between the horizon of the Wilcox quarry, on Odell's branch of Elk creek northeast of Greeley, and the horizon of the Merriam and Loop quarries, on the Maquoketa river southeast of Hopkinton, is usually coarse in texture, and lies in heavy, massive ledges, as shown in plate ix, figure 1. It becomes very much pitted on the surface, but in the mass resists the weather admirably, and tends to stand in vertical, picturesque cliffs and towers, some of which approach 100 feet in height. At the point called Wildcat Den, southeast of Hopkinton, the vertical faces of the cliffs rise fully 100 feet, the summit being 130 feet above the stream, which here flows near the base. The weather-beaten, massive, castle-like salient, between the floor of the Loop quarry at the summit and the roadway at the foot of the bluff, rises sheer for seventy feet on its outer wall, and a number of towers and chimneys in the same neighborhood are fully its equal in vertical dimensions. Table Rock, further down stream, in the southwest quarter of the same section, is a flat-topped mass of equal height, belonging to the same horizon, and almost completely isolated by circumdendation. In the southeast quarter of section 9,

*Geology of Jones county, by Samuel Calvin, p. 75, Iowa Geol. Surv., vol. V. Des Moines 1896.

Union township, the deep valley of Buck creek is walled in, in places, by vertical cliffs, that are more than eighty feet high from the top of the talus to the summit, and the top of the cliffs has an elevation of 120 feet above the level of the stream. In sections 32 and 33, North Fork township, similar cliffs rise sheer from the water in Plum creek, and overlook the low-lying Iowan drift plain in sections 34 and 35 of the same township. It is this same limestone that forms the impressive cliffs and towers at the Backbone in section 16, Richland township (plate xi, fig. 1). All along the canyon of the Maquoketa, from section 9 of Milo township to the south line of the county, the same rugged, weathered cliffs appear at short intervals, preserving fragmentary bits of preglacial scenery. Even over the prairies, remote from streams, particularly in the southeastern part of the county, ledges of this same horizon project through the thin drift in numberless places, some of which are referred to in discussing the topography of the county. Owen appropriately referred to this part of the geological column as the Coralline and Pentamerus beds of the Upper Magnesian limestone,* in his report published in 1852. In his earlier report, which covered work done in the autumn of the year 1839, he uses a term no less felicitous when he refers to the Coralline beds of the Upper Magnesian Cliff limestone.† The coral and Pentamerus-bearing beds of the Niagara limestone in Delaware county are preeminently cliff-forming, and that one characteristic will readily serve to distinguish them without further inspection.

Non-dolomitized portions of the Niagara Limestone.—A very unusual phase of the Niagara limestone is seen at a few points in Union township. A fine-grained, bluish, compact limestone, not dolomitic, and resembling some portions of the Devonian, occurs in small patches a few yards in extent. These patches were supposed at first to be Devonian outliers, but their relations to the ordinary granular Niagara dolomite, into

*See map accompanying Geol. Surv. of Wis., Iowa and Minn., by D. D. Owen. 1852.

†See heading over plates xiii and xiv, Rept. Geol. Expl., etc., in the autumn of the year 1839. Ordered printed 1844.

which they grade laterally and which sometimes overlies them, preclude their reference to the Devonian. One of the best examples of the phase described occurs a short distance west of the southeast corner of section 8 in the township named. Another patch of the same kind occurs near the northeast corner of the same section. More of the same stone is found one-fourth mile north of the center of section 19, and it is shown in an instructive exposure along the north line of section 29. Masses of the blue, fine-grained limestone lie in the midst of granular dolomite and are portions of continuous layers that, except in the non-dolomitized spots, possess the characteristics of the ordinary Niagara. All the exposures named are purely local phenomena, small patches of Niagara that in some way escaped the process of dolomitization.

More extensive non-dolomitized portions of Niagara limestone occur in Coffins Grove township. All the beds through a thickness of 20 or 30 feet and over an area some miles in extent, are non-dolomitic. Some of the beds are quite fossiliferous, the fossils being chiefly corals; and while the corals elsewhere at this horizon are usually silicified, they are here unchanged except by the interstitial deposition of calcite. Typical exposures of the beds under consideration are seen near the center of section 26 in the township named, and the same beds crop out in the bluffs along Prairie creek in section 28. The beds may be satisfactorily studied in the low bank of the creek at the point where the stream is crossed by the Masonville road, in the northwest quarter of section 28. Fine-grained, unfossiliferous, non-dolomitized Niagara, near Hazelton, is discussed in the report on Buchanan county.

Fauna of the Niagara.—The Niagara limestone, at any given horizon, varies locally both as to lithological characters and fossil contents. The life of the Niagara seas was not uniformly distributed over the sea bottom, but seems rather to have been segregated in colonies. Fossils are common only in the zones that lie between the two quarry stone horizons. No

indications of life were noted in the basal laminated beds, nor in any beds below the top of the lower quarry stone worked in section 16 of Elk township. Above that line, up to the base of the Merriam and Loop quarry zone, fossils abound in certain favored localities, while in other localities organic remains are rare or are wholly absent through scores of feet of the massive dolomite. In number of genera and species the corals are better represented than any other group. Usually the corals are silicified and they sometimes occur abundantly in the residual materials, mingled with reddish brown geest and shapeless fragments of chert, the beds in which they were originally embedded having been removed as a result of secular rock decay. *Halysites catenulatus* and *Syringopora tenella* range through the whole thickness of the fossil-bearing beds, but other species occur only in the Pentamerus zone or just above it. One of the best known localities in the county is that along Prairie creek, in section 28 of Coffins Grove township. Residual clays and cherts have in places a thickness of several feet, and these are rich in beautifully preserved specimens of silicified corals. Many are not described, but so far as they are now known the most common species are.

Zaphrentis stokesi Edwards & Haime.
Streptelasma patula Rominger.
Streptelasma spongaxis Rominger.
Cyathophyllum radicula Rominger.
Ptychophyllum expansum Owen.
Strombodes mamillare Owen.
Strombodes gigas Owen.
Strombodes pentagonus Goldfuss.
Cystophorolites major Rominger.
Cystophorolites minor Rominger.
Cystiphyllum niagarense Hall.
Favosites favosus Goldfuss.
Favosites niagarensis Hall.
Favosites alveolaris Goldfuss.
Favosites (*Astrocerium*) *hispidus* Rominger.
Favosites (*Astrocerium*) *hisingeri* Edwards & Haime.
Favosites obliquus Rominger.

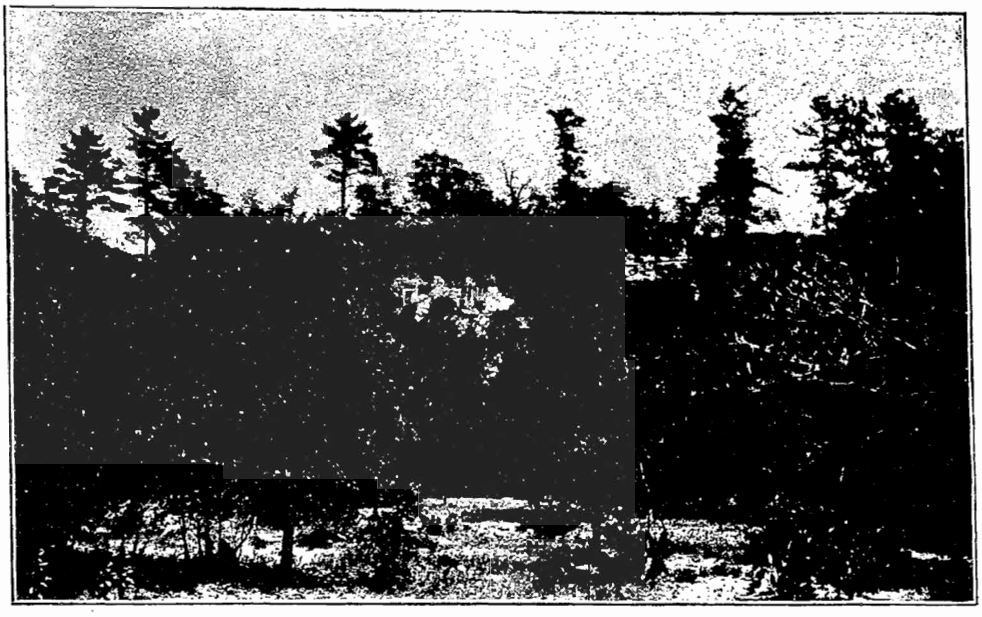


FIG. 1. Vertical cliff of Niagara limestone on west side of "Backbone." The cliffs rise sheer for ninety feet above the talus slope at the base.

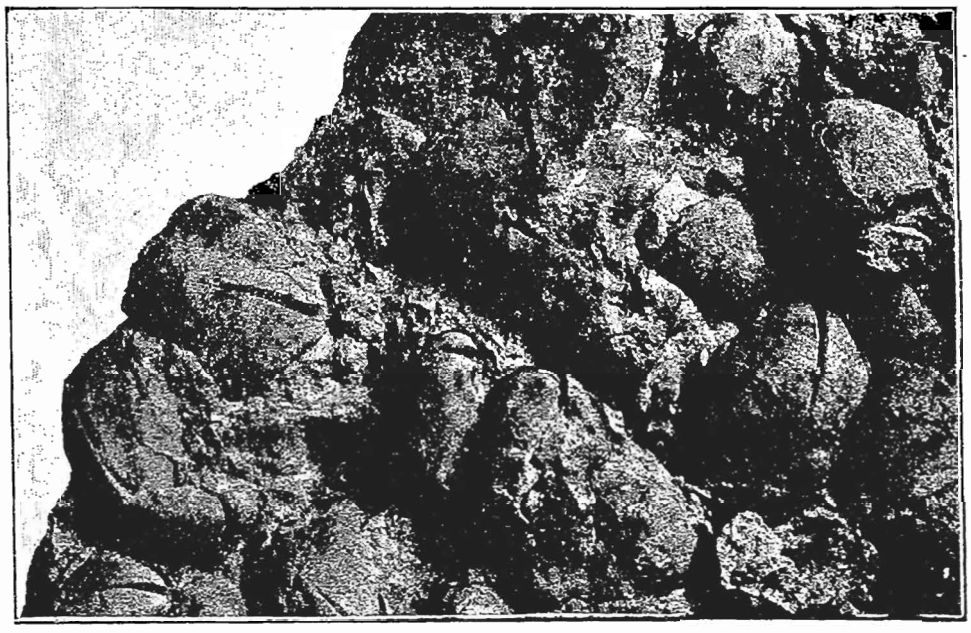


FIG. 2. Block of Niagara limestone from the Pentamerus-bearing horizon showing crowded casts of *Pentamerus oblongus*.

