
GEOLOGY OF JOHNSON COUNTY.

BY

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CONTENTS.

	PAGE
Introduction.....	37
Situation and Area.....	37
Geological work in Johnson County.....	37
Physiography.....	39
Topography.....	39
Iowan Drift Plains.....	40
Kansan Drift Plains.....	43
Topography of the Loess.....	44
River Flood Plains.....	45
Lake Basins.....	46
Table of Elevations.....	46
Drainage.....	47
Iowa River.....	47
Clear Creek.....	48
Buffalo Creek.....	49
Old Man Creek.....	50
Pardieu Creek.....	52
Rapid Creek.....	52
Sanders Creek.....	52
Stratigraphy.....	53
General Relations of Strata.....	53
Synoptical Table.....	54
Geological Formations.....	54
Silurian System.....	54
Le Claire Limestone.....	54
Anamosa Limestone.....	55
Bertram and Coggan Beds.....	57
Devonian System.....	57
Wapsipinicon Stage.....	57
Otis and Independence Beds.....	57
Fayette Breccia.....	58
Cedar Valley Stage.....	62
Typical Localities and Exposures.....	62
General Section.....	71

	PAGE
State Quarry Limestone.....	72
State Quarry Fish Bed.....	74
Distribution.....	76
Taxonomic Relations.....	77
Carboniferous System.....	79
Kinderhook Stage.....	79
Des Moines Stage.....	79
Iowa City Outlier.....	80
Anamosa Outlier.....	82
Fossils.....	83
Pleistocene System.....	83
Kansan Drift.....	83
Glacial Scorings.....	86
Iowan Drift.....	86
Loess.....	88
Genesis.....	89
Fossils.....	89
Alluvium.....	90
Depth of Pleistocene Deposits.....	90
The Preglacial Surface.....	91
Soils.....	92
Drift Soils.....	92
Alluvial Soils.....	92
Loess Soils.....	92
Deformations.....	93
Unconformities.....	94
Economic Products.....	95
Building Stones.....	95
Anamosa Stage.....	95
Wapsipinicon Stage.....	95
Cedar Valley Stage.....	95
State Quarry Stage.....	97
Des Moines Stage.....	98
Railway Ballast and Road Material.....	98
Ornamental Stone.....	99
Flagging Stone.....	99
Limes.....	100
Sand.....	100
Clays.....	101
River Junction.....	101
Oxford.....	101
Tiffin.....	101
Iowa City.....	102
Minerals.....	103
Water Supply.....	104
Water Powers.....	104
Acknowledgments.....	104
Forest Trees of Johnson County, by T. H. Macbride.....	105
On the Occurrence of Fossil Fishes in the Devonian of Iowa, by Dr. C. R. Eastman.....	108

INTRODUCTION.

SITUATION AND AREA.

Johnson county is situated near the southern limit of what is known as the east central part of the state. From Davenport directly west to the west line of this county the distance is about forty miles. Muscatine is, however, the nearest point of importance on the Mississippi river, and this point is only about seventeen miles distant from the southeast corner of Johnson county. Referred to the United States land surveys the county is included in townships 77-81 north, and ranges 5-8 west of the fifth principal meridian. Its area embraces about six square miles more than seventeen congressional townships. In form the county is a square to the southeast corner of which there is appended an area six miles in length from north to south and having an average width of about seven miles. The eastern boundary of the appended area is a continuation of the east line of the square making up the main body of the county; its western boundary follows the winding channel of the Iowa river.

Owing to the location of the territorial capital at Iowa City in 1839, Johnson was one of the first of the interior counties to be settled. A few pioneers had taken up claims here before the capital was located. They had become familiar in a general way with the abundant supplies of building stone which the region was capable of furnishing; and the known geological resources of the region exerted no small influence in determining the site to be chosen for the seat of government for the new territory.

GEOLOGICAL WORK IN JOHNSON COUNTY.

The pioneer geologist, Dr. David Dale Owen, was the first to do geological work in Johnson county and place the results on scientific record. In 1850 he examined the rock exposures at Iowa City. He followed up the Iowa river and noted the natural exposures in its banks to a point beyond the limits of

Johnson county. He explored the valley of Rapid creek and made a record of the outcrops along that stream. He recognized the fact that the limestones belong to the Devonian system and that certain sandstones found at a number of places in the county are Carboniferous.*

In 1855 Prof. James Hall began work as state geologist of Iowa, and in the prosecution of his investigations the geology of Johnson county received more or less attention. In Professor Hall's report† there are references to the rock exposures at Iowa City on pages 131-133, and beginning on page 260 a brief space is devoted to the discussion of the geology of Johnson, Linn, Benton and Iowa counties.

Dr. C. A. White, state geologist of Iowa from 1866 to 1869 inclusive, notes some of the geological features of Johnson county in his report.‡ On page 188, vol. I, there is a reference to the "Birds eye" marble which occurs in the Devonian limestone of the county, and on pages 308 and 309, vol. II., there is a brief description of the old "State Quarry" which is located on the Iowa river eight or ten miles northwest from Iowa City. There is also a reference to ancient peat from a Johnson county well on page 402, vol. II.

In his memoir on the Pleistocene History of Northeastern Iowa§ Mr. W J McGee makes frequent reference to the indurated rocks and superficial deposits of Johnson county, and C. R. Keyes|| in his compilation of the glacial scorings in Iowa, refers to some instances of ice planing near Iowa City.

Besides the official reports noted short papers, each dealing with a restricted range of geological phenomena presented by Johnson county, have appeared from time to time in scientific journals and other publications. Among the authors contributing such papers may be mentioned, Barris, Calvin, Keyes, Shimek, Webster and White.

*Report of a Geol. Surv. of Wis., Iowa and Minn., by David Dale Owen, 1852, pp. 85-89.

†Report on Geol. Surv. of the State of Iowa, vol. I. 1858.

‡Report on the Geol. Surv. of the State of Iowa, by Charles A. White, M. D., vols. I and II. Des Moines, 1870.

§The Pleistocene History of Northeastern Iowa, by W J McGee, Eleventh Ann. Rept. U. S. Geol. Surv., Part I. Washington, 1891.

||Iowa Geol. Surv., vol. III, pp. 152-153. Des Moines, 1895.

PHYSIOGRAPHY.

TOPOGRAPHY.

General description.—Johnson county lies within the area of anomalous topographic forms described by McGee*; an area in which drift plain interdigitates with loess ridge; an area in which the rivers go out of their way to avoid low lying plains and cut channels longitudinally through ranges of hills that rise forty, sixty, or eighty feet above broad lowland surfaces that apparently might have been traversed with less difficulty, and certainly would have afforded a shorter and more direct course; an area in which the divides are low and the highlands border the river valleys. The county presents an unusual number of topographic phenomena for the reason that it is traversed by terminal deposits of the Iowan glaciers, deposits forming irregular sinuous ridges that may possibly deserve to rank as moraines. Along the northern border of the county there are therefore some small lobes of the Iowan drift sheet continuous with the gently undulating plains characteristic of regions occupied by deposits of Iowan age in the counties north of Johnson. In the southern part of the county all stream valleys are wider and deeper, and the relief in general bolder than in the drift plains north of the Iowan moraine. The greater age of the Kansan deposit has afforded larger opportunities for the agents of erosion to carve and otherwise modify the surface. Through the northern half of the county the Iowan moraine already noted extends in a series of loops, and forms irregular ridges varying from forty to eighty feet in height. These morainic ridges are composed largely of drift, but they contain more or less sand, and are not infrequently overlain at the summit by loess. A fine yellow sand is a very common constituent of these ridges, and the highest points are sometimes crowned with it. Outside the moraine, and usually blending with it more or less perfectly, are interlobular and sub-marginal deposits of loess of

* Op. cit., p. 231.

considerable thickness, distributed over spaces from two to six miles in width. Where the loess forms deep deposits it exhibits the usual rounded steep sided hills, deep V-shaped ravines and other topographic features that everywhere accompany heavy accumulations of this material (Fig. 1). There are areas in which the loess blends with the older drift



FIG. 1. Loess topography near Iowa City.

plains south of the moraine, the loess finally forming but a thin veneer over the surface, and only partly disguising the topographic forms impressed upon the Kansan drift during the interglacial interval. Lastly there are level plains of considerable extent covered with alluvium.

Iowan drift plains.—A few small lobes of Iowan drift extend into the northern part of Johnson county, only two of which, however, are large enough to make an impression worthy of note on the general topography. One of these lobes traverses Big Grove and Cedar townships. The direction of its axis is southeast, and the length, in the county, is approximately ten miles. Solon is situated near one margin, and for this reason this lobe may appropriately be named the Solon lobe. This lobe of Iowan drift, like all other typical areas occupied by

the same deposit, is characterized by yellow till, large, light-colored granite boulders, and by the fact that it occupies a low plain when compared with adjacent loess-covered areas which are in general highlands of moderate elevation. A ridge bounding the Solon lobe passes from near the northwest corner of Cedar township to sections 1 and 2 of Graham, from which point it curves back into Cedar, makes a long sweep through sections 35, 34 and 33, and trending northwest passes south of Solon, and on to near the northeast corner of Big Grove township. The Burlington, Cedar Rapids & Northern Railway finds a natural gap through the ridge near Solon and thence follows the margin of the drift plain, with the terminal or interlobular ridge on the one hand and low-lying, level boulder-strewn fields on the other, until it leaves the county near Ely.

Iowan boulders are more or less common up to the very foot of the ridge described. They are most common where rain-wash has removed the rich, black loam which is very generally developed on the surface of the Iowan drift. A typical boulder-strewn area is found north of the Cedar Rapids road in the Nw. qr. of Sw. qr. of Sec. 15, Big Grove township. Within a small space are gathered a large number of masses of gray granite, some of which are twelve to fifteen feet in diameter.

The second lobe is larger and wider than the first. North Liberty is situated well within its area, on a portion that exhibits the typical characteristics of Iowan drift plains in counties farther north. This broad digit-like extension of the Iowan drift will therefore be called the North Liberty lobe. The topography of this lobe has been modified in two ways since its mantle of Iowan drift was deposited. The Iowa river traverses the lobe from west to east and has developed a broad flood plain into which the southern portion of the drift plain gradually blends. North of the river, accumulations of loess of greater or less thickness overlie, in places, the Iowan drift and conceal the physiographic features that, but for their presence, would normally be present. Allowing

for these modifications of the area the North Liberty lobe may be said to occupy the northwestern corner of the county, including all of Monroe, and parts of Jefferson, Oxford and Madison townships. The southern part of the lobe is a low-lying drift plain, merging without break, as already noted, into the broad alluvial valley of the Iowa river. North of the river the plain is somewhat higher and more billowy than on the south. Near the river the hills vary from forty to sixty feet in height. In the western part of Jefferson township, and even more conspicuously in the western part of Monroe township the hills are covered with loess, but for a space of more than four miles in width, almost equally divided between the two townships, there is no loess. The gently undulating drift to the north and northwest grades into slightly bolder, erosional topographic forms as the region approaches the river, and in sections 19 and 20 of Jefferson township there are hills bordering the river valley ninety feet in height, drift covered throughout their entire altitude, with Iowan boulders projecting from the surface at different elevations, and even showing Iowan till and boulders of Iowan age on their very summit.

The drift hills just described differ in aspect from the loess covered hills that front the river valley farther east or west. They lack the angularities and unfinished appearance of the loess. The contours are more flowing, the surface is smoother, the grass more luxuriant, the soil is deeper and blacker as is characteristic of drift soils in general.

Like the Solon lobe of Iowan drift, the North Liberty lobe trends southeast. Furthermore it is bounded by loess covered ridges or drift hills rising from forty to ninety feet above the level of the boulder-dotted plains. The drift in the hills, where exposed, proves to be generally of the Kansan type, very highly oxidized near what was the old surface, with the usual accompaniment of small striated boulders, and passing downward into the bluish, unoxidized facies of this older sheet of till. Along the northeast side of the lobe the bounding hills trend almost directly northwest-southeast from section 5 of Jefferson

township to section 17 of Penn township. From the point last named the highlands sweep around toward the west, and after traversing sections 24, 23 and 22 of Madison township, they trend northwest, to leave the county finally in section 6 of Oxford township.

A third area of Iowan drift, but of rather small extent, occurs in the northeastern part of Jefferson township. Shueyville is situated at the southern margin of this area. The hills which mark the boundary of the drift plain rise within the limits of the village plat. Immediately west of the village the ridge separating the Shueyville area from the North Liberty lobe, and made up chiefly of Kansan drift, extends northwest to the county line. Southward a series of loess-covered hills rise seventy feet above the drift plain, while eastward the area blends with rather indefinite boundaries into the Solon lobe.

The Shueyville area is continuous with a typical plain of Iowan drift that stretches northward from the village of Western. North of the Johnson county line the three areas described become united into one and merge finally into the great Iowan area that, with readily recognized characteristics, reaches away beyond the northern limits of the state.

The southern part of the North Liberty lobe and the whole area of the Solon lobe are marked by many rounded hills and elongated ridges of sand that owe their origin to events taking place during the period of melting and retreat of the ice. The ridges are in general parallel to the main axis of the lobe in which they lie, and parallel, it may be assumed, to the direction of the ice movement. Their height varies from ten to fifteen or twenty feet.

Kansan drift plains.—More than two-thirds of Johnson county naturally belongs to the area occupied exclusively by Kansan drift. But a broad belt of deep loess extends through the central part of the county south of the margin of the Iowan lobes, effectually concealing the drift surface beneath; and loess, becoming gradually thinner, mantles the surface

and partly disguises the pre-loessial topography all the way to the southern limit of the county. There are areas, however, where loess is absent, or so thin that the physiographic features imposed upon the surface of the Kansan drift during the interglacial intervals may still be ascertained. In the southwestern part of the county, including the valley of Old Man creek and the region south of it, there is a typical area of Kansan drift, only slightly modified by loess. The surface is rolling but the curves are less sharp and the irregularities much less than in the area of deep loess between the valley of Old Man creek and the southern margin of the North Liberty lobe of Iowan drift. The surface shows everywhere the long continued effect of erosion which carved the surface of the old drift sheet into a series of miniature hills and valleys. The valley of Old Man creek has been cut down 100 feet into what was at first a gently undulating drift plain, and the valley has gradually expanded until it is more than half a mile in width. The minor streams have cut valleys of proportionate width and depth, and the whole region exhibits topographic features of much greater maturity than those of areas occupied by Iowan drift.

Scott and Lincoln townships afford another area of the same type. All the county south of a line drawn from east to west through the middle of Scott and Hardin townships may be said to constitute one area exhibiting the physiographic features of the Kansan drift; but through this area the Iowa river has cut a valley from north to south and has developed a broad flood plain with flat alluvium-covered surface that is in striking contrast with the irregularities of the typical drift surface on either side. A few comparatively level areas of Kansan drift, not even yet invaded by the head waters of the smaller drainage streams, occur at certain points; as for example, in the central part of Washington and Scott townships in the western part of Sharon.

Topography of the loess.—Characteristic loess topography is exhibited throughout the broad belt of deep loess which

passes across the middle of the country from east to west; in the interlobular space between the Solon and North Liberty areas of Iowan drift; in a small area in the southwestern part of Monroe township; and in the high bluffs near the Cedar river northeast of the Solon lobe. Relatively to the drift plains, all the regions above mentioned are highlands. The surface is carved into a very intricate system of hills and ravines. The curves are all abrupt, the hills are steep and sharply rounded. The ravines are deep and angular at the bottom, and the surface, where cultivated or disturbed, is gullied and gashed by recent erosion. The transition from the comparatively level drift plains of Iowan age to the ridged and billowy loess is always abrupt, but the physiography of the loess grades without any sharp line of demarkation into the less pronounced erosional forms characteristic of the Kansan drift. In the southern part of the country the loess becomes thinner. In many places erosion has cut through to the underlying drift and reveals the fact that the loess is but a thin veneer moulded over the irregularities of an old deeply eroded surface. In this southern area the loess comes down with nearly uniform thickness upon the sides of the valleys and forms a cap over the crests of the hills. The present surface configuration of the region was developed before the loess was laid down.

River flood plains.—In a few instances the flood plains of the major streams become conspicuous topographic features. In the northeastern part of Cedar township the Cedar river wanders through a broad alluvial plain, two miles or more in width. On the west this plain is overlooked by hills of loess fifty to seventy feet in height. The great plain, followed by the Iowa river from the Iowa-Johnson boundary to where the stream enters a comparatively narrow canyon at the old Roberts Ferry bridge, is one of the most important areas of its kind in the country, and is only excelled in areal extent by the rapidly widening alluvial plain upon which the river enters after emerging from its canyon south of Iowa City.

In Pleasant Valley, Lincoln and Fremont townships this last plain attains a width of many miles, occupying practically all of Fremont township, and uniting with a plain of similar character that includes the lower course of the Cedar river and extends even beyond the Mississippi below Muscatine.

Lake basins.—A few small depressions, kettle holes or lake basins occur in the North Liberty drift plain, near the line along which the drift and alluvium merge into one continuous surface. The basin of Swan lake, which lies chiefly in sections 4 and 5 of Madison township, is the largest of these depressions. Its length is nearly half a mile, and it has an area of about sixty acres. At the period of settlement of the country, fifty years ago, Swan lake was a beautiful little sheet of clear water, twelve to fifteen feet in depth and well stocked with fish. The rim of the lake, superficially at least, is composed of sand and gravel, but the entire depression is mainly hollowed out of the stiff drift clay. For some years Swan lake has been simply a marsh supporting a luxuriant growth of sedges and rushes. The original basin is now largely filled. Rain wash has carried in sand and clay, dust has been blown in by the winds, and the annual decay of rank vegetation has contributed no small amount of peaty matter. The ponds and lakelets that once occupied the numerous other depressions of the region have met the same fate as Swan lake. It is probable that all the depressions here noticed had the same origin and were due to the final melting of detached masses of ice included in the glacial debris.

Anomalous divides.—The Solon drift lobe constitutes one of the anomalous divides so well described by McGee in the work already cited. From this low plain the land rises abruptly, and to a height of nearly 100 feet, in approaching the valley of the Cedar river on the one hand, or the valley of the Iowa river on the other.

Table of elevations.—The following table compiled from Gannett's Dictionary of Altitudes shows the elevation, in feet, above sea level of some of the principal points in the county:

Oxford.....	745
Tiffin.....	695
Iowa City, Chicago, Rock Island & Pacific Railway	685
Iowa City, Burlington, Cedar Rapids & Northern Railway	667
Solon.....	794
Morse.....	763
Elmira.....	751
Lone Tree.....	717

DRAINAGE.

The streams of Johnson county are not very numerous. One master stream, the Iowa river, controls almost the entire drainage of the county. A very small area in the northeastern corner of Cedar township pays tribute to the Cedar river, while in the southwestern part of Washington township the valley of Deer creek is drained into the English river. This last stream, however, while flowing through Washington county is a tributary of the Iowa.

