GEOLOGY OF JACKSON COUNTY.

BY

T. E. SAVAGE.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

The area embraced by Jackson county was a part of the territory purchased from the Indian Chief Black Hawk in 1832. It was originally included in the county of Dubuque from which it was separated in 1837, and named in honor of Andrew Jackson.

It lies near the middle line of the state from north to south, in the eastern tier of counties, and together with Clinton county, forms the most easterly projecting point of Iowa. Dubuque county bounds it on the north, Jones and Dubuque join it on the west, Clinton lies to the south, and its eastern border is formed by the channel of the Mississippi river.

The county is organized into 18 civil townships which are included within townships 84 to 87 north of the base line and ranges I to V east of the fifth principal meridian. It embraces an area of 638 square miles.

Jackson county is a region of bold relief where wagon roads wind up and down and around a monotonous succession of hills; where steep mural precipices border insignificant streams; and where the landscapes have a charming variety of picturesque ledges, wooded bluffs and fruitful fields. It was originally a forest-covered area such as the sturdy pioneer found an attractive place in which to build his home.

EARLIER GEOLOGICAL WORK.

In a report published in 1858 Professor J. D. Whitney* discussed briefly the topography and geological formations presented in Jackson county. He referred to deposits of iron ore reported to have been found in this region, and also to some diggings that had been made for lead along Morts creek. Dr. Charles A. White† mentions a few places in Jackson county, in describing the limits of the Maquoketa shale in eastern Iowa, but makes no further reference to points within the area.

In a monograph on the Pleistocene History of Northeastern Iowa.‡W J McGee describes the thickness of the Maquoketa

*Geology of Iowa, Vol. I, part 1, pp. 282-285, 420 and 446, 1858
†White: Geology of Iowa, Vol. I, p. 80, 1870.
‡Eleventh Ann. Rept., U. S. Geol Surv , pp 216, 326, 327, 426, 427, 436, 532, 533 and 553 1890

shale, the topography, some gravel benches, loess deposits, and well sections at certain points in the area under consideration.

A paper by Professor Herbert Osborn* on "Some Carboniferous Fossils from Jackson county, Iowa", describes an outlier of Carboniferous sandstone near Monmouth.

In his monograph on the Illinois Glacial Lobe** Mr. Frank Leverett discusses in a general way the Pleistocene deposits of the southern portion of Jackson and the northern part of Clinton counties.

In the Proceedings of the Davenport Academy of Sciences mention is made of a number of Indian mounds that have been explored in Jackson county, and a description of the contents of these mounds is given in some detail.†

Professor W. H. Norton describes a number of isolated deposits of sandstone and shale occurring within the limits of Jackson county, in a paper on Certain Devonian and Carboniferous Outliers in Eastern Iowa.§

A few years ago Mr. Harvey Reid published a short Outline Geological History of Jackson county, as a basis for an exhibition of maps and rock specimens before the Jackson county Normal Institute.‡ Two of the topographic sheets published by the United States Geological Survey cover a portion of the area under consideration. The south half of the sheet known as the Peosta quadrangle includes the greater part of the west half of the county. The topography of a small area in the southeast corner is represented on the Savanna sheet.

PHYSIOGRAPHY.

TOPOGRAPHY.

Over the greater portion of Jackson county the surface is generally quite rugged and broken. The topography for the most part resembles that of the driftless area, although it seems probable that the margin of the Kansan ice sheet overspread almost the entire county. A narrow strip of prairie in the southern and southeastern portion, and another small area of

*Osborn: Proc. Iowa Acad. Sci., Vol. I, part 2, p. 115.
**Monograph XXXVIII U. S. Geol. Surv., pp. 144-147, 1899.
†Proc. Davenport Acad. Nat. Sci., Vol. II, p. 173 and Vol. VI, pp. 81-83.
§Norton: Iowa Geol. Surv., Vol. III, pp. 117-133, 1895.
‡Reid: Outline Geological History of Jackson County, pp. 1-8, 1903.

level land near the northwest corner, are the principal exceptions to the trenched and furrowed character of the surface.

In the north-central portion of Butler township a narrow lobe of Iowan ice extended southward from Dubuque county, covering an area about eight square miles in extent. Over this region the surface is comparatively level, or but moderately gullied by the streams. Fresh looking bowlders of Iowan age are conspicuous in sections 15 and 16 of this township. Further south and west the loess becomes deeper and the surface becomes more and more profoundly eroded as the channel of the North Fork of the Maquoketa river is approached.

The narrow divide that separates the basin of the North Fork from that of the South Fork of the Maquoketa river extends from near the hamlet of Iron Hill past the village of Emeline, and continues towards the northwest into Jones county. This watershed has an elevation of 980 feet above the sea. It rises nearly 300 feet above the bottoms of the basins which lie about two miles distant on either side.

The narrow channels of these rivers are bordered by almost no alluvial deposits. They are often bounded on the south by discontinuous bluffs of Niagara limestone which in many places rise precipitously to a height of from seventy-five to 140 feet. The bluffs in the north banks of these rivers are usually more gently sloping and are more generally composed of superficial materials than those on the south, probably because of the more rapid weathering of the south facing slopes than of those inclining towards the north.

The lateral branches that owe allegiance to these rivers in Brandon township are short, and have a steep gradient. Their waters have in many places carved gorges entirely through the Pleistocene materials and cut deeply into the underlying dolomite. Along these rock bound channels the waters flow swiftly in a series of shimmering ripples and turbulent cascades.

The northern portion of Monmouth township is also much dissected . Even the smaller streams are in many places bordered by low ledges of weathered dolomite. These channels

are six to eight rods in width, and appear almost choked with the deposit of loess clay that mantles alike the summits, slopes and lowlands.

Across the central portion of this township a level plain, one to two miles in width, extends from the town of Monmouth, towards the southeast, past the villages of Baldwin and Nashville and across the southern portion of South Fork township. Near the town of Maquoketa this belt of prairie takes a more southward trend and expands to a width of from four to six miles. It is bordered both on the north and the south by hills which rise 80 to 100 feet above the level land. The hills contain drift of Kansan age and are usually covered with a blanket of loess several feet in thickness. Occasional low ledges of Niagara limestone appear near the base of the hills.

A short distance west of the middle of section 21, Monmouth township, just south of the point where the wagon road crosses the track of the Chicago and Northwestern Railroad, there are a number of bowlders scattered over the level lowland. These are mostly of pink or gray granites which show but little signs of decay. Both in its topography and in the character and distribution of the bowlders this restricted area presents the appearance of a typical Iowan drift surface. However, there is no well defined Iowan drift area connecting this strip with the lobe of Iowan which extends into the southeastern portion of Jones county. It seems possible that these bowlders might have been carried by ice floes from the margin of the Iowan glacier, when it stood a few miles to the northwest, and that they became stranded at this point where the valley becomes very much more expanded.

That this strip of prairie represents the channel of some preglacial stream is shown in the fact that near the town of Nashville, a short distance west of the middle of the north side of section 25, Monmouth township, a well boring passed through 225 feet of Pleistocene materials without encountering indurated rock. Low benches of Niagara limestone outcrop in the foothills both to the north and south of this point. One-fourth of a mile west of this well the rock outcrops near the

top of a hill seventy-five feet above the altitude of the curb. Other wells over this lowland penetrate the surficial materials to water-bearing layers without reaching indurated beds.

In the southern portion of Monmouth township, below Mill Rock, is an area over which the surface is exceedingly rugged. Monuments of massive dolomite stand in ragged towers and jagged peaks bordering the water courses, while at several points along the channel of Bear creek, in sections 32 and 33, vertical escarpments rise sheer 100 to 130 feet above the water.

Over the north half of South Fork township, and the whole of the townships of Farmers Creek and Otter Creek, the topography is very broken, a change in altitude of 300 to 400 feet is often encountered within a distance of three to four miles. The surface is carved into an exceedingly irregular series of hills and ravines. Along the larger streams cliff-forming ledges of the resistant Niagara limestone stand in steep ramparts and rugged columns. This rock represents the upper portion of the *Pentamerus oblongus* horizon, and the Cerionites and crinoid-bearing zone immediately overlying that of Pentamerus. Some distance back from the bluffs the rocks are buried beneath a covering of loess. Even here, however, the ravines are numerous, the slopes are steep, and the summits of the hills often rise 100 feet above the minor valleys.

Near the middle of the north half of section 6, South Fork township, is an area known locally as "the caves". These consist of a series of natural bridges that have been developed by the waters of a small creek eroding a subterranean passage, and the subsequent partial caving in of the roof of the cavern.

The upper or most northerly bridge has a length of 150 feet across the gorge and a width of about sixty feet. The stream flows in a channel about ninety feet below the top of the bluffs. It has carved a passage fifty feet in height beneath the span of the bridge. About eight rods further down the stream a second arch crosses the ravine. This latter is several rods in width, but is so choked with silt and drift wood that the passage can only be followed with difficulty.

A few rods further down the creek there is a sink hole sixty feet in depth, having a diameter at the top of seventy-five feet.

Climbing down to the bottom of this shaft the explorer can readily follow an underground passage three hundred feet in length, forty to seventy feet in width and eight to twenty-five feet in height. At various points along this main passage there are to be seen entrances to smaller galleries which wind in and out along the sides and roof of the cavern. A beautiful spring, furnishing a stream of water four feet in width, issues from one

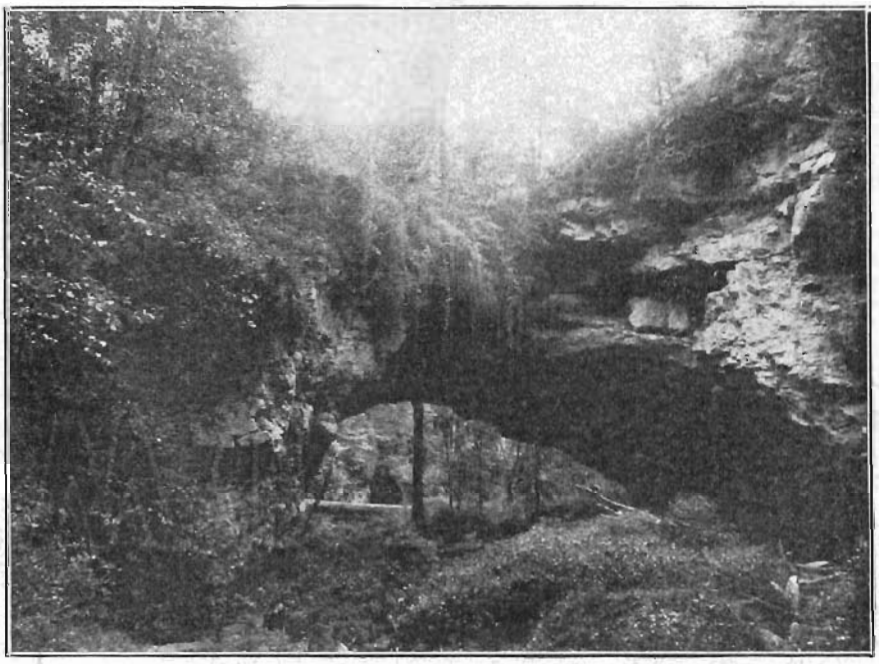

Fig. 64—Natural bridge formed by the erosion of an underground stream and the partial caving in of the roof. Section 6 of South Fork township.

of these lateral canals. At the lower end of the passage the stream emerges in a gorge whose bounding cliffs rise 125 feet on either side. This locality is a justly popular resort for drives and picnics for the people in all of the southwestern portion of the county.

In the southern part of Richland township, near the village of Cottonville, another series of caverns or underground passages have been developed.

Such channels are usually formed where streams having a steep gradient cut deeply into thick bedded limestones. Professor Shaler* has shown that their genesis also requires forest conditions. As the rain water filters through the leaf mould over woodland areas, it becomes charged with carbonic acid gas from plant decay. As this carbonated water slowly percolates along the crevices and joint planes of limestone strata, it gradually widens the fissures by taking into solution some of the material along the way. The amount of limestone thus dissolved by the water is always in direct proportion to the amount of carbonic acid gas that the water contains. As the passages become enlarged a larger volume of water follows them, and, in turn, the larger stream of water more rapidly increases the size of the channels by abrasion as well as by solution.

In the course of time the streams of such a region desert the surface, and find an outlet to their major streams through subterranean channels. If not too deep beneath the surface, the roof of these passages will eventually be broken through at some points giving rise to natural bridges. Gradually the underground channel may be converted into a gorge by the falling down of the roof along its entire course.

In section 6 of Prairie Spring township, the highest points have an elevation of 1190 feet above the sea, while at the middle of this township in the valley of Morts creek the altitude is only 740 feet. The uplands in the northern portion of Otter Creek township rise more than 250 feet above the beds of the streams. The divide between the Lytle creek basin on the west and that of Farmers creek on the east stands 1060 feet above the sea, while in Farmers Creek township the waters of these streams flow below the level of 700 feet.

A short distance back from the larger streams, and along the smaller tributaries in these townships, the bluffs and hills are composed of surficial materials. Deposits of loess are deep, and a considerable thickness of drift may in many places be seen along the water courses and on the flanks of the hills.

Over much of Maquoketa, Perry and Richland townships the same rugged type of topography prevails. At some points, as

*Shaler: Aspects of the Earth, p. 100.

along Brush creek in section 14 of Perry township, the waters of the streams wash the base of precipitous cliffs in which ledges of massive dolomite rise to a height of from ninety to 125 feet. In other places the banks are lower, and are crowned with weathered columns below and around which are strewn large, obdurate, fragmented masses of the slow disintegrating beds. From the top of the steeper bluffs the surface ascends

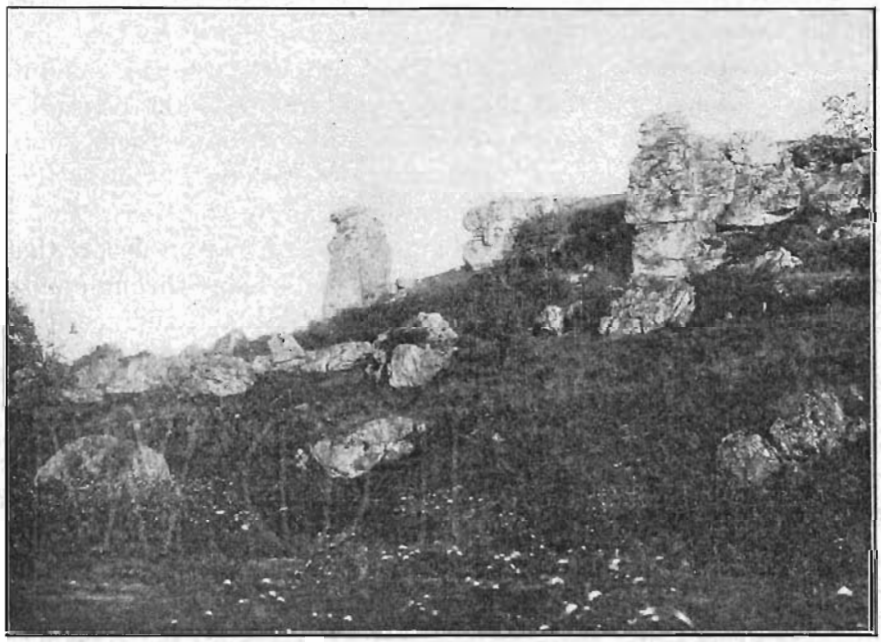

Fig. 65—View showing the manner in which the enduring bluffs of Niagara limestone slowly disintegrate and fall away.

in a succession of loess covered hills to an altitude 200 feet higher still. Notwithstanding the fact that the entire region is trenched and gullied by the streams, the loess mantled crests and slopes produce excellent crops of grass and grain in seasons of abundant rainfall.

In the extreme western and southern portions of Prairie Spring township the topography is such as is developed further south and west, as the result of water sculpture over regions whose surficial materials are underlain with beds of Niagara dolomite. In sections 4, 9 and 16 of this township springs

abound. Their waters issue low down in the bluffs, and the Maquoketa shale appears in the beds of the streams. On following down the valley of Morts creek from the middle of Prairie Spring township the channel gradually increases in width. Along the foot hills a gentle gradient has been developed on the Maquoketa shale to a constantly increasing height. Above the shale the steep ramparts of Niagara limestone, which confront each other across the valley, become ever more widely separated.

At the village of St. Donatus, in Tete des Morts township, the valley has expanded to a width of from one to one and one-half mile. On either side of the stream disconnected escarpments of Niagara limestone, forty to sixty feet in height, crown the cliffs which stand two hundred feet above the water. From the tops of the immediate bluffs the slopes rise quite rapidly

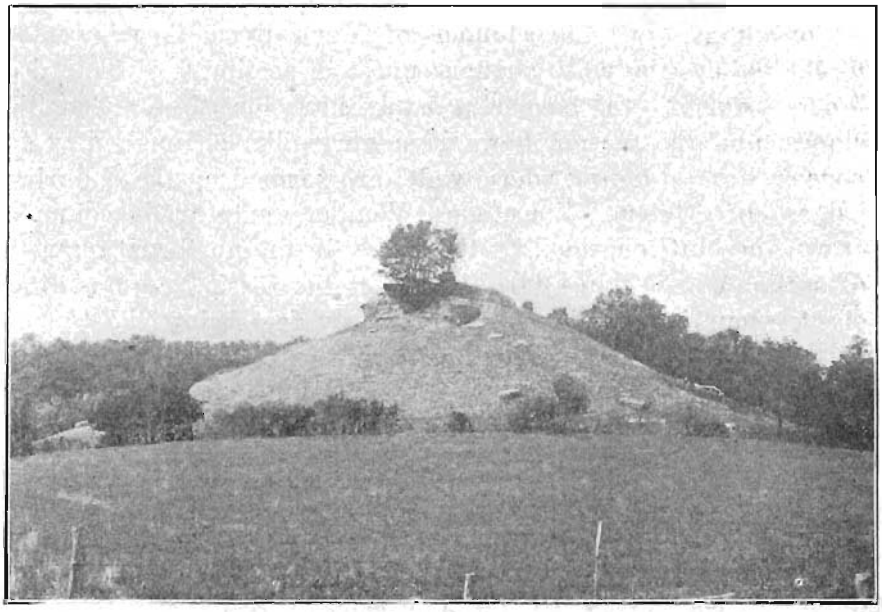

Fig. 66—Hill of circumdenudation in Tete des Morts township. The hill is protected by a cap of resistant Niagara.