Alveolites undosus Miller.
Cladopora laqueata Rominger.
Thecia major Rominger.
Halysites catenulatus Linnæus.
Syringopora tenella Rominger.
Syringopora verticellata Goldfuss.
Heliolites megastoma McCoy.
Heliolites interstinctus Linnæus.
Heliolites pyriformis Hall.
Heliolites subtubulatus McCoy.
Plasmopora follis Edwards & Haime.
Lyellia americana Edwards & Haime.
Lyellia decipiens Rominger.

Besides the species enumerated in the above list there are three or four species of Zaphrentis probably undescribed, one or two of Streptelasma, and one of Ptychophyllum differing from *P. expansum* in the greater number and much smaller size of the lamellar crests. There are also some strange forms of Strombodes. There are several unknown species distributed among the genera Cladopora, Thecia and Limaria and there is at least one species of Lyellia which, when the descriptions are published, may prove to be the same as some figured by Davis in *Kentucky Fossil Corals*.

Cystideans and Crinoids in identifiable condition are very rare, and the list may be summed up in the species *Caryocrinus ornatus* and *Eucalyptocrinus crassus*.

The list of Brachiopods also is small, the forms that can be counted as at all common embracing only *Pentamerus oblongus*, *P. pergibbosus*, *Stricklandinia castellana*, *Atrypa reticularis* and *Spirifer radiatus*. The last named species is indeed rare. The *Atrypa reticularis* is most abundant in a thin cherty bed occurring in the Pentamerus zone southwest of Hopkinton. *Stricklandinia castellana* can scarcely be said to be common. In fact there is but one really common species, the *Pentamerus oblongus*. This seems in places to have occupied the sea bottom to the almost complete exclusion of everything else, (Plate xi, Fig. 2,) and to have persisted long enough for fifty or sixty feet of limestone to accumulate.

The Mollusca are only sparingly represented. The collections embrace no identifiable Pelecypods. Gastropods are represented by internal casts of *Platystoma niagarensis* Hall, a Holopea, and one or two species of Straparollus. There are several genera of Cephalopods embracing Orthoceras, Huronia, Actinoceras, Discoceras and Gomphoceras.

Trilobites are very rare. One glabella and one pygidum of *Illænus imperator* Hall, and a rather imperfect cast of *Calymene niagarensis* Hall, were observed, and that is practically the entire list. In Cedar and Jackson counties, however, this horizon furnishes quite a number of genera and species.

The building stone beds of the Merriam and Loop quarry horizon have yielded some organic remains, as already noted. The flat form of Pentamerus occurs exclusively in these beds. *Calymene niagarensis* was found only in these beds in Delaware county, but it is known from lower horizons in some contiguous counties. Illænus ranges from the lower beds up into the quarry stone, and the same is true of Huronia. Some specimens of *Favosites favosus* were found in beds of this horizon in section 9 of Milo township.

Chert beds of the Niagara.—Chert occurs extensively as concretions in the layers of Niagara limestone or as partings between them. Its distribution, however, both horizontally and vertically, is very erratic. In some localities, at certain horizons, it is present in enormous quantities, making up fully half, or much more than half, of the entire mass of rock exposed; in other localities, at the same horizon, it may be entirely absent. The quarry worked in the Nw. $\frac{1}{4}$ of the Nw. $\frac{1}{4}$ of section 2, Milo township, furnishes about as much chert as limestone. The limestone is reduced to thin, irregular layers, between which there are beds of chert equal in thickness to the beds of limestone. Both chert and limestone are broken and shattered, the chert in particular being reduced to a great number of angular fragments that vary in size from a fraction of an inch up to six or eight inches. By exposure to the weather, particularly to frost, the chert is

broken up into a sort of natural macadam, and large amounts of it are used in road building.

In a low bluff in the western part of Hopkinton, beds containing a large amount of chert are worked for road material, the sandy soil of the region making road metal of some kind an absolute necessity.

While there are few rock exposures that do not show more or less of chert, the most remarkable beds of this material were seen in some of the rocky knobs protruding through the drift near the northeast corner of section 27, Bremen township. There seems to be here a solid bed of chert, and great detached blocks, eighteen inches thick and three or four feet in length and width, lie heaped on each other or scattered over the surrounding surface. The large blocks referred to showed no definite traces of fossils, but thousands of tons of silicified corals are embedded in the very thin drift and residual clay covering the adjacent fields. Vast numbers of these have been gathered and piled along the roadway into a rude stone wall, ten or twelve feet wide at base and several rods in length.

Devonian.

WAPSIPINICON STAGE.

There are no Devonian rocks naturally exposed in Delaware county. The southwest corner of the county, where these rocks should occur, if anywhere, is deeply covered with drift; but there are rock exposures on Buffalo creek, at Coggon, and even half a mile north of Coggon, within half a mile of the Delaware county line. These exposures, according to Norton,* include the Otis beds and Independence shales belonging to the Wapsipinicon stage of the Devonian. Connecting the exposures near Coggon with exposures of Devonian lying in the line of strike along Pine creek, southwest of Winthrop, in Buchanan county, the line traverses a drift covered region in

*Geology of Linn county, by William Harmon Norton, pp. 147, 148. Iowa Geol. Surv., vol. IV. 1895.

which no exposures are seen, and cuts off the hypothetical Devonian area represented on the geological map accompanying this report, in the southwest corner of the county.

Cretaceous.(?)

ROCKVILLE CONGLOMERATE.

The Rockville conglomerate was first recognized by McGee, and was fully described in his memoir on the Pleistocene History of Northeastern Iowa, previously cited. According to the author, "The formation to which this designation is applied consists either of a dark brown pudding-stone of well worn quartz pebbles in a matrix of earthy limonite, or of obscurely stratified ferruginous sandstone. It is destitute of definite bedding and other constant structural characteristics, is found in only a few scattered bodies of limited extent, is seldom seen in contact with older formations, and is not known to be fossiliferous."* This very fully describes the formation as it occurs near Rockville, in North Fork township. The exposures observed by the writer are located on sloping ground, a few yards west of the middle of the east line of the Sw. ¼ of the Nw. ¼ of section 24, about a fourth of a mile west of Rockville. The original exposure described by McGee was a short distance farther west and on higher ground. At the point where it was seen by the writer, the conglomerate projects above the thin sod over an area only a few yards in extent, and small bowlders of it lie scattered on the surface over a much larger space. The deposit is composed very largely of dark brown, ferruginous sand, which serves as a matrix in which a great number of small pebbles are embedded. Many of the pebbles seem to be quartz, but many are rolled fragments of local chert, and associated with them are angular pieces of chert ranging up to an inch or more in diameter.

Sandstone and conglomerate, probably of the same age as the Rockville conglomerate, is exposed under the loess in the

*Op. Cit., p. 304.

Ne. ¼ of the Se. ¼ of section 34, Elk township. The exposure is about six feet in thickness. While resembling the Rockville conglomerate in some respects, it differs in some important particulars. In the first place, the material is definitely stratified, and consists of fine-grained sandstone in thin layers at the base of the exposure, with coarser conglomerate layers above. In the second place, the deposit is not very ferruginous, the colors being drab and light grays, with some yellowish bands in the finer layers. A very large proportion of the fragments in the conglomerate beds is cystalline quartz. No local chert was observed. In the absence of fossils it is impossible definitely to fix the age of either the Rockville conglomerate or the light colored sandstone and conglomerate southeast of Greeley. Both are much younger than the Niagara limestone. Both probably were laid down during the same marine invasion of this part of Iowa. The reasons cogently stated by McGee in the work already mentioned make it reasonably probable that the deposits are Cretaceous in age.

Fragments of a ferruginous sandstone, resembling some phases of the Des Moines stage of the Carboniferous, are strewn somewhat thickly along the course of the intermittent stream that flows down Whittaker hollow, in section 23 of Union township. These fragments lack the conglomerate character of the exposures at Rockville and the upper part of the exposure near Greeley. Fragments of chert and silicified Niagara corals are embedded in the sandstone, but there are no coarse fragments of quartz. There are some plant impressions, but they are not identifiable. The sandstone in Union township was not seen in place, but the beds from which the scattered fragments were derived are probably not far away from the point where the fragments themselves were seen. The friable nature of the sandstone precludes the notion that it could be transported far by stream action, amid masses of chert and limestone, before being completely disintegrated. As to age, the Whittaker hollow sandstone may provisionally

be correlated with the Rockville and Greeley deposits, until more definite information is at hand.

Residual Materials.

In preglacial time, the Niagara limestone suffered decay on a very large scale, and residual materials resulting from such decay are conspicuously distributed underneath the drift, especially in the eastern part of the county. These residual products, or geest, present three distinct phases. First, a dark, reddish-brown, stiff clay is one of the results of weathering of the Niagara dolomite. A small amount of argillaceous matter is present in the limestone as an impurity; and, being insoluble, it is left after decay and removal, by solution, of the calcareous portion of the deposit. With the clay is left the iron constituent that is also present as an impurity in the limestone. The dark, ferruginous clay is seen in the upper part of nearly all rock exposures. It does not, as a rule, attain any great thickness, but it fills the spaces among the bowlders of disintegration in the zone of preglacial weathering, and fills all horizontal and vertical fissures, often to a depth of many feet from the surface. It were needless to mention localities, for it occurs practically in every quarry.

Second, the Niagara dolomite varies in texture, and apparently in fundamental structure, in different localities. Typically it is hard, compact and crystalline, but there are phases of it that are soft and granular where the rock seems to be composed of partially consolidated dolomite sand. Weathering in such instances removes the cementing material, and the rock disintegrates into a yellowish or grayish mass of incoherent granules, resembling loose sand. As a typical locality where this phase of residual material may be observed to advantage, reference may be made to the rock cut on the Great Western railway northwest of Millheim. Underneath the thin bed of drift there is a body of very black, ferruginous, residual clay that belongs to the first type of residual products. Beneath this is a mass of the incoherent dolomite sand

that represents the stage of decay when the cement holding the constituent grains of the dolomite together has been dissolved away. In some places this incoherent material is two or three feet in thickness. In other cases it descends along crevices to an even greater depth. Lying in it are fragments of the limestone not yet completely decayed, but so soft and friable that they may be crushed in the hand or ground to coarse powder between the fingers.