The Iowa river.—Within the limits of Johnson county the Iowa river has a course, counting its numerous sinuosities, of more than fifty miles in length. From Iowa county it crosses into Johnson in section 31, township 81 N., R. 8 W. For more than half the width of the county the general course of the stream is eastward. In section 19, township 81 N., R. 6 W., it turns at right angles to its former course, forming the great elbow so frequently mentioned by McGee,* and thence flows in the main southward, finally forming the western boundary of Fremont township. Before passing Fremont township the general course is changed toward the southeast, and this direction is maintained until the river reaches the low flood plain of the Mississippi.

In the first part of its course, after passing the western boundary of the county, the Iowa river winds back and forth in the broad flood plain already mentioned; but above the iron bridge south of Shueyville it leaves the plain to cut longitudinally through ridges, composed of loess, drift and limestone, that rise nearly 100 feet above the level of the plain from

*Pleistocene History of Northeastern Iowa.

which it turned aside. Even the highest part of the drift that, merging with the flood plain, reaches beyond North Liberty in the normal direction of the stream, is seventy feet lower than the hills through which the indirect, roundabout channel has been cut. At the great elbow it would have required only a few miles of cutting in the direction previously followed to have enabled the river to reach the low drift plain of the Solon lobe, but as if lowlands of Iowan drift were something especially to be avoided the stream abruptly changes its course to the southward to follow the high interlobular loess-covered area, until it finally emerges upon the low alluvial plain south of Iowa City.

Deep farm wells show that the Iowa river, in its course from the west line of the county to where it enters its canyon south of Shueyville, follows closely a preglacial valley that had been excavated to a depth of 150 feet below the present level of the river. The gorge followed by the stream from the iron bridge to Iowa City is comparatively recent, and in large part is probably post-Iowan. At all events the bed and sides of the channel are in places still rocky, and in portions of its course the stream is even now cutting into native ledges of Devonian limestone. South of Iowa City the stream follows an old and very wide gorge that, as shown by a number of borings, was originally 200 feet deeper than the present valley. In some places, and probably throughout its whole extent, the gorge was filled with Kansan drift, and this drift, in the present river valley, is now overlain by eight or ten feet of alluvium.

Clear creek.—The Iowa river receives no very important tributaries within the limits of Johnson county. Clear creek is the first of any consequence received from the west. It rises in Iowa county and follows a general direction a little south of east through Oxford and Clear Creek townships and joins the Iowa in Lucas township near Coralville. From above Tiffin to its confluence with the Iowa, Clear creek flows in a valley that, in its present aspect, has a history reaching back to the

close of the Kansan ice stage. The depth of the valley measured from the higher hill tops is 100 feet and the width varies from a half to three-fourths of a mile. Deep wells again show that parts at least of this valley were scooped out to much greater depths in pre-Kansan time.

An interesting tributary of Clear creek is Buffalo creek, which joins the larger stream a few miles above Tiffin. Buffalo creek drains a part of the North Liberty drift lobe. It has cut through the rim of loess-covered hills which bound the drift plain, but its direction is southwest, at right angles to the normal direction that would have been taken by a tributary of Clear creek, provided the major stream had developed its drainage basin by ordinary processes of erosion. It is doubtless true that, in the long inter-glacial interval between the close of the Kansan and the coming of the Iowan stage, the drainage area of Clear creek was normally developed, with a dendritic system of channels reaching out on either side of the main axis to the margin of the basin. In such a system, in the latitude of Iowa, the greater part of the drainage area would eventually come to lie on the north side of the principal east-west valley. During the Iowan stage the northern part of this normally developed drainage area was invaded by the North Liberty lobe of Iowan ice; and marginal deposits of sand and loess were piled up inside the basin in such a way as to obliterate the regularly developed channels on the north side of the valley. Accordingly the drainage area on the north is reduced to a narrow belt of highlands which is broken through at one point by the erratic course of Buffalo creek. The particular combination of circumstances that determined the direction in which this affluent cuts through the rim of hills and brings its tribute from the low Iowan drift-plain can only be conjectured.

As is also true of streams flowing east or west in the latitude of Iowa, Clear creek follows the southern margin of its valley, close to the foot of the northward facing bluffs. Furthermore the southern wall of the valley is steep, while

that on the north rises with gentler slopes to the more rapidly receding highlands and is more profoundly carved and sculptured by the agents of erosion.

Old Man creek.—Old Man creek drains the southern part of Johnson county west of the Iowa river. Rising in Iowa county it pursues a general eastward course to join the larger stream. Its valley, like that of Clear creek, is deep and wide, and its history dates from the retreat of the Kansan ice. Its drainage area is normal. The natural course of development suffered no interference by the encroachment of Iowan ice, or the accumulation within its area of marginal deposits of loess.

Near its confluence with the Iowa river Old Man creek flows southeast, and its tributaries in this part of its course are themselves eastwardly flowing streams. But where the direction of the main channel is toward the east, the stream flows near the southern edge of its valley. There are steeper bluffs on the south side than on the north. The larger part of the drainage basin lies north of the principal axis. The headwaters of the northern affluents reach to within a mile, or even less than a mile, of the valley of Clear creek; while on the opposite side of the axis, Deer creek and other branches of English river—the next eastward flowing stream south—rise within hailing distance, and restrict the drainage of Old Man creek in this direction to a fraction of a mile.

The region drained by Clear creek and Old Man creek is included in the Loess-Drift Area of McGee.* McGee, however, regards the topography and drainage of the area as related not to a single plane, but to a series of planes, each inclined to the south and uptilted along its northern edge. The eastward flowing stream is, in each case, located near the southern margin of the plane to which it is related, and the steep southern wall of each respective valley is simply the elevated margin of the next succeeding plane on the south.† No description could more felicitously represent the present

*Pleistocene History of Northeastern Iowa, p. 411, et seq.

†Op. cit., pp. 412-413.

aspect and relations of the several drainage basins of the area under consideration. But it seems possible after all to refer the whole system of drainage basins included in the Loess-Drift Area to a single plane, and that plane the original gently sloping surface of the great drift sheet after the retreat of the Kansan ice. This surface, in the region under discussion, was drained by a number of parallel streams, each flowing toward the east. As soon as these streams cut channels of any considerable depth, the two sides of each channel were differently affected by the agents of erosion. The northward facing surfaces suffered less than the opposite side of the channel from the alternations of freezing and thawing and consequent effects of erosion, in early winter and spring. They were less affected by the droughts of summer, which tended to check the growth of vegetation and render the surface more pulverulent and more easily attacked by dashing rain storms. The result was that as the channel was deepened the north side of the valley receded more rapidly than the south, the slopes soon became gradual, the small lateral streams on the north cut back into the highland with greater facility and greater speed, robbing the secondary streams developed on the south side of the next drainage area to the north; and so as a result of normal causes each drainage basin became unsymmetrical and was converted into a sloping plane with the main drainage stream along its southern margin. The east-west streams of the driftless area show similar effects as a result of the same cause, only the effects are modified in consequence of the fact that the stream valleys are cut in indurated rocks in place of the loose materials of the Kansan drift. The northward facing bluffs, however, are steeper than those on the opposite side of the valley. They are generally wooded, or at least are clothed with ranker vegetation that affords protection from atmospheric disintegration. As a result of the larger amount of material carried down from the southward facing slopes on the northern side, the bottom of the valley inclines southward, and the stream runs

close to the foot of the steep bluffs that face toward the north.

In the case of Clear creek and Old Man creek the aspect of the drainage area has in each case been more or less modified by the deposition of loess. As already noted Clear creek basin has suffered more from this cause than the other. In the drainage basin of Old Man creek the loess is simply a thin veneer spread over topographic forms that had practically reached their full present development before the loess was laid down. It is true the loess on the hill tops is usually a little thicker than on the slopes or in the bottom of the ravines, and so, taking no account of erosion of the bottom of the valleys since, the inequalities of the surface seem to have been somewhat accentuated as a result of its deposition; but after all the difference is so small that it may be disregarded, and we may look upon the present surface as essentially what it would have been had there been no deposition of loess.

Pardieu creek.—A small intermittent stream, known as Pardieu creek, begins near North Liberty, cutting its way in a southeast direction through the marginal loess covered ridges surrounding the North Liberty drift plain, and joins the Iowa about two miles above Coralville.

Rapid creek.—From the north and east the Iowa receives few streams of any consequence. Rapid creek is the most important. It traverses the loess belt south of the Solon lobe, cutting through to the Kansan drift, and through the drift down into the Devonian limestone. That part of its channel which lies above the northeast corner of section 36, Newport township, is probably comparatively new. It is in this part of its valley that the stream runs over limestones. The valley may have been made since the loess was laid down.

Sanders creek is a small and very erratic tributary of Rapid creek, that, like its primary, drains a part of the deep loess area south of the Solon lobe. Its history does not antedate the deposition of the loess. Its course is first southwest; then turning at right angles it flows northwest, and when

almost within a stone's throw of the Iowa river it bends sharply to the south to unite its waters with Rapid creek. A high loess ridge causes the sharp bend a mile above its mouth.

All other creeks flowing into the Iowa from the north and east are small. Two breaks in the rim of hills marking the southwestern boundary of the Solon lobe of Iowan drift—one in section 23 and the other between sections 16 and 17 of Big Grove township—permit small streams to carry off the drainage waters from the low drift plain.

A number of small streams, nearly parallel to each other, drain the drift covered areas of Monroe and Jefferson townships. One of the most important of these is Knapp creek that passes diagonally through the western part of Monroe township and joins the Iowa river in section 27, T. 81 N., R. VIII W.

STRATIGRAPHY.

General Relations of Strata.

A number of geological formations outcrop within the limits of Johnson county. The indurated rocks, however, are very generally concealed by the thick mantle of loose materials, in the form of drift, loess and alluvium, which cover the whole surface in some places to a depth of 300 feet. All rock exposures are limited to the northern and northeastern portions of the county. In the absence of such exposures in the southwestern townships the McKinley quarry in Washington county, one-half mile south of the Johnson county line, in Sec. 5, Tp. 77 N., R. VIII W., is important as throwing light on the geological age of the rocks immediately beneath the drift in the adjacent portions of Johnson.

The known geological formations of Johnson county and their taxonomic relations, are shown in the subjoined

SYNOPTICAL TABLE.

GROUP.	SYSTEM.	SERIES.	STAGE.
Cenozoic.	Pleistocene or Quaternary.	Recent.	Alluvium.
		Glacial.	Loess.
			Iowan Till.
			Kansan Till.
Paleozoic.	Carboniferous	Pennsylvanian, or Upper Carboniferous.	Des Moines.
		Mississippian, or Lower Carboniferous.	Kinderhook.
	Devonian.	Upper Devonian.	State Quarry.
		Middle Devonian. (Hamilton?)	Cedar Valley.
			Wapsipinicon.
	Silurian.	Niagara.	Anamosa.
			Le Claire.

Geological Formations.

SILURIAN SYSTEM.

LE CLAIRE LIMESTONE.

So far as known the Le Claire limestone is the oldest geological formation naturally exposed within the limits of Johnson county. A few small outcrops of this limestone occur near the base of the bluff which overlooks the Cedar river in the southwest quarter of the northwest quarter of section 2, Cedar township. A precipitous cliff, exposing the laminated quarry stone of the Anamosa stage, fronts the

river in the northeastern part of section 3 and adjoining parts of section 2 of the township named. The bluff is about half a mile in length, when it gives way at its southeastern end to a low plain which is a part of the alluvial lowlands extending for some miles on both sides of the stream. The small exposures of Le Claire limestone referred to are seen at intervals from twenty to thirty rods back from the river near the foot of the hill where it faces the low plain and trends nearly at right angles to the stream. The Le Claire limestone is here a very fine grained, hard, highly crystalline dolomite, light buff or cream in color. The several exposures indicate a thickness of about twenty feet. No fossils were seen. The reference of the rock to the Le Claire stage is based on lithological and stratigraphical grounds alone. As usual with the thoroughly dolomitized and crystalline beds of this horizon, the rock would make a very superior quality of white lime.

ANAMOSA LIMESTONE.

Characteristic beds of the Anamosa stage overlie the Le Claire limestone in the bluffs already noted in sections 2 and 3 of Cedar township.

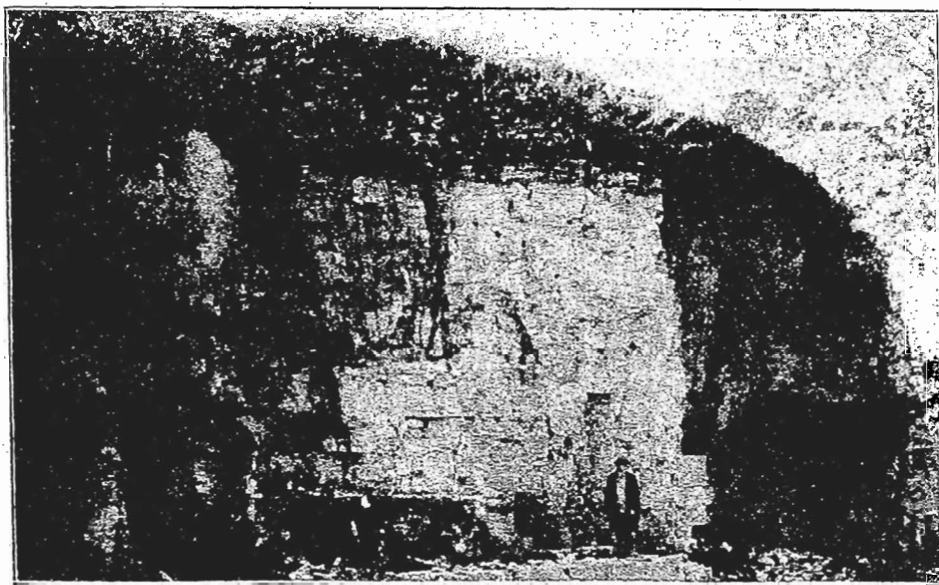


FIG. 2. View in the old McCune Quarry, Anamosa Limestone, Cedar Township, Johnson County, Iowa.

This exposure of Anamosa stone is about forty feet in thickness. The upper thirty feet is not divided into definite layers, but it splits readily along the planes of lamination into smooth-surfaced slabs of any desired thickness. In this part of the exposure there are many concretions of chert. In most respects it agrees with the upper white limestone of the quarries at Stone City.

In the lower part of the bluff the stone is a yellow, earthy, rather coarse dolomite, more definitely divided into layers, free from lamination and therefore showing no tendency to part except along the planes of bedding. In lithological characters these lower layers resemble the building stone beds of Anamosa age at Le Claire, in Scott county. The ledges of non-laminated stone at the base of the exposure range from four to eleven inches in thickness. A complete section of the bluff, not all exposed, however, at any one place, would give the following.

	FEET.
5. Arenaceous, light colored loess.....	2 to 4
4. Pebbly drift, containing a large number of bowlders from one to three or four feet in diameter. Prob- ably of Kansan age.....	4 to 6
3. Laminated bed of Anamosa limestone without defi- nite partings, with many lenticular and irregu- lar concretions of chert.....	30
2. Yellow, non-laminated ledges of Anamosa limestone from four to eleven inches in thickness.....	10
1. Hard, light colored crystalline dolomite of Le Claire stage.....	20

The laminated quarry stone of this locality has been known and, to a moderate extent, utilized for more than half a century. It is to this locality that Owen evidently refers in speaking of the source of the material used for gravestones by the pioneer stonecutters of Iowa City.* Owen, however, locates the exposure in the south part of township 82 N., R. V W., in place of in its true position in the north part of township 81, and instead of referring the strata to the Silu-

*Report of a Geol. Surv. of Wis., Iowa and Minn., p. 84. Philadelphia, 1852.

rian he includes them in his description of the limestones of Red Cedar, etc., belonging to the Devonian.

Lack of facilities for transportation has prevented the development of quarrying and lime burning industries in connection with these exposures of Anamosa and Le Claire limestone.

BERTRAM AND COGGAN BEDS.

In the counties of Jones and Linn the Anamosa limestone is succeeded by a coarse, irregularly bedded, earthy or non-crystalline dolomite that Professor Norton has called the Bertram limestone.* The beds of Bertram limestone are again succeeded in Linn county by what the same author calls the Coggan beds.† The Coggan beds are composed of "soft, buff, magnesian, fossiliferous limestone," and with the deposition of this limestone the record of the Silurian in Iowa is brought to a close. No representatives of either Bertram or Coggan beds have been seen in Johnson county.

DEVONIAN SYSTEM.

WAPSIPINICON STAGE.

Otis and Independence beds.—In Linn and Cedar counties—and probably the same is true of most other counties in which the contact of Silurian and Devonian occurs—the magnesian limestones of the Niagara series are followed by non-magnesian limestones and shaly beds of the Devonian. Immediately above the Coggan beds, where the series is complete, there lies a fine grained, drab colored limestone, called the Otis limestone, and this is succeeded by the shales and shaley limestones of the Independence shales. Both Otis and Independence beds belong to the Wapsipinicon stage as defined by Norton.‡ Neither Otis nor Independence beds, however, are known to be exposed in Johnson county. The lowest member of the Devonian series observed in

*Iowa Geol. Surv., vol. IV, p. 135. Des Moines, 1895.

†Ibid, p. 138.

‡Op cit., p. 155.

natural exposures is the brecciated phase of the Wapsipinicon stage which is well illustrated at Solon in Big Grove township. The geographical area within which outcrops of Bertram, Coggan, Otis and Independence strata might be expected to occur, the area between the cliff of Anamosa limestone on the Cedar river and the outcrops of breccia at Solon, is deeply covered with drift. No stream valleys cut down to the underlying rocks. Indeed, in portions of this area the rocks do not come within 200 feet of the surface. A well drilled on the farm of Mr. J. A. Henik in section 17 of Cedar township reached rock at a depth of 222 feet, and other deep wells in the same neighborhood show the same great depth of the superficial deposits. This region, or at least a part of it, seems therefore to be occupied by a preglacial valley over which the limestones and shales were cut away, probably down to the Delaware stage of the Niagara.

The Fayette breccia.—Southwest of the exposures of Niagara limestone on the Cedar river the first rocks seen in place occur at Solon and belong to the brecciated phase of the Wapsipinicon stage. This phase is typically illustrated in the great railway cut at Fayette, for which reason McGee has called the formation the Fayette breccia. The breccia occurs within the corporate limits of Solon and in the surrounding neighborhood. The characteristics and various phases of this zone, as they appear in Linn county, have been very fully described by Norton.*

Forty rods north of the center of section 24, Big Grove township, and the same distance from the northeast corner of the original town of Solon, the road cuts through ledges of breccia that correspond to Norton's first and second stages. On the whole, beds corresponding to the second stage predominate. The rocks are made up of angular fragments of very fine grained, gray or drab limestone lying in all possible positions in a softer, lighter colored, gray matrix. Some of the fragments are homogeneous throughout and break with

*Iowa Geol. Surv., vol. IV, p. 157. Des Moines, 1895.

conchoidal fracture; some are very finely laminated and tend to split along the lamination planes. No fossils occur in this portion of the breccia either in the matrix or in the embedded fragments.