250 feet higher, to the level of the ridges over the uplands. From the foot of the Niagara scarp the surface slopes gently down to the base of the Maquoketa shale for a distance of one-half mile on either side and to a vertical height of more than

100 feet. Over these gentle Maquoketa slopes large talus blocks of Niagara lie tilted at all angles, and each succeeding year they creep a little further downward towards the lowland plain.

At this place the flood plain of the creek is about forty rods in width. It is bordered on either side by a low bench or terrace of Galena limestone, twenty to twenty-five feet in height, which rises to the foot of the shales.

On the south side of the stream a large English Lutheran church overlooks the valley from a position near the top of the Maquoketa slope. At a corresponding position on the opposite bluff is a large Catholic church from which the worshippers have the inspiration of a like beautiful view over this charming valley. One hundred feet still above the site of the Catholic church a modest chapel lifts the cross towards heaven from the very summit of the bleak Niagara crest.

Continuing down the channel of Morts creek the character of the valley gradually changes until, in section 4 of Tete des Morts township, the bordering banks have lost the long gentle slopes, and the stream flows in a gorge-like channel, fifty to seventy feet in depth, whose walls are formed by the enduring ledges of Galena limestone. Weather-sculptured columns crown the bluff overlooking the valley in the northeast quarter of section 4 (see figure 68). Casts of the fossil *Receptaculites oweni* occur in abundance about twenty feet below the top of these resistant towers. Further down the channel the bounding walls of Galena rise constantly higher. Where this creek joins the Mississippi river, in section 3, the cliff on the north side of the gorge rises one hundred feet above the water.

Along the Iowa shore of the Mississippi river, south of the mouth of Morts creek, steep bluffs of Galena border the channel for several miles. The dip of the Galena strata towards the south and west brings the top of these beds constantly lower in the river bluff. At Gordons Ferry station the Galena cliff stands eighty feet above the water of the Mississippi river. Along the border of sections 11 and 13 these ledges rise only forty to fifty feet. Near the middle of the east side of section

24, the Galena is encountered in the north bank of a small stream to a height of sixteen feet. It again appears in the southeast quarter of section 36; and it is exposed at low water in the bed of Mill creek where that stream joins the river in the town of Bellevue.

Over all of the southeast portion of Tete des Morts township, water sculpture is conspicuous, but the precipitous character of the topography which prevails over the Galena and the Niagara areas is wanting. The surface rises and descends in gentle undulations such as are developed where stream erosion acts on the slightly indurated beds of the Upper Maquoketa shale. On the western horizon the interrupted Niagara scarp crowns the summits of the hills and forms the skyline some two to four miles back from the Mississippi river.

Along the middle portion of the east side of Bellevue township a thickness of thirty to fifty feet of Niagara limestone caps the bluffs and protects the underlying Maquoketa beds so as to form great cliffs 150 feet in height. Such a scarp overlooks the northwest corner of Bellevue, and another such rampart borders the channel of the Mississippi river for a distance of nearly one mile south of the limits of the town. In the south bluff, at the mouth of Mill creek, a complete section of the Maquoketa shale is exposed showing a thickness of more than 125 feet. Continuing down the river from this point the southward dip of the strata is more rapid than the fall of the river. The height to which the Maquoketa shale appears in the bluffs gradually decreases; the cap of the Niagara constantly increases in thickness; and the flood plain on the Iowa side of the river gradually expands. At Green Island the scarp stands more than two miles back from the immediate bed of the river. At this place the Maquoketa rises in the bluffs to a height of only about thirty feet above the river swamp, and it is succeeded by sixty to seventy feet of Niagara limestone.

About two miles east of Green Island, in section 29 of the civil township of Washington, the top of the Maquoketa appears about fifteen feet above the flood plain; while near Lainsville, four miles further eastward, the Niagara limestone may

be seen down to the very base of the bluffs. Three miles still further down the river, an arch in the strata crosses sections 12 and 13 of Union township. In the anticline of this fold the Maquoketa shale is again brought many feet above the river's plain. In the northeast quarter of section 24 the Maquoketa appears in the bluff to a height of more than sixty-five feet. From this point the strata again dip quite rapidly to the southward, so that in the extreme southeast corner of Jackson county the top of the shale horizon is but a few feet above the foot of the bluff.

East of the town of La Motte, in Richland township, the headwaters of Mill creek have cut into beds that occupy a position near the base of the Hopkinton stage. Low, weathered ledges outcrop along the crest of the hills or appear as discontinuous ramparts bounding the channels of the streams. Near the line between section 1 of Richland and section 6 of Bellevue townships the numerous springs that issue near the level of the streams indicate a zone at the top of the Maquoketa shale. These springs are conspicuous on account of their abundance and because of the volume of water that they supply. Continuing down the channel of Mill creek the valley grows broader, the gentle Maquoketa slopes fringe the foothills with an ever wider border and to a constantly increasing height, and the Niagara crowned bluffs rise ever higher on either side.

Near the old village of Paradise the Niagara summits are separated more than a mile apart across the channel. This town was located by the pioneers in a sheltered valley of rich, alluvial land, which was abundantly watered by pure, perennial springs, and heavily wooded over both slopes and lowland. It was within a few miles of a settlement on the Father of Waters, the great line of travel and traffic in those early days. It is small wonder that the locality appealed strongly to the early settlers of the county. It is small wonder too, that they should name their settlement Paradise. Unhappily the hamlet is now almost deserted. Like the story of another Paradise its people have been led far away from the quiet and seclusion of this favored valley in their efforts to secure the fruits of knowledge and obtain larger rewards for their toil.

Towards Bellevue the valley becomes wider and the Niagara scarp is raised higher above the water, by the deeper cutting of the stream into the deposits of the Maquoketa stage. The waters of Little Mill creek, Duck creek and Pleasant creek have cut deeply into the Maquoketa shale and have developed topographic forms similar to those encountered along Mill creek. The uplands separating the basins of these streams rise 200 to 300 feet above their flood plains. They are trenched by the pinnately or bipinnately spreading branches of the major streams. The ridges are generally quite deeply loess covered, and it is but rarely that indurated rocks are exposed along the slopes bordering the secondary branches.

Below the junction of the North and South Forks of the Maquoketa river, in Maquoketa and Fairfield townships, the river flows in a comparatively narrow valley which is seldom more than one-half mile in width. There is usually a narrow belt of fluvial deposit on one or the other side of the channel. The bluffs that bound the south side of the river are generally more precipitous, and are more frequently composed of walls of dolomite, than those on the north.

For a distance of one mile or more south from the river the numerous hills are built largely of sand and the lowlands are mantled with the same material. North of the river the hills are not less abundant but the covering alike of the ridges and valleys is generally of loess.

In Van Buren and Washington townships the channel of the Maquoketa river is somewhat wider, but the topographic features presented in this portion of its course do not differ materially from those developed along the valley further west.

Alluvial areas.—At numerous points along the larger streams of the county narrow belts of fluvial material border the channels. However, these areas are generally small and they do not often form conspicuous topographic features.

In the south half of section 24 and the northern portion of section 25 of Farmers Creek township, there is a lowland area of several hundred acres that seems to have been developed as an alluvial plain. It is situated in the angle between Farmers creek and the North Fork of the Maquoketa river, and appears

as an expansion of the creek and river bottoms at the confluence of these two streams. Sand bars abound over this low land, but it seems probable that the sand was in part at least, gathered from regions further westward and deposited here by the winds.

A small area of flood plain has been developed at the confluence of Otter creek with the channel of Lytles creek, in the northwest quarter of section 21 in Otter Creek township. Over this level lowland there are left a few small island areas of Niagara limestone that have escaped the degrading action of the streams. These monadnock-like ridges are longer than wide, and rise twenty-five to forty feet above the surrounding plain.

Another small monadnock mound occurs in the northwest quarter of section 31, Van Buren township, over the level area of the old Goose Lake channel.

In the southwest quarter of Van Buren township, and the southeast corner of Fairfield, there is a level plain that embraces eight or ten square miles. The area is underlain with Maquoketa shale, and is bordered more or less completely by hills or low ledges of Niagara limestone. This prairie area is at present drained by Deep creek. It extends eastward for some distance up the channel of Copper creek, and is continued westward along a tributary of Deep creek, in the southern portion of Fairfield township.

The plain represents a northward extension of the old Goose Lake channel. The great width of the valley at this place seems to be due to the fact that an arch in the underlying strata crosses the ancient channel at this point, bringing the easily eroded Maquoketa shales within reach of the denuding action of the streams. Between Spragueville and Green Island the temporary channel of the Mississippi is at present occupied by the Maquoketa river. Along this portion of its course the stream has cut into the obdurate Niagara limestone and hence its effects are much less pronounced than in that portion of the channel in the vicinity of Preston.

In the extreme southwest corner of Tete des Morts township, and the northeast portion of Bellevue, there is a region bordering the river over which sand dunes have covered the greater

portion of the vegetation and rendered almost barren an area of several hundred acres. These sands are being constantly shifted by the winds. Beautiful wind furrows resembling the ripple marks on the shore of a sandy beach, appear in abundance over the drifting surface.

Fig. 67—Sand dune invading a forest, near the northwest corner of section 1, Bellevue township.

The area is a modified alluvial plain. The bank of the river at this place is formed of the Maquoketa shale whose incoherent materials have been denuded down to near the level of high water over a strip many acres in extent. On this belt of lowlands the winds have piled up hills of sand and then removed, only to build again, the ever changing line of shifting dunes.

From the north line of Washington township down to section 29 of Union there are marshy lowlands lying between the bluffs that border the valley and the immediate bed of the Mississippi river. This flood plain has its greatest expansion in the vicinity of Green Island where it is two and one-half

miles in width. These lowland areas are often threaded with lagoons, especially in the southern part, and are subject to overflow during periods of high water. They are partially forest covered, but over the greater portion they appear as wide savannas supporting a luxuriant growth of marsh grass which furnishes a large amount of wild pasturage and hundreds of tons of native hay.

Terraces.—Remnants of a gravel bench are to be seen at a number of points bordering the channel of the Mississippi river, and for some distance up from the mouths of many of the tributary streams. Such a bank of gravel appears in the roadside near the southeast corner of section 1, Bellevue township. The wagon road between Sabula and Lainsville, just west of the railroad, follows on this old terrace twenty to twenty-five feet above the present flood plain.

About two and one-half miles east of Green Island, a gravel terrace twenty feet in height borders the valley and can be traced for some distance up the channel of a creek that joins the river at that point. Patches of such a terrace appear along a creek in section 1 of Iowa township, and at points near the mouths of other streams that owe allegiance to the Mississippi river in Jackson county. The terrace materials are composed of rather small and rounded water-worn pebbles, the age of which could not be definitely determined.

In the southwest quarter of Van Buren township, the flood plains of the present streams lie fifteen to eighteen feet below the level of the old Goose Lake channel. This terrace is in some places composed of sand and silt, while at others it consists of a low bench of Niagara limestone.

ALTITUDES.

The difference in elevation between the highest and the lowest points in the county is more than 600 feet. The surface relief in Prairie Spring township alone exceeds 500 feet.

The highest known point in the county is a short distance north of the middle of the east half of section 6 in Prairie Spring township, where the elevation reaches 1190 feet above the sea. The lowest point is on the flood plain of the Mississippi river in the extreme southeast corner of the county,

where the altitude is about 570 feet. The elevations of towns, with railroads, given below are taken from Gannett's Dictionary of Altitudes in the United States, and give the height above sea level of the top of the ties at the several stations named. The other elevations furnished are taken from the topographic sheets of the United States Geological Survey.

TABLE OF ALTITUDES	FEET.
Andrew	870
Baldwin	712
Bellevue, C. M. & St. P. R. R. Station	618
Mississippi river Com. H. W.	598
Mississippi river Com. L. W.	578
Brandon township, middle	955
Bridgport	640
Butler township, middle	1010
Butler township, middle of south side section 18	1085
Canton	730
Cottonville	990
Crabb Hill	700
Duggan	830
Emeline	963
Farmers Creek township, middle	700
Fulton	745
Garry Owen	975
Gordons Ferry Station	610
Green Island	599
Hurstville	664
Iron Hill	940
Lainsville	597
La Motte, C. M. & St. P. R. R.	911
La Motte, U. S. G. S.	923
Maquoketa, C. and N. W. Station	684
C. M. & St. P. Station	692
Weather Bureau	688
Maquoketa township, middle	700
Miles	780
Mill Rock	715
Monmouth	761
Monmouth township, middle	790
Nashville	712
Otter creek	1025
Otter Creek township, middle	800
" northeast corner	1080
" middle of N. side section 4	1050
Ozark	728
Perry township, middle	870
Prairie Spring township, middle	740
near middle of E. half section 6	1190

	FEET.
Preston	660
Richland township, middle	840
middle of N. E. quarter section 3	1125
Sabula, Station	604
siding	595
bridge over river	607
Miss. river Com. L. W.	576
Miss. river Com. H. W.	593
St. Donatus, U. S. G. S.	674
South Fork township, middle	660

A study of the above table shows that the surface of the county has a general slope towards the south and east. The divide that extends across the county in a north and south direction shows the following elevations: near the northwest corner of Prairie Spring township 1190, Cottonville 990, Andrew 870, and Maquoketa 684. Across the county from west to east we have the following altitudes: Emeline 963, Iron Hill 940, Andrew 870, and Green Island 599.

DRAINAGE.

The Mississippi river is the master stream of the county. It receives tribute in the area from the Maquoketa river and from Morts, Spruce, Mill, Duck and Pleasant creeks. The Maquoketa river and its branches drain the larger part of the south half, and the most of the northwest portion of the county.

Maquoketa river.—The Maquoketa river is formed by the confluence of the North and the South Forks of the Maquoketa, which meet in the northwest quarter of section 18 in Maquoketa township. It crosses in an east and west direction a short distance north of the middle of this township. Soon after entering Fairfield township it swings northward to near the north line, about the middle of which it again turns toward the southeast, entering Van Buren township not far from the middle of the west side of section 18. About one mile north of the village of Spragueville, in section 15 of this township, it meets the old Goose Lake channel. At this point the river departs from its general southeasterly trend, which is the characteristic direction of flow for the rivers of eastern Iowa, and swings strongly towards the northeast to its junction with the Mississippi river. It enters the flood plain of its master

stream immediately above Green Island, and its waters join those of the Mississippi through two channels about two miles north of the last mentioned town.

Brush creek is the largest stream that joins the Maquoketa river from the north, while Prairie creek and Deep creek are its most important affluents from the south.

Goose Lake Channel.—The Goose Lake channel, which the Maquoketa river follows from Sprague ville to Green Island, represents the temporary channel occupied by the Mississippi river during a portion, at least, of the Illinoian ice invasion. When the lobe of this glacier pushed over into the southeast corner of Iowa, from Illinois, the channel of the Mississippi river was blocked with ice, and its waters were forced to find a passage around the margin of the ice sheet. In seeking a new course to the west of the lobe of ice the river left its pre-Illinoian channel at Green Island. It followed up the pre-existing Maquoketa valley to a point near the middle of section 18 of Van Buren township. At this place the temporary Mississippi forsook the Maquoketa channel and continued southward across sections 19, 30 and 31 forming the broad valley which is at present occupied by Deep creek. This channel of the temporary Mississippi river passes southward across Clinton county. Near the south border of this county it swings towards the southwest, crossing the west side of Scott county, the southeast corner of Cedar, the west half of Muscatine and Louisa, and continues in this direction as far as the northwest corner of Henry. At this point it swings towards the south and southeast across the counties of Henry and Lee, and again enters its pre-Illinoian channel not far from the present city of Fort Madison.*

In Jackson county the bottom of the temporary Mississippi valley was twenty to twenty-five feet higher than the present bed of the Maquoketa river in the same portion of its course, and was several feet above the bed of Deep creek which now occupies the ancient valley in sections 19, 30 and 31 of Van Buren township. It seems probable that the divide between the headwaters of Deep creek and Brophys creek, in Clinton

*Leverett: *Illinois Glacial* Lobe, Monograph XXXVIII, U. S. Geol. Survey, p.

county, formed a barrier which the temporary Mississippi river never succeeded in cutting down to the level of the valley of the Maquoketa river in the vicinity of Spragueville. This is indicated by the fact that the present altitude of this divide where it is crossed by the temporary Mississippi channel a short distance south of Goose Lake, is about 665 feet above the sea, while ten miles farther north the elevation of the flood plain of the Maquoketa river, near Spragueville, is not far from 600 feet.

A bench of Niagara limestone that extends nearly across this channel on the north side of the wagon road, in the northwest quarter of section 19 of Van Buren township bears witness to the presence of some such obstruction. The remnants of a terrace of fluvial materials twenty-five feet in height that borders this old valley further south, in sections 30 and 31, also point to some probable obstruction further down the channel.