In the third type of residual material angular fragments of chert predominate. The region around Delaware Center affords typical illustrations of the chert beds that result from decay of limestone in which bands and concretions of chert are common. The road between sections 25 and 36 of Delaware township passes over some hills that have been denuded of drift, and heavy beds of residual chert, forming a natural macadam, are exposed. The interstices between the fragments of chert are filled with a small amount of reddish-brown residual clay. Similar exposures, forming natural roadways, occur very generally throughout the eastern part of the county.

At a number of points in the north half of sections 27 and 28, Coffins Grove township, the residual materials consist of beautifully preserved, silicified fossils, embedded in reddish-brown clay. The fossils represent the cherty constituent of the beds that have undergone decay, and the clayey portion of the residuum is the argillaceous constituent stained deeply with iron oxide.

The residual products, that constitute so important a part of the superficial materials in this part of Iowa, have resulted from chemical disintegration of the Niagara limestone in some or all of the geologic ages between the close of the Silurian and the beginning of the Pleistocene. Similar changes are doubtless still in progress to some extent, but it is impossible at present to assign any given portion of the residuum to any particular age.

Pleistocene Deposits.

SUB-AFTONIAN DRIFT.

No Pleistocene deposits older than the Kansan drift were recognized in any of the exposures observed, but the existence of a sub-Aftonian or pre-Kansan drift is indicated by the presence of a soil and forest bed, between bodies of bluish till, reported by well drillers from different parts of the county. Satisfactory details could not in all cases be obtained. Two wells reported by McGee* are typical and may serve as illustrations of the general phenomena. His well, numbered 44, on land of the late Mr. John S. Barry in Prairie township, gives the following section, copied from the report cited.

		FEET.
3.	Unstratified yellow clay, with pebbles and bowlders...	8
2.	Compact blue clay, with small pebbles and bowlders of greenstone	17
1.	Brownish and black earth, like surface soil, with sticks, twigs, branches and other fragments of cedar	2

"Water was obtained in forest bed and is periodically foul." Since the record reported by McGee was obtained a succession of dry seasons has necessitated the boring of deep wells all over Iowa. On the Barry farm, and on adjoining farms, the deep wells have shown the whole drift series to be from seventy to eighty feet in depth, so that below the soil and forest bed reported above, there is a body of drift approximately fifty feet in thickness. According to recent intrepretations, this lower body of drift is beyond question sub-Aftonian. The soil and forest bed, No. 1 of the well section, is Aftonian. The blue clay, No. 2, is Kansan drift, and the unstratified yellow clay, No. 3, is Iowan.

No. 45 of McGee's well records, quoted from the work cited, gives the following section.

*Pleistocene History Northeastern Iowa, p. 520.

		FEET.
4.	Pebbly yellow clay	4
3.	Clean laminated blue clay	17
2.	Black loam, with partially decomposed logs, sticks, bark and twigs of coniferous wood	2
1.	Dense blue clay, with a few pebbles and a water bearing sand vein, depth not stated	

This last well is located at Greeley. No. 1 is very probably sub-Aftonian drift, and Nos. 2, 3 and 4 will readily be correlated with Nos. 1, 2 and 3 respectively of the Barry well.

KANSAN DRIFT.

The bed of blue clay above the soil and forest bed in the wells noted is typical of the unweathered Kansan. Nearly all excavations of any considerable depth, in the drift-covered portions of the county, reveal this same blue clay with its greenstone bowlders and pebbles. A good section showing Kansan till, weathered and unweathered, is seen in the recent railway cutting in the southwest quarter of section 6, Oneida township. The unweathered Kansan is more or less jointed, and has typical blue color, while the weathered Kansan has by oxidation been changed to reddish or yellowish-brown. The whole section here shows:

		FEET.
3.	Light yellow Iowan till	8
2.	Oxidized Kansan till, yellowish-brown	3
1.	Non-oxidized Kansan, blue	8

Narrow bands of weathering and oxidation descend along joints in the Kansan almost to the bottom of the exposure. Numerous striated greenstones occur in both the oxidized and unoxidized zones. Sub-Aftonian till is not exposed, but forest bed material was found in the bottom of the cut when trenches were dug to lay drain tile along the sides of the road bed. There are no signs of forest material between Kansan and Iowan.

Many interesting exposures of Kansan till occur in areas not occupied by Iowan. These areas have been discussed

under head of Topography on account of the special topographic forms that distinguish them from the Iowan drift plain. Within these areas the Kansan drift is usually overlain by loess, and the deposition of the loess seems to have been accomplished so quietly as not to disturb in any degree the characteristics acquired by the surface of the drift in the long interglacial interval that, in this part of Iowa, followed the retreat of the Kansan ice. Accordingly, the full effects of the weathering that had taken place up to the time of the deposition of the loess are perfectly preserved. This old surface is very ferruginous, very much oxidized, and completely leached so far as calcareous matter is concerned. It is also very red or reddish-brown, and, owing to the effects of rain erosion in carrying away the finer silts, it usually contains a larger proportion of pebbles than the main body of the drift where weathering has not taken place. In the northeast corner of the county, outside the limits of the Iowan drift, reddish-brown, pebbly Kansan is exposed beneath the loess, one-fourth of a mile north of the center of section 28, Elk township. It occurs on both sides of a ravine, and its surface, underneath only a thin mantle of loess, conforms to the present slope of the hills. The slopes and contours were essentially the same as now before the loess was laid down. Another exposure, showing the same phenomena and leading to the same conclusion relative to the pre-loessian topography, occurs near the southwest corner of section 22 of the same township. These and many other similar exposures are located within less than a mile of the margin of the Iowan drift. Eight miles farther east, Kansan till appears with its usual characteristics beneath a thin veneer of loess, along the west line of section 13, Colony township. The eastern limits of the Kansan are not so sharply defined as in the case of the Iowan, but there are reasons for believing that the locality last mentioned is very near the margin of the Driftless area. In the northeast quarter of section 13, for example, there are many sink holes which are inconsistent with the presence of

any considerable body of drift, and drift is certainly absent in that part of the valley of Little Turkey river that passes through sections 1 and 2 of the township named.

A considerable body of Kansan drift is well exposed for some distance both east and west of the center of section 15, Colony township, and there are indications of drift in sections 4, 5 and 6; but in sections 1 and 2 signs of drift were not observed, and the whole aspect of the country is suggestive of the Driftless area.

Buchanan Gravels.—Extensive beds of gravel were laid down during the melting and retreat of the Kansan ice. The floods that carried and deposited the gravels seem to have swept over valleys and highlands alike, for stratified deposits of the Buchanan stage occur indifferently at all elevations In the region invaded by Iowan ice these deposits are invariably overlain by Iowan drift; in the loess-Kansan area, beyond the Iowan margin, they are overlain by loess.

A good illustration of Buchanan gravels is seen at a gravel pit on the land of Mr. M. V. Newcomb, in the northern part of the southeast quarter of section 26, Oneida township, near Earlville (Plate xii, Fig. 1). The gravel bed has been worked extensively for road material, and has contributed in large degree to the improvement of the streets of Earlville. A vertical face of fifteen feet is now exposed, but test pits show that the deposit continues twenty feet below the level now worked. The deposit is a mixture of coarse sand and gravel, with occasional small bowlders ranging up to a foot in diameter. The coarse and fine materials are not arranged in definite bands, but lenses and irregular masses of coarse gravel are frequently embedded in gravel or sand of comparative fineness. There is a large amount of Niagara chert in the coarser beds, but in general the pebbles and bowlderets are of foreign origin. Some of the beds are very ferruginous and firmly cemented, and all are more or less conspicuously iron-stained. All of the present exposure shows the effects of prolonged weathering. Oxidation is complete. A large

proportion of the granite pebbles and bowlders are so perfectly decayed that they crumble to fragments on the application of the slightest force. Test pits made at various points show the entire hill, which rises gradually to the north of the present working, to be underlain by gravel at a short distance beneath the surface. The rusty, weathered and oxidized deposits of the Buchanan stage are covered with a thin layer of Iowan drift containing some unweathered bowlders.

An immense bed of Buchanan gravel extends over some hundreds of acres in a low plain in sections 25 and 36 of Bremen township. The plain is covered with two or three feet of Iowan drift, and large Iowan bowlders are liberally sprinkled over its surface. The gravels lie beneath the Iowan drift. The upper zone, three or four feet in thickness, is deeply weather-stained and oxidized. The bedding is more regular than is usually seen when the gravel beds occur on higher ground, as near Earlville. The materials are also finer, ordinary quartz sand making up a larger proportion of the deposit, and the bowlders a few inches to a foot in diameter, common in the beds at greater elevations, are practically absent. Furthermore, the oxidation and weather staining, probably owing to the finer and more compact character of the deposit, do not affect the beds to so great a depth as at Earlville. Heavy beds of the same gravels, exhibiting the commoner, upland phase, occur under thin beds of loess at a number of points in Colony township, the best exposures being seen forty rods north of the center of section 9, near the northwest corner of the southwest quarter of section 4, and near the center of section 6. All of these points are from six to eight miles east of the extreme eastern margin of the Iowan drift.

Near the southeast corner of the county Buchanan gravel makes up a conspicuous ridge that begins in the southwest quarter of section 13, Tp. 87 N., R. III W. (South Fork township), and extends into the northwest quarter of section 24. The gravels here are very ferruginous, are of the coarse

FIG. 1. Buchanan gravel underneath a thin layer of Iowan drift, on land of Mr. M. V. Newcomb, north of Earlville.

FIG. 2. Fountain Spring Mills, on Odell's branch of Elk creek. The topography of the region is that of the driftless area, and the streams are fed by springs

upland type, contain the usual decayed granites, together with striated pebbles and bowlders of Kansan age, and show a fair degree of cementation. The ridge in which they occur rises considerably above low lying drift plains to the south and southwest.