The streets in the northern edge of Solon pass over ledges of breccia which illustrate Norton's second and third phases of this formation. The phase exhibiting the fine-grained, drab colored fragments is overlain by the phase in which the fragments are lighter gray or buff in color and coarser and more granular in texture. The embedded fragments of this third phase contain well preserved specimens of *Atrypa reticularis*, *A. aspera*, *Orthis iowensis* and *Pentamerus (Gypidula) comis*.

On the Cedar Rapids road, in the western edge of Solon, there are exposures of beds partly brecciated that occupy a position geologically higher than the beds just described. The fauna is more extensive and includes the following: *Dolatocrinus* (sp. und.), *Favosites alpenensis*, *F. placenta* or a closely related species differing chiefly in the mode of growth, *Stropheodonta dimissa*, *Orthis macfarlanei*, *Spirifer pennatus*, *Atrypa reticularis*, *A. aspera*, *Rhynchonella intermedia* and *Pentamerus comis*. Besides the species mentioned there are casts of a large gastropod, probably a *Platystoma*, and an undetermined species of *Gomphoceras*. The strata at this point are very much shattered, the bedding planes are obliterated, oblique joints intersect the beds and divide the mass into numberless shapeless pieces from a few inches to a foot or more in diameter, the color ranges through various shades of light brown, yellow and gray, and the texture is coarse and granular. The stone is quarried and used for building purposes to a limited extent. The beds here correspond well with the fourth stage of the brecciated zone as described by Norton. They are geologically equivalent to the *Spirifer pennatus* beds of Buchanan county.

On the low hill which rises above the level of the beds described, there are numerous weathered coralla of *Phillips-*

astrea billingsi, and *Acervularia davidsoni*. The corals are not in place, but are parts of the residual products resulting from the decay of strata that normally lie above the level of the horizon exposed in the roadway. At Independence, Troy Mills and other typical localities *Phillipsastrea* occurs immediately above the *Spirifer pennatus* zone, and *Acervularia davidsoni* occupies a position from ten to fifteen feet higher.

Twenty rods west of the point just considered there is another exposure on the south side of the road. The beds here have a strong local dip toward the east, and the west end of the exposure shows the fine grained drab fragments, free from fossils, characteristic of the lower phases of the brecciated zone.

There are some exposures of the Fayette breccia on the headwaters of Rapid creek, the most important being that which occurs on the farm of Mr. J. Beecher, near the north-east corner of section 22, Graham township (T. 80 N., R. V W). Here the rocks have been quarried to a considerable extent. The phase represented is No. 4, of Norton. In some of the beds the brecciation is more complete than any seen at the corresponding horizon near Solon. The fauna includes the small *Favosites* that has been provisionally referred to *F. placenta*, together with *Orthis iowensis*, *Atrypa reticularis*, *A. aspera*, and *Pentamerus comis*. This is the most easterly exposure of Devonian rocks in Johnson county, the most easterly exposure, indeed, of any kind in this direction until the ledges of Niagara limestone are encountered along the Cedar river in Cedar county. Between the Beecher quarry and the exposures of Niagara on the Cedar, there extends the same preglacial valley that separates the Devonian outcrops near Solon from the cliffs of Niagara limestone in section 2 of Cedar township.

The southwesterly dip of the strata, if uniform, would carry the breccia below the succeeding members of the Devonian series in passing down the valley of Rapid creek; but the strata have been thrown into a series of low folds (Fig. 3),

and so at a few points in the axes of the anticlines the breccia is revealed farther down the creek. The most instructive exposure due to the cause mentioned was seen in the Se. qr.

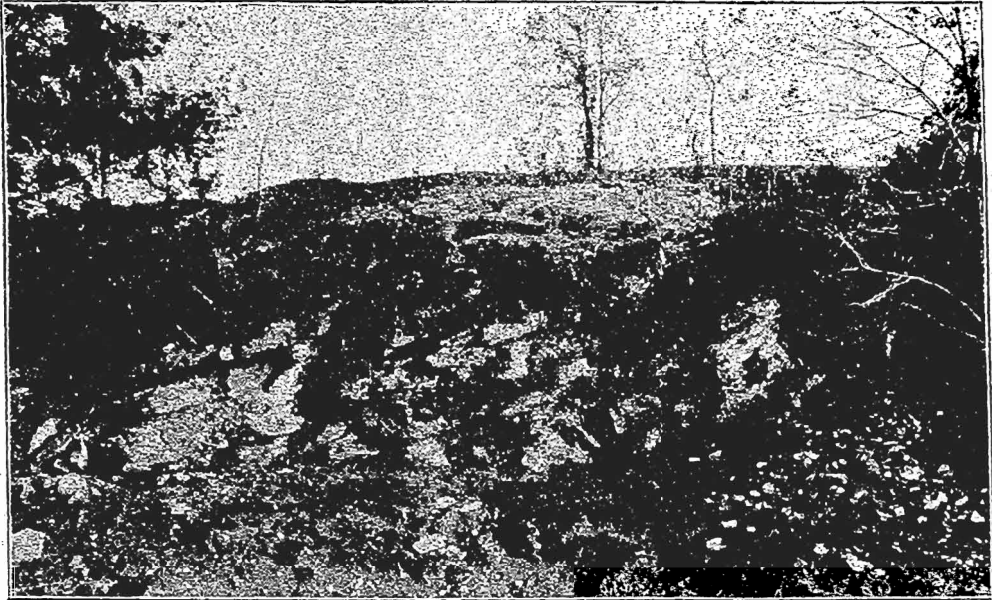


FIG. 3. Local dip due to folding of Devonian strata. South bank of Rapid creek. Section 20, Graham township.

of the Ne. $\frac{1}{4}$ of Sec. 20, Graham township. Here the fold is quite sharp, the strata dipping from the axis on either side at an angle of fifteen degrees. The cliff at this point is higher than usual, and in the axis of the fold shows the following section.

	FEET.
3. Evenly bedded, rather soft, shaly limestone, yellowish in color, capable of being quarried in large slabs; characterized by many small individuals of <i>Atrypa aspera</i> and numerous body plates and segments of stems of <i>Megistrocrinus farnsworthi</i>	6
2. Hard rock, not shattered or brecciated, few fossils, a number of coralla of <i>Phillipsastrea billingsi</i> in a single layer near the middle of the bed, and a large celled species of <i>Alveolites</i>	8
1. Fourth phase of brecciated zone, imperfectly bedded, rock hard but very much shattered, and divided into small angular pieces by oblique joints. Fauna contains <i>Orthis iowensis</i> , <i>Atrypa reticularis</i> , <i>A. aspera</i> and <i>Pentamerus comis</i>	12

In this section number 1 belongs to the Wapsipinicon stage, while numbers 2 and 3 represent the Cedar Valley stage of the Devonian. Owing to the sharpness of the fold the Phillipsastrea beds descend below the level of the creek a few rods east of the axis, and the Megistocrinus beds attain a thickness of fifteen feet.

THE CEDAR VALLEY STAGE.

All the limestone beds in Iowa of Devonian age, at least all lying between the Independence shales and the Lime Creek shales, have been grouped under the name of Cedar Valley limestone by McGee* and Keyes.† Norton,‡ however, places the Fayette breccia, including the *Spirifer pennatus* beds, together with the Independence shales and the Otis limestone, under the Wapsipinicon stage. According to this arrangement the Cedar Valley stage begins with the coral-bearing horizon overlying the *Spirifer pennatus* beds.

The characteristics of the Cedar Valley limestone, as developed in Johnson county, are best illustrated in the following sections.

TYPICAL LOCALITIES AND EXPOSURES.

The exposure which most clearly shows the contact of the Cedar Valley with the Wapsipinicon stage is that already described in the northeast quarter of section 20, Graham township. The Phillipsastrea beds, number 2, and the Megistocrinus beds, number 3, of that section belong to the Cedar Valley, while the brecciated beds, number 1, belong to Norton's Wapsipinicon. The Megistocrinus beds are well exposed at many points farther down the creek, their last appearance along this stream occurring near the northeast corner of section 36, Newport township.

Near Solon, along a small creek that flows through the northern part of section 26, Big Grove township, there are several small quarries worked in the Megistocrinus beds.

*Eleventh Ann. Rept. U. S. Geol. Surv., p. 314.

†Iowa Geol. Surv., vol. I, p. 34.

‡Iowa Geol. Surv., vol. IV, p. 157.

The layers are soft, shaly, and in color vary from light gray to yellow. They are intersected by oblique joints which, however, do not interfere with quarrying out blocks of considerable size. The bedding is parallel. The fauna includes *Phacops rana* Green, two or three species of *Platyceras* or *Capulus*, *Stropheodonta demissa* Conrad, *Orthis iowensis* Hall, *Spirifer pennatus* Owen, *Spirifer subundiferus* M. & W., *Atrypa reticularis* Linne, *A. aspera* Scloth., *Megistocrinus farnsworthi* White, *Aulocophyllum princeps* Hall, *Acervularia* related to *A. davidsoni* as that species is generally recognized, *Favosites alpenensis* A. Winchell, or a related species, a hemispherical species like *F. emmonsii* Rom., and *Astræaspongia hamiltonensis* M. & W. The beds in these quarries are equivalent to the *Megistocrinus* beds of the preceding exposure. The *Atrypa aspera* is small as is usual in beds of this horizon. The *Megistocrinus*, *Aulocophyllum*, small *A. aspera* and *Astræaspongia* are the most characteristic forms of the *Megistocrinus* fauna.

At Eicher's quarry, located in the left bank of the Iowa river in northwest quarter of section 27, Newport township, the following section is exposed.

	FEET.
9. Brown limestone, with crinoid stems, a <i>Cladopora</i> related to the form described by Hall as <i>Striatopora rugosa</i> , but having the branches and polyp tubes very much smaller, and a large coarsely ribbed variety of <i>Atrypa reticularis</i>	4
8. Drab granular limestone, no fossils.....	8
7. Coral reef composed chiefly of coralla of <i>Acervularia davidsoni</i> E. & H., but containing many coralla of <i>Favosites</i> and <i>Ptychophyllum</i> ..	2
6. Moderately hard bed with crinoid stems, <i>Spirifer parryanus</i> , <i>Atrypa reticularis</i> , <i>Favosites</i> , <i>Cyathophyllum</i> , <i>Cystiphyllum</i> , etc.	1½
5. Shaly limestone with many small crinoid stems, <i>Chonetes scitula</i> Hall, <i>Spirifer parryanus</i> Hall, <i>Tentaculites hoyti</i> White, and <i>Monticulipora monticola</i> White	1½
4. Hard ledge with many small crinoid stems, <i>Cladopora</i> , <i>Ptychophyllum</i> and some large coralla of <i>Acervularia</i>	2

	FEET.
3. Yellow shaly bed with <i>Atrypa</i> , <i>Orthis</i> , etc.....	2
2. Yellow and gray shaly limestone, without fossils.....	13
1. Moderately hard limestone, intersected by a number of oblique joints, light colored, laminated, with many stem segments and some perfect calyces of <i>Megistocrinus</i> and other species characteristic of the <i>Megistocrinus</i> fauna. <i>Megistocrinus</i> beds.....	15

At the Hutchinson quarry (figure 4) on the west side of river at Iowa City, the section exposed shows —

	FEET.
11. Loess	2 to 6
10. Kansan drift	8
9. White limestone, fine grained, breaking with con- choidal fracture, containing in places many casts of <i>Straparollus cyclostomus</i> Hall	12
8. Rather fine grained, grayish limestone, crowded in some places with stems of <i>Idiostroma cæspitosum</i> Win.	2
7. Gray, earthy, granular limestone	6
6. Irregularly bedded limestone in rather thick layers with many included coralla of <i>Acervularia</i> , <i>Stro-</i> <i>matopora</i> , <i>Idiostroma</i> , etc	10
5. Hard, grayish-blue limestone, weathering yellow, in ledges 6 to 10 inches thick, quite free from fossils.	5
4. Coral reef (No. 7 of Eicher's quarry)	2
3. Bluish-gray limestone	4
2. Dark colored bed with many corals, <i>Cystiphyllum</i> , etc.	1
1. Blue limestone, in heavy ledges, 1 to 2 feet in thick- ness, with <i>Atrypa reticularis</i> , <i>Spirifer parryanus</i>	6

Numbers 1 and 2 of the Hutchinson quarry section are equivalent to numbers 5 and 6 at Eicher's, while number 5, though only five feet in thickness, is equivalent to 8 and 9 of the Eicher quarry. At the Eicher quarry the uppermost member of the section is still below the *Idiostroma* horizon, which is represented by number 6, of the Hutchinson section. About one-half mile east of Eicher's quarry, in the valley of Sanders creek, the *Idiostroma* beds, with their characteristic crinkled coralloid stems, are well exposed. The channel of the creek cuts down to the coral reef bed, number 7 of Eicher's, number 4 of Hutchinson's. Between the two bridges at Iowa City an



FIG. 4. View in Hutchinson Quarry, west side of river at Iowa City.

exposure shows that the white limestone in the upper part of the Hutchinson quarry grades up into a peculiar brecciated phase six to eight feet in thickness.

A very instructive section is found at the Euclid Sanders quarry (Fig. 5) south of the old Terrill mill near Iowa City.

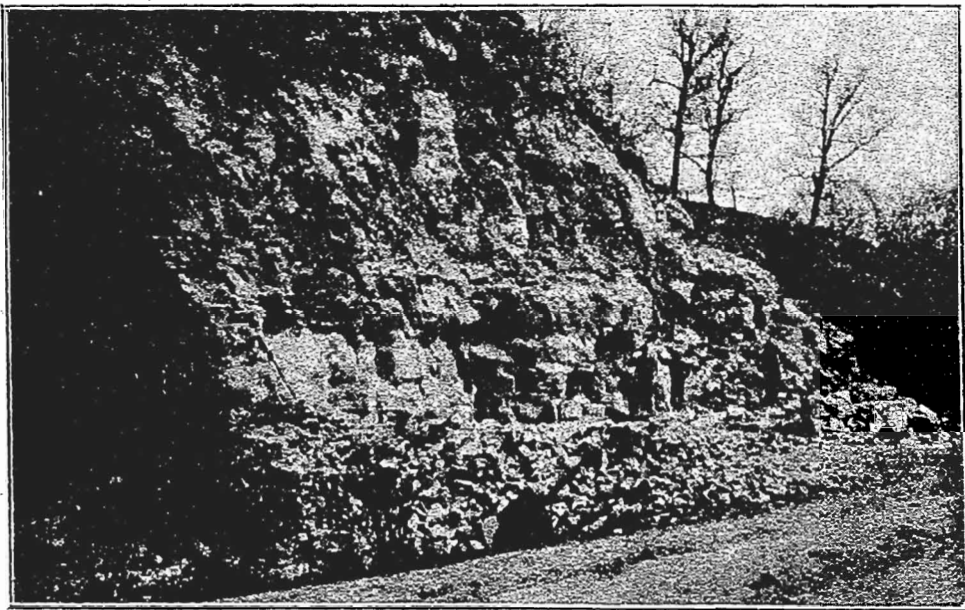


FIG. 5. Sanders Quarry near the old Terrill mill north of Iowa City. The part worked at the time of taking the view lies between two parallel points.

This quarry has been worked for some years by Mr. Gilbert Irish. The section, below a thin bed of loess and Kansan till, shows—

	FEET.
8. Hard, ferruginous, reddish brown sandstone of Des Moines stage, Upper Carboniferous.....	6
7. Whitish-gray, fine grained limestone.....	8
6. Idiostroma beds, containing as usual many massive stromatoporoids and some coralla of <i>Acervularia</i> ...	15
5. Heavy tough ledge of limestone.....	4
4. Bluish-gray limestone, weathering yellow, containing large, coarse ribbed <i>Atrypas</i> and the small branched, small celled <i>Cladopora</i> found at same horizon in Eicher's quarry.....	8
3. Bluish-gray limestone in two ledges, first ledge containing many crinoid stems.....	4
2. Coral reef equivalent to 4 of Hutchinson's and 7 of Eicher's.....	2
1. Bluish beds with great numbers of broken, crushed, detached valves of <i>Spirifer parryanus</i> and the robust, large celled <i>Cladopora</i> (<i>C. iowensis</i> Owen sp.) described as <i>Striatopora rugosa</i> by Hall.....	2

The coral reef bed of the preceding sections is very constant throughout the county. The reef is made up chiefly of coralla of *Acervularia davidsoni* E. & H., with which are associated *Ptychophyllum versiforme* Hall, *Favosites alpenensis* Winchell, and a *Favosites* resembling *F. emmonsii* Rominger, but differing from it only in having the tabulæ complete. The reef is preceded by beds containing *Spirifer parryanus* Hall, and *Cladopora iowensis* Owen. It is followed by beds that are at first barren, but which generally, a few feet above the reef, become fossiliferous and yield the large coarse ribbed *Atrypa reticularis* and the small unnamed *Cladopora* of the same type as *C. iowensis*. Lithologically the beds above the reef are different in different localities. In some places they are hard bluish-gray limestone, in other places, partly on account of weathering, they are yellow limestone, and in still other localities they present the appearance of yellow calcareous shale.

A few rods southeast of the bridge over Rapid creek, near the northeast corner of section 36, Newport township, the coral reef is seen extending across the wagon road. All the exposures between that point and the headwaters of the creek near Elmira lie below the coral reef horizon. The most easterly exposures, as already described, belong to the brecciated phases of the Wapsipinicon stage. This same coral reef, with the same association of beds, lithologically and paleontologically, above and below it, occurs as far north as Littleton in Buchanan county.

Between Linder's boat house and the bridge at Butler's landing, sections 33 and 34, Penn township, the rock exposures in south bank of river embrace all the strata between the *Cystiphyllum* and *S. parryanus* beds beneath the coral reef, and the white, fine grained limestone at the top of the sections in the Hutchinson and Sanders quarries. The coral reef occurs in the bed of a small wash west of the boat house, and in following it down the river it rises higher and higher above the water. It here affords specimens of *Acervularia davidsoni* of exceptional beauty and perfection. The white limestone at the top of the bluff was formerly used extensively for lime burning. The upper surface of this hard, fine grained limestone retains glacial scorings which, as usual in this vicinity, have an average direction of south 63° east. Some portions of this limestone are much shattered and show a tendency to brecciation.