The presence of such a barrier probably explains why the Mississippi river returned to its pre-Illinoian channel soon after the melting of the Illinoian ice sheet. It also accounts in part for the fact that the Maquoketa river soon abandoned the course south from Spragueville, along the valley of the temporary Mississippi, and again developed an outlet to its master stream towards the northeast between Spragueville and Green Island, in a direction of flow opposite to that of the waters of the temporary Mississippi river.

North Fork of Maquoketa river.—The North Fork of the Maquoketa river enters Jackson county not far from the middle of the west side of section 31, Butler township. Near the southwest corner of section 32 it bends southward and continues to flow in this direction down to the old town of Ozark. At this place it swings eastward and with many meanders it passes across the northern portion of Brandon township, and as far east as the southeast quarter of section 9 in the township of Farmers Creek. From this point it trends southward for more than two miles whence it again swings eastward to a

point nearly one mile east of Fulton. Here it once more bends to the south and meets the South Fork of the Maquoketa near the northwest corner of section 18, Maquoketa township.

In Brandon township this river flows in a narrow valley which in many places is bordered on one or both sides by precipitous cliffs of limestone, as in the southeast quarter of section 4. In Farmers Creek township, and southward to its junction with the South Fork, the valley of the river grows wider, the ledges of limestone that appear in the banks are lower and much less continuous, and become more nearly concealed by the mantle of surficial materials.

South Fork of Maquoketa river.—The South Fork of the Maquoketa crosses the Jones-Jackson county line a short distance north of the town of Canton, near the southwest corner of section 18 in Brandon township. With numerous curves to the north and the south the river persists in a general southeasterly course to the town of Maquoketa. At this place it swings northward for a distance of three-fourths of a mile, to its confluence with the North Fork above described.

Throughout the greater portion of their flow in Jackson county the courses of the North and the South Forks are practically parallel, and their channels are not more than four to five miles distant from each other. On account of the fact that this interstream area is so narrow the North Fork has no important affluents on the south, nor do any streams of importance render tribute to the South Fork from the north.

In the northwest portion of the county Lytles creek and Farmers creek owe allegiance to the North Fork of the Maquoketa, while Bear creek is the most important tributary to the South Fork in the area under consideration.

Lytles creek.—Lytles creek enters Jackson county near the northwest corner of Otter Creek township. It meanders across the west side of this township and meets the North Fork a short distance east of the middle of section 8 of Farmers Creek township. It drains an area of about fifty square miles, including the greater portion of the east half of Butler, and practically the whole of Otter Creek township. This creek has

carved its bed in the resistant Niagara limestone. Low bordering ledges occur at frequent intervals in the northern portion of its course in the county, but they become more rare and are much more nearly loess covered along the lower portion of its flow.

Farmers creek.—The headwaters of Farmers creek are found in the trenches and gullies in the southwest quarter of Prairie Spring township. The stream flows for a distance of twenty-five miles in a general direction a little west of south. It joins the North Fork near the southeast corner of section 24, Farmers Creek township. It carries the run-off from the southwest quarter of Prairie Spring township, the west half of Richland, the northwest quarter of Perry and the northeast portion of Farmers Creek.

Bear creek.—Bear creek, with its branches, drains the greater portion of Monmouth township. It enters the county near the northwest corner of section 31 of this township. It flows a little south of east for a distance of two miles and then swings northward, entering the old Monmouth-Maquoketa valley not far from the southeast corner of the town of Baldwin. It follows eastward down this valley to near the middle of the east side of section 23. Instead of continuing farther down this natural waterway, the creek here swings strongly towards the north, cutting a channel one hundred feet in depth through the hills that border the valley in sections 13 and 24. It joins the South Fork of the Maquoketa not far from the center of section 13.

Near the middle of the east side of section 22, Bear creek receives tribute of a small stream from the west. This creek enters Monmouth township in the west side of section 8. It follows the preglacial valley eastward to a point one mile east of the town of Monmouth. At this place it forsakes this ready formed channel for no assignable reason, and makes a detour through the hills that bound the north side of the valley. It flows north for about three-fourths of a mile, whence it again takes a southeasterly course emerging once more into the ancient valley a short distance east of Baldwin. The hill around which this circuit is made rises 120 feet above the valley. It

lies immediately to the northwest of the town of Baldwin and is a conspicuous topographic feature of this region.

Prairie creek.—Prairie creek is the largest affluent of the Maquoketa river from the south. It enters the county a short distance west of the middle of the south side of section 35 in South Fork township. It drains the southeast corner of this township and the southwest quarter of Maquoketa, and meets its major stream near the middle of the east half of section 17 of the latter township.

Deep creek.—Deep creek follows the old temporary Mississippi river channel from the south side of section 31 of Van Buren township to its junction with the Maquoketa river in the south half of section 18. A widely branching tributary of this creek on the east drains the larger portion of Van Buren township, while an affluent on the west flows across the southern portion of the township of Fairfield.

Brush creek.—The headwaters of Brush creek lie in the southeast quarter of Richland township. The stream meanders in a general southward direction down to the vicinity of Andrew whence it swings towards the southeast for half a dozen miles, joining the river near the northeast corner of section 5, in the township of Fairfield. It carries the excess of water from an area of about fifty square miles, which includes the southeast quarter of Richland township, the east half of Perry, and the west and the south portions of Jackson. At some points in Jackson township, and in sections 14 and 23 of Perry, the banks which border the outer side of the meanders of the stream consist of high dolomite cliffs, but in other places along its course the banks are low, and the ledges are mostly concealed by deposits of loess.

Morts creek.—A short distance west of the north side of section 4 of Prairie Spring township, Morts creek crosses the Dubuque-Jackson county line. It flows in a southeasterly direction down to the middle of the northeast quarter of section 22. At this point it swings towards the northeast crossing the east half of Prairie Spring and the north half of Tete des Morts townships. It meets the Father of Waters near the northeast corner of the county. This stream together with

Spruce creek in the southern portion of Tete des Morts township, drains practically the whole of the two northern townships of Jackson county.

Mill creek.—Mill creek rises in the northeast quarter of Richland township. It follows a general southeasterly course across Bellevue township and joins the river near the southeast corner of the town of Bellevue. This stream has exposed in its banks the lowermost fifty feet of the Niagara limestone and practically the entire section of the Maquoketa shale. It drains the north half of the township of Bellevue. Its largest tributary, Little Mill creek, drains the central and southwest portions of this township.

Other streams.—Duck creek drains eight or ten square miles in the southwest portion of Bellevue township and the northeast corner of Jackson. It has a flow of about eight miles, and joins the Mississippi river in the northeast quarter of section 29 of Bellevue township. Like the Mill creeks, it has exposed along its banks the basal beds of the Niagara and a thickness of many feet of Maquoketa shale.

The headwaters of Pleasant creek lie in the northwest quarter of Jackson township. The stream flows for a dozen miles in a direction slightly north of east. It enters the channel of the Mississippi river in the northeast quarter of section 4, Washington township. It carries the run-off from the larger part of the north half of Jackson township and the northwest quarter of Washington.

The greater portion of Iowa township is drained by the headwaters of Elk creek which flows southward into Clinton county, meeting the Mississippi river three and one-half miles below the southeast corner of Jackson.

A number of other minor streams render tribute to the Father of Waters from Jackson county, but the most of these are small and relatively unimportant.

STRATIGRAPHY.

General Relations of Strata.

The geological formations that are well exposed in Jackson county belong to four different systems; the Ordovician, Silurian, Carboniferous and the Pleistocene. Of the Ordovician

system there are present rocks of the Trenton series which include the strata belonging to the Platteville-Galena and the Maquoketa stages.

Between the deposits of the Ordovician and those of the Silurian system there is evidence in Jackson county of an interruption in the sedimentation making an unconformity of overlap. At two or three different points the Niagara limestone appears to occupy an old channel of erosion which was carved in the Maquoketa shale prior to the deposition of the Niagara sediments. The Niagara series embraces all of the rocks which belong to the Silurian system in our area. Of this series there are present strata of the Hopkinton and the Gower stages. All of the rocks in the county which belong to the Niagara series are dolomites, being calcium-magnesium carbonates in composition.

At one point in the county a number of Devonian fossils have been found associated with a local bed of shale. These may represent an outlier of Devonian rocks or they may have been transported and deposited by the glacier when it moved down from the northwest. No outcroppings of undoubted Devonian strata were seen in Jackson county.

The deposits of the Silurian and the Carboniferous systems are separated by an enormous time interval and by a very conspicuous unconformity. The Carboniferous sediments of our region consist of small and scattered outliers of sandstone or sandstone and shale none of which are continuous over areas of any considerable extent. All of these outliers belong to the Upper Carboniferous series and represent deposits of the Des Moines stage.

Another gap of exceedingly great extent intervenes between the deposits of the Carboniferous system and those of the Pleistocene. The latter materials consist of unconsolidated beds, composed of drift, loess, alluvium and sand, which have been transported and deposited by the agencies of ice, wind and water. These beds belong to the Glacial and the Recent series. Of the former there are present over portions of our area sheets of drift that were spread out during the Kansan and the Iowan stages of glaciation. A portion of the deposits

of loess, sand and alluvium also belong to the Glacial series, but these can not be differentiated from the corresponding materials that have been more or less worked over and respread by the action of wind and water since the permanent withdrawal of the glaciers from our state.

The following table shows the relations of the different geological formations that appear in Jackson county.

TABLE OF FORMATIONS.

GROUP.	SYSTEM	SERIES.	STAGE.
Cenozoic	Pleistocene	Recent	Soil, loess and alluvium
		Glacial	Iowan
			Kansan
Paleozoic	Carboniferous	Upper Carboniferous or Pennsylvanian	Des Moines
	Devonian?	Meso- Devonian?	Wapsipinicon?
	Silurian	Niagara	Gower
			Hopkinton
	Ordovician	Trenton	Maquoketa
			Platteville-Galena

ORDOVICIAN SYSTEM.

GALENA STAGE.

The Galena stage corresponds with what has formerly been referred to in the Iowa Geological Survey reports as the upper part of the Galena-Trenton. Inasmuch as it is now thought that the Trenton limestone of the upper Mississippi valley is not the exact equivalent of the Trenton beds in the type locality, Dr. Bain* has proposed, as a substitute for the term Trenton in our region, the name Platteville from the town of Platteville, Wisconsin, at which place the rocks of this horizon are well exposed. The term Platteville is to be restricted to the beds between the Saint Peter sandstone and the top of the "Green Shales," while all the beds above the "Green Shales" will be called Galena. This change in nomenclature has been adopted by Professor Calvin and it will be followed in the present report.

The rocks of the Galena stage that are exposed in Jackson county, represent the uppermost portion of the Galena as those

*Bain: Lead and Zinc Deposits of Northwestern Illinois, Bull. 246, U. S Geol. Surv., p. 19.

rocks are developed in the neighboring county of Dubuque. With the exception of a thickness of a few feet near the top, the materials are subcrystalline, yellowish colored, thoroughly dolomitized limestones occurring in layers of considerable thickness. They are the equivalent of that portion of the Galena beds lying above the chert-bearing zone described in the report on the geology of Dubuque county.*

Distribution.—The upper typical phase of the Galena limestone is exposed at numerous points over sections 3, 4, 10, 11, 13, 14, 15, and 24 of Tete des Morts township. It appears in the channel of Morts creek from a point one-half mile west of St. Donatus to its mouth. It forms the conspicuous bluff bordering the west bank of the Mississippi river from the northeast corner of the county to section 24 of Tete des Morts township. It outcrops in a low ledge along the channel of Spruce creek, a short distance south of the middle of section 36 of this same township. The most southerly exposure of the rocks of this horizon occurs in the town of Bellevue where it may be seen along the bed of Mill creek during low water for a distance of a few rods above its junction with the Mississippi river.

Typical Exposures.—At a small quarry in the village of St. Donatus a thickness of more than twenty-five feet of the uppermost strata of the Galena appears at the foot of the Maquoketa slope. The section here exposed is as follows:

		FEET.
5.	Bed consisting of grayish-yellow dolomite in layers three to eight inches in thickness, which are separated by narrow partings of shale; containing a number of fossils in the form of casts or molds	5½
4.	Layer of yellowish colored dolomite similar to No. 5 above, and containing similar fossils	2
3.	Two layers of yellow dolomite each about eight inches in thickness, which are separated from each other and from those adjacent by two-inch bands of shale	1⅜
2.	Bed of rather hard dolomite which is imperfectly separated into layers respectively 2, ¼, 2, ¾ and 1½ feet	6½
1.	Yellow colored, fossiliferous and somewhat vesicular dolomite, consisting of layers 2, 3, 2½, ½ and 3 feet in thickness	11

All of the layers in the above section contain fossils which are in the form of casts or moulds, and are in many cases not

*Calvin and Bain: Iowa Geol. Surv., Vol. X, p. 425

well preserved. The following were identified by Professor Calvin from this exposure: *Streptelasma corniculum, Lingula iowensis, Orthis biforata, Plectambonites sericea, Rafinesquina deltoidea, Rhynchotrema capax, Hormotoma subangulata?* Ctenodonta sp., and Orthoceras sp.

About one mile southwest of St. Donatus a low ledge has been worked in the south bank of Morts creek. A quarry face is here exposed to a height of about ten feet above the water. The layers worked correspond with those of numbers 2 to 4 inclusive in the section at St. Donatus. The stone is a yellowish colored, fossil-bearing dolomite, occurring in rather thin layers which are separated by partings of shale quite similar to that in the St. Donatus exposure. The following fossils were collected at this place: Owenella sp., *Lingula iowensis, Orthis biforata, O. testudinaria, Plectambonites sericea, Rafinesquina deltoidea, Murchisonia gracilis,* and a few individuals of other species of gastropods.

Layers belonging to this same horizon outcrop along the wagon road near the southeast corner of section 23, and at several points in the west half of section 15 where they form a conspicuous bench along the streams. *Lingula iowensis* is very abundant at all of these exposures, and *Orthis biforata, Plectambonites sericea* and *Murchisonia gracilis* are usually present.

In following down the bed of a small stream that flows north from the wagon road, near the line between sections 13 and 14 of Tete des Morts township, a thickness of about sixty-five feet of blue colored, plastic shale is passed over. Below this shale there is encountered a thickness of about twenty-eight feet of yellowish-gray, rather fine-grained dolomite composed of layers which vary from three to eight or nine inches in thickness, and which are usually separated by partings of shale. These layers contain *Lingula iowensis, Orthis biforata, Murchisonia gracilis,* and fragments of a number of other fossils. They seem to be the equivalent of the rocks described in the section at St. Donatus.

Below the horizon of the layers described above, the rocks in the bed of the stream change to a darker yellow. They become more crystalline and vesicular, and contain numerous

quite large, irregular and botryoidal cavities. The layers also increase in thickness, and partings of shale are not present. *Receptaculites oweni, Murchisonia major,* Bellerophon sp. and remains of a number of other small gastropods were collected from a zone about fifty-five feet below the base of the Maquoketa shale. The contact of the Galena beds with the Maquoketa shale is clearly exposed in this ravine, and the transition from the dolomite below to the plastic shale above is quite abrupt, but there is here to be seen no evidence of unconformity between the two formations.

In the northeast quarter of section 4, Tete des Morts township, the north bank of Morts creek is bordered by a scarp of

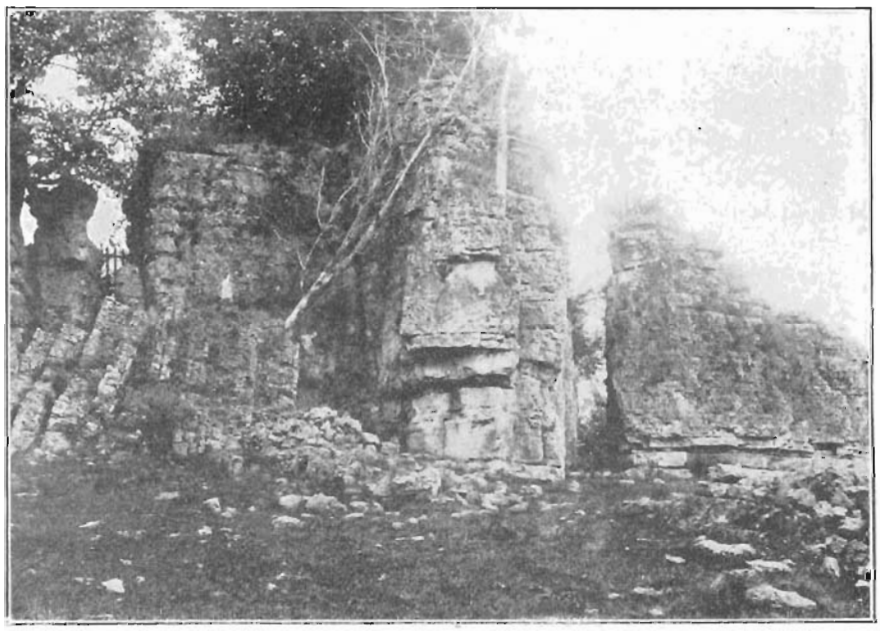

Fig. 68.- Weather-carved cliffs of Galena limestone. Section 4 of Tete des Morts township. Seventy feet above the bed of the creek.