In the northwest corner of the county these gravels cover considerable areas in Richland township, the lowland phase appearing conspicuously beneath the Iowan drift along the valley of a branch of the Maquoketa, in section 19, and the upland phase occupying a ridge in the southwest quarter of section 32. In a sort of terrace at the bottom of the valley on the west side of the Backbone in section 16, weather-stained beds of the Buchanan stage occur under beds of sand and gravel of more recent origin, the contrast between the older and the newer portions of the terrace being very striking. The valley here is older than the Buchanan stage—older than the Kansan.

At Hartwick, in Delhi township, as already noted, reddish-brown deposits of this age are seen at the bottom of the gorge underneath terrace material which is probably not older than the Iowan stage, and reference has also been made to the occurrence of these gravels in the river valley near Hopkinton.

Honey Creek township is generously supplied with gravels of the Buchanan stage, particularly along the valley of Lindsey creek and Honey creek. In fact these gravels occur in almost every township of the county, affording at numerous points the very best of material for the improvement of miry roads. An outcrop deserving special mention is located west of Delaware in the southeast quarter of section 31, Oneida township. While the deposit is genetically the same as the ordinary Buchanan gravels, the material used is very largely residual Niagara chert of local origin. Reddish-brown sand and gravel is, however, interstratified with the beds of chert; and near the base of the pit, which is about eight feet in depth, the usual characteristics of the Buchanan stage are well displayed. A great amount of chert that must have been

transported and deposited by strong currents of water, yet retaining to a large extent the sharp angles of the individual fragments, occurs near the top of the exposure with practically no admixture of any other material.

IOWAN DRIFT.

The Iowan drift is well displayed over the larger part of Delaware county. It overlies the Buchanan gravels at scores of points within the Iowan area, but in general it rests upon the weathered and eroded surface of the much older Kansan till. The Iowan drift is very new and fresh as compared with the Kansan. Its surface has suffered scarcely any erosion since it was laid bare by the melting and disappearance of the Iowan ice. The topography of the Iowan area is characterized by long sweeping curves, the low eminences being separated by broad, shallow, concave depressions which, at the time of settlement of the county, were marshy and supported a luxuriant growth of coarse slough grass. The irregularities of the present surface are in part controlled by the topography of the old Kansan surface upon which the mantle of Iowan drift was laid down, and in part by local variations in the amount of drift deposited by the Iowan ice.

The study of the distribution of the Iowan drift in Delaware county has revealed some unexpected phenomena and presented a number of interesting problems that are not yet fully settled. In the first place the extreme eastern margin of this drift sheet is quite sharply defined by moraine-like ridges of loess that rise conspicuously above the drift plain, and extend in a very tortuous line from the northwest corner of Elk township to Dyersville. All of Colony township, the greater part of Elk, approximately one-third of Bremen, and a small fraction of Oneida were not invaded by Iowan ice. But in addition to the extra marginal area just noted, there are island-like areas that rise out of the level sea-like plain of Iowan drift areas that were surrounded, but not invaded, by the

glaciers of the Iowan stage. These anomalous areas are all higher than the ordinary drift plain by which they are surrounded. The larger ones are topographically different from the plain, resembling in this particular the Driftless area. Neither Iowan drift nor Iowan bowlders are found within their limits, but heavy beds of loess molded over a very much weathered and eroded surface is a prominent characteristic. Sometimes the loess rests on reddish-brown, oxidized Kansan drift. In other cases it rests on undisturbed residual clays and cherts.

These anomalous areas are of two kinds. First, there are small detached hills a few acres at most in extent, loess-covered, and standing prominently above the drift plain. These are the paha of McGee referred to in the section of this report devoted to togography. The paha are more or less elliptical in shape with the longer axes trending northwest-southeast. They are too numerous to be described in detail, but a concrete example occurs in the south half of section 3, Honey Creek township. The summit is fifty-five feet above the Iowan drift at the base. Gullies cut along the roadside on the southern slope show that the paha is composed of Kansan drift overlain by a cap of loess. Another paha near the northeast corner of section 27, Oneida township, has a core composed chiefly of a prominent point of limestone, but the limestone is overlain by a thin sheet of much weathered Kansan drift, and the loess, which is an essential part of all paha, forms a mantle over the whole a few feet in thickness. The paha are limited to a belt, a few miles in width, lying inside the margin of the Iowan drift. There are some interesting groups north of Earlville. There are a few rather prominent examples in the northwest corner of Elk township. They are very numerous in the northeastern half of Honey Creek township. They are in general conspicuous features of the marginal portion of the Iowan drift plain.

Second, there are some comparatively large areas, each embracing a number of square miles. One of these, with

heavy beds of loess and Driftless area topography, stands in the midst of Iowan drift in the central part of Richland township. This area constitutes the Richland highlands. At a number of points on the high ground west of Forestville the loess is seen resting on undisturbed residual clays and cherts. The Maquoketa flows through the highlands in a comparatively deep canyon. Iowan drift is absent, and the Kansan drift is seen but rarely.

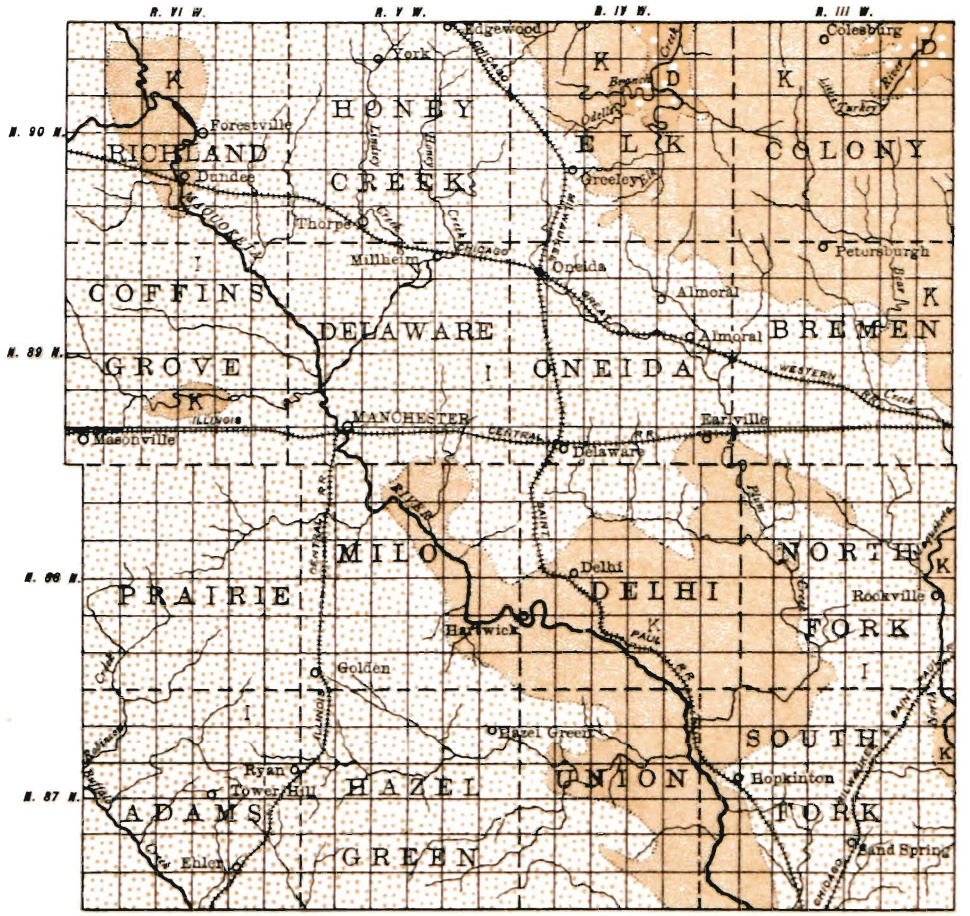
The largest area of the kind under consideration is the Delhi plateau, described at some length under the head of topography. It is surrounded by Iowan drift, but contains none within its limits. Kansan drift, weathered and oxidized as usual, occurs under the loess at numerous points. Near Hopkinton, as already noted, the loess rests on Buchanan gravels. In many places, however, there are no signs even of a Kansan invasion of the region, and loess lies on residual products. By way of explanation of these anomalous areas it can only be said that it looks as if the Iowan ice had been too thin near its margin to overflow eminences rising fifty feet or more above the general level, and so it simply flowed around them. The upper surface of the ice in general was doubtless somewhat higher than the tops of the eminences in question, so that when the flow was at its maximum these areas lay at the bottom of shallow, basin-like depressions within which fine silt or loess was deposited. The facts, however, may have been quite different from those which the peculiar phenomena, at first sight, seem to suggest.

The Iowan drift is a light yellow, highly calcareous clay, unchanged by weathering and oxidation even at the surface. It presents a strong contrast to the deeply weathered, leached and oxidized upper zone of the Kansan. Its presence, however, may be detected without special tests by the gently undulating topography free from erosion forms, and by the presence of large granite bowlders strewn over the surface. Mingled with the granites other forms of crystalline rocks occur occasionally. A fine, large quartzite bowlder, five feet

long, three feet wide and fifteen inches thick is seen on the Sw. ¼ of Se. ¼ of section 16, Delaware township, and another similar in type, and probably from the same original ledge, was noticed in the southeast quarter of section 3 of the same township. Both bowlders show very perfectly the lamination planes of the original bedding, and in both the surface is beautifully ripple-marked.

Loess is the name given to the fine, silt-like clay that in general covers the area outside the margin of the Iowan drift. Loess also covers the paha, and very generally it covers the other island-like areas that seem to have been completely surrounded by Iowan ice without being overflowed by it. The composition, structure and distribution of the loess indicates that it was derived from the Iowan drift, and its deposition was in some way connected with the presence or retreat of the Iowan ice. Approximately one-third of Delaware county is loess-covered, the localities so covered having been already described. Quartz sand, to a large extent, takes the place of loess in the northern and central parts of the Delhi plateau. In many other localities the loes is underlain by stratified sand. This is particularly true along valleys that may have served as drainage courses to carry off the water from the melting Iowan ice. An interesting occurrence of sub-loessial sand was seen in Whittaker hollow, a mile or two southwest of Hopkinton. Heavy beds of loess lie on the sloping sides of the valley, and at one point in the southwest quarter of section 23, Union township, a bed of highly colored, reddish-orange, stratified sand is exposed beneath twenty-five feet of loess. The sand, six feet in thickness, rests on the bottom of the valley, showing that Whittaker hollow, as well as the rest of the drainage courses of the region, was eroded to its present depth before the sand or loess was deposited. All these valleys are in fact pre-Kansan, as shown by the presence at various points of undisturbed Buchanan gravels.