In the northeast quarter of the northwest quarter of section 21, Penn township, there is a rock-walled ravine which leads down to the river in the northeast quarter of the same section, and exposes the full series of beds from a few feet below the coral reef to the top of the white limestone. The corals are here distributed through a greater thickness of rock than at the other localities described, and are associated with large specimens of *Spirifer parryanus*, the coarse ribbed *Atrypa reticularis* and *Pentamerella dubia*. The white limestone and part of the *Idiostroma* bed were formerly made

into lime to a limited extent. The lime kiln at this point, however, has for some years been abandoned.

A short distance east of the locality above described, in the bluff forming the left bank of the river, there is an exposure extending for more than half a mile above the mouth of Turkey creek. Turkey creek has here cut a valley 150 feet in depth, and up this valley for some distance there are exposures of the same beds seen in the bluff facing the river. In the river bluffs, as well as in the bluffs of its tributary, the rocks are largely concealed by talus, and hence it is impossible to make a section in detail. At the upper end of the river bluff, however, almost directly south of the center of section 15, in Newport township, the strata at the level of the water contain *Phillipsastrea billingsi* and *Acervularia profunda*. We have here the lowest member of the Cedar Valley stage. About seven feet of the *Phillipsastrea* bed are exposed. The bed does not show definite stratification, and it breaks up, on weathering, into small angular chips.

The *Megistocrinus* beds follow, as usual, those containing *Phillipsastrea*. They are regularly stratified and the effect of the weather breaks them up into large slabs or plane-surfaced blocks. Some layers are heavy, hard, and capable of furnishing good quarry stone. Others are soft, shaly, yellowish in color and agree well with the common phase near Solon and along Rapid creek. The usual fossils occur, *Orthis iowensis* being in some places unusually abundant. Above the *Megistocrinus* beds the rocks are shaly as at the Eicher quarry, and the hill slope is covered with talus. Among the loose material are many weathered coralla of *Acervularia davidsoni*, along with species of *Favosites*, *Idiostroma* and other forms, all of which belong to higher horizons. Seventy feet above the level of the river, near the south end of the bluff, a ledge seen in place contained *Acervularia davidsoni*; and in the bluff facing Turkey creek, eighty feet above the level of the valley, there is an abandoned lime kiln, near which is an old quarry showing the *Idiostroma* bed overlain

by white, fine grained, horizontally bedded limestone. Between the base of the Phillipsastrea beds and the summit of the white limestone there occurs the whole thickness of the Cedar Valley stage as it is developed in Johnson county.

The quarry north of the iron bridge, in section 25 of Jefferson township, shows some modifications of the succession of strata occurring farther down the river. The following is the section at this point.

	FEET.
10. Loess.....	2 to 10
9. Pebbly drift, Kansan.....	3
8. Decayed limestone, with bowlders of disintegration embedded in highly oxidized dark reddish-brown residual clay.....	3
7. Light colored, evenly bedded, fine grained white lime- stone.....	10
6. Coral breccia, composed of coralla of Acervularia, small cylindrical Favosites, a peculiar Diphy- phyllum, a very elongated Cyathophyllum, Idios- troma and massive stromatoporoids.....	5 to 8
5. Reef of closely crowded masses of Acervularia.....	2
4. Regular heavy layers of fairly good quarry stone, con- taining coralla of Acervularia and Favosites sparsely distributed.....	5
3. Blue limestone in layers from 6 inches to 2 feet thick, composed of fragments of crinoids and broken shells of brachiopods.....	7
2. Shale and shaly limestone.....	1½
1. Heavy blue limestone with concretions of pyrites....	2

Spirifer pennatus occurs in the lower part of number 3. In the upper part are *S. parryanus* and *S. asper*. Number 4 contains, besides the corals, *Dielasma iowensis*, *Pentamerella dubia* and a *Conocardium*. No. 5 seems to be the coral reef bed of the sections near Iowa City with the layers between the Acervularia reef and the Idiostroma bed omitted. No. 6 is the Idiostroma bed, but it is here very much richer in true corals, such as Favosites, Cyathophyllum, Diphyphyllum, and Acervularia, than usual. Nos. 7 and 8 together represent the white limestone with which the normal Devonian sections of the county terminate.

At the railway quarry, on land belonging to Mr. E. Clark, in the west bank of the river north of Coralville, beds equivalent to the upper part of the sections already described, are exposed. Beneath the overlying loess and drift the following strata occur.

	FEET.
5. White limestone	12
4. Stratum crowded with casts of <i>Straparollus cyclostomus</i> Hall	1½
3. Limestone weathering into thin fragments, containing some specimens of <i>Idiostroma</i> and colonies of a cylindrical <i>Favosites</i>	4
2. Gray limestone crowded with <i>Idiostroma</i> and other stromatoporoids. This with No. 3 represents the <i>Idiostroma</i> beds of preceding sections	8
1. Hard blue limestone, containing some large coralla of <i>Acervularia</i>	4

At the state quarries on the west side of the river in section 5, of Penn township, the Cedar Valley limestones are exposed near the base of the river bluffs and in the sides of the small tributary valleys. One of these valleys, in the left bank of which there are three or four quarries which may be called the south quarries of the state quarry stone, gives a complete section from the upper part of the *Megistocrinus* beds to the white, fine-grained limestone with which the Cedar valley stage terminates in this locality. Near the river the beds contain the stem segments of crinoids, the *Atrypa aspera* and the broad *Orthis iowensis* of the *Megistocrinus* zone. For a short distance, following the ravine back from the river, the beds are not well exposed, but thirty rods from the mouth of the valley the beds show the horizon of *Spirifer parryanus*, above which the coral reef bed is typically developed, and this is followed by yellow shaly limestone. Further up the valley exposures are found at intervals. One-half mile back from the river the *Idiostroma* bed occurs in sides and bottom of the small creek channel, and is followed normally by the white fine-grained limestone. A thin layer above the *Idiostroma* zone is crowded with shells of *Strap-*

arollus cyclostomus. The beds, as they successively appear in the creek in following up the ravine, give the normal section of the Cedar valley stage and nothing more. That section does not include the quarry stone of the state quarries. In the bluffs along the river front the quarry stone rests on the *Megistocrinus* bed, but in the secondary valleys its base rises in the bluffs more rapidly than the bottom of the ravine ascends, and within less than one-half mile back from the river it entirely disappears. The beds constituting the state quarries are a local deposit, and do not belong to the Cedar valley section.

From the several sections and exposures described the general section of the Cedar valley stage may be constituted.

GENERAL SECTION, CEDAR VALLEY LIMESTONE.

FEET.

11. White, fine-grained limestone, brecciated in upper part. Fossils rare except in bed near base, which is sometimes crowded with shells of <i>Stroparollus cyclostomus</i>	20
10. Upper <i>Idiostroma</i> bed of Hutchinson quarry. This bed is not everywhere separated from the lower bed No. 8	2
9. Gray, limestone, resembling No. 11	6
8. Bed with large stemmed <i>Idiostroma</i> , spherical <i>stromatoporoids</i> , some colonies of <i>Acervularia</i> and many small cylindrical forms of <i>Favosites</i>	10
7. Beds varying much in different localities, usually shaly and yellow in color after exposure to weather	5 to 10
6. Coral reef	2
5. Bed with numerous small crinoid or cystidean stems, <i>Cladopora iowensis</i> Owen, and <i>Strobilocystites calvini</i> White—Nos. 5 and 6 of Eicher's quarry	3
4. Blue quarry stone in most quarries, with <i>Cystiphyllum conifolle</i> , <i>Cyathophyllum robustum</i> , <i>Ptychophyllum</i> and <i>Acervularia</i> . Nos. 3 and 4 of Eicher's quarry	4 to 8
3. Beds varying locally, usually without fossils, No. 2 of Eicher's quarry	12 to 20
2. <i>Megistocrinus</i> beds, typically developed in the quarries one and one-half miles southwest of Solon, and along Rapid creek in sections 20 and 21, Graham township	15
1. <i>Phillipsastrea</i> beds	8

The most southerly exposure of Cedar valley limestone in the county occurs on land belonging to Mr. James McCollister near the center of section 22 in Lucas township. There are beds exposed in the river bank, and there are reefs of rock in the river channel. The beds exposed are equivalent to 3, 4 and 5 of the Hutchinson quarry section. North of the McCollister place, on land belonging to the Richard Sanders estate, there is an abandoned quarry showing the *Idiostroma* beds overlain by the white limestone. The most westerly exposure in the valley of Clear creek occurs at the old woolen mill in section 1, T. 79 N., R. 7 W. All rock exposures of every kind are limited to the northern part of the northeastern half of the county.

STATE QUARRY LIMESTONE.

At the state quarries, or North Bend quarries, in sections 5 and 8 of Penn township, there is a body of limestone of Devonian age, possessing marked characteristics which set it off sharply from the rest of the Devonian in Iowa. The formation has a thickness of about forty feet. At present there is some uncertainty as to its exact taxonomic relations.

On fresh fracture the state quarry rock is light gray in color. In texture it varies somewhat in different beds, but near the middle of the formation it is composed of coarse, imperfectly comminuted fragments of brachiopod shells cemented together, the spaces being filled with interstitial calcite. Among the recognizable species of shells *Atrypa reticularis* is the most common, but some beds contain very large numbers of *Dielasma* (*Crancena*) *iowensis*. At some horizons shells of an *Orthothetes* are common. *Orthis impressa* is not rare and *Rynchonella pugnus* (*Pugnax pugnus*) occurs occasionally. The shells, or fragments of shells, making up the limestone are not embedded in a matrix. They are simply piled on each other and cemented together in a manner illustrated by the formation of the modern coquina along the east coast of Florida. The rocks near the middle of the state quarry beds

are a brachiopod coquina having the interstices completely filled with crystalline calcite.

Near the middle of the formation the rock consists of thick ledges which, some years ago, were worked extensively. (Fig. 6.) From these beds came the large limestone blocks used in the foundation of the new state capitol. Although



FIG. 6. View in the State Quarry, Section 5, Penn township. A man stands in front of the principal ledge from which the limestone blocks used in the foundation of the present state capitol were obtained. Some of the rejected blocks in the foreground contain considerable quantities of chert with which are associated great numbers of fish teeth.

the ledges show no definite lamination, and split as readily in one direction as another, the weathered surfaces on opposite sides of the numerous joints often show obscure signs of oblique bedding. The material was evidently swept into place by moderately strong currents.

The ledges worked in connection with the building of the new capitol are the heaviest afforded by the formation. The lowest one is four feet in thickness. It is made up of rather finely triturated brachiopod shells, the most common species being *Atrypa reticularis*. This bed, it seems, did not furnish satisfactory material for it was quarried only to a limited extent. The ledge furnishing the greater number of available blocks lies directly above the first. It is five feet in thick-

ness, and is intersected by numerous joints. Among the great multitude of unrecognizable fragments of which it is chiefly composed it contains large numbers of entire detached valves of *Atrypa* and *Orthothetes*. The next ledge in ascending order which yields usable stone is separated from the last by a talus covered space of two or three feet. It also is five feet thick, and in it *Atrypa* and *Dielasma* are the prevailing brachiopods. In a fourth ledge, four feet in thickness, the rock is fine-grained, the materials are very perfectly comminuted, species cannot be recognized, but it is evident that the bed is composed of debris from brachiopod shells mingled with triturated fragments of crinoids. Above the fourth ledge the layers vary from six inches to two feet in thickness, and toward the upper part of the exposure the rock is made up almost wholly of the remains of crinoids.

Below the first ledge noted above, the beds vary from a few inches to a foot or more in thickness, the thinner beds prevailing near the base of the formation. Brachiopod shells constitute the major part of the material of which they are composed.

The state quarry fish bed.—Among the waste material of the main quarry there are many large blocks, eighteen inches thick, through which masses of chert are irregularly distributed. The position of the bed from which the chert-bearing blocks were obtained, was not determined; though it is probable that it lies in the talus covered space between ledges 2 and 3 of the main workable portion of the quarry. Whatever its position it is a bed of remarkable interest, for it is in places crowded with fish teeth that lie embedded in the chert or among triturated brachiopod shells in the calcareous portions of the layer. It looks as if an entire fish fauna had suffered death at once. Such general fatality may have been produced by any one of several probable causes; and furthermore the cause, whatever it may have been, was doubtless in some way related to the crustal movements recorded in the region, and to be more particularly noted further on. Changes

in oceanic currents attended by rapid elevation or depression of temperature, earthquake shocks even, or concentration of sea water in a temporarily isolated basin, would be competent to produce the observed result. Whatever the cause, it was effective, and every square yard of sea bottom received its quota of dead fishes.

Several genera and species are indicated amid the profusion of fish remains interred in this old cemetery. One of the most common forms is the well known Devonian type, *Ptyctodus*. Teeth of this genus are sometimes literally crowded together to form a sort of fish tooth conglomerate. These teeth or tritons vary in size and shape, and in the degree of wear to which they were subjected before the death of their owners; but in the opinion of experts to whom they have been submitted, they probably all belong to the single species *Ptyctodus calceolus*. Along with *Ptyctodus* are remains of one or more species of Devonian Placoderms, as indicated by great numbers of imperfect dermal plates. The Dipnoan genus *Dipterus* is represented by a number of the interesting wing-shaped teeth characteristic of this very old but persistent type; and there are teeth evidently related to *Dipterus*, but so different as probably to make generic separation necessary.

But more interesting than all the rest, and far outnumbering the teeth that could at first sight be referred to *Dipterus*, or to related genera, is a vast assemblage of teeth of varying shapes and dimensions, that bear a striking external resemblance to the crushing teeth of certain genera of Lower Carboniferous sharks. In the opinion of Dr. C. R. Eastman, however, it is doubtful if there are any Selachian teeth in the entire lot. He finds that, microscopically, so far as sections have been made, they are all identical in structure with the teeth of Lung fishes or Dipnoans. They seem indeed to be primitive Dipnoans, exhibiting a stage of evolution not far removed from the point whence the Dipnoan and Elasmobranch type diverged; and their careful study will doubtless throw much light on the nature of the relationships existing

between these two groups of fishes. Dipterine fishes have long been known from the Devonian of eastern Europe, but it is only recently that this type has been found in the Devonian of America. Until the discovery of the state quarry fish bed our Devonian Dipterines all belonged to a single genus, and came from the Upper Devonian formations (Chemung and Catskill) of Pennsylvania. Now we find the type in the Mississippi valley; but here it is represented by several genera, and is connected by inter-gradations with exceedingly primitive Dipnoan forms. It is a matter of interest as yet unexplained that the collections, so far as determined, afford no examples of teeth of true sharks.

The material has been placed in the hands of Dr. Eastman, who will in due time furnish a full report upon it. In the meantime the scientific significance and bearings of the discovery are well set forth in his preliminary notes in another part of the present volume. His final report will be awaited with very great interest.

Distribution.—At present the State Quarry limestone is known only in Johnson county, Iowa, though it doubtless will be found at many other points in Iowa, and probably in adjacent states. The main body as now recognized occurs in sections 5 and 8 of Penn township (Tp. 80 N., R. VI W.). It is found in the bluffs on the west side of the Iowa river from the north line of section 5 to a little more than one-fourth of a mile below the north line of section 8, the principal development occurring near the south side of the first named section. The width of the area occupied by the formation in this region is less than half a mile. In fact in following up the small tributary valleys the State Quarry stone is in most cases found to disappear in less than one-fourth of a mile.

A second body of State Quarry limestone is found near the southwest corner of section 20 of Graham township, at which point the formation is almost exclusively crinoidal as to composition; a third body of this limestone, but of no great thickness, is seen near the top of the hill southeast of the

bridge over Turkey creek in section 23, Newport township; and another body of the same stone occurs in rather puzzling relations to the Megistocrinus beds in section 23, Big Grove township, southwest of Solon. At the last named locality Rhynchonella or Pugnax, is the prevailing fossil. The very fossiliferous limestone seen near the base of the quarry south of Shueyville is of a very different character and belongs to a different horizon.*

Taxonomic relations.—As already intimated, the taxonomic relations of the State Quarry stone are not very clear. At first it seemed that it might possibly represent local deposits made contemporaneously with the Cedar Valley beds, but later investigations indicate that it is younger than the Cedar Valley and was laid down on a deeply eroded surface. In support of this view it may be noted that at the mouth of the ravine below the south quarries in section 5 of Penn township, the State Quarry stone rests on the Megistocrinus beds of the Cedar Valley stage. In following up the ravine the quarry stone rises higher and higher in the bluffs and soon disappears, while the members of the normal Cedar Valley section appear successively in the bottom of the creek. The contact of the two formations cannot, however, be definitely traced. On Rapid creek in section 20 of Graham township, the relations are nearly the same; the State Quarry stone occurs only a short distance above the Megistocrinus beds. At Solon the equivalent of the State Quarry stone occurs on the west side of a small ravine, while on the east side of the ravine, only four or five rods distant, the typical Megistocrinus beds, wholly different in character and with an entirely different fauna, occur at the same level. The quarry beds at the last named locality are composed largely of shells of Pugnax (Rhynchonella). They extend westward along the north side of the valley of a small creek for about one-eighth of a mile and then suddenly disappear, their place in the low bluff being taken by the normal Megistocrinus beds of the

*McGee: Tenth Census Rept. vol. X, Quarries and Building Stone, p. 262.

Cedar Valley section. In the bluffs above the bridge over Turkey creek, at the point already noted, in section 23 of Newport township, these beds occur above the white limestone at the top of the Cedar Valley formation, so far as it is developed in this part of Iowa. No Devonian beds of any kind have so far been found above the State Quarry stone. The anomalous relations of this formation, the limited areas to which it is confined, the abrupt manner in which it appears and disappears, sometimes at the level of one member of the Cedar Valley section and sometimes at the level of another, all lead to the conclusion that it was deposited unconformably on the Cedar Valley limestone after the lapse of a considerable erosion interval. (Fig. 7.) The same view

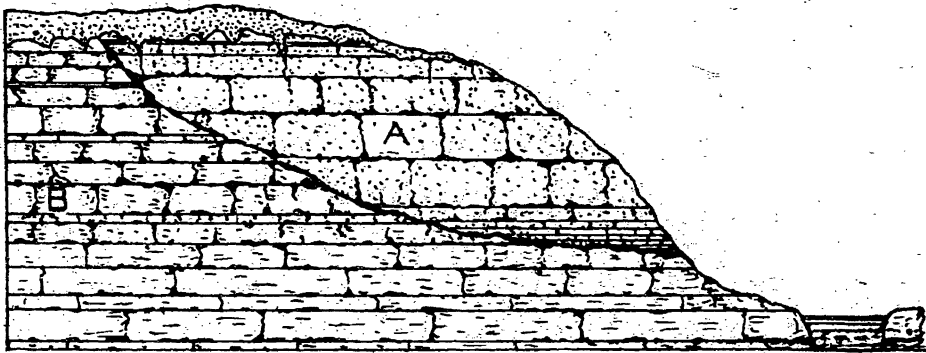


FIG. 7. Hypothetical section showing the probable relations of the State Quarry stone A, to the Cedar Valley limestone B, along the river front in section 5, Penn township.

is even more strongly suggested by the fact that in certain respects the fauna of the State Quarry beds is unique. The deposit near Solon furnishes *Pugnax pugnax* Martin, *Melocrinus calvini* Wachsmuth, and a very peculiar stromatoporoid, none of which is found in the other Devonian formations. Of other species that have a greater vertical range, as for example *Atrypa reticularis*, there is sufficient variation to distinguish them from individuals of the same species found at other horizons. The *Orthothetes*, so common in the beds in section 5 of Penn township, is associated with *Pugnax*, and like it is limited to the State Quarry stage. The great mass of cemented crinoidal debris comprising the beds in Graham township and the upper ten or fifteen feet of the forma-

tion at the state quarries, has no parallel in any other stage of the Iowa Devonian. The presence of *Dipterus*, which elsewhere occurs only in the upper Devonian, tends likewise to separate this from the underlying Cedar Valley formation. In this connection it may be noted that the Rhynchonelloid shell *Pugnax pugnus* is a Carboniferous rather than a Devonian type. It is true that this species is found in the upper Devonian of New York, and at the same horizon in Europe; but it is in the Carboniferous, particularly in Europe, that it attains its fullest development. Faunally, therefore, the relations of the State Quarry limestone are with the upper, and not with the middle Devonian as is the case with the Cedar Valley beds; and so all the phenomena relating to this limestone and its interesting fauna seem to require for their interpretation a number of crustal movements and a period of erosion in the Iowa Devonian, heretofore unsuspected.