Galena dolomite which rises sixty-five feet above the water. The upper portion of this ledge has weathered into a number of picturesque pinnacles and towers twenty to thirty feet in height, shown in figure 68. In a layer a few feet above the base of these columns there is a narrow zone in which remains

of *Receptaculities oweni* are exceedingly numerous. Receptaculites is the characteristic fossil of this horizon and marks a zone about fifty-five or sixty feet below the top of the Galena beds in Jackson county. Imperfectly preserved brachiopod remains and some casts of gastropods are also present in this bed.

At the junction of Morts creek with the Mississippi river the scarp on the north side rises eighty to ninety feet in height. It consists of heavy, massive ledges of dolomite, in layers four to six feet in thickness. These are subcrystalline in texture and quite free from concretions of chert. This phase of the Galena forms the bluffs which border the Iowa side of the Mississippi river for some miles south from the mouth of Morts creek. It doubtless corresponds with numbers 12 and 13 of the section at the Eagle Point Lime Works, in Dubuque, as given in the Dubuque county report.*

A point of Galena limestone is exposed on the east side of the wagon road, in the northeast quarter of section 24, in this same township. The section shown is given below:

		FEET.
8.	Weathered ledge of hard, yellowish-gray dolomite which is indistinctly separated into layers and presents a very rough surface	6
7.	Three layers of hard buff colored dolomite respectively 3, 3 and 1 foot in thickness, the surface showing numerous small cavities	7
6.	Heavy layers of yellow dolomite, *Receptaculites oweni* abundant near the middle portion	5
5.	Layer of hard, sub-crystalline limestone, yellow in color, showing numerous cavities, fossils few and poorly preserved	4
4.	Bed similar in character to No. 5 above, which weathers into indistinct layers three to six inches in thickness	5
3.	Ledge consisting of two layers, each about two feet in thickness, containing a number of indistinct fossil remains	4
2.	Layer of hard buff colored dolomite similar to No. 3	3½
1.	Hard, massive ledge of yellow, vesicular dolomite, down to level of water	4½

In the above section number 6 represents the Receptaculites horizon which appears near the base of the columns in figure 68. It belongs about fifty-five feet below the top of the

*Calvin and Bain: Iowa Geol. Surv., Vol. X, pp. 423 and 424.

Galena limestone. The upper phase, in which the layers are narrow and partings of shale numerous, occurs above number 8 of the section last given.

MAQUOKETA STAGE.

In Iowa, the aggregate of strata that constitute the Maquoketa stage are exceedingly variable. They change in lithology and thickness within areas separated by only a few miles. The fossils that they carry are as lawless in their development and as local in their distribution as are the strata that enclose them.

The most constant phase of the Maquoketa consists of a heavy body of non-fossiliferous, bluish-gray, plastic clay shale, from 100 to 150 feet in depth. At the top of the shale bed there are generally present narrow layers of indurated limestone, three to six or eight inches in thickness, which are separated one from another by bands of shale of about equal thickness with the calcareous layers. The Niagara limestone often immediately succeeds this fossil-bearing phase of alternating shale and limestone layers without any other transitional beds. This is the case near Green Island, in an exposure near the middle of the south side of section 24, Washington township in Jackson county, and also at Patterson's spring, near the town of Brainard in Fayette county. At other points the very fossiliferous zone may be entirely wanting and the heavy body of blue shale is separated from the Niagara limestone by a thickness of twenty-five or thirty feet of transition beds which consist of indurated yellow-colored, impure limestone which weathers into thin bands and carries but few fossils. At still other points these transition, barren beds intervene between the fossil-bearing layers and the Niagara.

The middle and the lower beds of the Maquoketa stage are even more inconstant and variable than the upper. In Jackson county the heavy body of plastic shale passes downward quite abruptly into the thin-bedded dolomite phase of the Galena.

In Dubuque county Professor Calvin designates this plastic clay phase as the Upper Maquoketa and records for it a thickness of 150 feet.* Below the Upper Maquoketa beds there

*Calvin and Bain: Iowa Geol. Surv., Vol X, p. 443.

occur fifty to seventy feet of indurated shale and limestone layers which contain very numerous fossils, and which were referred to as the Lower Maquoketa.

A few miles farther northwest, in the counties of Fayette and Clayton, the upper Maquoketa phase consists of about 125 feet of plastic shale which is barren of fossils except in a narrow zone at the top. Below these Upper Maquoketa deposits there occurs about fifty feet of limestone which is usually thin bedded and contains very numerous chert nodules—the Middle Maquoketa of the Fayette county report and the Fort Atkinson limestone of Professor Calvin's report on Winneshiek county. Below the Fort Atkinson limestone, in these counties, there are present about 100 feet of shales and argillaceous limestones that are in places very fossiliferous and that belong to the Maquoketa stage. These constitute the Lower Maquoketa beds of the Fayette county report; and the Clermont shale, and Elgin shales and limestones of Calvin in Winneshiek county.

In Jackson county all of the deposits corresponding with the Middle and Lower Maquoketa divisions, which attain an aggregate thickness of more than 125 feet in Fayette and Clayton counties, are entirely wanting. The Maquoketa beds of our area, like the deposits of this stage in Delaware county, are argillaceous throughout, with the exception of the calcareous, fossil-bearing bands and the transition beds in the upper part. There is present here only the Upper Maquoketa phase, which is the equivalent of the Upper Maquoketa beds of the Dubuque and Fayette county reports, and corresponds with the Brainard shale of the report on the geology of Winneshiek county.

This bed consists of about 100 feet of blue, plastic shale which is barren of fossils throughout the greater portion of its depth. In the upper part there are usually present thin seams of limestone three to eight inches in thickness which are crowded with fossil remains. These calcareous layers are separated one from another by bands of shale which are also often very fossiliferous. At a few points in the county this fossil-bearing zone is succeeded by transition beds of yellow-colored, rather fine-grained, earthy limestone, with but few fossils, which break

up into thin layers, under the influences of weathering. In other places, notably along Morts creek and the Mill creeks and in the vicinity of Bellevue in the northeastern portion of the county, the very fossiliferous zone of alternating shales and limestones is absent. The plastic shale is separated from the Niagara limestone by a thickness of twenty-five to thirty feet of indurated transition beds similar in lithology and texture to those referred to above.

Distribution.—The Maquoketa shale appears in the bluff which bounds the Mississippi river on the west from the town of Bellevue to the southern border of the county. It appears along Morts creek throughout all of its course in Prairie Spring and Tete des Morts townships. This deposit fringes a portion of all of the larger streams that render direct tribute to the Father of Waters from our area, and makes itself manifest in the gentle erosion curves to a variable distance from the river. It immediately underlies the Pleistocene deposits over a large portion of Tete des Morts township and a considerable area in the township of Bellevue. It extends in a narrow belt across the south half of the townships of Van Buren and Fairfield.

Typical Exposures.—Detailed description of the following exposures will make clear the character of the Maquoketa materials in Jackson county. The contact of the Maquoketa shale with the underlying Galena beds is best seen in the channel of a small stream, near the line between the south half of sections 13 and 14 of Tete des Morts township. Along this stream a thickness of sixty-five feet of the basal portion of the Maquoketa shale is well exposed. The material is a bluish colored, non-indurated shale, without fossils. At the bottom there is an abrupt change in the character of the materials at the line of contact of the Maquoketa with the Galena deposits.

The entire thickness of the Maquoketa sediments is present in the river bluff near the southeast corner of the town of Bellevue. The uppermost layers of the Galena dolomite appear in the bed near the mouth of Mill creek. At the summit of the scarp at this place there is a thickness of about thirty

feet of Niagara limestone. The vertical distance from the base of the Niagara, at the top of the bluff, to the dolomitized layers of Galena in the bed of Mill creek is more than 100 feet.

A small affluent that joins the creek a few rods west of this point exposes along its bed about thirty feet of blue-gray shale which is barren of organic remains. Along a stream that comes down from the upland near the northwest corner of Bellevue the upper portion of the Maquoketa shale is well exposed. The succession of beds at this place is shown in the section given below:

		FEET.
8.	Bed of hard, massive, crystalline dolomite, in heavy layers three to six feet in thickness; indistinct remains of fossils not rare. Niagara limestone	13
7.	Yellowish-gray, rather fine-grained, impure limestone, in even layers four to fourteen inches in thickness, weathering into bands of one to two inches; carrying a few fossils; without chert nodules	14
6.	Bed of argillaceous, earthy limestone in layers two to six inches in thickness; containing a few fossils. On weathered faces thin partings of shale appear between the layers	19
5.	Ledge of yellowish colored, argillaceous stone, which is bluish-gray where not exposed to the action of the atmosphere; in layers one to three feet in thickness; weathering into narrow bands one to three inches thick. Occasional nodules of chert appear in lower part	15
4.	Bed of grayish-blue, indurated, calcareous shale, which weathers into thin bits; without fossils but carrying a few chert nodules	3⅓
3.	Layer of rather fine-grained yellow colored, impure limestone much decayed and showing numerous close lines of lamination	⅔
2.	Bluish-gray shale, somewhat indurated, weathering into small polygonal and irregular fragments, without fossils.	10
1.	Bed of blue colored, plastic, nonfossiliferous shale	30

In this section number 8 represents the basal portion of the Niagara limestone. It is harder and more resistant to weathering than the underlying beds and forms an overhanging shelf two to four feet in width. Numbers 1 and 2 are shale beds that represent the upper portion of the main body of plastic shale. Numbers 3 to 5 inclusive are indurated beds which were originally of a bluish color. They contain a large amount of argillaceous material. It seems probable that they represent a

local modification of the shale deposit after the sediments were laid down. Number 6 also contains a large amount of argillaceous material. Numbers 6 and 7 together represent a transition phase from the Maquoketa shale to the Niagara dolomite. A few fossils were taken from the layers of numbers 6 and 7 among which were *Orthis testudinaria, Leptaena rhomboidalis,* Zygospira sp. and the pygidium of a trilobite resembling *Calymene mammilata* Hall. No traces of fossils could be seen in the beds below number 6 of the section. The materials of number 7 have been worked to some extent as a quarry horizon, supplying stone for local use.

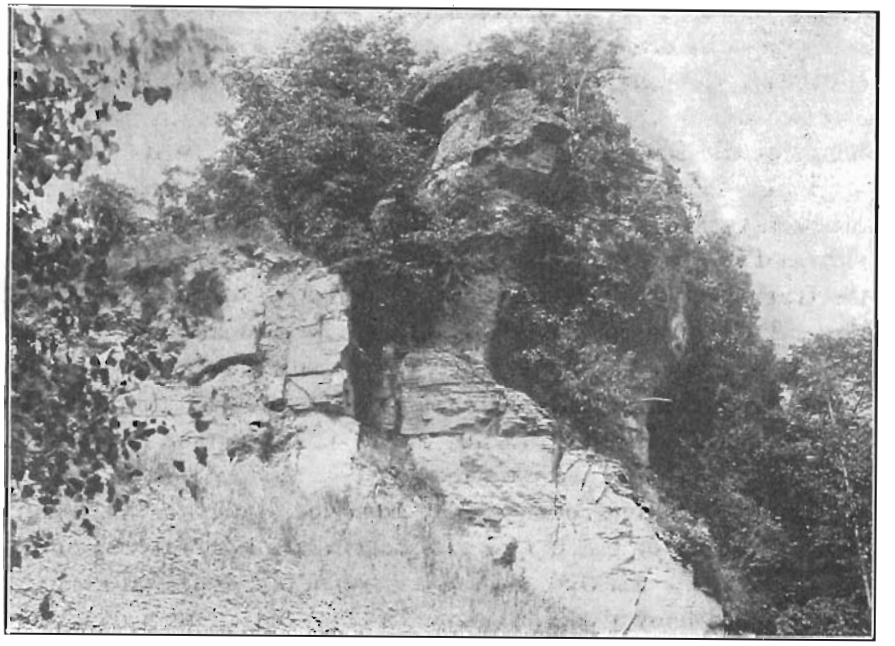

Fig. 69 View showing the unusual character of transition beds at the upper portion of the Maquoketa shale; near Bellevue. The cap at the summit is Niagara.

It seems probable that numbers 6 and 7 of the section represent the typical transition beds below the Niagara which are well developed in the counties of Delaware* and Dubuque.† These same beds are well exposed near the top of the bluff about one-half mile south of Bellevue, where they attain a

*Calvin: Iowa Geol. Surv., Vol. VIII, p. 141.
†Calvin and Bain: Iowa Geol. Surv., Vol. X p. 444.

thickness of thirty or thirty-five feet. They bear no fossils, but their characteristic manner of weathering may be clearly seen at the latter outcrop. See Fig. 69.

On following up the bed of a small stream that crosses the wagon road near the southwest corner of section 14, Prairie Spring township, there are passed over about fifty feet of blue, plastic shale. This body of shale is succeeded by about thirty feet of yellow, rather fine grained magnesian limestone, in thin layers which contain *Orthis testudinaria*. These layers also represent the transition beds of the Maquoketa. They are overlain by a ledge of massive dolomite forty feet in thickness which belongs to the Niagara series.

Along Mill creek, near the east side of section 1, Richland township, the Maquoketa transition beds are well developed. Fragments of these materials are conspicuous in the talus heaps at the foot of the ledges and along the beds of the streams. In every place where the uppermost strata of the Maquoketa are exposed over the north half of Bellevue township and in the townships of Prairie Spring and Tete des Morts the transition beds have a thickness of thirty or more feet. At none of these points were any of the fossil-bearing shale and limestone layers seen; nor were any fossiliferous fragments to be found along the channels of the streams, as they are in regions where the fossiliferous phase of the Upper Maquoketa deposit is normally developed.

About two miles south of the town of Bellevue the fossil-bearing layers of the Upper Maquoketa are encountered along the bed of a stream that joins the river in the southeast quarter of section 29, township 86 north, range V east. On walking up the channel of the stream a thickness of about 80 feet of blue colored, tenacious shale is encountered. This is overlain by a bed composed of alternating bands of shale and limestone which have an aggregate thickness of about twelve feet. Both the calcareous and the argillaceous layers are crowded with the characteristic fossils of the Upper Maquoketa stage, among which *Plectambonites sericea, Rafinesquina alternata, Leptaena*

unicostata, Orthis occidentalis, O. testudinaria, Rynchotrema capax and *Tentaculites sterlingensis* are abundant. The transition layers were not observed at this place.

This fossiliferous phase of the Upper Maquoketa layers appears again along Duck creek, in the southern portion of Bellevue township. Numerous rock fragments resembling a brachiopod coquina, which came from this horizon, were seen in the bed of Pleasant creek and along the channels of the tributary streams over the north half of the township of Washington.

Near the middle of the north half of section 16 in the last named township, there is an excellent exposure of the uppermost layers of the Maquoketa beds. They outcrop in the banks of a stream on the west side of the wagon road and resemble quite closely the beds at Patterson's spring near Brainard in Fayette county. This is one of the most favorable places of our area in which to collect the fossils belonging to the Upper Maquoketa horizon. The indurated layers are four to six or eight inches in thickness and the intervening seams of shale are almost as crowded with fragments of shells as are the calcareous bands. The following forms occur in great abundance: Strophomena resembling *S. nutans,* an undescribed species of Strophomena, *Orthis occidentalis, O. testudinaria, Rynchonella (?) anticostiensis, Rhynchotrema capax, Byssonychia radiata* and a small, branching monticuliporoid. There are here no well developed transition beds between this fossil-bearing zone and the Niagara limestone.

Another good exposure of the upper layers of the Maquoketa deposits occurs in a ravine south of the wagon road near the middle of the south side of section 24, township 85 north, range V east, one fourth mile southwest from the town of Green Island. There is given below a section of the beds encountered in this exposure:

		FEET.
6.	Heavy layers of yellow dolomite, coarse grained and somewhat crystalline, carrying traces of a few fossils.....	15
5.	Bed composed of very uneven and irregular layers of yellow colored dolomite, two to four inches in thickness, which are cut at frequent intervals by conspicuous chert bands two to three inches thick.....	25

		FEET.
4.	Bed of yellowish, rather fine-grained dolomite, free from chert, in layers that were originally eight to twenty-four inches in thickness, but which have weathered into narrow bands one to one and one-half inch	9
3.	Layer of blue colored shale	2
2.	Bed composed of alternating shale and limestone layers which carry in abundance the characteristic Upper Maquoketa fossils	20
1.	Blue colored, tenacious shale, without planes of stratification, carrying no fossils, but containing numerous nodules of iron pyrites	25

In the above section numbers 1 to 3 inclusive are the typical Upper Maquoketa deposits. Number 4 differs in lithological appearance and in its mode of weathering from the transition beds further north and it seems probable that this member represents the basal layers of the Niagara limestone as those materials are developed in the southern portion of Jackson county. No fossils could be found in this member, but it is quite uniformly present to a variable thickness underlying the chert-bearing horizon. Number 5 of the section is characterized by the presence of numerous bands of chert, which are intercalated between narrow layers of coarse-grained, earthy, yellowish colored dolomite. It is a well marked horizon in the lower portion of the Niagara deposits over the greater portion of our area.

About one mile west of Sabula the upper portion of the Maquoketa appears near the top of the bluff just south of where the wagon road passes up the hill from the bottom land. There are about eighteen feet of the Niagara at the summit of this bluff, below which outcrops twenty-five feet of yellowish-gray, non-fossiliferous, impure limestone which presents many of the characters of the transition beds. This exposure is on the south slope of an arch that extends with a trend slightly south of an east-west direction from Savanna, Illinois, to near the east side of Fairfield township in Jackson county. Below the transition beds the surface inclines gently down to the flood plain of the river through a vertical distance of sixty-five feet. The gentle slope is so completely sodded over that few outcrops of the plastic shale are to be seen.