For four or five feet above the base of the loess, at the point under consideration, there are irregular pockets of the



PLEISTOCENE MAP OF DELAWARE COUNTY, IOWA,

BY

SAMUEL CALVIN

I — IOWAN DRIFT

K — NO IOWAN DRIFT. CHIEFLY LOESS RESTING ON KANSAN PARTLY DRIFTLESS

D — NO DRIFT

IOWA LITHO CO. DES MOINES.

DRAWN BY F. C. TATE

bright-colored sand, not mingled with the clay, but simply enclosed in it, as if they had been deposited as frozen pellets. The sub-loessial sand is clearly an aqueous deposit, and the sand pellets included in the basal portion of the loess were certainly not transported by wind. In the upper part of the exposure, about fifteen feet above the base of the loess, a few specimens of *Succinea avara* were noted. The whole body of loess at this point is quite distinctly banded, and is more than usually arenaceous.

With reference to the areas actually invaded by Iowan ice the distribution of the loess seems to be generally, if not invariably, extra-marginal. Except at the point noted under Topography in sections 27 and 28 of Hazel Green township, it is not certain that the loess of this region ever rests on Iowan drift. The contact of the loess with Niagara limestone, with residual products such as dark-brown clays and cherts, with Kansan drift and with Buchanan gravels, may be observed at scores of points; but nowhere, except in the single instance mentioned, was it seen resting on drift of Iowan age. It may yet indeed be possible that the morainic ridges referred to in Hazel Green township are composed of Kansan drift with Iowan drift lapping up on the sides, but not reaching the top; and that after all the loess does not rest on till of Iowan age, but on Kansan, as is its almost universal habit.

ALLUVIUM.

Narrow belts of alluvium occur along the principal drainage courses in all the areas that were not invaded by Iowan drift. The Little Turkey river has in places a beautiful, flat-bottomed valley, which is covered with heavy beds of rich alluvium. Alluvial plains, but of no great width, border Elk creek and its branches; and Buck creek, Plum creek and the Maquoketa river have their flood plains covered with alluvium within the limits of the Delhi plateau. Alluvium covers the flat bottom of the valley through which the Maquoketa flows at the Backbone in Richland township, and a small amount of the same deposit is found along the

North Maquoketa, in sections 1 and 12 of South Fork township. Streams, such as Buffalo creek, that flow through the area of Iowan drift, have no flood plains, or alluvial plains, in any true sense; for the gently undulating surface of the region through which they flow, covered with drift and sprinkled with bowlders, continues without interruption to the water's edge.

TERRACES.

Well defined terraces, composed of stratified sands and gravels, occur along the streams of Delaware county, particularly in the areas inside the Iowan margin, but which are free from Iowan drift. The height to which the terraces rise above the water in the adjacent stream varies considerably in different localities. Near Hopkinton the upper surface of the terrace on the east side of the river is fifty feet above the water level. Near Millheim, in Delaware township, a terrace composed of fine stratified sand has an elevation of thirty feet above the water in Honey creek. At other points in the county the height of the terraces above the water in the nearest stream varies within limits ranging from ten to fifty feet.

At Hopkinton the terrace material is piled against the side of an ancient valley, that was bounded by rocky cliffs seventy-five to a hundred feet in height. The town is built on a platform that overlooks a rather wide bottom land, or flood plain, the platform corresponding in height to the upper surface of the terrace. The descent from the top of the terrace to the bottom land is abrupt. In the center of the town the Niagara limestone is encountered a few feet below the surface, but near the margin of the platform wells seventy-five feet in depth are made without striking rock. The same sandy terrace extends for more than a mile northwest from Hopkinton on the left side of the river. A gravel terrace begins on the west side of the stream, near the center of section 11, Union township, and continues beyond the north line of section 2.

In section 2 it is set off by an abrupt descent of fifteen feet from the narrow flood plain. Excavations show that the main body of this terrace is made up of very old, weathered, ferruginous material of the age of the Buchanan gravels. The deposit presents all the characteristics of the valley phase of this formation. The materials are finer than on the highlands. The coarser material is at the top of the deposit, with sandy beds below. The weathered zone at the top has the usual reddish-brown color.

Manchester is built on a sandy and gravelly terrace, the material showing perfect stratification when seen in fresh section. The terrace deposit extends up Honey creek for several miles, and is also well displayed at intervals, above the mouth of Honey creek, along the Maquoketa river. At the Backbone, in Richland township, a sand terrace on the left side of the stream rises thirty feet above the water. This terrace is composite, for fresh sands overlie rust-colored, oxidized gravels of Buchanan age. The contrast between the older and newer portions of the deposit is very striking. In some places, however, the old gravels seem to underlie nothing but the talus derived from adjacent slopes.

It is interesting to note that the terraces observed in this county are nearly all referable to the period of ice melting following the invasion of the Kansan glaciers. In some cases there have been some additions to the terrace deposits in times more recent than the Buchanan gravels, but the significant point is that these valleys are pre-Kansan in origin.

Soils.

Delaware county affords quite a variety of soils. The typical soil of the Iowan drift region, covering two-thirds of the surface of the county, is a deep black loam, rich in organic matter and containing an abundance of the soluble mineral constituents from which the crops of the farmer draw so large a supply of plant food. The largest continuous area of Iowan drift embraces the townships lying southwest of the Maquo-

keta river, and it is here that the rich, black, loamy soils of the type described are best developed. Between the Maquoketa river and the Iowan margin there are large areas, more or less interrupted, however, by the island-like paha and other patches free from Iowan drift, over which soils of the same superior quality are distributed. Every township in the county, except Colony, has some areas covered with soils derived from Iowan drift. In some parts of Oneida, Bremen, North Fork, South Fork and the other townships included between the Maquoketa river and the Iowan drift margin the soils are thin. Rock ledges and residual clays and cherts come near the surface or even become superficial by projecting through the scant materials belonging to the drift. Over an area of several miles in extent around Delaware the thin soil, in many places, is insufficient to conceal the rocks and residual cherts which form numerous stony knobs and flint hills unfit for cultivation. Angular fragments of chert mixed with ferruginous residual clay, constitute a natural macadam of excellent quality in many of the roadways. Near the margin of the Iowan ice the amount of fine clayey material transported and deposited was very small, and hence it is that thin soils characterize so much of the surface in a zone, six or eight miles in width, immediately adjacent to the margin of the Iowan drift plain. The townships of Hazel Green, Adams, Prairie and Coffins Grove, together with the southwest half of Milo, are in general covered with a heavy bed of drift upon which a soil unexcelled in the Mississippi valley has been developed since the retreat of the Iowan ice.

Around Rockville there are extensive areas covered with æolian sands and presenting a type of soil far from desirable. Sands that bear evidence of having been carried and deposited by winds occur at numerous points in the belt of thin soils inside the Iowan margin. Such sands occur abundantly near Earlville, Delaware, and generally throughout North Fork, Bremen and Oneida townships. They are lodged usually on the gentle slopes of the low hills, the broad swales or low

lands being generally free from sand and covered with a heavy black loam. In a low ridge near the northwest corner of section 7, Oneida township, there are four to six feet of æolian sand resting on an old soil bed, as demonstrated by excavations made by Mr. B. F. Hoyt. Sand, derived from terrace material along the stream valley, characterizes the soils on both sides of the Maquoketa for some distance above and below Manchester.

In the portion of the county not covered with Iowan drift the soils are either loess clays, sands or residual products. Northeast of the Iowan boundary line loess is the prevailing material. The surface is hilly and uneven. Yellow loess clay, quite free from organic matter, but rich in lime carbonates and other forms of mineral plant-food, gives color and character to the fields, and presents a strong contrast to the deep, black, mellow loam which prevails over the region of Iowan drift. On steep hill slopes loess soils are not very productive. They wash badly, and the surface often presents a series of impassable ditches and gullies. In the central and southern part of Colony township there is an area more than usually level for a region covered with loess and Kansan drift. The storm waters are carried off slowly. The surface is not gashed or gullied, and the loess type of soil is here seen at its best. Such a soil is very fertile, is adapted to a great range of crops, and ranks with the best known anywhere in the great fertile northwest.

Loess covers the paha in the marginal zone of Iowan drift, and where the surface is not too steep the soil possesses many admirable qualities. Loess covers the highlands in the central and northern part of Richland township. The surface is rather hilly north and northeast of the Backbone, so that the country is better adapted to orchard culture or timber culture than to ordinary farming. The Delhi plateau is largely covered with loess, but the broken and hilly character of the surface in general indicates that the production of ordinary farm crops is not the purpose to which the region is best

adapted. It should be reserved as forest land, but where this is not practicable it should be devoted to orchards, vineyards or the cultivation of small fruits. Some portions of this plateau are covered with sand, the region about Delhi being typical in this respect. The sand beds are at least ten to fourteen feet in thickness, and, near the northern margin of the plateau, seem to take the place of the loess. The sandy soils about Hopkinton seem to be derived from sand terraces that are probably as old as the close of the Kansan glacial stage.

Taking the county as a whole the average grade of its soils is high.

Deformations.

No very marked foldings of the indurated beds were observed in the county, but there are indications of a very interesting deformation affecting the strata over a large area in the northern and northwestern townships, and interfering with the normal dip toward the southwest. The Pentamerus beds, for example, are exposed in section 20 and in adjacent sections of Elk township. In place of the usual dip, however, these beds actually rise slightly toward the west and appear at the Backbone in the center of Richland township. They are found at intermediate exposures, as near Millheim and Forestville. The same reversed dip is continued westward, outcrops of Niagara occurring in townships of Buchanan county, west of Richland; and a salient angle of the Niagara area cuts a deep notch in the eastern edge of the Devonian.* Massive ledges of Niagara are exposed on the Wapsipinicon river, near Fairbank, in the southwest corner of Fayette county.

*See Geological map, Plate ii. of this volume. Note in the eastern edge of the Devonian the re-entrant angle, having its apex near the northwest corner of Buchanan county.

ECONOMIC PRODUCTS.

Building Stone.