CARBONIFEROUS SYSTEM.

KINDERHOOK STAGE.

No rocks of Kinderhook age are naturally exposed within the limits of Johnson county, and yet there can be no doubt that Kinderhook beds occur beneath the superficial deposits in Washington, Sharon and other southwestern townships. At the McKinley quarry, one-half mile south of the county line, in section 5, Tp. 77 N., R. VIII W., beds of the Kinderhook are exposed in the side of a small valley. The rock consists of heavy ledges of yellowish brown sandstone separated by thin bands of chert. The base of the quarry is 120 feet below the crest of the bluff whose summit coincides with the general level of the country for many miles to the north, northeast and northwest. From the dip of the Kinderhook beds at the quarry mentioned it is inferred that they extend underneath a considerable area in the southwestern part of Johnson county.

DES MOINES STAGE.

General description.—In the northeastern part of the county there are numerous outliers of coal measure sandstones and

shales belonging to the Des Moines stage. Deposits of this stage were once general over the whole area, but erosive agents have swept them nearly all away, and it is only in a few favored localities that they have been protected and preserved. During the time represented by the Lower Carboniferous (Mississippian) series the northeastern part of the county was dry land and subject to subaerial erosion. With the retreat of the Kinderhook sea the whole county became subject to the same influences. As the land rose higher and higher above sea level, deep valleys were cut in Devonian and Kinderhook strata. During the Des Moines stage of the Carboniferous, however, the county was part of a great area of subsidence over which the sea eventually returned and spread sheets of coal measure shales and sandstones. The erosion valleys were filled, and the highlands may even have been covered with Carboniferous sediments. Denudation has long since stripped off these sediments except where they were protected in the pre-Carboniferous valleys.

The Iowa City outlier.—There are two principal areas of coal measure deposits in Johnson county. The first begins in the northern part of Iowa City and extends beyond the middle of section 3 in Lucas township. It occupies an old valley that, as ascertained by borings, was more than eighty feet in depth. The residence of Mr. Euclid Sanders stands almost directly over the center of the valley. The right wall of the valley is seen at the Sanders quarry below the old mill where coal measure deposits overlap eroded edges of Devonian strata. (Fig. 8.) The left wall is seen in Sanders' pasture, thirty rods east of the barn. The coal measure beds end abruptly and their place is taken by the white limestone of the upper part of the Cedar Valley stage. The left wall was at this point more precipitous than the right, for only a few rods away a shaft made in prospecting for coal went down from forty to sixty feet without striking limestone.

North of the old Terrill mill there are two exposures of shaly sandstone belonging to the Iowa City Carboniferous

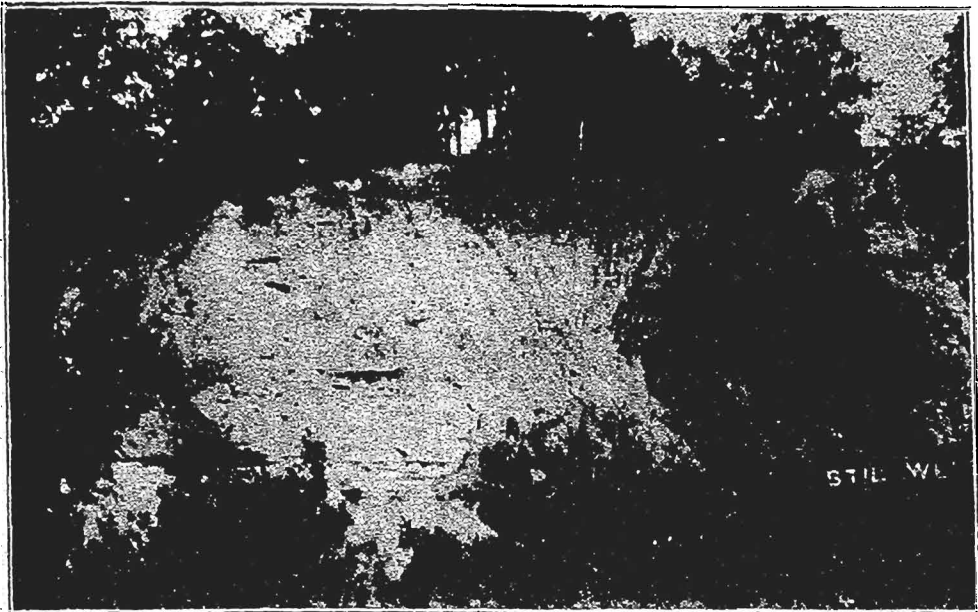


FIG. 8. Contact of Carboniferous with Devonian strata at the Sanders quarry north of Iowa City. The heavy ledges at the right are Devonian limestones; the rapidly weathering talus forming beds at the left of the limestone are Upper Carboniferous sandstone. There is here seen a portion of the rocky cliffs that marked the right side of a pre-Carboniferous valley.

outlier. (Fig. 9.) The beds here contain nodules of iron pyrites, and there are many large lenticular or spheroidal concretions. The exposed edges of the strata are stained in places by the oxidation of the pyrites. By the first settlers



FIG. 9. Outlier of Carboniferous sandstone north of the Terrill mill, near Iowa City.

of this region these beds were quite extensively quarried for building stone, but their tendency to discoloration and to split into thin laminae on weathering led to their disuse. At the residence of Mr. Sanders the beds are quite shaly, and contain a thin layer of coal varying from half an inch to an inch or two in thickness. In the pasture of Samuel Hess, south of the Sanders pasture, there are beds of shale, too thin to be of use, but of excellent quality for the manufacture of pottery or paving brick.

The old valley in which the Iowa City outlier occurs has a direction east of south, cutting through the Hess pasture and the pasture next on the south. It passes under the high hill in the northern part of Iowa City, and has been re-excavated in part by the present valley of Ralston creek.

A shaft dug on the land of Mr. Hess showed the following section.

	FEET.
6. Loess	6
5. Shale and shaly rock	40
4. White sandstone	2½
3. Shale	3
2. Sandstone	5
1. Limestone (Devonian)	10

Number 1 is Devonian, numbers 2, 3, 4 and 5 belong to the Des Moines stage of the Carboniferous.

The Amana outlier.—The second body of Carboniferous deposits in Johnson county is on land belonging to the Amana society and may be called the Amana outlier. This outlier begins in the salient bluff that occupies the angle between the Iowa river bottom and the valley of Knapp creek, in section 27 of Monroe township. From this point it continues westward in the bluffs facing the river into Iowa county. The deposit is here a heavy bedded, and often cross bedded, sandstone, composed of coarse grains of silica imperfectly cemented with iron oxide and calcium carbonate. The colors are dingy red and brown with some darker purplish streaks. The rock has been quarried at various points, and one of the

quarries recently worked is near the mouth of Knapp creek. The following section is there exposed.

	FEET.
5. Loess and till	6 to 8
4. Sandy shale.....	1
3. White sandstone	$\frac{1}{2}$
2. Heavy-bedded sandstone	10
1. Talus down to creek.....	15

Small patches of Carboniferous deposits are found at intervals along the Iowa river, and there are some in other parts of the county. One on Rapid creek in section 30, Newport township (Tp. 80 N., R. V W.) is mentioned by Owen,* and McGeet† notes the common occurrence of small outliers along the Iowa river, between Iowa City and the great elbow of the stream at the north end of Penn township. Some of these are seen on the top of the bluffs in the neighborhood of the state quarries.

Fossils.—The coal measure beds of Johnson county have yielded few recognizable fossils. Plant remains may reasonably be expected to occur in the shaly portions of the formation, but in these no recent excavations have been made. Certain sandstone beds of the Iowa City outlier near Terrill's mill have furnished specimens of *Lepidodendron* and *Calamites*.

PLEISTOCENE SYSTEM.

The surface of Johnson county is very generally covered with Pleistocene deposits. These include an older and a younger drift sheet, a bed of loess and, along the stream valleys, beds of alluvium.

KANSAN DRIFT.

All the known drift in the southern half of the county belongs to the Kansan age. There may be a pre-Kansan drift sheet beneath the Kansan, for throughout the greater part of Iowa the Kansan drift records not the first, but a second ice invasion which spread glacial detritus over an older sheet of

*Owen's Geol. Surv. of Wis., Iowa and Minn., p. 87. 1852.

†Eleventh Ann. Rep U. S. Geol. Surv., p. 309. Washington, 1891.

till. But the older till, so far as known, is not exposed at the surface within the limits of Johnson county. Its presence, however, seems to be indicated by an unstratified blue clay beneath a black, friable soil with woody fragments, in McGee's well record, No. 172.* The well referred to is located in section 1 of Graham township. The blue till above the soil and forest bed is probably Kansan. Yellow till recorded as occurring above the blue, may be either Iowan or upper oxidized Kansan, and the sandy beds at the surface belong to the age of the loess.

The Kansan drift, which is the only drift known in all the southern part of the county, is usually overlain by loess, but the loess and the drift upon which it lies are separated by a long interglacial interval. At numberless points the loess has been removed by erosion, and the Kansan drift is exposed. The surface of the drift was very much modified by meteoric agencies, and by the growth of plants before the loess was laid down. In the first place it was very deeply eroded, as is indicated by the fact that the loess forms a relatively thin veneer of nearly uniform thickness over the ridges and ravines of a rather bold erosional topography, which had been fully developed before any loess was deposited. In the second place, during the interglacial interval, the superficial materials of the Kansan drift were very completely oxidized. The drift of this stage was at first a blue clay, and is so still at depths below the influence of oxidizing agents. But at and near the surface the ferrous oxide of the blue clay was changed to the red and brown oxides, with the effect that beneath the loess the Kansan till is dark reddish brown in color. The original drift was rich in lime carbonate, and at moderate depths it retains all of this constituent that it ever possessed, but as a third change to be noted as occurring before deposition of loess, the superficial part of the deposit had the calcareous matter completely removed, partly by growth of plants and partly by the leaching effects of meteoric waters. Fourthly,

*Eleventh Ann. Rept., U. S. Geol. Surv., p. 534.

within the zone subject to the effect of modifying agents, all bowlders of certain kinds of granite suffered decay. They crumble under slight force into a coarse sand; many, especially near the surface, are now represented by masses of incoherent particles distributed through finer glacial debris.

Natural sections showing the reddish brown oxidized zone of the Kansan drift overlain by loess, charged with disintegrated granite bowlders, and having its line of contact with the loess conforming to the inequalities of the present surface and maintaining essential parallelism with it, occur at numerous points along the roadways in the southern part of the county. One of these exposures is found in the west side of a small valley near the northeast corner of section 30 of Lucas township. Another of equal significance is seen south of the bridge over Old Man creek near Windham. Along the west and south sides of section 10 in Washington township there are several good exposures of the same kind. There are in fact scores of similar exposures in Washington, Sharon and other southern townships, one of the most instructive being seen on the county line eighty rods east of the southwest corner of section 33, and another near the northeast corner of section 19, both in Washington township. In Scott township there are excellent sections showing the same phenomena. A railway cut near the northeast corner of section 7, and a number of cuts in the wagon road which follows the south line of sections 1 to 5 will serve as examples. All the cases are consistent, and all support the view that a very long interval elapsed between the deposition of the Kansan drift and the laying down of the loess which, to a large extent, prevented further change.

As already intimated the Kansan drift was originally a blue clay. The bowlders of the Kansan are small when compared with those of the Iowan till. Specimens exceeding four feet in diameter are very rare, and it is seldom that any portion of the bowlders project above the surface of the thick sheet of drift. The Kansan bowlders are very largely dark colored,

fine grained varieties of trap, though there are many small light colored granites, and occasionally one finds numerous transported fragments of limestones, sandstones or other sedimentary rocks. Of the included pebbles and boulders, unusual numbers are planed and striated on one or two sides, a fact which indicates that, notwithstanding the great thickness of the Kansan deposits, a large part of the material was transported during all, or part of its journey, as subglacial drift.

Glacial scorings.—There are a few points in the county where the Kansan drift rests on planed and scored ledges of limestone. In general it is the hard, brittle, fine grained white limestone in the upper part of the Cedar Valley stage that has preserved the glacial markings. Such markings occur at the summit of the Hutchinson quarry and at points between the quarry and the upper bridge west of Iowa City. At the site of the old woolen mill on Clear creek the rocks in the bottom of the stream are very beautifully planed (Plate I), and at the lime quarry of Mr. Linder, two miles northwest of Iowa City, the white limestone retains the glacial striae. The direction of the striae is essentially the same at all the points observed, the main movement of the ice being south 63° east.

IOWAN DRIFT.

The younger drift sheet exposed in Johnson county is known as the Iowan. It is limited to the northern part of the county, and is especially interesting for the reason that, so far as it appears in this county, it was deposited by the extreme southern, lobulate margin of the Iowan ice. Two lobes of this ice sheet, pushing out beyond the average limit, invaded Johnson county and deposited typical Iowan drift in two distinct areas which, in the description of the topography of the county, have been called respectively the Solon lobe and the North Liberty lobe. The limits of these beds have already been described. The Iowan drift differs from the Kansan in a number of particulars. It is not covered by



GLACIAL PLANING ON DEVONIAN LIMESTONE. CLEAR CREEK, WEST OF IOWA CITY.

loess. Its surface has suffered but little erosion since it was deposited. The rolling country south of the Iowan margin, carved as it is into a series of rounded hills and steep-sided ravines, is in marked contrast with the very gently undulating surface of the Iowan drift, where the waterways have cut but a few feet below the general level, and an unbroken plain stretches away to the horizon. Between Coralville and North Liberty the distance is some six miles, but in passing from the first to the second village the road winds for more than two-thirds of the way among loess covered hills and deep gorge-like valleys that illustrate the topography of the Kansan area where it is covered with a thick mantle of loess. But a mile and a half south of North Liberty the loess ends abruptly, the steep hills and deep valleys are left behind and the roadway leads out upon a drift plain that as yet has scarcely been attacked by the agents of erosion. The transition is so sudden as to create surprise. It is like passing into a new country.

The plain upon which the road enters south of North Liberty is occupied by prosperous farms with black, mellow easily cultivated soil. Beneath the soil there is a yellow till which shows scarcely any evidence of change since it was laid down. Oxidation is not more marked at the surface than in the deeper parts of the deposit. Calcareous matter is about as abundant at the grass roots as it is ten feet lower down. The bowlders are sound and hard, showing no signs of decay. Furthermore the bowlders are of gray granites with very few if any of fine grained, dark colored trap. Not many of the bowlders are planed or scratched, and there are scarcely any fragments of transported sedimentary rocks.

The margins of the Iowan drift lobes in Johnson county are marked by hills that rise from forty to eighty feet above the level of the drift plain. These moraine-like hills have already been described in discussing the topographic features of the county.

THE LOESS.

This is a deposit of fine glacial silt evidently derived from the Iowan drift. In Johnson county it is distributed in regions that lie beyond the margin of the area that was covered by Iowan ice. With the exception of the paha of McGee it is very unusual to find loess anywhere in any considerable amount, very far within the territory occupied by Iowan till. The hills that mark the marginal limits of the Iowan ice sheet are everywhere deeply covered by this deposit, and all the remaining portions of the county outside the Iowan drift lobes were overlain to a greater or less depth by the same material.

General description.—The loess of Johnson county is a part of the extensive deposits of this material distributed over certain areas in eastern Iowa. In some particulars it is quite distinct from the loess of the Missouri river valley. With respect to Iowa, therefore, there are two distinct phases of loess, one of which may be called the eastern loess, the other the western. Where typically developed this eastern loess is a yellow clay mixed with particles of silica too fine to be denominated sand, and containing a considerable amount of disseminated calcium carbonate. In Johnson county, however, the deposit is very variable in composition. In the hills that were heaped up around the margin of the Iowan ice, the loess often contains a large percentage of sand. This sand may be gray in color and may make up more than half the deposit as is particularly true in the neighborhood of Solon, and in parts of the low moranic hills which extend southeastwardly from Solon to section 36, of Cedar township. More frequently the sand is finer, bright yellow in color, and mixed with a greater proportion of the typical loess clay. This phase of the sand is well illustrated at numerous points, as, for example, in sections 8, 17, 21 and 22, of Big Grove township, and in sections 19 and 30, of Penn. Then again the materials first transported from the margin of the Iowan ice and deposited over the extra marginal surfaces were coarser than those

transported later, for at the base of the deposit, for some distance from the source of supply, there is usually a sandy layer underneath finer and more typical loess. This sandy layer, which constitutes the sub-loessial sand of Norton, is not found, however, more than a few miles beyond the margin of the Iowan drift.

Genesis.—That the loess is a silt derived from the finer materials of the Iowan drift is supported by the color and composition of the deposit, by its geographical relations to the margin of this drift sheet, and by its superposition sometimes on Iowan till and sometimes on eroded and oxidized surfaces of Kansan till. The nature of the agents whereby it was transported and deposited is not so clear. Some beds of the deposit may possibly indicate transportation from dried and dusty surfaces by wind; but the thick body of loess piled up around the margin of the Iowan drift, with accompanying sands near the source of supply and finer silt carried to greater distances, seems to be best explained by assuming sluggish currents from the melting ice sheet as the agent of distribution and deposition. To summarize the facts relating to the distribution of the coarser and finer materials of the loess it may be stated that at a distance greater than six or seven miles from the margin of the Iowan drift the whole sheet of loess is composed of fine silt; the greater the distance from the margin, the less yellow and more ashen in color the deposit becomes; the sub-loessial sands overlain by true loess are limited to a belt around the drift lobes three or four or five miles in width; and in the moraine-like hills contiguous to the drift margin the entire thickness of the loess from base to surface is frequently arenaceous.