In the north part of the town of Savanna, across the river east from Sabula, the upper beds of the Maquoketa appear near the top of the bluffs almost 100 feet above the water. The fossil bearing layers are here well developed and contain *Streptelasma corniculum,* numerous biscuit-shaped colonies of some bryozoan, a branching monticuliporoid, *Leptaena unicostata, Plectambonites sericea, Rafinesquina alternata, Orthis occidentalis, O. testudinaria, O. biforata, Rhynchonella? anticostiensis* and *Rhynchotrema capax.* This zone is separated from the very cherty horizon of the Niagara by a bed of yellowish, non-fossiliferous, rather fine grained dolomite four to seven feet in thickness.

The fossiliferous phase of the upper beds of the Maquoketa appears again about eight miles west of Sabula, in the southwest quarter of section 13 in Van Buren township. A weathered bed of blue shale along the roadside furnished *Leptaena unicostata, Plectambonites sericea, Orthis occidentalis* and *Rhynchonella? anticostiensis.* This same phase of the Upper Maquoketa layers may be seen at a number of points in the wagon road which crosses the north half of section 23. At these outcrops the biscuit shaped bryozoan colonies are abundant. Some of these are flattened masses from two to five or six inches in diameter. Others have a more narrow cylindrical form, four or five inches in length, which shows at intervals rather deep annular constrictions as if the colony had experienced unfavorable conditions for growth which alternated with periods of more rapid development. Associated with the above were *Streptelasma corniculum, Plectambonites sericea, Orthis occidentalis, O. testudinaria, O. whitfieldi, Zygospira modesta, Rhynchonella? anticostiensis, Rhynchotrema capax, Byssonychia radiata, Cyrtolites ornatus?* and fragments of large individuals of a trilobite belonging to the genus Isotelus. One-half mile north of the town of Preston a bed of blue shale appears in the roadway and along the banks of a ravine near the foot of the hill bordering the old Goose Lake Valley. The fossils at this place are similar to those found in section 23, but aneroid readings gave the elevation at two points of the latter

outcrops as respectively ninety and 115 feet higher than that of the exposure near Preston.

The upper portion of the Maquoketa beds is again encountered about four miles west of Preston, near the southwest corner of section 26 in Fairfield township, at an altitude eighty feet above the Preston exposure. The fossil-bearing layers are not exposed at this place, nor do fossiliferous rock fragments appear in the bed of the stream. However, a body of blue shale, the top of which determines a zone of springs, can be seen underlying the thin bedded cherty phase of the Niagara.

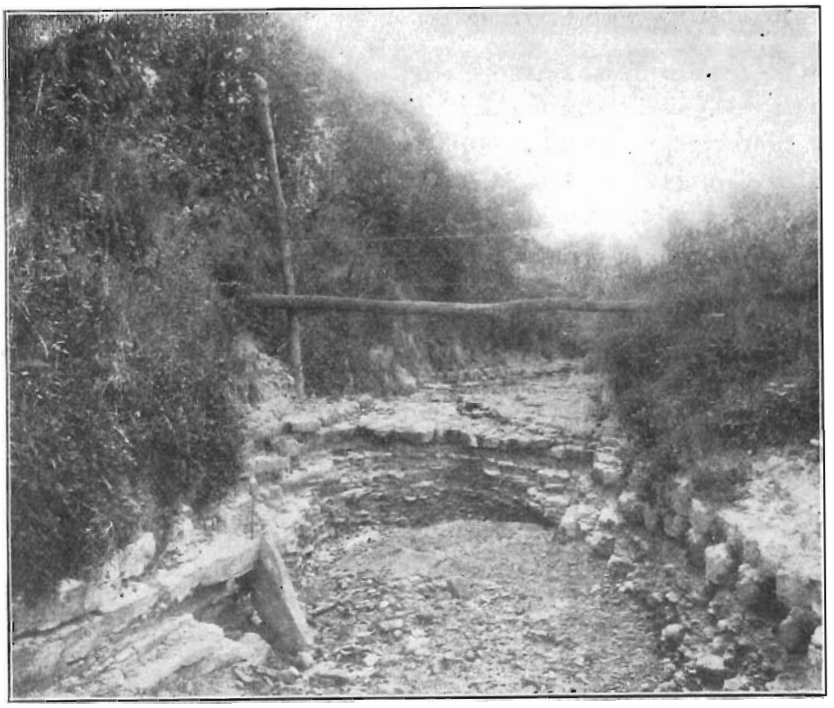

Fig. 70—Small fall due to hard layer underlain by weaker beds. Photo by Calvin.

In the channel of a stream that crosses the southwest quarter of section 28 and the southeast quarter of section 29, Fairfield township, the upper layers of the Maquoketa outcrop almost continuously for a distance of sixty rods. The beds include the very fossiliferous horizon of alternating shale and limestone

bands. In the eastern portion of the exposure the layers incline quite uniformly towards the east, almost with the fall of the stream. At a few points they dip strongly towards the north at an angle varying from 15 to 35 degrees.

The floor of the stream channel is cut by numerous small, parallel joints that extend in a nearly east and west direction. These are crossed by another series of fissures trending at about right angles to the first. The joints are from ten to fifteen inches apart, and were doubtless induced by the local strains of tension at the time the deformation of the strata took place.

In the west half of the outcrop the layers are thrown into numerous small folds such as are developed in the crumpling of shaly materials under the influence of lateral pressure. In many places the layers are inclined as much as 45 degrees. At three points along this portion of the outcrop, the inclined Maquoketa layers may be seen abutting against a vertical wall of Niagara limestone. The Niagara beds are not in all cases level, but their departure from the horizontal is not great, nor does it seem to bear any relation to the arching and dipping of the adjacent Maquoketa layers.

There seems no doubt that at these points the Maquoketa shale had suffered erosion prior to the deposition of the Niagara sediments; that the later materials occupy a channel of erosion and are separated from the Maquoketa deposits by an unconformity of overlap. The elevation of the Upper Maquoketa layers here is 95 feet higher than that of the rocks of the corresponding horizon on the border of the Goose Lake channel near Preston.

The most westerly exposure of the Maquoketa shale in the south half of the county occurs at the western extremity of the anticline referred to above, in sections 29 and 30 of Fairfield township. Aneroid readings at both places gave the elevation here 175 feet above the old plain at Preston. The layers are best seen outcropping along the smaller affluents that flow southward to the major stream in this region.

Near the middle of the south side of section 29, the Upper Maquoketa beds appear in an unusual relation to deposits of the later Paleozoic series. Across the north side of section 32

the south side of a stream is bordered by a somewhat loess covered bluff of Niagara limestone forty or more feet in height. The low bank on the opposite side of the stream is composed of sandstone of the Des Moines stage. This sandstone ledge extends for a distance of thirty rods and has a height of eighteen to twenty-five feet. On following up the bed of a lateral stream that has cut through this ledge of sandstone, the arenaceous material soon gives place to shale, and a thickness of thirty-five feet of the Maquoketa beds may be seen within a distance of as many rods. The phase exposed here represents the upper, alternating shale and limestone layers that carry very numerous fossils. Some of the bands are composed largely of shells of a few species, and similar fossil zones recur a number of times. The following forms were collected at this place: *Streptelasma corniculum,* Orbiculoidea? sp., *Strophomena incurvata, S. planumbona,* Strophomena sp., *Plectambonites sericea, Leptaena unicostata, Rafinesquina alternata, Orthis occidentalis, O. biforata, O. testudinaria, O. whitfieldi, O. proavita, Zygospira modesta, Rhynchonella? anticostiensis, Rhynchotrema capax, Tentaculites sterlingensis, Byssonychia radiata, Pterinea demissa,* Megaptera sp., Modiolopsis sp., Cyrtodonta? sp., Lophospira sp., Liospira sp., Bellerophon sp., Orthoceras sp., *Calymene senaria* and *Isotelus gigas?*

These fossils are typical of the upper layers of the Maquoketa beds in the counties of Clinton, Dubuque, Clayton, Fayette, Winneshiek and Howard wherever in those areas the upper fossiliferous phase is developed. Professor Calvin* has shown that they are also similar to the fossils of the corresponding horizon in southeastern Indiana and southwestern Ohio.

Summary.—Of the deposits of the Maquoketa stage there are present in Jackson county only the Upper Maquoketa beds. The formation is argillaceous with the exception of twenty to thirty-five feet of the dolomitic transition beds or of fossiliferous, alternating shale and limestone bands. The total thickness of the Maquoketa beds in our area does not much exceed 100 feet. The thickness of the Maquoketa deposits increases towards the north, attaining its maximum in the

*Calvin: Iowa Geol. Surv., Vol. VIII, p 141

counties of Fayette, Clayton and Winneshiek. It then decreases rapidly towards the northern border of its extension in the state. In the southern portion of the Maquoketa area only the Upper Maquoketa beds are developed. In the extreme northern portion of its outcrop, the argillaceous part of the upper beds has faded out and there are represented only the calcareous, fossil-bearing horizon and the transition beds of the Upper Maquoketa, and beds corresponding with the Lower Maquoketa of Dubuque county.

SILURIAN SYSTEM.

Niagara Series.

The Niagara limestone forms the foundation rocks upon which is spread the mantle of Pleistocene materials over more than five-sixths of the surface of Jackson county. Its massive courses may be seen bordering all of the larger streams and many of the smaller water courses in the region outside the limits of the Ordovician deposits. They stand in precipitous ledges and steep escarpments, more than 100 feet in height, at points along Bear creek in Monmouth township; Brush creek, in Perry; in the vicinity of the "caves", in the township of South Fork; and at a number of other points over the area under consideration.

HOPKINTON STAGE.

With the exception of a deposit of limited extent in Brandon township, all of the strata of the Niagara series in our area belong to the subdivision known as the Hopkinton stage. These consist for the most part of very heavy layers, two to six or eight feet in thickness, which are but imperfectly separated by planes of stratification. They represent the basal portion of the Niagara limestone, the horizon of *Pentamerus oblongus*, and the Cerionites and crinoid beds that immediately succeed the Pentamerus layers.

The basal beds outcrop in the west bluff of the Mississippi river, almost continuously, from section 1 of Bellevue township to the southeast corner of Union. They appear just across the river from Sabula in the north part of the town of Savanna. They may be seen along the border of the Maquoketa shale in

Van Buren and Fairfield townships and they are exposed in the banks of all of the important streams that render tribute to the Mississippi river in Jackson county.

Typical Exposures.—A section of the beds exposed in the banks of a small stream near the middle of the south side of section 24, in Washington township, was given under the discussion of the Upper Maquoketa layers. At this place there is to be seen, overlying the uppermost zone of the Maquoketa, a bed of yellow, non-fossiliferous dolomite which is rather fine-grained in texture and is free from chert nodules. This zone varies in thickness from as low as four or five feet to as much as ten or twelve. It is generally present as the basal member of the Niagara limestone. It is probable that this zone corresponds with the basal Niagara beds of Calvin, which are better developed in Dubuque county.

Overlying the above member there is quite uniformly developed a bed of yellow-colored earthy dolomite, in rather thin layers, between which, at intervals of a few inches to one or two feet, there are intercalated bands of chert. These cherty beds have a thickness of eighteen or twenty feet and are especially prominent in the southeastern part of the county. They are conspicuous near the middle portion of the bluff from Sabula southward to Elk River Junction, in Clinton county, and they appear towards the top of the ledge at Green Island.

In section 36 of Washington township the dip of the strata brings this horizon down to the level of the flood plain. A creek that flows eastward through sections 2 and 1 of Iowa township, joining the river in section 6 of Union, shows no Maquoketa shale throughout its entire length. A quarry is worked in the Niagara limestone near the northwest corner of section 1, and the Niagara layers are clearly exposed at the level of the water near the middle of the east half of the same section. In section 13 of the civil township of Union, an arch in the strata once more brings the Maquoketa beds many feet above the water level. Along this anticline west of Sabula, the Niagara cliff recedes from the river for a distance of more than two miles. South of this line the strata dip strongly southward so that at the extreme southeast corner of the county, the

Maquoketa has generally disappeared from the bank of the river, and the Niagara is exposed almost to the level of the flood plain. The strong arching of the strata, and the relation of the cherty beds and the underlying even-bedded zone to the upper layers of the Maquoketa, are well shown in the north part of the town of Savanna, in Illinois.

Near the middle of the southwest quarter of section 30 in Union township, a ledge has been worked in the lower beds of the Niagara exposing a quarry face twenty feet in height.

Fig. 71—Lowermost, cherty beds of the Niagara limestone in a quarry in the southwest quarter of section 30, Union township.

Bands of chert, two to four inches in thickness, are conspicuous in the upper half of the ledge. See figure 71. The stone is a yellowish-brown dolomite, in original layers six to eight inches in thickness, which on weathering are divided into bands one to two inches thick. Traces of a few coral remains were found at this place.

In passing up the hill that borders the old Goose Lake channel, about one-half mile north of Preston, a thickness of fourteen feet of chert-bearing layers is well exposed at a horizon twenty feet above the outcrop of Maquoketa shale described above. The rock here is a yellowish-brown, somewhat granular dolomite, in layers three to six inches in thickness. Between these bands there are intercalated seams of chert about equal in thickness to the layers of limestone. The strata here dip strongly toward the east and are inclined at a lesser angle towards the north. The layers carry no recognizable fossils. They represent the upper portion of the cherty beds. Residual cherts are abundant on the slopes in the roadsides and overlying the ledges in this vicinity. Near the crest of the next hill, a few rods further north, there is an outcrop in which the layers are heavy and contain a large number of small individuals of *Pentamerus oblongus,* and several species of corals. This Pentamerus horizon is about seventy-five feet above the top of the Maquoketa shale exposure that was seen at the foot of the hill about forty rods further south. The dolomite of this horizon is very granular and yields readily to weathering. In the upper part it is so thoroughly decomposed that a spade can be easily pushed down into the top of the beds.

The chert-bearing beds are also well exposed at the cross-roads near the middle of section 22 of Van Buren township, and at a few other points in this vicinity, at a horizon not far above the top of the Maquoketa shale. The character of the materials here is similar to that of the beds exposed north of Preston. The layers also are strongly inclined, but the direction of dip is different in different parts of the outcrop. The cherty beds can be seen again in the hill near the southeast corner of section 27, in Fairfield township, a few feet above the Maquoketa shale outcrop in the bed of the stream.

Along the road crossing the north half of section 20 and the east half of 19 of Van Buren township, the granular phase of the dolomite appears in low cliffs to a height of thirty to forty feet. The beds are thick and do not weather into distinct layers. They carry numerous corals, among which *Halysites*

catenulatus, Favosites favosus and Favosites sp. are the most common. This coarsely granular phase appears again in section 16 of the same township.

Over the north half of the county the lower beds of the Niagara are harder and more crystalline than in the southeastern portion. They do not yield readily to weathering, but stand in precipitous cliffs near the crests of the hills that bound the stream channels. In the lower portion there is a considerable amount of chert, above which, at the horizon of the somewhat granular beds further south, the layers are hard and enduring and carry numerous corals. On weathered surfaces these strata show rather thin layers in which *Halysites catenulatus, Favosites favosus, Lyellia americana* and *Syringopora* sp. are not rare. The beds appear in the east half of section 18 of Prairie Spring township.

This horizon probably corresponds with the Syringopora beds described by Calvin* in the report on the Geology of Dubuque county. A quarry near the northeast corner of the southwest quarter of section 20, Iowa township, shows the following succession of layers:

		FEET.
7.	Bed of decayed, earthy, yellow dolomite, containing much chert; the bedding planes destroyed by the breaking down of the rocks on weathering	10
6.	Ledge of yellow colored dolomite, very cherty, weathering into layers about one inch in thickness	3
5.	Layer of very cherty dolomite	2½
4.	Layer of earthy dolomite, with chert	2
3.	Bed of yellow dolomite bearing, near the center, a band of chert two inches in thickness. Weathering into thin layers one to two inches thick	2⅓
2.	Layer of yellow dolomite, free from chert	1½
1.	Yellow colored, rather fine grained dolomite, without chert, in a single layer	2

The above section is representative of the basal beds of the Niagara limestone. The lower part of No. 1 is very close to the top of the Maquoketa shale. Numbers 1, 2 and 3 represent the non-cherty, rather fine-grained and even-bedded layers at the very base of the Niagara. Numbers 4 to 7 inclusive represent the chert bearing layers which lie a few feet above the Maquoketa.

*Calvin and Bain: Iowa Geol. Surv., Vol. X, pp. 446 and 447.

The above outcrop is along the line of the anticline that extends westward from Sabula, which accounts for the lowermost Niagara beds being brought to the surface at this point.

Near the southeast corner of section 10, Butler township, a quarry has been opened in a hill on the north side of the wagon road, showing a vertical face thirty feet in height. The material is a yellow, non-fossiliferous dolomite. In the upper half of the exposure the layers are from three to six or eight inches in thickness. Lower down they thicken to as much as eighteen to twenty-four inches. Cherty materials form conspicuous bands between the layers. It seems probable that the beds here exposed correspond with the cherty phase encountered in the southeastern portion of Jackson county.

A short distance east of the middle of section 21, Otter Creek township, a small quarry has been operated in layers which contain *Halysites catenulatus, Favosites favosus, F. hisingeri, Lyellia americana* and Syringopora sp. Near the top of the bluff not far from the middle of the east side of section 19, Tete des Morts township, there were found among the residual cherts *Plasmopora follis, Alveolites undosus, Heliolites interstinctus, H. megastomus, Strombodes pentagonus, Halysites catenulatus, Favosites favosus, F. niagarensis* and *Orthis flabellulum*.