There are at present no quarries operated on a commercial scale in Delaware county. Building stone of excellent quality occurs in abundance; outcrops of the beds capable of furnishing it are numerous and not unfavorably situated; but so far the quarries have been developed only to the extent of supplying local demands; they are worked intermittently; there are none supplied with other than the simplest machinery and appliances for getting out the stone; there are none that ship any considerable portion of their output beyond the limits of the county.

Quarries have been opened in almost every neighborhood in the northeastern half of the county. There are two horizons at which evenly-bedded, easily-quarried stone occurs, and the quality of the stone at both horizons is such as to place it among the best in Iowa. The lower quarry stone horizon begins about thirty feet above the base of the Niagara limestone and has a thickness of more than thirty feet. The other horizon occurs near the top of the Delaware stage, above the Pentamerus beds, and has about the same thickness as the lower quarry stone horizon.

The principal quarries of the lower horizon are located in Elk township. There are at least four in section 16, one in section 23, and two or three occur in section 2. All are worked more or less constantly during the summer season. The Wilcox quarry, already described in discussing the characteristics of the lower portion of the Niagara limestone, is in the southwest quarter of section 16, and is typical of all the others at this geological level. It presents a vertical face of about thirty feet. The beds range from three or four inches to thirty-six inches in thickness. The ledges, especially near the middle of the exposure, are fine-grained and suitable for use as cut stone in the best grades of masonry. Stone for all structural purposes, including bridge piers and heavy founda-

tions, as well as the range courses and trimmings of ordinary buildings, might be obtained here with great facility if only the conditions of the market demanded it. The other quarries of this neighborhood are capable of producing stone of equally high grade.

There are quarries at the same horizon in Bremen township. One of these is located south of the center of section 13, and there are two or three in section 26. A quarry on the land of Paul Steger, in the northern part of section 26, furnishes good stone for rough masonry. The rock is granular, vesicular, much pitted by weathering where exposed, rather evenly-bedded; beds are horizontal and vary from a few inches to more than a foot in thickness. The pitted condition due to weathering is peculiar and distinguishes the rock of this locality from the equivalent beds on Elk creek. The quality is inferior when compared with stone from the Elk creek quarries. Another quarry in which the stone shows similar peculiarities of weathering occurs on land belonging to John Lappe, a short distance southwest of the center of section 26, Bremen township.

Beds of this lower quarry stone horizon, resembling those on Elk creek, are exposed at many points along the Little Turkey river and its branches in the northeastern part of Colony township.

The best exposures of the upper quarry horizon are seen in Union township, a few miles southwest of Hopkinton. The Merriam quarry, in the southeast quarter of section 23, has been worked longer than any of the rest and may serve as a general illustration. I am indebted to notes furnished by Prof. A. G. Wilson, of Lenox college, for the following description of the Merriam quarry section.

		FEET.	INCHES.
11.	Layers of limestone alternating with layers of chert, each about three inches thick.....	2	4
10.	Single layer, with embedded concretions of chert.....	2	

		FEET.	INCHES
9.	Three to six inch layers of limestone alternating with two to three inch layers of broken chert	5	
8.	Fair rock with little chert	1	3
7.	Even-grained rock, cleavable		10
6.	Good quarry stone in several layers	3	
5.	Compact layer with large, flat Pentamerus	2	
4.	Lowest layer worked		10
3.	Vesicular ledges below base of quarry	3	
2.	Cherty layers	4	
1.	Cherty and vesicular layers down to talus	18	

The Merriam quarry has from fifteen to twenty feet of excellent quarry stone. There are two or three other quarries worked at the same horizon in the same quarter section.

The Loop quarry is situated in the northwest quarter of section 25, Tp. 87 N., R. IV W., about one mile southeast of the Merriam quarry. This quarry has been worked only a short time, but it gives promise of furnishing a large amount of valuable building stone. The stone is fine-grained, homogeneous, easily worked and of good color. As the quarry is carried farther back into the hill the aggregate thickness of the available stone will increase to twenty-five or thirty feet. The beds now exposed furnish excellent material for rubble, range courses and dimension stone up to ten inches in thickness.

Quarry stone belonging to the Merriam quarry horizon crops out at a number of points along a small ravine in the east half of section 17, South Fork township. The bedding seems to be thinner here than on the west side of the Maquoketa in Union township. Some of the beds, however, are ten inches in thickness; and quarries worked on land of H. Davis, in the northeast quarter of section 17, and on the land of M. McGlade, in the southeast quarter of the same section, have furnished a large amount of good building stone for local use. Another small opening at this same horizon was noted in section 14 of South Fork township.

There are several quarries in the upper building stone beds in Milo township. The largest are located in the eastern part of section 9, near the north end of the highlands, called in this report the Delhi plateau. The land on which the quarrying is done is nearly 200 feet higher than the Maquoketa river at the nearest point. The rock is here less magnesian than at other exposures in the county. A large proportion of it is bluish in color, and there are many large pockets of calcite. The bedding is quite regular, but the quality of the stone is not equal to that at the Merriam and Loop quarries further south. A much better quality of stone is furnished by the quarry of T. B. Matthews, located near the center of section 4. The Matthews quarry has beds ranging from two inches up to two feet in thickness. The stone is a good color, rather fine texture and may be used for the better grades of structural work.

In Delhi township the upper quarry stone is worked to some extent at Beal's quarry, in the town of Delhi. It is exposed, and might be easily quarried, in the bluff south of Fleming's mills, in section 29, and there are a number of other exposures, though at rather inaccessible points, along the bluffs of the Maquoketa, in sections 29, 30, 33, 34 and 35. A small quarry capable of affording very excellent stone is opened on land of George H. Norris, in the northeast quarter of section 23.

The Pentamerus beds are usually massive and break on quarrying into shapeless pieces, but at a few points in the county they lie in comparatively thin, even layers that may be quarried without difficulty, and yield stone suitable for a number of purposes. The position of the Pentamerus beds is between the two quarry stone horizons already described. A small quarry is worked in the Pentamerus horizon in the northwest quarter of section 3, Colony township. In the same township there is another quarry at this horizon near the center of section 27, and still another is worked in the southwest quarter of section 35. The last mentioned has been operated more extensively than the other two. The quarry

face is about eight feet in height. The beds are somewhat shattered near the top. Chert is abundant as partings between the layers, or as concretions embedded in them. The limestone is overlain by a very reddish-brown, pebbly Kansan drift. *Pentamerus oblongus* is the prevailing fossil, but along with this species there occur Receptaculites sp., Stromatoporoids undetermined, *Lyellia americana*, *Halysites catenulatus*, *Syringopora tenella*, *Strombodes pentagonus* and *Streptelasma patula*.

Some of the most important quarries worked in the Pentamerus beds are located in the southwest quarter of the northwest quarter of section 31, Bremen township. In one of these quarries (Plate x, Fig. 2) there is an exposed section, thirteen feet in thickness, which shows.

		FEET.
2.	Coarse vesicular stone in heavy ledges, ledges varying from eight to thirty inches in thickness.....	8
1.	Evenly-bedded stone in layers two to six inches in thickness. Some of the layers contain Pentamerus oblongus with shells partly preserved. Stone is soft earthy dolomite, with some chert.....	5

The massive beds of No. 2 contain Lyellia, Favosites and other corals. These thick ledges are undermined in taking out the thinner layers of No. 1, and great blocks left without support fall down on the floor of the quarry, as shown in figure 2 of plate x.

Some stone is obtained from this horizon near Sand Spring, in South Fork township. Pentamerus limestone is used for foundations and bridge piers at Forestville, in Richland township. Near the northwest corner of section 2, Milo township, there is a small quarry that with rather coarse, thin-bedded limestone furnishes an unusual amount of chert.

Lime.

With an abundance of stone of first-class grade for lime-burning it is a little surprising to find that only a small amount of lime is produced in Delaware county. There are no kilns

that are operated continuously or that attempt to do more than supply some temporary local demand. There are scores of localities where the Pentamerus and coral-bearing beds, lying between the two quarry stone horizons, are massive, crystalline and free from chert. In such case, if properly managed, they will produce a superior quality of lime. Remains of abandoned limekilns are found in almost every neighborhood where the Niagara limestone outcrops, but no kilns were seen in operation. There are half a dozen or more of these old kilns in the neighborhood of Hopkinton. No better lime was ever made anywhere than that which these kilns produced when they were operated. The raw material is abundant and easily obtained. What is lacking is capital, organization and efficient management. Dubuque lime, and other limes not one whit better than the home product, but made on a large scale by improved methods, are able to supplant the home product when made by the primitive appliances adopted by the pioneer settlers of the county.

Clays.

Loess clays and drift clays suitable for brick making are widely distributed in Delaware county. The Mattox brickyard at Manchester is probably the oldest in the county. It has been operated for twenty-one years. The clay used is Iowan drift, which is here quite free from pebbles. Beneath the thin layer of Iowan there is blue Kansan till, rich in pebbles, and many of the pebbles were derived from limestone. The presence of these limestone fragments renders the Kansan till unfit for use in brick making. The brick made at the Mattox yard are hand molded. They are dried on the yard and subsequently burned in the ordinary cased kilns. There is very little loss from checking either in drying or burning. The capacity of the kilns vary from 150,000 to 300,000. The greatest output in any one year was 900,000. The brick are of good color, and individually weigh about four and one-fourth pounds.

The Williamson and Stead brickyard is located about one mile south of Hopkinton. Loess clay is used, the thickness of the bed being about fifteen feet. The brick are molded in a Martin machine, operated by horse power, and having a capacity of 15,000 per day. A re-press is used on some of the product. The clay from the pit is soaked in water and is used without mixing with sand. There is little trouble from checking. The clay, unlimited in quantity, would make good pressed brick of excellent color if there were a demand sufficient to warrant the outlay for the necessary machinery.

Brick have been made from loess clay at two points east of Colesburg. Both kilns are in section 3, Colony township. The brick were hand molded. They stood firing well, burned hard and took on a good color. No brick were made here in 1897.

A pottery at Colesburg, operated by Frank Brock, makes a good grade of earthenware from Maquoketa shales. The whole thickness of the shales is exposed in a deep gorge in sections 2 and 3 of Colony township, and the clay used at the pottery is taken from near the middle of the deposit, the pit being located in the Se. ¼ of Ne. ¼ of section 3. The shales here are non-fossiliferous, and consist throughout their whole thickness of beds that weather into smooth, fine-grained plastic clay, suitable for the manufacture of pottery and various grades of brick. The raw material is unlimited in amount.