Fossils and other contents.—Since the deposition of the loess some segregation of its limy constituent has taken place, and calcareous concretions known as loess-kindchen are more or less common in typical portions of the formation. In some fine clayey beds vertical "pipes," apparently due to deposition of iron oxide in successive laminar sheaths around long

slender roots of plants, attract popular attention on account of their shape and conspicuous reddish brown color. Certain dark colored, fine grained portions of the loess are very fossiliferous. Shells of *Ferussacia*, *Helicina*, *Mesodon*, *Patula*, *Pupa*, *Succinea*, *Vallonia*, *Vertigo*, *Zonites* and a few other genera of land snails are common. Along with the more strictly terrestrial forms are species of the pond frequenting genera *Limnæa*, *Physa* and *Planorbis*, while very rarely there occur shells of the aquatic bivalve *Pisidium*. Prof. B. Shimek, who probably has handled more of these fossils than any other collector, identifies about sixty species from this formation.

ALLUVIUM.

Alluvial deposits occupy areas of greater or less extent along all the principal drainage streams of the county. A broad belt of warm, sandy alluvium, underlain by gravel, occupies the valley of the Iowa river from the point at which the stream crosses the west line of the county until it enters the gorge bounded by loess covered hills, near the iron bridge south of Shueyville. There are smaller areas of alluvium at intervals between the iron bridge and Iowa City. South of Iowa City there is a continuous alluvial plain which widens rapidly, particularly on the east side of the river, and embraces many square miles of rich farming lands in Lucas, Pleasant Valley and Fremont townships. Clear creek and Old Man creek run in wide valleys, and each has its flood plain covered with heavy deposits of alluvium. Rapid creek, in its lower course flows for some miles through a rich alluvial plain. A similar plain, on both sides of the Cedar river occupies a number of square miles in the northeastern corner of the county.

DEPTH OF PLEISTOCENE DEPOSITS.

The Pleistocene deposits of Johnson county vary greatly in depth. There are places where the indurated rocks are exposed without any covering of loose superficial materials.

whatever, and there are other places where the deepest wells reported have failed to penetrate the entire thickness of the superficial deposits. In the central part of Cedar township wells are bored to a depth of 200 to 225 feet before reaching the indurated rocks, while at Solon, on one side and McCune's quarry in sections 2 and 3 of Cedar township on the other, the rocks come to the surface. There is here evidence of a preglacial, rock-walled valley 200 feet in depth. The plain through which the Iowa river flows from the west line of the county to the iron bridge, has deposits of river sand and gravel 150 feet in depth. The loess and drift in the southeast corner of Scott township have an aggregate depth of 200 feet as shown by well borings, and a well at Lone Tree, Fremont township, was bored through alluvium and drift to a depth of 212 feet without reaching the bottom of the Pleistocene. At Oxford, and other points in the valley of Clear creek, the Pleistocene beds reach a depth of 256 feet, and south of Frytown, in Washington township, a well is reported 282 feet deep without encountering anything but loose, superficial materials.

THE PREGLACIAL SURFACE.

Combining the evidence from well records and known rock exposures, it is seen that the preglacial surface of the county was very irregular and was diversified with deep valleys and rocky, precipitous hills, as a result of a period of erosion immediately preceding the distribution of the first glacial drift. The drift sheets, which aggregate in some places 300 feet in thickness, leveled up the irregular surface by filling the valleys with glacial detritus. Only in a comparatively few cases do even the preglacial hilltops project above the surface of the thick mantle of unindurated loess and drift. The obliteration of the preglacial hills and valleys by the distribution of loose surface materials, has contributed much to the convenience and success of every citizen of Iowa.

SOILS.

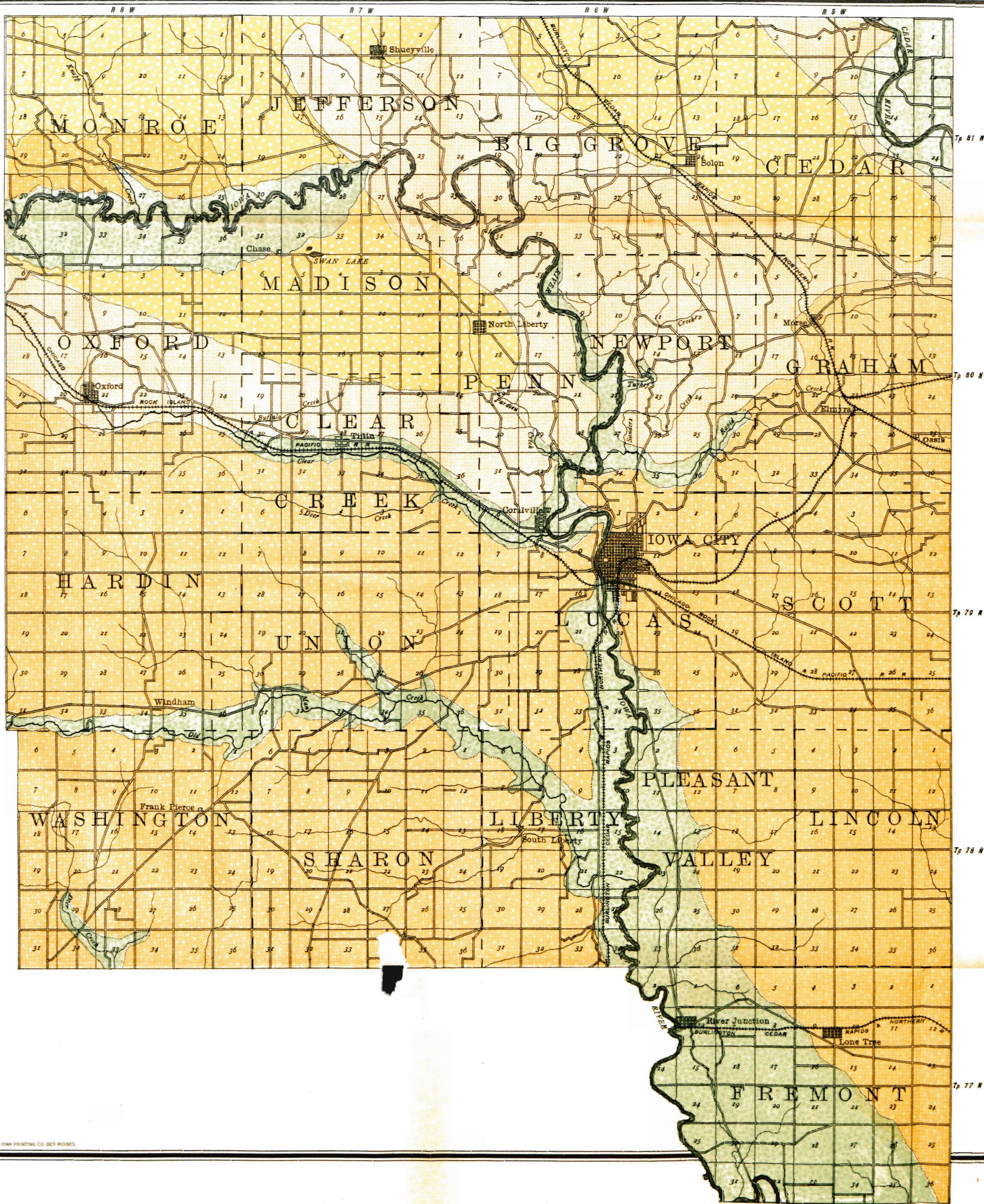
The soils of Johnson county may be arranged in four divisions between which will be found in some instances numerous intergradations.

1. The soil of the Iowan drift lobes is probably the most distinct of any of the divisions. It is typically a rich, mellow black loam of great depth, easily tilled and very productive. Evidences of thrift and prosperity abound throughout the region over which the Iowan drift is deposited.

2. Kansan drift overlain by a thin veneer of loess constitutes the second type of Johnson county soils. This type is best developed south of Old Man creek in Washington, Sharon and Liberty townships; but excellent examples of it are found throughout Scott township and in the northern part of Lincoln. This soil is exceptionally fertile and responds most generously to the labors of the farmer. It has at least one advantage over the soils of the Iowan drift lobes in that it is free from the great numbers of granite boulders which sometimes encumber farms located on Iowan drift. The elegant homes, large, overflowing barns, well kept stock, and all possible labor saving devices, that are seen on every hand where this soil exists, attests its great productiveness when the labor of the farm is directed by quickened intelligence.

3. Alluvial soils occupy a considerable area within this county. The distribution of alluvium has already been noted. Some parts of the alluvial plains in the northern part of the county are rather sandy, but in general the soils of these plains rank with the best. As a rule they are warm, mellow, rich in plant food, and thoroughly underdrained by reason of the beds of gravel which usually occur at no great depth from the surface. The largest areas of alluvial soils occur in Oxford, Madison, Pleasant Valley and Fremont townships.

4. A fourth type of soil occurs in the heaped up ridges around the margin of the Iowan drift and in the region of



IOWA GEOLOGICAL SURVEY

MAP OF THE
SURFACE DEPOSITS
OF
JOHNSON
COUNTY,
IOWA.

BY
SAMUEL GALVIN
1897.

LEGEND

- ALLUVIUM
- IOWAN DRIFT
- IOWAN LOESS
OVERLYING IOWAN DRIFT.
- IOWAN LOESS
UNDERLYING DRIFT UNKNOWN.
- IOWAN LOESS
OVERLYING KANSAN DRIFT.



deep loess which is found for a distance of three or four miles south of the margin. Loess is of course the prevailing material constituting the soils of this type, but near the margins of the drift lobes there is more or less of sand. A sandy ridge extends from Solon southeast to section 2, of Graham township. Sand mixed with loess clay occurs in all the marginal ridges around the Iowan lobes, but the greater part of the area has soils composed of typical loess. The region is very much broken and rolling. No vegetable mould develops over the loess ridges. The yellow loess clay is turned over by the plowshare, and to one accustomed to the rich black loam of the drift covered areas the fields present a very uninviting and barren appearance. Loess is rich in lime carbonate and some other substances utilized by plants, so that where the surface is comparatively level good crops are produced though at relatively great expenditure of time and labor. On the steeper slopes, however, that some persist in cultivating, the soil washes badly, the surface is gashed and furrowed by every rain, great irregular ditches excavated by erosion are not infrequent, the crops are poor and thin, and the labor involved in cultivating the soil is excessive as compared with the reward. Small, uncared-for, unpainted houses, ungrassed dooryards, straw covered sheds, and the few implements of husbandry that have been laboriously gathered together wasting in sun and rain for lack of shelter, are characteristic of the hilly regions covered by deep loess.

Deformations.

No marked deformation of strata indicative of folds affecting any considerable thickness of the crust have been observed in Johnson county. There are, however, numerous small local folds in both the Wapsipinicon and Cedar Valley stages of the Devonian. Some of the best examples of such local plications occur along Rapid creek in sections 20 and 21 of Graham township. Others are found near Solon, and quite a number occur between the Robert's Ferry bridge and Iowa City.

Some of the folds are probably due to inequalities of deposition. Strata increase rapidly in thickness when traced in certain directions, and again they feather out completely. Lens-shaped masses of no great horizontal extent are sometimes intercalated between certain beds that elsewhere are in contact, a fact well illustrated at an abandoned quarry south of that now worked by G. R. Irish on the property of Euclid Sanders. The strata laid down on the uneven surface exhibit a number of flexures that simulate true folds.

Unconformities.

There are two striking cases of unconformity among the indurated rocks of Johnson county. The first occurs between the Cedar Valley and State Quarry stages of the Devonian. Between these two stages there is a record of an erosion interval heretofore unsuspected in the Devonian of Iowa. The Cedar Valley beds belong to the Middle Devonian. The State Quarry limestone, with its types of Chemung and Catskill faunas, must be correlated with the Upper Devonian. The second case of unconformity exists between Devonian limestones and Carboniferous shales and sandstones of the Des Moines stage. The erosion interval preceding the deposition of the Des Moines sediments was much longer than that between the Cedar Valley and State Quarry stages of the Devonian. During this last interval the land stood probably higher than at present, for the gorge in which the Des Moines shales and sandstones at the home of Euclid Sanders were laid down descends sixty feet below the channel of the present river.

The indurated rocks are overlain unconformably by the earliest drift; the Iowan drift is unconformable on the Kansan, and the loess is conspicuously unconformable with the Kansan drift upon which it lies throughout all the region south of the limit reached by the Iowan ice.

ECONOMIC PRODUCTS.

Building Stones.

Anamosa stage.—The exposure of Anamosa limestone, Niagara series, in sections 2 and 3 of Cedar township has been quarried since the early settlement of the county. In the upper part of the exposure the rock is very finely laminated, without definite bedding planes, through a thickness of thirty feet. The stone is, however, easily split along the planes of lamination, and so it is possible to take out smooth-surfaced blocks of almost any desired dimensions. There is more or less chert along some of the planes in the upper part of the quarry. Below the laminated portion, down to the level of the river, there are ten feet of definitely bedded, non-laminated ledges, from four to eleven inches in thickness, capable of affording good material for many kinds of masonry. The productiveness of this quarry is checked by lack of facilities for transportation.

The Wapsipinicon stage.—Brecciated beds of the Wapsipinicon stage of the Devonian are quarried at Solon and at the Beecher quarry near Elmira. The stone from these quarries is used to supply a rather limited local demand.

The Cedar Valley stage.—There are numerous small quarries in beds belonging to the Cedar Valley stage, but none are worked on an extensive scale, and none at present are engaged in shipping stone beyond the limits of the county. Still it must be said that the aggregate amount and value of the stone annually taken from these quarries is very great. The blocks from certain beds are easily shaped with the hammer and are well adapted to rough surfaced ashlar and rubble work. For cellar walls, foundations, and all ordinary masonry a large area of country is dependent on the product of quarries in this stage of the Devonian.

The Megistocrinus beds, No. 2 of the general section (p. 71) are quarried along Rapid creek in sections 20 and 21 of Graham township. The same beds have been worked even

more extensively a mile and a half southwest of Solon. In the lower part of the Eicher quarry the *Megistocrinus* beds were worked. Hard ledges of this zone from which large blocks of excellent quality, with parallel surfaces, might be quarried, occur near the upper end of the bluff above the mouth of Turkey creek, in section 15 of Newport township.

The Hutchinson quarry on the west side of the river at Iowa City works the beds of the general section numbered 4 to 11 inclusive. During the working season this quarry employs from six to eight men. The product is used chiefly in Iowa City, but a considerable amount of it is taken to the country to be used in foundations for barns and other structures. The best building stone comes from the lower part of the quarry. The Sanders quarry south of the old mill near Iowa City furnishes annually a large amount of rock which finds its market in the towns and farming communities of the county. The ledges furnishing the most serviceable stone lie above number 6 of the general section. The material from the uppermost beds comes out in rather shapeless blocks, but a large amount of it is used for rip-rap in the immediate vicinity of the quarry.

The Crowley quarry in the channel of the river south of the old bridge at Iowa City, works only a few beds, including some below and some above the coral reef, number 6. The aggregate thickness of the beds does not exceed ten or twelve feet. The quality of the stone is the same as from corresponding beds in other quarries.

The quarry near the Iron bridge, two and one-half miles south of Shueyville, has been worked by different persons for a number of years. The stone is in general of the same quality as that furnished by the quarries near Iowa City, rather superior if there be any difference, but suited only for such structures as may be built of stone shaped roughly and quickly with the hammer. In this quarry the beds numbered 8, 9, and 10 in the general section are blended into one, and this single bed is exceedingly rich in true corals such as

Acervularia, Cyathophyllum, Diphyllum and Favosites. Idiostroma and other stromatoporoids are abundant, but they are not so prominent as in the corresponding beds farther south.

The railway quarry north of Coralville furnishes stone of the same quality as that from the other quarries of the Cedar Valley stage, the best product coming from the firm blue ledges above the coral reef, number 6 of the general section. The McCollister quarry in section 22, Lucas township, is worked in rather light-colored beds between the coral reef and the stromatoporoid horizon number 8. Numerous other quarries have been operated temporarily at this horizon, the work being done in each case to supply the immediate needs of some small neighborhood, or probably of only a single farm. The aggregate annual value of the building stone, taken from this stage is large, but the work is distributed among many quarries. In none is the equipment very expensive. The ledges are loosened up by blasting, and afterwards broken by sledges into pieces convenient to be handled without hoisting machinery.

The State Quarry stage.—The beds of the State Quarry stage are capable of furnishing a building stone that in point of durability and ease of cutting is unexcelled. The rock resists the action of the weather admirably. The ledges vary from a few inches to five feet in thickness, and thus furnish a wide range of choice, so far as dimensions are concerned. The state quarries are located in section 5 of Penn township, in the west bluff of the Iowa river. They were first worked in connection with the building of the old capitol at Iowa City. They were worked even more extensively to furnish blocks for the foundation of the new capitol at Des Moines. Among the products of these quarries are bases for heavy monuments, blocks for bridge piers, curbstone, crossing-stone, and stone for ordinary building purposes. The finer grained ledges, composed of thoroughly triturated shells of brachiopods and skeletal parts of crinoids, afford good material for cut stone of the best grades.

For some years these quarries have been practically idle owing to the lack of transportation facilities and the expense of getting the product to market. A few small openings in the thinner bedded portions of the deposit are still operated to supply a rather limited local demand. Some of the smaller quarries in this horizon are in section 8 of Penn township. There are a few north of the main quarry in section 5. In section 20, of Graham township, beds of this horizon are quarried on a limited scale, and the exposure near Solon has also been worked to a small extent. The main body of this limestone in Penn township is the only one likely to attain commercial value in the future.

Des Moines stage.—Carboniferous sandstones of the Des Moines stage have been quarried at a few points in the county. The first work in beds of this horizon was done near Iowa City. In the early development of the city a number of houses were built of the laminated, shaly sandstone taken from quarries opened in the Iowa City outlier near the Terrill mill. The rock was found to discolor badly, and in other ways it soon showed the effect of weathering. In recent years stone from beds of this stage near Iowa City has been neglected.

The Amana outlier of the Des Moines stage, included in part in sections 27 to 30 of Monroe township, is a coarse non-laminated, rather friable sandstone. This has been quite extensively worked by the Amana society. There is one quarry in the salient headland near the mouth of Knapp creek, and a number of other exposures have been quarried more or less, between Knapp creek and the western limit of the county.

Railway Ballast and Road Material.