Near the middle of section 32, Richland township, ledges of Niagara limestone twenty to fifty feet in height, bound the channel of Farmers creek. These beds contain the corals *Halysites catenulatus, Favosites favosus, F. niagarensis, Lyellia americana* and a species of Syringopora. This coral zone is quite generally present at a horizon a few feet above the cherty phase of the lower Niagara beds. It doubtless corresponds with the *Syringopora tenella* beds of the Dubuque county report.

Along a ravine near the southeast corner of section 30, in Richland township, numerous corals are found among the chert fragments and residual materials. Among these the following are abundant: *Halysites catenulatus, Favosites favosus, F. hisingeri, F. niagarensis, Lyellia americana, Heliolites interstinctus, Cannapora annulata,* Syringopora sp., *Amplexus*

shumardi, Strombodes sp. and *Cystiphyllum niagarense.* There seems no doubt that these corals came from the horizon of *Syringopora tenella.* This coral zone in our area varies in thickness from twenty to thirty feet. It occurs above the cherty phase and underlies the horizon of *Pentamerus oblongus.*

The *Pentamerus oblongus* beds consist of massive dolomite layers which are pre-eminently the cliff-forming ledges of the

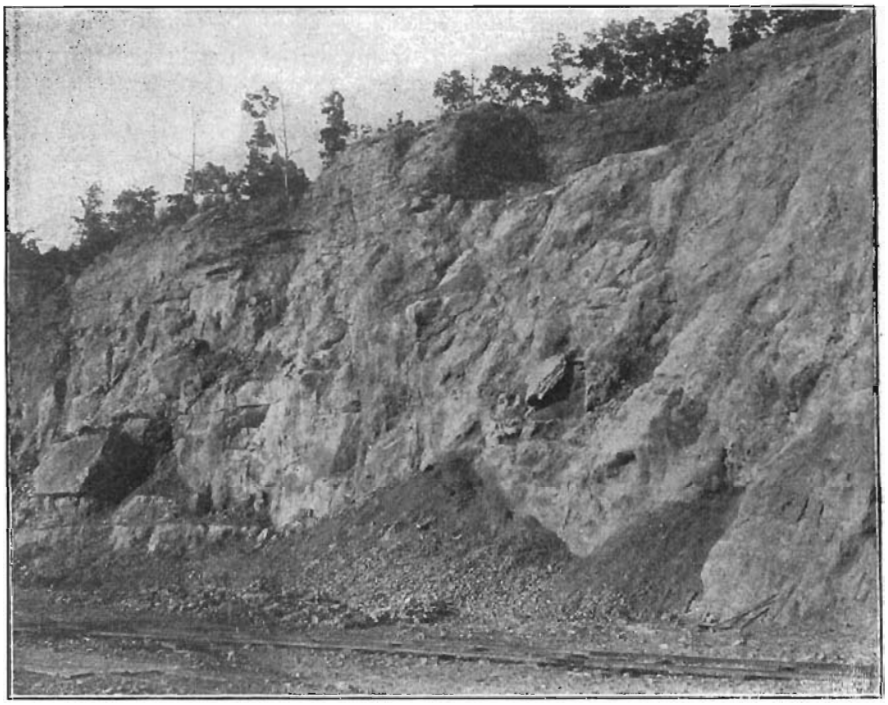

Fig 72 - Quarry furnishing stone for lime burning at Hurstville.

Niagara limestone in the county. The large lime works in our area quarry the upper portion of the Pentamerus horizon and the overlying beds containing crinoids and *Cerionites dactylioides.* Below is given a section of Hurst's lime quarry east of the river, at Hurstville.

	FEET.
3. Ledge of somewhat decayed, yellowish-brown dolomite, weathered into layers from a few inches to three or four feet thick; containing Cerionites, crinoids and Pentamerus	15

		FEET.
2.	Massive ledge of yellow dolomite, imperfectly separated into layers six to eight feet in thickness, which contain crinoids and Halysites and Favosites besides numerous individuals of Pentamerus	30
1.	Ledge of buff colored dolomite crowded with rather small individuals of *Pentamerus oblongus*	8

The above ledge outcrops along the river for a distance of twenty-five rods. The entire thickness is used for lime burning. Below the first member of the section there occurs a heavy ledge, ten or twelve feet in thickness, which contains chert in considerable quantities making it unsuited for manufacture into lime. In the old quarry on the west side of the river there may be seen practically the same succession of beds as in the section given. The following fossils were collected from this quarry zone at Hurstville. *Cerionites dactylioides, Halysites catenulatus, Favosites favosus,* Syringopora sp., *Zaphrentis stokesi, Caryocrinus ornatus,* Culicocrinus sp., *Pentamerus oblongus, P. pergibbosus, P. maquoketa, Meristina nitida, Atrypa reticularis, Spirifer radiatus, Bucania chicagoensis, Pleurotomaria occidens,* Mandaloceras sp., and the form described by Whitfield as *Discoceras conoideus.*

The lime quarry of O. W. Joiner, located near the middle of the south side of section 20, South Fork township, is operated in beds which correspond with those at Hurst's quarry. From the upper half of Joiner's quarry there were collected *Cerionites dactylioides, Halysites catenulatus, Favosites favosus, F. hisingeri,* casts of Zaphrentis sp. and Lyellia sp., Culicocrinus sp., Melocrinus sp., Stropheodonta sp., *Orthis biforata, Pentamerus pergibbosus, P. maquoketa, Stricklandinia castellana,* Meristina sp. and fragments of a small species of Orthoceras. From the lower portion of Joiner's quarry the following were taken: *Cerionites dactylioides, Favosites favosus,* Zaphrentis sp., *Melocrinus verneuili,* Culicocrinus sp., *Leptaena rhomboidalis, Orthis biforata, Pentamerus oblongus, Stricklandinia castellana, Amphicoelia leidyi, Bucania chicagoensis, Platystoma niagarensis, Discoceras conoideus* and *Illaenus imperator.*

The beds represented in this quarry exposure are present in the bluffs that border the streams in all of this portion of the

county. These rocks form the rampart that more or less continuously bounds the South Fork of the Maquoketa river. They appear in the weathered towers along Bear creek in the vicinity of Mill Rock. They stand in steep escarpments at the "caves" in South Fork township, and along Brush creek in section 14 of Per[illegible]. In short, wherever in the county very prominent cliffs are formed by Niagara ledges alone, the presence of the beds of this horizon may be looked for with confidence.

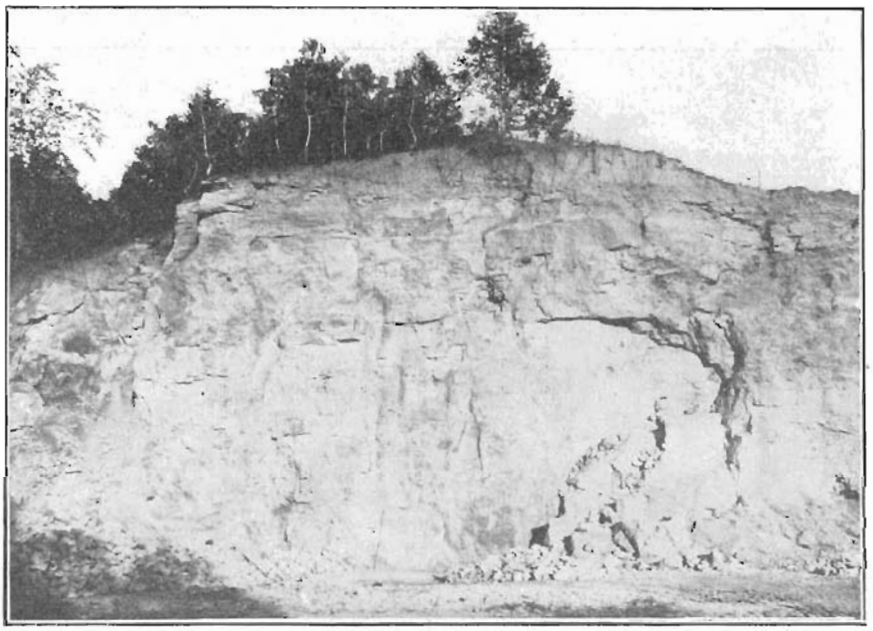

Fig. 73 Lime quarry working the Pentamerus horizon of the Niagara limestone, section 20, South Fork township

In the quarry of the Keystone Lime Company, near the middle of the west half of section 32, Monmouth township, the ledges worked embrace the above mentioned beds and include a layer of Pentamerus limestone, eight feet in thickness, which occurs below number 1 of the Hurst quarry section. In this quarry a thickness of forty feet of Pentamerus beds has formerly been exploited below the base of the layers now worked. These lower beds, however, contain too much chert to be profitably used for lime burning. They are largely composed of

casts and moulds of very large individuals of *Pentamerus oblongus,* many of which can be broken from the matrix in an almost perfect condition. From calculations based on the log of two wells put down in the vicinity of this quarry, Mr. L. B. Stewart estimates a thickness of sixty feet of Pentamerus-bearing rocks in Monmouth townships and about ninety feet of Niagara limestone below the *Pentamerus oblongus* beds. This thickness seems to be a little greater than that of the corresponding beds in the eastern portion of the county.

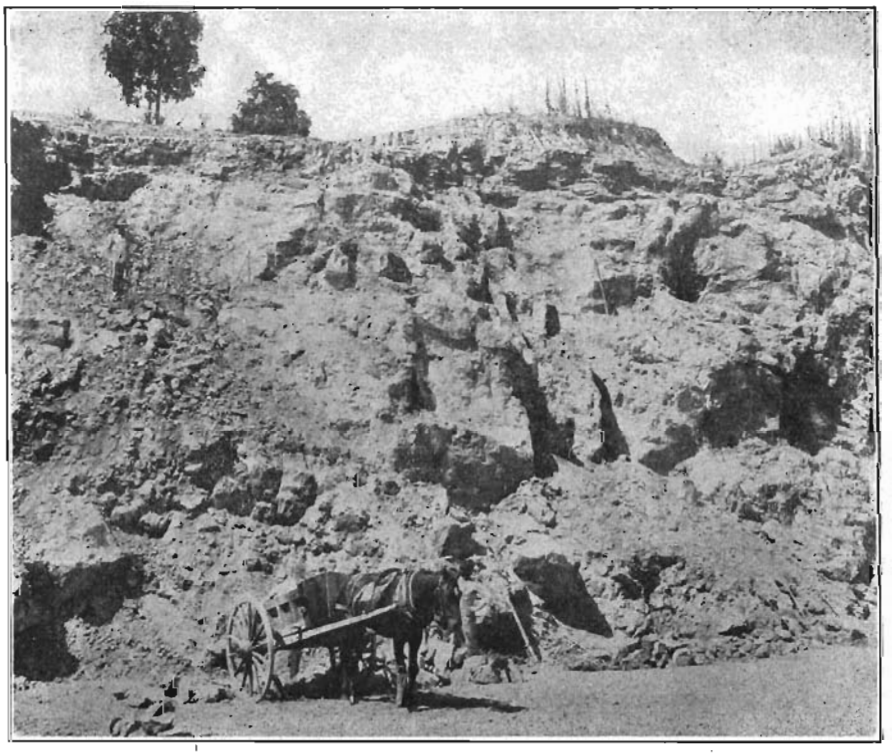

Fig. 74--Lime quarry in section 32 of Monmouth township.

Besides the fossils generally found in the rocks of this horizon there were taken from the Keystone quarry *Euomphalus tricarinatus* Calvin, *E. bicarinatus* Calvin, *Orthoceras crebrescens* Hall, and *Illaenus imperator* Hall.

Above the horizon of Cerionites there occur, in Brandon township, some few feet of massive dolomite layers which contain quite a number of the more common species of Niagara

corals. This zone is developed only over limited areas in the northwest portion of Jackson county. At a few points in sections 9 and 10 of Brandon township it is overlain by the even-bedded quarry-stone layers of the Gower stage.

GOWER STAGE.

The rocks of the Gower stage in our area consist of even-bedded layers of yellow dolomite, without fossils. They outcrop at only a few points in sections 9 and 10 of Brandon township.

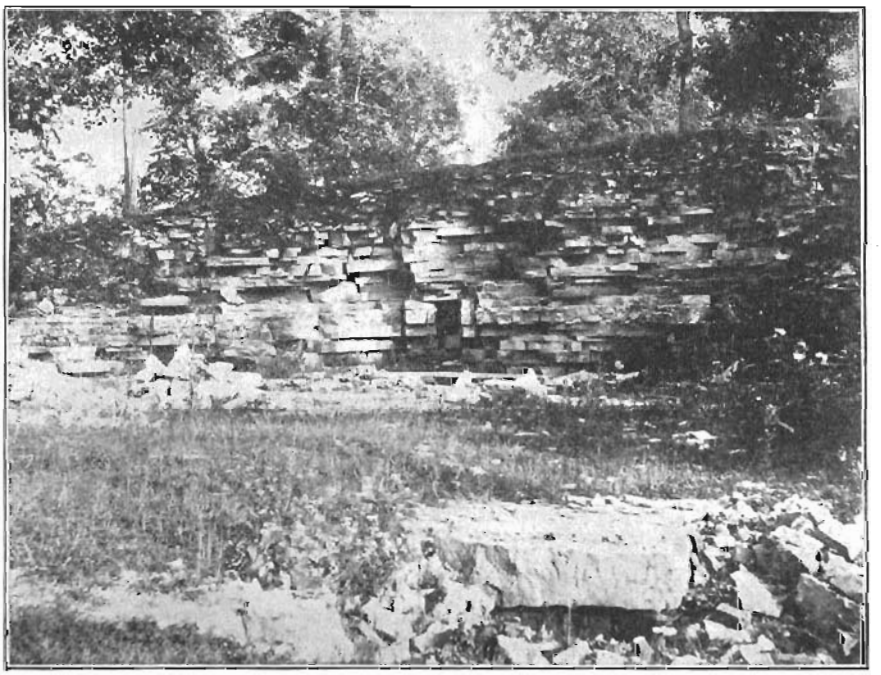

Fig. 75-- Building stone quarry of the Gower stage; near the southwest corner of section 10, Brandon township.

A quarry on land owned by Mr. John Archibald, in the south bank of the North Fork of the Maquoketa river near the middle of the east side of section 9, has furnished considerable stone for local purposes. The section of the layers here exposed is given below:

		FEET
3	Bed composed of thin layers of yellow magnesian limestone, two to four inches in thickness, much weathered..... ...	0

		FEET.
2.	Yellow, rather fine-grained dolomite, in regular layers two to twelve inches in thickness, showing numerous fine lines of lamination	8
1.	Layers of yellow dolomite, eight to eighteen inches in thickness, finely laminated and splitting readily along the lamination planes	9½

The stone here is easily quarried and resembles the Anamosa type of stone found in Jones county. In its even bedding, finely laminated character, and it finely granular texture it differs very markedly from the quarry stone of the Hopkinton stage.

Near the southeast corner of section 9, a quarry on land belonging to Mrs. P. J. Fads shows the even character of the layers in this horizon. (See figure 75.) The section of the quarry is as follows:

		FEET.
3.	Bed of weathered and broken, finely laminated layers of yellow dolomite, one to three inches in thickness	4
2.	Even, fine-grained finely laminated layers, from two to eight or ten inches in thickness	10
1.	Three layers of yellowish-gray, laminated stone respectively 14, 10 and 16 inches in thickness	3⅓

The stone here is of excellent quality, and is readily accessible. It occurs at a horizon a short distance above that exposed in the quarry of J. W. McCullough, about one-half mile further west. At the latter place the following beds may be seen below the surficial materials:

		FEET.
3.	Layer of hard, yellowish-gray dolomite	1½
2.	Ledge of even-bedded finely laminated dolomite in layers two to four inches in thickness	6
1.	Bed composed of layers six to twenty inches in thickness, fine-grained and finely laminated	7⅔

This stone weathers into thin pieces where long exposed in contact with the ground, but it proves durable when laid in a wall. It can be quarried easily and dressed readily into elegant blocks of any dimensions desired. The layers in this quarry have furnished flagstones 8 x 12 feet x 14 inches and supplied excellent blocks for caps, sills, and water tables. A large proportion of the stone used in the western portion of the county comes from the above mentioned quarries in the Gower limestone. A thickness of seventy to ninety feet of deposits of the Hopkinton stage

intervenes between the horizon represented in these quarries and the bed of the North Fork of the Maquoketa river.

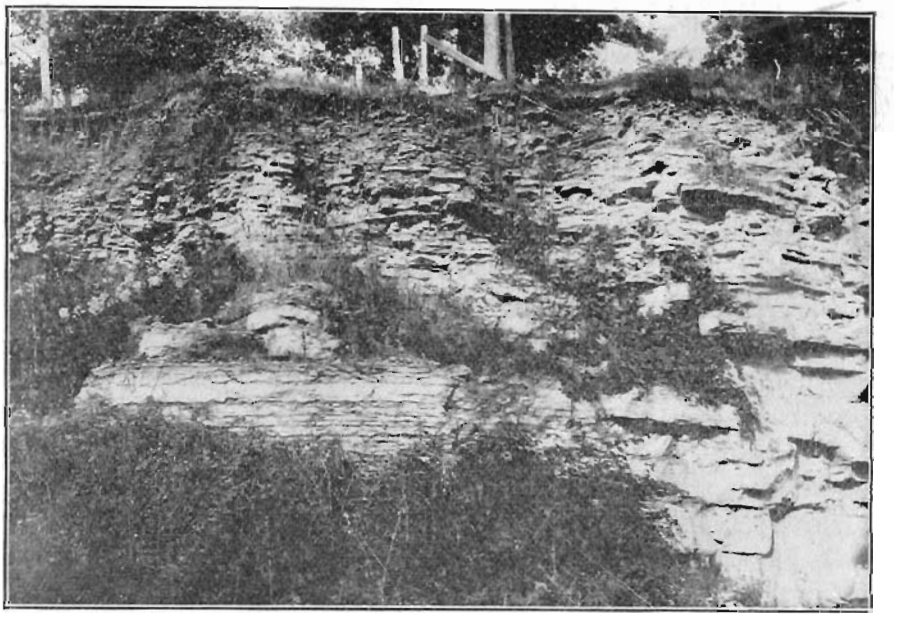

Fig 76- Quarry stone of Gower type which supplies building stone to a large portion of Butler township.