Cement Rock.

The transition beds, twenty-five feet in thickness, between the shaly portion of the Maquoketa formation and the base of the Niagara, have the qualities of beds used in the manufacture of natural cement. No tests have yet been made to determine the quality of the product these beds would yield, but the experiment of making cement from the beds of this horizon is well worth trying.

Iron Ore.

A body of bog ore, limonite, underlies Iowan drift in some low meadow land in the south half of the southeast quarter of section 1, Delaware township. Similar ore was encountered in digging surface wells in adjacent parts of section 12. The area within which this ore is known to exist is about 100 acres.

The iron ore is quite impure, being mixed with sand and pebbles. In thickness the bed varies from a few inches to six feet, as reported by persons who had made test pits to determine the question. A small gully is in process of excavation by head-water erosion, in the lowest part of the meadow; and at the head of the excavation the ore is naturally exposed. At this point the bed is thin and the ore occurs in large flakes and irregular masses separated one from the other by ferruginous sand and clay. The iron rests on blue clay of Kansan age. The overlying Iowan drift varies from one to more than six feet in thickness.

At present this deposit possesses little economic value, its chief interest lying in the fact that it records the existence at this point of an interglacial marsh of long duration, and adds another link to the irrefutable chain of evidence that the ages of the Kansan and Iowan drift sheets are separated by long reaches of time. The bog ore is an interglacial deposit, bearing witness to the fact that the interglacial climate for many centuries favored the growth of luxuriant vegetation.

Road Materials.

Throughout the whole northeastern half of Delaware county material for the improvement of roads is abundant. Loess clay answers an excellent purpose on sandy roads, and such clay is usually plentiful within easy hauling distance of almost every point along the Maquoketa river or in the area lying northeast of that stream. Better and more permanent improvement is made by the use of chert and broken lime-

stone. The streets of Hopkinton, which are naturally sandy, have been covered with risidual clay, chert and fragmentary limestone from a pit in the western edge of the town, and the results are very satisfactory. A stretch of road in sections 11 and 12, Tp. 87 N., R. IV W., formerly almost impassable by reason of deep sand, has been put in excellent condition by the use of the same kind of material taken from the river bluff in the northeast quarter of section 11. A quarry in the northwest quarter of section 2, Milo township, has furnished a large amount of very desirable road metal in the form of chert and limestone. Material of the same kind is generally distributed except in the prairie townships southwest of the Maquoketa.

Residual chert alone is used to a large extent in Delaware, Oneida and Delhi townships. Some stretches of road in the central part of the county are provided by nature with a macadam of residual chert in place, and beds of fragmentary chert, grading down into beds of partially decayed chert and limestone, are coextensive almost with the outcrops of indurated rocks.

In the Pleistocene formation the most important road materials are the Buchanan gravels. These have been already described. The pit near Earlville, on the land of Mr. M. V. Newcomb, has furnished more material for use on wagon roads than any other in the county, but there are other deposits equally good awaiting the enterprise that will develop them and use the material on the loamy and clayey roads that at certain seasons of the year are impassable for loaded teams. The great pit near Dyersville, in section 25 of Bremen township, is the largest in the county. The product has been used for ballast on the line of the Chicago Great Western railway. The gravel deposits here occupy an area of several hundred acres in sections 25 and 26, and could supply material enough to improve the larger part of all the roads needing improvement in the entire county. A bed almost as extensive as that in Bremen occurs in sections 18 and 19, Richland township.

The townships of Honey Creek, Colony, Delaware, Oneida, Milo, Delhi and South Fork are also well supplied with gravels. Beds were also noted in Coffins Grove and Prairie townships. There is no county better supplied with easily-worked materials for the improvement of the ordinary prairie roads.

With an abundance of residual cherts and Pleistocene gravels ready to hand it is not likely that resort need very soon be made to stone mechanically crushed or broken for use on streets and roads, but should the demand for such a product arise, there are rock exposures in almost every neighborhood, except the southwest part of the county.

Railway Ballast.

The Buchanan gravels are already used to a large extent for railway ballast, and their use might, with small expense, be greatly extended; for deposits occur near railway lines at Earlville, as well as at numerous other points throughout the county. The gravel pit of the Chicago Great Western railway near Dyersville has been noted. A similar pit is worked by the Illinois Central a few miles south of Manchester. When broken stone ballast comes to be needed, the county can furnish it in quanities to meet any probable demand.

Water Supply.

Delaware county is well watered by streams which are in the main permanent even in seasons of drouth. Springs are numerous and bountiful, the permanence of the streams being due largely to the volume of water which the springs supply. Along Elk creek and its numerous tributaries there are many copious springs along the outcrop of the transition beds between the Maquoketa shales and the Niagara limestone. Springs also abound at the same horizon along Little Turkey river and its branches in Colony township. At the Backbone in Richland township there are a score or more of springs issuing from crevices in the shattered limestone below the

horizon of *Pentamerus oblongus*. The same horizon is marked by springs, some of large volume, in Honey creek and Delaware townships, near Millheim, and in South Fork township, near Hopkinton. The splendid springs that supply Spring creek, in section 35 of Delaware township, and in sections 2, 3 and 10 of Milo, come from about the same geological level. The bountiful supply of pure spring water poured out from the rocks along the valley of this creek has afforded the opportunity for establishing here one of the largest and best equipped fish hatcheries under the control of the United States fish commission. Springs, in short, occur at intervals along all streams that cut their channels through the superficial deposits down into the indurated rocks.

Well water is obtained in streaks of sand and gravel in the Pleistocene deposits. Formerly wells twenty to forty feet in depth afforded an unfailing supply of water throughout all the prairie portion of the county; but lately it has been necessary in most cases to bore through the drift and for some distance into the underlying rock, in order to get the volume of water needed on the ordinary farm. In the southern part of Prairie township, for example, the drift series is from 80 to 120 feet in thickness, and the farm wells are bored from 70 to 100 feet, or even more, in the Niagara limestone underlying the drift. The well on the estate of John S. Barry is 285 feet deep, and on land of S. M. Shofner, near the northeast corner of section 27, a well is 300 feet in depth. On other farms in the same neighborhood the wells range in depth from 150 to 200 feet.

Near Hopkinton the deeper wells go through the Niagara limestone and for some distance into the Maquoketa shales. A typical well of this locality gives the following section, taken from notes furnished by Prof. A. G. Wilson.

		FEET.
5.	Sandy soil	2
4.	Clay subsoil	8
3.	Niagara limestone, buff	130
2.	Limestone, nearly white	20
1.	Maquoketa shales, blue	40

The well is located on land of Charles Root, in the northwest quarter of section 18, South Fork township. The well head, as reported by Professor Wilson, is about 140 feet above the level of the river. Some of the wells of the neighborhood are reported as going 100 feet into Maquoketa shales.

While supplies of water for farm and isolated household purposes may be obtained in the drift, in the Niagara limestone or in the Maquoketa shales, at depths ranging from twenty to 300 feet, supplies for cities must be drawn either from permanent streams or from the great water-bearing sandstones that, throughout the county, lie at depths of 1,500 or 2,000 feet beneath the surface. Manchester obtains its water supply from a deep well reaching to the basal portion of the Saint Croix sandstone. A summary of the record of this well, published by Norton,* gives the following.

		FEET.
10.	Niagara	225
9.	Maquoketa	205
8.	Galena-Trenton	354
7.	Saint Peter	33
6.	Upper Oneota	65
5.	New Richmond	49
4.	Lower Oneota	275
3.	Jordan	90
2.	Saint Lawrence	229
1.	Basal sandstone (penetrated)	345

The depth of this well, according to Norton's report, is 1,870 feet, and the bottom is 944 feet beneath tide level. The water, as shown by the official analyses, is of excellent quality.

Water Powers.

Water powers with head varying from eight to fourteen feet have been developed along the Maquoketa river at the following points.

1. Forestville, Richland township.
2. Quaker Mills, Delaware township.
3. Manchester, Delaware township.

*Iowa Geol. Surv., vol. VI, p. 219. Des Moines, 1897.

4. Hartwick, Delhi township.
5. Fleming's Mills, Delhi township.
6. Hopkinton, South Fork township.

Mill sites on Honey creek are found at Millheim, in section 3, and at two points in section 20, near Manchester, Delaware township. The Fountain Spring mills (Plate xii, Fig. 2) are on Odell's branch of Elk creek, in section 16, Elk township. There is an abandoned site on Elk creek about a mile south of the Clayton county line. A sawmill was once operated near the mouth of Plum creek, and there was another on Buck creek, in section 10, Union township.

ACKNOWLEDGMENTS.

In the prosecution of the field work in Delaware county, the writer received substantial help from a large number of individuals, all deeply interested in the purposes for which the Survey is maintained. Especial acknowledgments are due to Prof. A. G. Wilson, of Lenox college, whose intimate knowledge of the geology of the county, acquired through many years of painstaking study, has been freely placed at the disposal of the Survey. Professor Wilson accompanied the writer in the field for several days, and his private note-book has been drawn upon for a number of facts embodied in this report. Mr. B. F. Hoyt, of Manchester, a careful student of natural phenomena, rendered very effective assistance, and the writer is also indebted to Judge Blair and Judge Seeds, of Manchester, for valuable assistance and information concerning the location of points of interest. To Prof. J. W. Rosser, of Greeley; Mr. Frank Grimes, of Colesburg, and Mr. Grant Crawford, of Hopkinton, thanks are due for aid rendered while work was being prosecuted in their respective localities. The Survey is indebted for many favors to Prof. T. H. Macbride, and we owe the subjoined report on the forest trees of Delaware county to the courtesy of Mr. John E. Cameron.

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF DELAWARE COUNTY, IOWA.

BY

SAMUEL CALVIN
1893.