For some years the Chicago, Rock Island & Pacific Railway Co. operated a stone crusher at the quarry north of Coralville. The crushed stone was used for ballast along the line of the road. For such purposes the material is excellent and the supply inexhaustible.

The products of the quarries near Iowa City have been used extensively in macadamizing the public streets, and recently a large amount of crushed stone has been employed in making concrete foundations for brick paving. In the absence of available gravels it can only be a question of time until the use of macadam is extended to the clayey thoroughfares outside the cities. Throughout most of the northeastern half of the county stone for macadamizing the country roads will be found in convenient locations and inexhaustible abundance.

Ornamental Stone.

The corals embedded in the different zones of the Cedar Valley limestone are, in most cases, preserved in such a way as to render them available in the manufacture of paperweights and other small objects for which stone taking a high polish may be used. The articles so made are very attractive, and the annual value of the product is not inconsiderable. The original structure of the corals is perfectly preserved, and infiltrated calcite fills the pores, rendering the whole compact and in condition to receive a very beautiful polish. These polished corals have long been known as Iowa City marble. The species available for the manufacture of ornamental articles are *Acervularia davidsoni*, *Phillipsastrea billingsi*, Favosites, different species, and the various massive and cæspitose stromatoporoids. The first is the common "birds eye" of the marble shops. The second, in common parlance, is "cats eye." All the species of Favosites are grouped under the common name of "fish egg," and the massive stromatoporoids furnish the "wavy marble." Specimens for cutting and polishing are not found in pieces of any considerable size.

Flagging Stone.

Flag stone of excellent quality is furnished by the thinner bedded portions of the State Quarry formation. Large amounts have already been used for sidewalks in various parts of the county, and there is an abundant supply for all

future needs. Flag stones of almost any desired dimensions may be obtained. Even when laid in the most trying situations these flags are unaffected by the weather, and under the ordinary tread of foot passengers they last indefinitely.

Limes.

Stone suitable for the manufacture of lime occurs in the county at two horizons. The Le Claire limestone exposed on the Cedar river in section 2 of Cedar township would make a lime equal to the best made anywhere in the world. There is no evidence that it has been utilized in Johnson county, but beds of the same age and of similar quality furnish the limes of deservedly high reputation from Cedar valley, Sugar creek and Port Byron. The white limestone, number 11 of the general section of the Cedar Valley stage, has been burned into lime at a number of points in the northeastern part of the county. One of the most important kilns producing lime from beds of this zone was operated by Mr. Linder in section 34, Tp. 80, N., R. VI, W. Kilns using stone from the same horizon have been worked in sections 8 and 21 of Penn township, near Iowa City in Lucas township, and near the northeast corner of section 22 in Newport township. The local limes, however, have been almost entirely superseded by more desirable magnesian limes made from the Le Claire stage at Cedar valley and Sugar creek in Cedar county.

Sand.

Building sand has been obtained at a number of localities, the most important beds, economically considered, being found in the present flood plain of the Iowa river near Iowa City. There are some fairly good beds of sand in abandoned flood plains, or plains that are now submerged only during the very highest floods, as is illustrated in the southwest quarter of section 22 of Lucas township. There are also sands in the Iowan area southeast of Solon; and along the Iowa river in Oxford and Madison townships there are sand

beds of considerable extent. Very little sand suitable for building purposes is found in the southwestern part of the county.

Clays.

The clays of the county support a number of brick and tile factories. Workable clays are confined chiefly to the loess and alluvium. Clays of good quality are found in the Carboniferous outlier near Iowa City, but the beds are too thin to be worked with profit.

River Junction.—A brickyard owned by J. D. Musser is operated at River Junction. The clay used is a thin layer of alluvium and vegetable mould overlying Kansan drift. Hand moulded, sand-rolled brick are made, dried on the yard, and burned in a common cased kiln. Two kilns, with a capacity of 500,000 each, are burned annually. No machinery is used beyond the ordinary horse-power pug mills.

Oxford.—At Oxford, a brickyard is owned and operated by Mr. John W. Oser. An alluvial clay or modified loess overlying till of Kansan age, is used. The bed is about twelve feet in thickness with two feet of black loam at the top, beneath which is a band of strong bluish clay, followed in descending order by reddish, highly ferruginous clay which might be used in the manufacture of red pressed brick. A steam plant and Plymouth machine with force feed constitute the principal part of the equipment. The brick are side cut; they are dried in sheds and burned in cased kilns. The machine has a capacity of 30,000 brick per day. In actual practice the daily output when running is from 10,000 to 12,000. To prevent checking the clay has to be mixed with sand.

Tiffin.—Brick and tile are manufactured by the Tiffin Tile Co. An alluvial clay from the flood plain of Clear creek furnishes the raw material. The clay bed is ten to twelve feet thick, and is underlain by sand. It is only recently that the company has undertaken the manufacture of brick. The plant embraces a steam plant of forty-five horse-power, a

Brewer-Tiffany machine, with a capacity of 10,000 three-inch tile daily, steam heated drying sheds, two circular down draft kilns twenty-two feet in diameter, a repress machine, and the necessary trucks, elevators, tramways and chutes for handling the material in the various stages of manufacture. The product embraces six sizes of drain tile, from three to eight inches inclusive, together with side-cut and repressed brick.

Iowa City.—At Iowa City there are two yards that make brick, and one that makes brick and tile. In all cases the clay used comes from the loess. The yard of Mr. Goss is located in the northeastern part of the city. The loess here has a thickness of more than thirty feet, and the part recently worked shows a vertical breast of eighteen feet. The lower part of the exposure is a fine bluish clay, streaked vertically and horizontally with red. The vertical streaks are due to the "pipes" of iron oxide already noted. The lower bluish phase of the loess is very fossiliferous. The upper part of the vertical face is yellow in color, but there are a number of undulating, horizontal ferruginous bands that may represent successive surfaces covered at intervals by wind-driven dust or water-laid silt. The brick are hand made, dried on the yard—each tier, when drying, having separate roof and side curtains for protection from rain—and burned in large clamp kilns.

Mr. C. Gaulocher operates a yard just east of that belonging to Mr. Goss. The clay used is essentially the same, and the process of manufacture is not materially different. No machinery is used beyond the ordinary pug mill. The brick are sand rolled, hand made, and the temporary cased kiln is used for burning. The annual product of the Gaulocher and Goss yards, together, approximates 2,000,000 brick. The brick have a good color and are of excellent quality for ordinary structural purposes.

The third yard is located in the southeastern part of the city and known as the Nicholas Oakes Brick and Tile works. The product of this yard includes ordinary structural brick,

sidewalk brick, repressed brick, and drain tiling ranging from three to eight inches in diameter. Various grades of loess clay are used, and are mixed for the several products in the proportions demonstrated by experience to be best. The bed of clay now used is eighteen feet in thickness. A thirty-horse power steam plant, and a Nolan & Madden auger machine adapted to make both brick and tile, constitute the most important part of the equipment. The machine has a capacity of 12,000 three-inch tile, or 40,000 brick per day. End cut brick are produced. A Perfection repress machine, with a capacity of 5,000 a day, is operated part of the time. The ware is dried in permanent sheds. Two down draft kilns, each twenty-two feet in diameter, are used for burning tile. The brick are burned in a common clamp kiln, the kiln having a capacity of 400,000. Three million brick have been made by this firm in a single year. During the season of 1896 fifteen kilns of tile were burned.

Minerals.

There are a few minerals that occur in the county, but in quantities too small to be of economic importance. There are some thin seams of potter's clay in the Iowa City Carboniferous outlier, and near the home of Mr. Euclid Sanders the same formation contains a thin vein of coal. Coal has also been found either in the drift or immediately beneath it at a number of points in Washington township, and indications of coal are not uncommon in other localities.

Crystals of zinc sulphide (sphalerite) are frequently met with in small cavities or pockets in the Cedar Valley limestones, and good examples of ferrous sulphide (pyrite) is common at the same horizon. These minerals occur here generally in beds containing embedded corals such as *Acervularia* and massive *Favosites*. In certain localities these corals have been transformed into hollow geode-like masses as a result of solution, and it is in the cavities so formed that the sphalerite and pyrite are usually found. More frequently, however, the cavities are lined with beautiful crystals of calcite.

Water Supply.

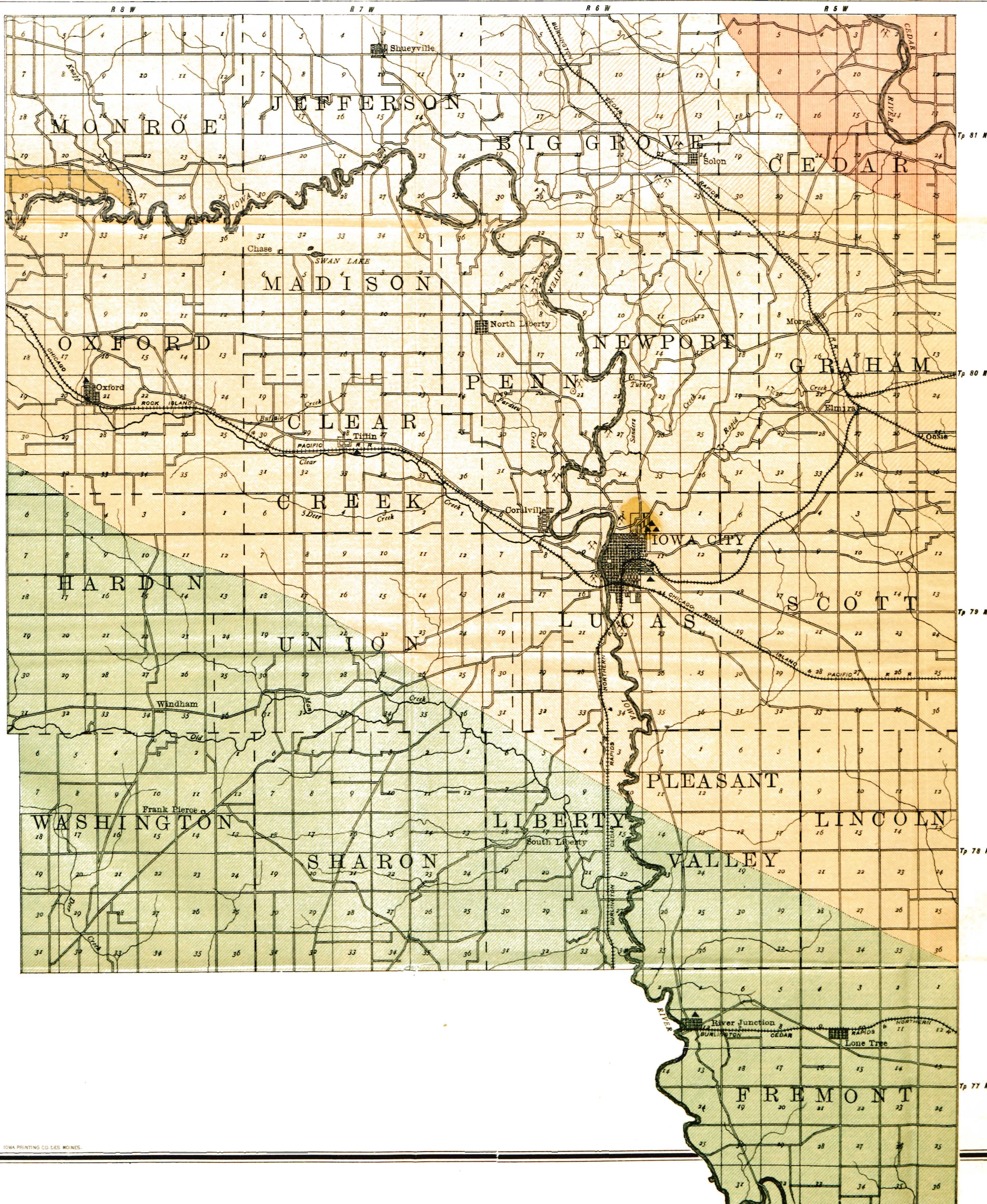
The Iowa and Cedar rivers are the only streams of the county that can be certainly counted as permanent during periods of drought. Portions of the county distant from these streams must depend on wells for a permanent water supply. Fortunately water is abundant in the superficial deposits at depths ranging from fifty to 300 feet. At very few points is any rock drilling necessary to get bounteous supplies of pure, wholesome water.

Water Powers.

The principal water powers in the county are two, one at Coralville and one at the Terrill mill north of Iowa City, both on the Iowa river. At the first the head is twelve feet, at the second it is seven or eight feet. At each there is water enough going to waste to supply additional industries with power.

ACKNOWLEDGMENTS.

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IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF **JOHNSON** COUNTY, IOWA.

BY
SAMUEL CALVIN
1897.

LEGEND GEOLOGICAL FORMATIONS

DES MOINES	
KINDERHOOK (NOT EXPOSED)	
STATE QUARRY	
CEDAR VALLEY	
FAYETTE	
OTIS AND INDEPENDENCE (NOT EXPOSED)	
BERTRAM AND COGGAN (NOT EXPOSED)	
LE CLAIRE AND ANAMOSA	

INDUSTRIES

QUARRIES	⚡
CLAY WORKS	▲
LIME KILNS	○

FOREST TREES OF JOHNSON COUNTY.

BY T. H. MACBRIDE.

The following is a list of the native larger shrubs and trees growing in Johnson county.

Asimina triloba Dunal. Common Papaw. Found sparingly in the southern part of the county.

Tilia americana L. Basswood. Common.

Xanthoxylum americanum Mill. Northern Prickly ash. Sometimes reaching a height of fifteen feet.

Ptelea trifoliata L. Hop-tree. Not common. In southern part of county.

Euonymus atropurpureus Jacq. Burning bush. Common.

Rhamnus lanceolata Pursh. Buckthorn. Not rare.

Æsculus glabra Willd. Fetid Buckeye. Found only in the southwestern part of the county.

Acer saccharinum Wang. Hard maple, Sugar maple. Not rare. Occurring chiefly on rocky hillsides.

Acer dasycarpum Ehrh. Soft maple. Common along streams.

Acer rubrum L. Red maple. Rare.

Negundo aceroides Moench. Box elder. Common.

Staphylea trifolia L. American Bladder-nut. Rather frequent.

Rhus glabra L. Smooth sumach. Common. Often becoming a small tree.

Robinia pseudacacia L. Common locust, Black locust. Not rare. Frequently cultivated for ornament.

Gymnocladus canadensis Lam. Kentucky Coffee-tree. Rare.

Gleditschia triacanthos L. Honey Locust. Rather common. Often almost destitute of thorns.

Prunus americana Marsh. Wild plum. Very common.

Prunus virginiana L. Choke cherry. Common along rocky hillsides.

Prunus serotina Ehrh. Wild cherry. Frequent. Scattered throughout the forest-area of the county.

Pyrus coronaria L. American crab apple. Everywhere common.

Crataegus coccinea L. Common hawthorn. Common.

Crataegus coccinea L. var. *mollis* Torr. and Gray. Red hawthorn. Common. The comparatively large fruit of this form is edible.

Crataegus tomentosa L. Scarlet thorn. Common.

Crataegus crus-galli L. Cockspur thorn. Not rare.

Amelanchier canadensis Torr. and Gray. Shad-bush, Service-berry, June-berry. Common along rocky slopes.

Cornus asperifolia Mx. Dogwood. Not rare in sandy places.

Cornus stolonifera Mx. Red-osier dogwood. Common along streams.

Cornus paniculata L'Her. Panicked cornel. Very common on high grounds.

Viburnum dentatum L. Arrow-wood. Rather rare.

Viburnum lentago L. Black haw, Sheep-berry. Still quite common along streams.

Viburnum prunifolium L. Black haw. Rare. This and the preceding species were formerly very common, but the clearing of creek and river bottoms for pasture and farm lands has materially affected both species, the latter perhaps suffering more.

Cephalanthus occidentalis L. Button-bush. Common in swampy places.

Fraxinus americana L. White ash. Common. Chiefly along streams.

Fraxinus viridis Mx. f. Green ash. Less frequent than the preceding.

Ulmus fulva Mx. Slippery elm, Red elm. Common.

Ulmus americana L. American elm, White elm. Very common.

Celtis occidentalis L. Hackberry. Very common along the Iowa river.

Morus rubra L. Red mulberry. Not common. More frequently found in the northern part of the county.

Platanus occidentalis L. Sycamore, Buttonwood. Rather common along the Iowa river.

Juglans cinerea L. Butternut, White walnut. Common on hillsides and along streams.

Juglans nigra L. Black walnut. Becoming rather less common. Formerly very abundant along all the streams in the county.

Carya alba Mott. Hickory. Very common, chiefly on higher grounds.

Carya sulcata Nutt. Shell-bark. One tree, probably of this species, is found near Iowa City.

Carya amara Nutt. Bitter-nut, Pignut. Common, chiefly on higher grounds. Specimens of bitter-nuts, resembling *Carya porcina* Nutt. have also been collected, but the occurrence of the species in Johnson county is not established beyond question.

Betula nigra L. River birch, Red birch. Common along the larger streams.

Corylus americana Walt. Hazel-nut. Very common.

Ostrya virginica Wild. Ironwood, Hop horn-beam. Very common, chiefly on higher grounds.

Carpinus caroliniana Wild. Ironwood, American horn-beam. On rocky banks along the smaller streams. Less common than the preceding.

Quercus alba L. White oak. Very common.

Quercus macrocarpa Mx. Bur oak. Very common.

Quercus muhlenbergii Eng. Chestnut oak. Found occasionally on rocky hillsides along the Iowa river.

Quercus rubra L. Red oak. Common on higher grounds.

Quercus coccinea Wang. Scarlet oak. Common chiefly on lower grounds.

Quercus coccinea Wang, var. *tinctoria* Gray. Quercitron, Black oak. Rare.

Quercus palustris Du Roi. Swamp oak, Spanish oak, Pin oak. Occasional along the Iowa river in the northern part of the county.

Quercus imbricaria Mx. Shingle oak, Laurel oak. Found only in the southern part of the county, where it is not rare on the Iowa river and Old Man's creek bottoms.

Salix nigra Marsh. Black willow. Common along the Iowa river and other streams.

Salix amygdaloides Anders. Black willow. Common with the preceding.

Salix discolor Muhl. Glaucous willow, Pussy willow. Quite common on low grounds, chiefly along small streams.

Salix cordata Muhl. Heart-leaved willow. Common on low grounds.

Populus tremuloides Mx. American aspen, Quaking asp. Common generally on low grounds.

Populus grandidentata Mx. Large-toothed aspen, Quaking asp. Poplar. Very common, soon taking possession of neglected clearings on higher grounds.

Populus monilifera Ait. Cottonwood, Necklace poplar. Common on low grounds.

Juniperus virginiana L. Red cedar. Formerly common on rocky bluffs along the Iowa river. Now quite rare.

The nomenclature in the above list is that of the sixth edition of Gray's Manual.

ON THE OCCURRENCE OF FOSSIL FISHES IN THE DEVONIAN OF IOWA.