DEVONIAN SYSTEM. ?

No outcrop of rocks of undoubted Devonian age was seen in Jackson county. A bed of sandstone and shale which is exposed in the wagon road near the middle of section 18 in Brandon township, about one-half mile north of the village of Canton, has been tentatively referred to this system.

The sandstone showed beautiful ripple marks and contained impressions of plant remains. No fossils could be found in the shales as at present exposed. Professor Norton,* who studied the outcrop when the beds were better exposed than at present, writes as follows concerning this deposit:

"A yellowish-gray sandstone outcrops about half a mile north of Canton in Jackson county. It occupies a narrow shelf in the Upper Silurian limestone, sixty feet above the present flood plain of the Maquoketa river, and extends east and west

*Norton: Iowa Geological Survey, Vol. III, pp. 122-126.

along the south slope of the hill a distance of about eighteen rods. The total thickness as defined by outcrops of the Upper Silurian both above and below it, cannot be over twelve feet. As shown in a well on the crest of the hill the limestone there rises between twenty and thirty feet higher than the sandstone. The latter, which occurs in a field in scattered bowlders and with one or two ledges a foot or more high, presents nothing to differentiate it from perhaps a dozen or more other outliers of sandstone in northeastern Iowa. Fortunately, however, at the western end of the outcrop on the brow of a hill, a road crosses it, displaying a very interesting section. On the west side of the road there are noticeable some small, badly weathered bowlders of brecciated limestone which, in the structural and lithological characteristics of both fragments and matrix are indistinguishable from the lower portions of the Fayette breccia of the Devonian. Three of these bowlders were found and a half dozen rudely oval nodules of quartz with pitted surfaces, the latter peculiarly characteristic of the Kenwood shale, which in Linn county lies beneath the Fayette breccia. On the same side of the road the sandstone is exposed in a small gully for a distance of nearly two rods. Above this lies a stiff gray or greenish unctuous clay, in places highly arenaceous, in others nearly free from sand. It extends five rods up the hill. This clay had been scraped clean in working the road and the surface was substantially free from foreign material. On the weathered surface of the clay, fragments of silicified fossils are quite plentiful. They comprise *Acervularia davidsoni, Atrypa reticularis, Orthis iowensis,* a Strophеodonta, several species of Spirifers, one indistinguishable from fragments of a Spirifer at Bertram. Specially numerous were the rostral portions of the ventral valve of *Cyrtina umbonata* Hall, their preservation being due to the fact that this portion of the shell is strengthened by the cardinal area and mesial septum. Still more abundant were fragments of simple rugose corals and of favositids.

The occurrence of these remnants of Devonian beds of considerable thickness thirty miles east of their nearest outcrops was entirely unexpected. With the exception of the outliers

above described, viz. Bertram, Lisbon and on Clear creek in Cedar county, no Devonian outliers had previously been known in the state and none had been found in this region resting on the rocks of an earlier geological age. It therefore becomes necessary to consider and, if possible, to disprove every other working hypothesis of the presence of these Devonian fossils and bowlders at Canton. Any suggestion of a fortuitous mingling of Devonian drift from northwestern outcrops with the sandstone and clay of a Carboniferous outlier was seen to be quite untenable. The fragments of fossils were siliceous, specifically identical with forms from the Devonian sandstone at Bertram. The distribution of Devonian rocks and fossils was exactly conterminous with the outcrop of sandstone and clay on the west side of the road, being found along its entire extent and entirely absent both above and below. Further, this outlier is situated near the margin of the driftless area. The drift here is thin and inconstant, forming a thin, pebbly layer resting on geest or intermingling with it. No drift appears along the outcrop of the sandstone and clay, but seven rods farther up the hill the rotten Upper Silurian limestone is overlain by a foot of residuary chert and clay mixed with pebbles of the northern drift. The bowlders of Devonian limestone and breccia show no indication of transportation by water or ice. Fossils and breccia fragments are in relief. The surfaces are irregular and pitted. The quartz nodules retain their original form and their surfaces are vesicular from the dissolution of associated calcite.

To be doubly sure of the relation of the fossils, breccia bowlders and quartz nodules to the clay and sandstone, a hole was dug in the undisturbed bank by the roadside, giving the following section:

		FEET.
3.	Soil passing below into clay	½
2.	Clay, stiff, reddish-brown, free from pebbles (passing below into number 1)	1
1.	Clay, stiff, greenish gray, sandy, non calcareous, containing silicified fragments of Devonian fossils	1½

The fossiliferous clay overlies a sandstone, which in turn rests upon a clay, as shown by the fact that a few years since

an excavation was made in the middle of the road, and fire-clay was found to extend to a depth of six feet. The intimate association of clay and sandstone is shown by the following section on the east side of the road, where the bank is six feet higher than on the western:

		FEET.	INCHES.
6.	Soil, passing into loess	1	
5.	Loess, fine, buff loam, rather stiff, with the lower inch a transition in color and texture into number 4	3	
4.	Clay, fine, white, unctuous, with rounded fragments of sandstone		4
3.	Clay, light brown, resembling fire clay		2
2.	Clay, light-red, as above, with fragments of reddish sandstone	1	4
1.	Clay, white, as above	1	

On the same side of the road no Devonian limestone or fossils were found. The width of the outcrop is the same on both sides.

The little deposit of foreign rock on the brow of the Canton hill is full of meaning. Hitherto there has been no evidence that the Devonian sea ever trangressed the present western boundary of the Upper Silurian in Iowa. This outcrop affords proof that the ancient shore line must have extended at least as far east as Canton. It hardly can represent rocks deposited in some shallow estuary, connected with the Devonian ocean to the west. More probably it represents one or more distinct beds of the Devonian series elsewhere of considerable thickness and deposited under oceanic conditions. Quartz nodules are common only in the Kenwood shales, though one is sometimes found in the Fayette breccia. The hard drab limestone with conchoidal fracture which forms the fragments of the Canton breccia characterizes a definite horizon of Lower Devonian from Davenport to Fayette. It lies above the Kenwood shales of Linn county and, where its beds are disturbed, forms the lower portion of the Fayette breccia. It demands oceanic conditions for deposition and probably for brecciation. The fossils, if unassociated with sandstone and clay, would be referred to no horizon lower than the coralline beds above the breccia. The sandstone and clay are of doubtful position.

They may be the Montpelier, or they may be related to the arenaceous material sometimes found associated with the matrix of the Fayette breccia.

It seems, therefore, highly probable that the strata of the Lower Devonian, and perhaps some of the Upper Devonian were laid down as far east as the western part of Jackson county and have since been removed by secular decay and erosion. It is a mere accident that in one place, at least, their remains were preserved from the ice invasions on the lee of a hill of obdurate Upper Silurian dolomite, at the margin of the driftless area."

In the above discussion Professor Norton presents a possible interpretation of the presence of the Devonian fossils and of the fragments of Devonian limestone far to the east of their normal area of outcrop. There are a few Devonian corals in the Museum of the Iowa Geological Survey, at Des Moines, which were collected by Mr. Lonsdale and bear the locality label "One-half mile north of Canton, Jackson county." These were doubtless taken from the deposit described by Professor Norton. Unfortunately the rocks at this place can be studied at present over but a very small area and they are at best very imperfectly exposed. No fossils could be found at the time of the writer's visit. The sandstone and shale do not differ in any appreciable way from those seen in outcrops that are unhesitatingly referred to the Des Moines stage. Professor Norton has also stated a great difficulty in this connection in that these Devonian corals and other fossils do not normally occur associated with such beds of sandstone and shale. Inasmuch as Professor Norton studied this deposit under much more favorable conditions of exposure than the writer, it seemed best to give the interpretation of the facts as he presented them.

CARBONIFEROUS SYSTEM.

Upper Carboniferous or Pennsylvanian Series.

DES MOINES STAGE.

A number of outliers of Des Moines sandstone and shale occur within the borders of Jackson county. Individually they are of but a few acres in extent, and generally are of no great

vertical thickness. One of the largest sandstone beds is found in sections 31, 32 and 33 of Monmouth township, about three miles south of the town of Monmouth. This outlier was first described by Professor Herbert Osborn,* and later by Professor Norton.†

The ledge extends interruptedly for a distance of more than two miles, in a northeast-southwest direction. It lies in the form of a crescent somewhat parallel with the course of Bear creek, and only a short distance south of that stream. It occupies a pre-Carboniferous valley eroded in the Niagara limestone. This depression has a width of fifteen to twenty rods and a depth below the tops of adjacent Niagara ledges of fifty or more feet.

On the west side of the wagon road, near the southeast corner of section 31, a thickness of thirty feet of sandstone is exposed. The ledge consists of hard layers, one to four feet in thickness, which in places appear massive and show very distinct cross-bedded structure. In the corresponding bank that borders this small stream on the west there outcrops nearly as great a thickness of the sandstone. At the bottom of the Des Moines ledge at this place the sandstone merges into a coarse, pebbly conglomerate which is eight to twelve inches or more in thickness. The pebbles are mostly rounded nodules of chert which vary from one to three and one-half inches in diameter. They were probably derived from the decay of the Niagara ledges during the long interval of pre-Carboniferous erosion. Such a pebbly conglomerate at the base of the deposits of the Des Moines stage has been found at other points in Iowa, and it is very commonly encountered at that horizon further east and south in the state of Illinois.

The waters of Bear creek have cut out this sandstone ledge from the west half of section 33, but near the middle of the north half of this section the north end of the outlier is well exposed. The stone is iron-stained and the layers are hard and enduring. They have been quarried at a number of points for local use. Where the ledge is crossed by a small stream, the

*Osborn: Proc. Iowa Acad. Sci., Volume I, Part 2, p. 115.
†Norton: Iowa Geol. Survey, Vol. III, pp. 128-130.

thickness is about twenty feet. The basal conglomerate does not appear at this place. There are few fossils to be seen, and no shale is found associated with the sandstone layers in this deposit.

In the northwest quarter of section 17, Brandon township, there outcrops a ledge of sandstone overlain by a bed of plastic shale, both of which were thought to belong to the Des Moines stage. The exposure is in a ravine, on land owned by Mr. Charles Ross. The shale is two and one-half to three feet in thickness and is quite plastic. Some of this material was made into brick by Mr. Lyman Parshall, of Canton, and was used in constructing an arch for a charcoal oven. The brick endured the heat of burning the charcoal in this oven for a period of fifteen years. This outlier is less than one-half mile north and three-fourths of a mile east of the sandstone and shale exposure which Professor Norton referred to the Devonian system. It is possible that these beds also represent Devonian deposits, but there were found no fossils to indicate the age, and, since the lithological characters of the materials resemble those of the Des Moines stage rather than the Devonian, the beds are considered as belonging to the Carboniferous system.

In the southeast quarter of section 9 of Brandon township, there may be seen, in the roadway, near the top of the hill on the south side of the river, a low ledge of Des Moines sandstone. On turning east into the lane leading from the main road to the house of Mrs. P. J. Eads, a thickness of five feet of sandstone is passed over. At this place the sandstone occupies a depression in the quarry stone beds of the Gower stage. This outlier of sandstone is about one-fourth of a mile north, and one and three-fourths mile east of the last exposure mentioned above. It is about on a line with that deposit and with the sandstone and shale outlier one-half mile north of Canton, as will be seen by referring to the Geological map of Jackson county accompanying this report.

Near the southeast corner of section 13, Maquoketa township, a very pretty Carboniferous outlier is exposed in the slopes on both sides of a stream that crosses the wagon road along the

east line of this section. A thickness of fifty feet of reddish-brown, coarse-grained sandstone outcrops below the mantle of Pleistocene materials. On following down this stream, towards the west, there appear reddish colored sandstone layers alternating with beds of gray or drab colored shale. The base of the outlier may be seen resting on a ledge of Niagara limestone. The total thickness of the shales and sandstones in this outcrop exceeds seventy feet.

About one mile south of the latter exposure the following layers outcrop along the north bank of a stream and in the wagon road, in the southwest quarter of section 19 of Fairfield township and the east-central portion of section 24 of Maquoketa:

		FEET.
9.	Bed of gray sandstone, much decayed	6
8.	Purplish colored, dry, fissile shale	4½
7.	Reddish gray sandstone	2
6.	Bluish colored shale	1
5.	Sandstone	3
4.	Band of slate colored, dry shale, breaking into thin bits on weathering	⅔
3.	Bed of iron-stained, coarse-grained sandstone, in layers one to three inches in thickness	20
2.	Drab colored to black shale	3
1.	Brown, coarse-grained sandstone in uneven layers eight to eighteen inches in thickness	3½

Another small outlier of sandstone and shale occurs along the middle of the west half of section 17 and near the center of the east side of section 18 in Fairfield township. Beds of ferruginous sandstone have been quarried at two or three different points along the channel of a stream in the northeast quarter of section 29 of the same township.

Across the north end of section 32 of Fairfield township, a ledge of Des Moines sandstone borders the channel of a stream, on the north, for a distance of several rods and to a maximum height of twenty-five feet. (See figure 77.) This bed of sandstone is rather coarse-grained in texture and is stained a reddish or yellowish brown by the presence of iron oxide. It is rather massive, showing imperfect planes of stratification at intervals of from six inches to two feet. This bed of Des

Moines sandstone rests upon and abuts against a bank of Maquoketa shale. Where small lateral streams have cut through the ledge it has a width of eight to ten rods. At the same level a bed of Niagara limestone forms the south bank of the creek and faces the sandstone ledge across the stream. This sandstone outlier, like most of the others above described, occupies a trough that was carved by the waters of some pre-Carboniferous stream. The materials were thus protected from complete denudation by the sides of the trough, between which they lie.

Fig. 77—Ledge of Des Moines sandstone abutting against a wall of Maquoketa shale and facing a bluff of Niagara limestone, twenty rods distant across a stream Section 32, Fairfield township

Another small outlier of sandstone was encountered in the northwest quarter of section 15 of Maquoketa township, and still another ledge of sandstone material was found in Perry township, about three miles north of the town of Andrew.

A Carboniferous outlier was reported to occur in the southeast quarter of section 4 in Maquoketa township, but this deposit was not seen.

The presence of these Carboniferous outliers, many of them occupying old erosion channels in the Niagara limestone,

testifies to a number of oscillations in the relative level of the sea and land. After the deposition of the Niagara beds the region which now embraces Jackson county was elevated above the sea. For a long time this area remained a land surface subject to the denuding action of the agents of erosion. We have no means of estimating the thickness of sediments that were swept from the surface during the long period that intervened between the close of the Niagara and the laying down of the earliest sediments of the Des Moines stage. We know, however, that by the close of this period of erosion the surface of our land was trenched by the stream waters into hills and valleys much as we see it today. The deposition of the shales and sandstones of the Des Moines stage was initiated by a subsidence of all of this portion of Iowa. During this age a broad shallow mediterranean sea stretched far across the Illinois coal fields on the east and beyond the borders of Iowa towards the southwest. The pre-Carboniferous valleys were filled, and sediments were spread over all of this sea bottom probably to a depth of hundreds of feet. The deposition of the sediments of the Des Moines stage was closed by a movement of the earth's crust which resulted in bringing our area once more above the level of the sea. Ever since that long distant time the agents of weathering and erosion have been ceaselessly at work. The greater portion of the Des Moines sediments have been removed from the surface of Jackson county. Only a few scattered outliers of small extent remain, and these owe their preservation to the fact that they occupied depressions in the older limestones and thus were protected from the denudation that wasted the general surface.

RESIDUAL MATERIALS.

The submergence, during which the sandstones and shales of the Des Moines stage were deposited over Jackson county, was followed by a subsidence of the sea relative to the level of the land, and this region became a theater of erosion. For an exceedingly long interval our area was subject to the forces of degradation.

If the Rockville conglomerate* in Delaware county and the Pine Creek conglomerate† of Muscatine county belong to the Cretaceous system, it would seem probable that the great mediterranean sea that covered a large area in the interior of our continent during a part of the Cretaceous period overspread the whole of Iowa. It is possible that the region now embraced in Jackson county was then submerged. The fact of the occurrence, in this county, of a basal conglomerate underlying sandstones of undoubted Des Moines age at points much nearer the above mentioned outcrops than any known beds of Cretaceous sediments would suggest that possibly the small conglomerate outliers in Delaware and Muscatine counties might also represent remnants of coarse, clastic deposits of the Des Moines stage.

However this may be, it seems certain that if the Cretaceous sea ever overspread our area, all of the sediments that were then deposited were removed from the surface prior to the deposition of the Pleistocene materials. There are no means of definitely measuring the thickness of the mantle that was swept from this area during the long ages that it stood above the sea between the later portion of the Pennsylvanian period and the early part of the Pleistocene. Professor Calvin‡ has estimated that the thickness of the strata removed by solution and erosion from the summit of Iron Hill, in Allamakee county, was between 800 and 1000 feet.