R. VI W. R. V W. R. IV W. R. III W.

T. 90 N. T. 89 N. T. 88 N. T. 87 N.

RICHLAND HONEY CREEK ELK COLONY
COFFINS DELAWARE ONEIDA BREMEN
GROVE MANCHESTER
MILO DELHI NORTH FORK
PRAIRIE
ADAMS HAZELGREEN UNION SOUTH FORK

Edgewood York Colesburg Forestville Dundee Greeley Thorpe Millheim Oneida Petersburgh Almoral Earlville MASONVILLE DELAWARE Delhi Hartwick Rockville Golden Hazel Green Ryan Tower Hill Hopkinton Sand Spring Ehler

LEGEND

GEOLOGICAL FORMATIONS

- ROCKVILLE CONGLOMERATE (CRETACEOUS ?)
- FAYETTE (NOT EXPOSED)
- OTIS AND INDEPENDENCE (NOT EXPOSED)
- CODDAN (NOT EXPOSED)
- NIAGARA
- MAQUOKETA

INDUSTRIES

- QUARRIES
- CLAY PITS
- LIME KILNS
- GRAVEL
- IRON ORE

Scale 1 2 3 4 5 Miles
1 2 3 4 5 Kilometers

IOWA LITHO. CO. DES MOINES. DRAWN BY F. C. TATÉ

College - Lenox - Hopkinton

FOREST TREES OF DELAWARE COUNTY.

BY JOHN E. CAMERON.

The surface of Delaware county is divided into prairie and timber land. The timbered area occupies about one-fourth of the county and is confined to the rougher and more broken regions. The timber is well distributed, following as it does the south fork of the Maquoketa river and its branches in its diagonal course through the county. Extensive forests exist along Elk creek in the north central, and along the Little Turkey river, in the northeastern part of the county.

Most of the wood is second growth, but some large and valuable timber remains west of the Maquoketa, in Union township, and in the valley of the Little Turkey, in Colony township. The best example of the original forest is to be seen in a piece of timber owned by Dr. Hugh Livingston, located two miles south of Hopkinton, in South Fork township.

A few miles above Manchester there is a valuable strip of timber east of the Maquoketa river, which has grown up since the country was first settled. But while in a few instances the timber has extended its range, in the last few years great tracts of second growth have been cleared for farms, pastures and farming lands, so that where once stood valuable forests we find to-day the poorest farms of the county.

There is a marked difference between the forests of the drift-covered regions of the south and the Driftless area of the northern part of the county. In the former we have the woods common to this latitude, while in the latter these give place to a large extent to the chestnut oak (*Quercus muhlenbergii*), white or canoe birch (*Betula papyrifera*), rock elm (*Ulmus racemosa*), witch hazel (*Hamamelis virginiana*), leatherwood (*Dirca*

palustris), white pine (*Pinus strobus*) and the red cedar (*Juniperus virginiana*).

The appended list of shrubs and trees of Delaware county is represented by specimens in the State university herbarium. In arrangement and synonomy Gray's Manual, sixth edition, has generally been followed.

DICOTYLEDONES.

TILIACEÆ.

Tilia americana L. Basswood. Hills and rich woods. Common.

RUTACEÆ.

Xanthoxylum americanum Mill. Prickly-ash. Frequent in moist woods.

CELASTRACEÆ.

Celastrus scandens L. Climbing bittersweet. Frequent on uplands, climbing over low shrubs.

Euonymus atropurpureus Jacq. Burning-Bush. Waahoo. Rare in moist woods.

RHAMNACEÆ.

Ceanothus americanus L. New Jersey tea. Dry woodlands and prairies. Common.

VITACEÆ.

Vitis riparia Michx. Wild grape. Common on low, rich soil.

Ampelopsis quinquefolia Michx. Virginia creeper. Common.

SAPINDACEÆ.

Acer dasycarpum Ehrh. Soft maple. Frequent on low bottoms.

A. saccharinum Wang. Sugar or rock maple. One of the commonest of the forest trees.

Negundo aceroides Moench. Box elder. Sparingly along the streams.

Staphylea trifolia L. American bladder-nut. Noted only in North Fork and Richland townships.

ANACARDIACEÆ.

Rhus typhina L. Staghorn sumach. Only in the north-eastern part of the county.

R. glabra L. Smooth sumach. Common on high, open ground.

R. toxicodendron L. Poison ivy. Frequent on dry soils. Often confounded with the Virginia creeper. The former has three leaflets; the latter has five.

R. canadensis Marsh. Sweet-scented sumach. Noted only in Union and Delhi townships.

LEGUMINOSÆ.

Amorpha fruticosa L. False indigo. Low sandy soils along streams. Frequent.

A. microphylla Pursh. On rocky soil. Rare.

Tephrosia virginiana Pers. Goat's rue. Rare. Grows in very sandy soils.

Robinia pseudacacia L. Common locust. Escaped from cultivation in places.

Gymnocladus canadensis Lam. Kentucky coffee-tree. Only a few small trees were found south of Hopkinton along the river.

Gleditschia triacanthos L. Honey locust. A few trees along the river south of Hopkinton.

ROSACEÆ.

Prunus americana Marshall. Wild plum. In clumps on low ground. Common.

P. virginiana L. Choke cherry. Common.

P. serotina Ehrh. Wild black cherry. A common forest tree.

Physocarpus opulifolius Maxim. Nine bark. Common along rocky hillsides in the northern part of the county.

Rubus strigosus Michx. Wild red raspberry. Frequent.

R. occidentalis L. Black raspberry. Rather common.

R. villosus Ait. Blackberry. This species and the two preceding were formerly quite common, but the pasturing of the timber land has killed them out to a large extent.

Rosa blanda Ait. Wild rose. Frequent in open ground.

Pyrus coronaria L. Crab apple. Common on low ground.

Cratægus coccinea L. Hawthorn. Frequent.

C. coccinea L. var. *mollis* Torr. and Gray. Rare.

C. tomentosa L. Rather common in upland woods.

C. crus-galli L. Cockspur thorn. Rare on low grounds.

Amelanchier canadensis Torr. and Gray. Service-berry; Juneberry. Found only east of Colesburg.

SAXIFRAGACEÆ.

Ribes cynosbati L. Prickly gooseberry. Reported.

R. gracile Michx. Missouri gooseberry. Common along the streams.

R. oxyacanthoides L. Frequent on the hillsides.

R. floridum L'Her. Wild black currant. Rich open ground. Rare.

HAMAMELIDEÆ.

Hamamelis virginiana L. Witch hazel. Rare, except in northeastern part of the county. It is a rather tall shrub, blossoming late in autumn, when the leaves are falling, and maturing its seeds the next summer.

CORNACEÆ.

Cornus circinata L'Her. Round-leaved cornel or dogwood. Low rich soils. Frequent.

C. stolonifera Michx. Red-osier dogwood. Common along the streams.

C. paniculata L'Her. Panicled cornel. Frequent in thickets along the streams.

C. alternifolia L. Rather common on the hillsides.

CAPRIFOLIACEÆ.

Sambucus canadensis L. Black-berried elder. Common in open, rich land.

S. racemosa L. Red-berried elder. This rare shrub is found in a deep ravine, near Pine spring, east of Colesburg. Occurs rarely in the state.

Viburnum opulus L. Cranberry tree. High cranberry bush. Only found along streams in the northern part of the county.

V. dentatum L. Arrow-wood. On low ground. Frequent.

V. lentago L. Sheep-berry. Along the streams. Rather rare.

Lonicera sullivantii Gray. Honeysuckle. Frequent on rocky bluffs.

L. glauca Hill. In the northern part of the county on rocky hillsides. Rare.

OLEACEÆ.

Fraxinus americana L. White ash. Common.

F. viridis Michx. Green or black ash. Common.

THYMELÆACEÆ.

Dirca palustris L. Leatherwood. Infrequent.

URTICACEÆ.

Ulmus fulva Michx. Slippery or red elm. Abundant in upland woods.

U. americana L. American or white elm. Common in moist, rich soils.

U. racemosa Thomas. Cork or rock elm. This valuable tree is common in the northeastern portion of the county.

Celtis occidentalis L. Hackberry. Frequent along the streams.

Morus rubra L. Mulberry. One tree noted south of Hopkinton. Others have been reported as occurring along the Maquoketa river bottom.

PLATANACEÆ.

Platanus occidentalis L. Sycamore. In the south part of the county a few small trees occur along the river. It is reported that trees six feet in diameter were cut in an early day in that vicinity.

JUGLANDACEÆ.

Juglans cinerea L. Butternut. Common.

J. nigra L. Black walnut. Very common.

Carya alba Nutt. Shell-bark hickory. Common in upland woods.

C. amara Nutt. Bitternut; Pignut. Common.

CUPULIFERAE.

Betula papyrifera Marshall. Paper or canoe birch. Frequent on the rocky hillsides in the northeastern part of the county.

B. nigra L. River or red birch. Confined to the western and southern parts of the county along the streams.

Corylus americana Walt. Hazelnut. Common.

Ostrya virginica Willd. Iron wood. Common on moist hillsides.

Carpinus caroliniana Walt. Blue or water beech. Very common along the streams.

Quercus alba L. White oak. Common.

Q. macrocarpa Michx. Bur oak. Abundant.

Q. muhlenbergii Engelm. Occurs in Union township, south of Hopkinton, and in the northern part of the county along rocky hillsides.

Q. rubra L. Red oak. Common.

Q. coccinea Wang. Scarlet oak. Common on all soils.

Q. coccinea Wang. var. *tinctoria* Gray. Occurs with the last.

SALICACEÆ.

Salix nigra Marsh. Black willow. Banks of streams, bending over the water.

S. discolor Muhl. Pussy willow. Frequent along streams.

S. humilis Marsh. Prairie willow. On dry uplands. Not common.

S. tristis Ait. Dwarf gray willow. Borders of thickets on dry hillsides.

Populus tremuloides Michx. American aspen. Frequent on low soils.

P. grandidentata Michx. Large-toothed aspen. Frequently occurs where other timber has been removed.

P. monilifera Ait. Cottonwood. Common on rich soils, in low places on the prairie and along streams. Not infrequently planted.

MONOCOTYLEDONES.

LILIACEÆ.

Smilax hispida Muhl. Greenbrier. In rich woods. Frequent.

GYMNOSPERMÆ.

CONIFERÆ.

Pinus strobus L. White pine. Only in the northern part of the county. Mostly on rocky ridges—the "Backbone."

Juniperus communis L. Common juniper. On dry hillsides. Usually taken for a young red cedar.

J. virginiana L. Red cedar. Common along the hills and bluffs in the northern part of the county.

Taxus canadensis Willd. American yew. Ground hemlock. A low, straggling evergreen, on rocky bluffs, in the northern part of the county.