BY DR. C. R. EASTMAN.

The fish faunas of the Devonian and Carboniferous systems present such marked differences as in a measure to justify the assertion that a great revolution in ichthyic development took place toward the close of the former period. During the Devonian, the fishes commonly known as Placoderms greatly preponderated over the Elasmobranchs, which continued to hold a subordinate position, both relatively and

absolutely, from the date of their initiation onward. But with the extinction of the Placoderms at the close of the Devonian, the Elasmobranchs entered upon a new era of development, increasing prodigiously in point of numbers and variety, attaining greater size, and becoming more formidably armed. In contrast with the remarkable dearth of Elasmobranchs in the Silurian and Devonian, upwards of 600 species have been described from the Carboniferous of this country and Europe; and it is probable that this group of fishes was much more abundant during the Carboniferous than at present or during any other geologic period.*

With the exception of *Cladodus* and its allies, very few representatives of Carboniferous genera have been met with in the Devonian, and these are restricted chiefly to the upper members of the system. Again, while the earliest and most primitive type of Elasmobranch dentition with which we are acquainted (*Protodus*, *Diplodus*, *Cladodus*) was adapted for piercing, and while this type prevails to the exclusion of almost all others in the Devonian, at least three-fourths of the known Carboniferous species possessed crushing teeth, which were "adapted to the trituration of mollusks and crustaceans; and the number of those provided with cutting or piercing teeth was comparatively small."† All of these crushing teeth are more or less highly specialized, yet they appear suddenly and in great profusion in the lowermost Carboniferous, apparently unlinked to any forms that have gone before. Thus the large group of the *Cochliodontidae* is commonly supposed‡ to be confined to the Carboniferous; and the same may be said of the *Psammodontidae*, if we except a very doubtful species founded on imperfect material from the Corniferous limestone (*Psammodus antiquus* Newb.).§

*"The defensive spines found in the Carboniferous rocks outnumber ten to one those of all other geological systems, and they surpass in very much greater proportion anything we find in the living fauna."—Newberry, J. S., *Paleozoic Fishes of North America* (Monograph XVI of the U. S. Geol. Survey, p. 79) 1889.

†*Op. cit.*, p. 184.

‡If we can regard the genus as correctly determined, a fragment of *Cochliodus* has been found in the Upper Devonian of Belgium. Cf. Dormal, V., *Sur les poissons dévoniens dans le bassin de Namur* (Proc. verb. Soc. Malacol. Belg., vol. XVI, p. cxxxv). 1887.

§The only account of this species is that given by Newberry in the Bulletin of the National Institute for 1857, copies of which are now very scarce. The author was careful to state that no perfect specimens had been secured, and it was conceded as "possible that they are generically different from *Psammodus*." It is not known whether the originals of this description are still in existence; a search for them at the School of Mines Cabinet of Columbia University proved unsuccessful, and the form has not been recognized in other collections.

These families comprise the bulk of Carboniferous Selachian teeth; but although certain generic relationships are observable among their respective members, we know as yet nothing of intermediate forms connecting the two families, nor of the manner in which compound teeth originated from marginal. That the separation of Psammodont and Cochliodont forerunners took place during the Devonian can hardly be doubted; but how the teeth were arranged in the ancestral condition, and first became fused together, we have had as yet no means for determining.

The Dipnoans likewise possess compound teeth which are curiously modified; but here again we must confess ignorance of the stages of specialization passed through by them. It is conceded that this group of fishes was derived from the Elasmobranch stem; nevertheless we cannot say definitely when the Dipnoan branch was given off, although it was probably subsequent to the development of compound teeth in the parent stock. If by any chance the primitive stages of Dipnoan and Elasmobranch compound dentition should become known to us, and should prove to be in essential agreement, it could not be doubted that the former are directly inherited from the latter. Let it be proved that the compound teeth of Dipnoans and Elasmobranchs have arisen through *convergence* instead of parallelism, and we can state positively that the divergence of these groups took place not earlier than the Devonian. Fortunately, additional evidence is now at hand, which affords some insight into these problems, and reveals closer affinities between Dipnoan and Elasmobranch dentition than have been known to exist before. Among other things it acquaints us with types of compound teeth, such as existed in primitive Dipnoans; and the analogy with primitive Selachian teeth is such as to leave no doubt that they had a common origin, for which no earlier date than the Devonian can be assigned. Evidence of this character, it is needless to remark, is of far greater importance than the discovery of merely new genera and species, no matter how much intrinsic interest the same may possess.

The evidence in question consists of large numbers of perfectly preserved fish-teeth, forming part of a remarkable fauna recently discovered by Professor Calvin in rocks which he considers to be of Upper Devonian age. Some of the teeth bear such close resemblance to those of Carboniferous sharks that they were at first mistaken for them or their allies; but with the acquisition of larger material very remarkable transitions were observed between them and undoubted Dipterid species (*cf.* Plate iv, Figs. 32-42). Among other features, a true root was found to be absent, as in the Dipterids; and when finally the microscopic structure was compared with that of a number of Dipnoan genera, no essential differences could be detected. As in *Dipterus*, *Otenodus*, *Ceratodus*, etc., the dental plates are composed of an osseous tissue instead of dentine; the vascular canals, which are of nearly uniform size, form an irregular network, and give off numerous exceedingly minute canaliculi; moreover, small lacunæ, very distinct from the vascular canals, are interspersed here and there in the ground substance. All this is very different from the structure of dentine, in which lacunæ are absent, and there is either a pulp-cavity or a system of medullary canals corresponding to it. In a word, we have here a variety of new Dipnoan forms, differing widely from those that have been hitherto described, and remarkable in many respects. Owing to the absence of other parts of the skeleton nothing can be stated at present in regard to their family position.

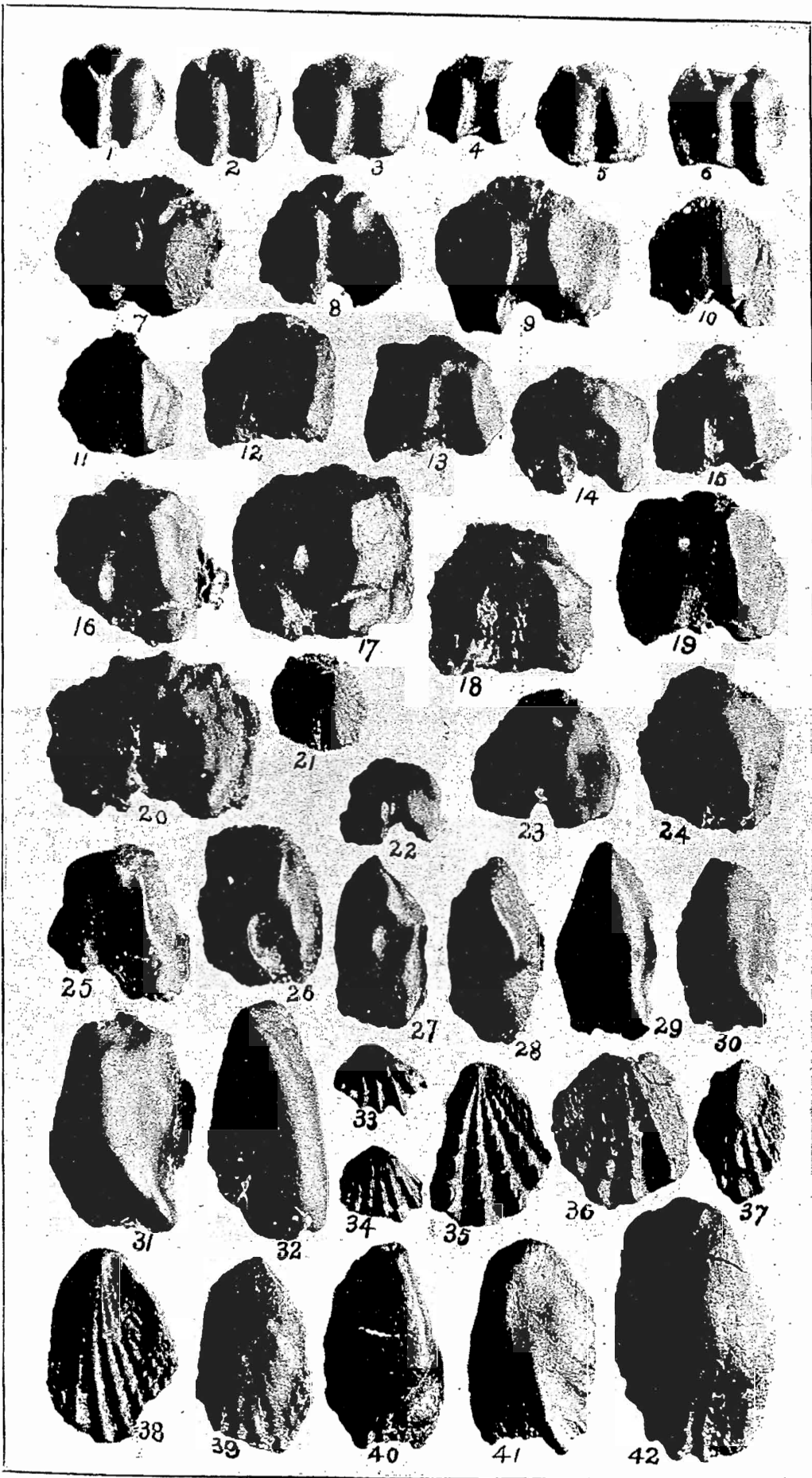
Although it is beyond the scope of the present article to enter into any descriptions of these remains, still a few words may be said concerning the series of variations exhibited by the form which we will designate provisionally as *Synthetodus*.* Some of these variations obviously represent different stages of growth; others, which are capable of being co-ordinated with one another, enable us to distinguish between upper and lower dental plates; and still others, which are of more trenchant character, may be regarded as having specific value.

* $\sum \text{uv. } \delta \text{ } \epsilon \text{ } 17009$, put or welded together; $\delta \text{ } 17009$, tooth.

Several examples of a species for which the name *S. trisulcatus* is suggested by Professor Calvin, are shown in the two uppermost rows of Plate iv. This may be regarded as the most primitive type of Dipnoan dentition that has yet been discovered. A comparison of a number of examples proves that the form shown in Fig. 1 represents a young, or at least, an immature stage, having the sutures between its constituent elements more or less open. The next stage (Figs. 4, 8) is marked by a gradual coalescence of the lateral and symphyseal elements, together with a filling in of the median area, so that this last appears nearly flat on the oral surface.

A parallel to the condition just described is furnished by several species of *Copodus* among the sharks, although here all traces of a median longitudinal suture have disappeared. The upturned lateral margins of *C. spatulatus* and *C. prototypus* are clearly homologous with the two lateral elements of *Synthetodus*. That the dental plates of *Synthetodus* were supported by cartilage, as in the sharks, instead of by bone, appears probable from the occurrence of a distinct plate lying directly across the symphysis, as well as from the nature of the base. Considering the wonderful preservation of these teeth, we should expect to find some of them still attached to the palato-pterygoid and splenial bones, providing the cranium was ossified. As no traces whatsoever of bone have been found, and as the dentition is comparable with that in *Copodus* (cf. Fig. 25) and other genera of sharks, the conclusion appears irresistible that we have here evidence of lowly forms of Dipnoans, whose dental plates recall the ancestral conditions of pavement teeth such as was developed by Elasmobranchs prior to the divergence of lung-fishes.

The adult stages of *S. trisulcatus* are not shown in any of the photographed specimens, but in Plate iv, Figs. 14-16 may be seen mature individuals of another species of *Synthetodus*. Evidences of wear are very palpable at this stage, and hollows are excavated in the central portion conformable to the opposing dentition (Figs. 18, 19). Long continued



TEETH OF DEVONIAN LUNG-FISHES. FROM THE STATE QUARRY FISH BED, JOHNSON COUNTY, IOWA.

abrasion gives rise to smooth, elliptical or tongue-shaped depressions, precisely similar to the worn surfaces in the teeth of *Copodus*. Finally, in old age, when detrition of the surface is no longer compensated for by growth of the tooth from its base, the oral surface is worn nearly flat, and the margins become greatly attenuated. Several examples have been observed exhibiting this stage. Figures 12 and 21 show it approximately.

Synthetodus and its allies or derivatives make up the greater part of the Dipnoan remains from this horizon. A few teeth have been noticed which bear some resemblance to those called *Conchodus* by M'Coy, and *Cheirodus* by Pander;* and these are seen to pass by gradual transitions (Figs. 38-42) into true Dipterid forms. The genus *Dipterus* is represented in this country by two species from the Catskill and four from the Chemung group of Pennsylvania;† but the forms discovered by Professor Calvin in the old State Quarry beds, near North Liberty (Figs. 33-38), are not identifiable with any of these. It is possible, of course, on the theory of the shagreen origin of dental plates to explain Figures 39-42 as representing obsolescence instead of initiation of radial ribbing. But as the ground-type, *Synthetodus*, borne possibly by a cartilaginous lung-fish, is seen to have been smooth; and since, furthermore, a passage is observable between plications (Fig. 19) and ribs (Fig. 41), as well as between smooth ribs and denticulated (Figs. 33-35); it appears preferable, at least in the opinion of the present writer, to regard the dental plates of *Dipterus valenciennesi*, *Otenodus cristatus*, etc., as extreme modifications of a type that was first entirely smooth, and next became smooth-ribbed. The crenulation of the margin in

*Pander's work on "Die ctenodipterinen des devonischen systems" has remained as yet inaccessible to the present writer, and he is indebted to Mr. A. S. Woodward, to whom photographs were submitted, for having suggested a similarity to some of the Russian forms.

†An unfinished manuscript lately discovered among the effects of Professor Newberry, and to be issued as a posthumous publication under the editorship of Mr. Bashford Dean, contains descriptions of two new species of *Dipterus* from the Chemung group of Pennsylvania. Mr. Dean was kind enough to compare the originals with photographs of the new Iowa species, and pronounces them distinct. The same MS. also mentions the occurrence of *Ptyctodus* teeth in the so-called "Kinderhook beds" of Louisiana, Missouri; and it is stated that no differences can be detected between them and the well-known *P. calceolus*, which is limited to rocks of Devonian age. This is important, for it furnishes additional confirmation of the view contended for by Calvin and Keyes that a part of the formation at Louisiana is unquestionably Devonian.

Psephodus does not indicate the decadence of ribbing, but a primary stage of its introduction.

Indications of Arthrodires occur in the form of large, heavy fragments, some of which must have pertained to fishes of considerable size. Most of the remains that have been examined thus far are too imperfectly preserved for satisfactory determination, but one or two are plainly referable to the genus *Dinichthys*. One fragment shows the base of the supra-occipital region of the cranium, indicating a creature of about the size of *D. intermedius*. Another shows the articulating condyle of an antero-dorso-lateral plate. As this genus is already known from the Devonian of Manitoba, and from the Hydraulic limestone (Hamilton) of Wisconsin, its occurrence in the North Liberty beds is not surprising. It is to be hoped that further search may be rewarded by the discovery of more numerous and perfect specimens than have yet been secured.

Turning our attention lastly to the Elasmobranchs, we find that Cladodonts and other types of piercing and cutting teeth are conspicuously absent; neither have any crushing teeth been encountered that can be positively identified as Selachian, although in the case of some forms it will require careful microscopic study to determine their nature absolutely. It is also noteworthy that no dermal spines have been met with; hence, as far as present evidence goes, there is nothing to disprove the generalization that defensive armament was uncommon among pre-Carboniferous sharks.

The absence or paucity of Selachian remains in these beds is compensated for by prodigious numbers of Chimæroids. So far as observed, they all pertain to a single species of *Ptyctodus* (*P. calceolus*), and as a rule, only the detached and partly abraded tritoral areas are preserved. Nevertheless these fragments are so plentiful that the rock may be said to be fairly charged with them in places. The average size of the tritors appears to be somewhat smaller than in *P. calceolus*, but where the complete jaw or dental plate has been observed, it presents no characters which serve to distinguish it from

that species. The accompanying text-figures are instructive inasmuch as they show for the first time the nature of the symphyseal region in the American and also a European species. The inner face of the dental plates (both of the figures show the outer face) retains markings at the symphysis where they were suturally united with their fellows. These dental plates possessed but one tritor each, in advance of which was a cutting edge terminated

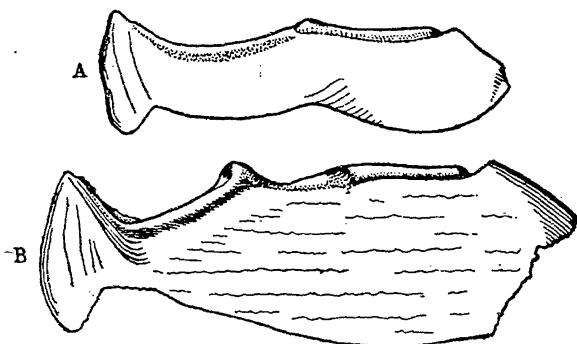


FIG. 10. Dental plates of *Ptyctodus*, showing outer surface. A *Ptyctodus calceolus* N. and W. (from Iowa); B *Ptyctodus molaris* Eastman (from Europe).

in front by a sharp projection. The original of figure B is the most perfect of several examples preserved in the Museum of Comparative Zoology at Cambridge, all from the Middle Devonian of the Eifel district, in Rhenish Prussia. For this form the name *P. molaris* is proposed. Other species with two tritors to each dental plate, have been described from the Middle Devonian of Russia and the Baltic Sea Provinces. The solitary American species has, so far, been reported from the Middle Devonian (Hamilton) of Canada, and from a few localities in Iowa, Illinois, and Missouri.

From the foregoing it will be apparent that we have here to deal with a unique and highly interesting assemblage of fossil fishes. A number of new Dipnoan genera are encountered, some of which present astonishing resemblance to primeval sharks, and others are connected by gradual transitions with *Dipterus*. Careful study of these forms can hardly fail to clear up many difficult problems affecting Paleozoic fishes. The presence of *Dipterus* and *Arthrodiros* brings the Iowa fauna into relationships with the Chemung and Catskill of Pennsylvania on the one hand, and with the Waverly of Ohio on the other. Nevertheless the different aspects of these faunas when compared with one another are very

considerable. Through *Ptyctrodus calceolus* the fauna is related also to the Hamilton of the Mississippi valley. The abundance of this form, and the absence of all other Elasmobranchs is a surprising circumstance. However, it is more than likely that further search will bring to light many forms which we should naturally expect to find in rocks of this horizon.

These, in brief, appear to be the leading conclusions arrived at from a somewhat superficial examination of the material that has been thus far collected. The results of a more detailed investigation will form the basis of a future report.

An idea of the perfect preservation of these fish remains may be had from an inspection of the accompanying plate, reproduced from a photograph. On this it is only possible to show a few of the more interesting forms.