The present streams of the region have carved their beds at least 700 feet below the tops of the more elevated points.

Professor Salisbury has found chert and silicified fossils, that have been derived from the Niagara beds, mingled with the gravels that cap the tops of the quartzite range of hills near Baraboo, Wisconsin.§ If these gravels, cherts and silicified fossils are of the nature of residual materials, as Salisbury suggests, they would indicate the removal from the tops of the mounds of all of the series of strata lying between the Baraboo quartzite and the Niagara limestone. This involves a vertical

*Calvin: Iowa Geol Surv., Vol. VII, pp. 160-164.
†Udden: Iowa Geol. Surv., Vol. IX, pp. 316-320.
‡Calvin: Iowa Geol. Survey, Vol IV, p. 99
§Salisbury: Journal of Geol., Vol III. p. 565.

thickness of at least 1000 feet of sediments. The larger streams of Wisconsin have cut their channels 700 to 800 feet below the tops of these elevations.

There seems abundant evidence that the streams of the upper Mississippi valley have denuded the land surface to a vertical depth of one-third of a mile. Much of this has probably been accomplished since the late Tertiary or early Pleistocene period. If the sea had successively withdrawn from the land as soon as an approach to peneplanation of the surface was accomplished, the depth of sediments denuded from our area during the entire Pennsylvanian-Pleistocene interval would be measured by thousands of feet.

At a number of places over the county there occurs, immediately above the Niagara ledges and underlying the Pleistocene materials, a mantle of geest which consists of stiff, red colored clay in which are mingled fragments of chert. This clay represents the very small proportion of argillaceous matter that was disseminated through a many times greater thickness of Niagara limestone, and which has been concentrated as the soluble portion of the beds was slowly removed by drainage waters. The chert fragments were derived from the obdurate siliceous nodules that were enclosed in the Niagara beds.

On a hill near the middle of the north side of section 5 in Brandon township, such red colored residual materials have a thickness of from one to three feet. They occur a short distance east of the middle of section 21 in Otter Creek township. They may be seen on a hill near the southwest corner of section 30, Richland township, and at many other places in the county.

The drift over portions of the townships of Van Buren, Fairfield and Maquoketa is very thin, and it is impossible to distinguish the part of this material that is of pre-Pleistocene age from that which has been disintegrated in post-glacial times.

It was upon a surface over which a considerable amount of geest or residual matter had been developed, and where uplands stood well above the valleys—the relief in Monmouth township was at least three hundred feet—that the protective mantle of Pleistocene materials was spread.

PLEISTOCENE SYSTEM.

Over large areas in the county the finer part of typical drift material is very thin or entirely wanting. The topography is essentially that of a driftless region. However, the presence and mode of distribution of the bowlders and bowlderets of foreign derivation, consisting of quartz, greenstones and granites, would indicate that a sheet of ice overspread practically the entire area.

Occasional glacial bowlders occur in the roadside near the southeast corner of section 28 of Prairie Spring township. They may be seen along the wagon road crossing the northwest quarter of section 30, in Tete des Morts township. A bed of drift, with a number of granite bowlders, one to two and one-half feet in diameter, appears in the roadside a short distance west of the village of St. Donatus, in the southwest quarter of section 7 in Tete des Morts township. South of these points there are considerable areas over which few signs of drift are exposed, but scattered glacial bowlders and remnants of a drift mantle are encountered so frequently and in such localities as to leave little doubt of the former presence of an ice sheet.

There is clear evidence that at least two ice sheets, the Kansan and the Iowan, invaded portions of Jackson county. These were separated from each other by a very long time-interval. The earlier of these incursions, known as the Kansan, was far the more widespread. It carried much the larger load of debris and covered much the greater portion of our area.

KANSAN STAGE.

Kansan drift.—The Kansan drift is deepest and most generally present over the southern and western portions of the county. The characteristics of this drift in Jackson county do not differ in any essential points from those of thin deposits of corresponding drift in other portions of the state. Where long exposed to the atmosphere the superficial portion is leached of its lime constituent and oxidized to a reddish-brown color for a depth of from one to four or more feet. Where the deposits are deep this ferretto zone grades downward through less perfectly leached and yellow colored material into the unchanged bluish-gray till of the main body of drift.

Excellent exposures of the ferretto phase may be seen along the wagon road crossing the middle of section 21 in Perry township. Reddish, pebbly drift overlain by a mantle of loess occurs near the middle of the east side of section 19, Richland township. It appears in the northwest quarter of section 31 of Otter Creek township, and at numerous other points in the south and west portions of the area.

Crossing the north side of Maquoketa township, in sections 3, 4 and 5, there is a belt of unusually heavy Kansan drift that carries a considerable number of bowlders. Many of these are of exceptionally large size for the drift of this age, the larger masses having a diameter of six to nine feet. The monument erected to the memory of Colonel Thomas Cox, in the cemetery at Maquoketa, consists of an undressed granite bowlder 6½ x 4½ x 3 feet in size, that was taken from this bowlder train.

In putting down a well on the Henry Little farm, in the northwest quarter of section 25, Monmouth township, a thickness of 225 feet of surficial materials was penetrated without reaching indurated rock. Much the greater portion of this depth was through deposits of the Kansan stage. Such deep deposits of drift material are rare in the county, and are limited to the southern portion.

Occasional beds of ferruginous sand and gravel are encountered. The largest deposit of such coarse material that was seen underlies a portion of the town of Maquoketa.

As stated above, the finer constituents of normal drift are wanting over considerable areas. The chief witnesses to the former presence of an ice sheet in such regions are the pebbles and bowlders of foreign origin that appear at numerous points immediately overlying, or intermingled with, the residual materials. The distribution of these bowlders is such as to indicate that at least a thin body of Kansan ice overspread practically the entire surface of Jackson county.

IOWAN STAGE.

Iowan drift area.—A narrow tongue of Iowan ice moved southward beyond the limits of Dubuque county, spreading over a few square miles in the north-central portion of Butler township, in the county of Jackson. The eastern border of this lobe extends

IOWA GEOLOGICAL SURVEY

MAP OF THE SUPERFICIAL DEPOSITS OF JACKSON COUNTY, IOWA.

BY
T. E. SAVAGE,
1906

Scale 125,000
1 ½ 0 1 2 3 4 5 Miles
1 ½ 0 1 2 3 4 5 Kilometers

LEGEND
Iowan Drift
Loess-Kansan
Partly Driftless, but it is probable that Kansan ice covered the entire area.

R.III E. R.IV E.
R.I E. R.II E.
T. 87 N.
T. 86 N.
T. 85 N.
T. 84 N.
R.I E. R.II E. R.III E. R.IV E. R.V E. R.VI E. R.VII E.

PRAIRIE SPRING
TETE DES MORTS
BUTLER
OTTER CREEK
RICHLAND
BELLEVUE
BRANDON
FARMERS CREEK
PERRY
JACKSON
WASHINGTON
MONMOUTH
SOUTH FORK
MAQUOKETA
FAIRFIELD
VAN BUREN
IOWA
ZONE

STATE OF ILLINOIS
MISSISSIPPI RIVER

GORDONS FERRY STA.
ST DONATUS
LAMOTTE
CIGARRY OWEN
HUGO
BELLEVUE
OTTER CREEK
COTTONVILLE
DUGGAN
SMITHS
PLEASANT CREEK
SPRING BROOK
GREEN ISLAND
LA RSVILLE
ROCKAWAY
SABULA
CANTON
EMELINE
CRABB HILL
FULTON
ANDREW
WEST IRON HILL
EAST IRON HILL
HURSTVILLE
BRIDGEPORT
MAQUOKETA
SPRAGUEVILLE
VAN BUREN
STERLING
MONMOUTH
BALDWIN
MILLROCK
NASHVILLE
PRESTON
MILLS

THE CEM. LITHO. CO. DAVENPORT IA.

southward across the west half of sections 2 and 11, and bends a little east of south in section 14 down to near the middle of the southeast quarter. From this point the margin trends towards the west across the southwest quarter of section 14, and passes near the south side of sections 15 and 16. It here swings towards the northwest and crosses the northeast corner of section 17 and the east half of sections 8 and 5.

The entire area of the Iowan plain in this portion of the county does not exceed ten square miles. The ice that passed over this region left but a scant covering of drift. Fresh looking granite bowlders, two to four or five feet in diameter, are occasionally encountered. Such masses are most abundant on the southeast quarter of section 16 and the southwest quarter of section 15. No satisfactory exposure of Iowan drift was seen. The entire area is covered with a thin veneer of loess. This fact would seem to indicate that possibly the ice mantle melted from this region previous to the withdrawal of the main body of Iowan ice that lay a few miles further towards the north and west.

In the west-central portion of Monmouth township there is an area of about 500 acres that possesses all the essential characteristics of an Iowan drift plain. It embraces the southern portion of section 17, the north half of section 20, and the northwest quarter of section 21. In the last section the bowlders that seem to belong to the Iowan stage are the largest and most abundant.

While this surface presents the appearance of an Iowan plain, it is isolated from any large body of Iowan drift. West of the town of Monmouth for some miles the only connection this area seems to have with a well defined Iowan lobe is down a valley at present occupied by a tributary of Bear creek. This valley is rather large for the present stream, but it has not the appearance of having been filled with a tongue of ice during the Iowan age. It seems more probable that this channel was the line of discharge of a large volume of water during the time the Onslow lobe of Iowan ice was melting. Under such conditions the bowlders may have been carried in masses of ice

during periods of great flood, and become stranded where the stream debouched upon the broad lowland plain, one mile in width, in the vicinity of the village of Monmouth.

THE LOESS.

The greater portion of the surface of Jackson county is mantled with a deposit of loess which varies from two or three to as much as twenty-five or thirty feet in thickness. As in other portions of the state the fine material is spread over hills and valleys showing, if anything, a preference for the more elevated points. Notwithstanding its independence of topography and of the formations upon which it rests, the loess is by no means distributed uniformly over our area.

Distribution.—Over much of Monmouth township a deep body of loess covers the summits and slopes both to the north and the south of the Monmouth valley. While low ledges of dolomite appear more or less interruptedly in the immediate banks of the streams, the bottoms of the channels are often choked with fine, loess-like material. The dissected upland between the North and the South Forks of the Maquoketa is covered with loess which at some points has a thickness of fifteen feet. Loess is deep over the larger portion of Butler township, but the Iowan drift area here is not rimmed with such a conspicuous border of loess hills as is usually found around the margin of a well developed Iowan drift plain.

A thick blanket of loess covers the indurated rocks over much of the townships of Prairie Spring, Tete des Morts, Richland, Bellevue, Perry, Washington and Jackson, except in close proximity to the larger streams. Over this region the surface is very broken. The slopes are steep and the summits of the hills often rise more than one hundred feet above the minor valleys. Beds of typical drift are generally wanting; yet there are large areas over which the indurated rocks are completely buried by surficial materials. This fine-grained mantle deposit has a known maximum thickness of more than twenty-five feet. At some points, as in the exposure on Brush creek near the middle of the southwest quarter of section 29 in Jackson township, the loess carries numerous univalve shells. These fossils

represent the common species of air breathing mollusks that are usually found in such deposits.

Quite a large area in the north and east portions of Farmers Creek township shows no loess, being covered with a blanket of sand, as also are several square miles in the central and western portions of Van Buren; a belt south of the Maquoketa river, in the township of Maquoketa; and a considerable area in the northeast corner of Bellevue township and the southeast corner of Tete des Morts.

Over the southern part of Van Buren, and extending east into Iowa township, there are considerable areas over which the dolomite ledges have received no covering of surficial materials. Even the residual products of decay have been removed by wind or wash as fast as disintegration of the rocks has proceeded. Other small patches having no loess or other mantle covering occur at a number of points in the southeastern part of the county, within a few miles of the Maquoketa river.

There seems little doubt that a portion of the loess material in Jackson county is of Iowan age, since it is somewhat continuous with the marginal belt of deep loess that borders the Iowan drift plain in the neighboring counties of Jones and Dubuque. It is probable too, that a portion of the material has been added in more recent times, as post-Iowan deposits of loess are known in other portions of the state. A portion of the materials may even be older than the Iowan stage of glaciation, for pre-Iowan loess has also been distinguished in Iowa.* No exposures of loess were seen in which the materials showed evidence of a long break in the continuity of deposition. However, if these deposits were formed by the wind, there seems no reason why a portion of the materials should not have been shifted, removed, or added as often as winds found access to such beds through the protective cloak of vegetation, or as constantly as dust-laden currents of air found, in these deposits, or in the vegetation that they supported, an obstruction in their path.

*See citations by Shimek in Bull. State Univ. of Iowa, Vol. V, No. 4, pp. 340 and 366-368 See also Geology of Winneshiek county, by S. Calvin, this volume, p. 126

Post-Glacial Deposits.

ALLUVIUM.

Beds of fluviatile materials that were, in part at least, laid down during the present age are found along the flood plains of the Mississippi and the Maquoketa rivers. The larger areas occur along the eastern border of the south half of the county. In the vicinity of Green Island this alluvial plain has a maximum width of nearly three miles. In our county the area of flood plain bordering the "Father of Waters" is about 19000 acres. Between Green Island and Sprague ville the flood plain of the Maquoketa river has an average width of nearly one mile. A narrow belt of alluvial materials borders one or both sides of the Maquoketa river west of Sprague ville, and occasional patches occur along the North and South Forks.

The surface of lowland prairie that stretches across the central portion of Monmouth township, the southern part of South Fork and the southwest corner of Maquoketa represents a modified alluvial plain, as does that of the old Goose Lake channel in the southwest quarter of Van Buren township. In addition to the above, small patches of flood plain are occasionally encountered along the larger creeks of the area.

EOLIAN DEPOSITS.

There seems no doubt that winds have been carrying and depositing materials over the surface ever since its emergence from the sea. The deposits that were thus formed prior to the Pleistocene period were largely removed when the glaciers moved over the region.

It is probable that all of the eolian deposits that can now be studied in Jackson county have been built since the retreat of the Kansan ice sheet, and possibly much of the present surface materials of these beds have been worked over since the close of the Pleistocene period. Materials of eolian origin in Jackson county consist of considerable deposits of sand and a somewhat discontinuous blanket of loess. It is probable that an appreciable portion of the finer materials of the alluvium and of the soils was also brought by the winds from more or less

distant points. The areas over which the respective eolian materials are distributed at the surface have been outlined under the discussion of the alluvium and the loess.

Soils.

Four different types of soil are found in Jackson county. They may be designated as loess, sandy, alluvial and residual. Each of these types is determined by the character of the subsoil material upon which, and in which, the soil has been developed.

Loess soil.—The loess soil occurs over more than three-fourths of the area of the county. Over all of this region the surface is very much dissected. The slopes are so steep that little humus has been permitted to accumulate, so that the color of the soil is prevailingly yellow. The loess particles are intermediate in size between fine sand and clay, forming a fine loam. The soil is loose and porous, and at the same time sufficiently close to prevent rapid evaporation of its water, and to furnish a good degree of capillary action. The particles represent the finer parts of drift and alluvium or other surficial materials. They are rich in lime carbonate and other mineral constituents of plant food. Where a proper rotation of crops is practiced, and when the rain fall is abundant, this soil is surprisingly productive.

Sandy soil.—Because of its open texture sandy soil rapidly loses its water by evaporation. The inter-granular spaces are so large that water is not readily brought up to the surface from a considerable depth, hence crops in such soil early suffer from drought. When the particles of sand are composed of quartz or silicon dioxide there is but a small quantity of soluble matter in the soil, and the minerals that are essential to the growth of plants are often wanting. Even when fertilizers are applied, the open texture of the soil permits of rapid downward leaching of the important soil constituents, and they are soon lost. Such soils are generally infertile. The area of sandy soil in Jackson county would aggregate a few hundred acres, yet the proportion of sandy to the more fertile types of soil is small.

Alluvial soil.—A large portion of the alluvial land along the flood plain of the Mississippi river is covered by wide marshes and threaded with lagoons. The most of this area is too low to be successfully cultivated in ordinary seasons. Portions of the flood plain of the Maquoketa river are also subject to overflow so that its value for farming land is impaired. The alluvial soil generally contains some of the desirable constituents present in all of the types of soil occurring over the basin drained by the stream. It usually contains sufficient sand to render it porous, sufficient silt to insure proper retention of water, and sufficient humus or decaying organic matter together with the necessary soluble minerals to furnish abundant food for the rapid growth of vegetation. Where sufficiently high and efficiently drained, such soils are superior to almost any other in their durability and ease of cultivation, and in their productiveness. The fertility of the modified alluvial soil occurring over the lowland plain between Monmouth and Maquoketa and over the limited area of the old Goose Lake channel is equalled by no other soils of the county. These areas yield large harvests of corn and small grain even in unfavorable seasons of drought or flood.

Residual soil.—Limited areas of residual soil occur where the loess has for some reason failed to be deposited over the Niagara ledges. They are found in occasional patches of small extent over a belt four or five miles in width on either side of the Maquoketa river. In places the constituent particles consist of grains of quartz or dolomite, so that the soil partakes of the nature of sand. At other points the material is composed of heavy reddish clay mingled with chert fragments. Over these areas the depth of the loose material is insufficient to retain the moisture required for a crop, hence such soils are generally unproductive.

Deformations.

The conspicuous example of deformation that occurs in Jackson county consists of a low arch that extends in an east and west direction from Savanna, in Illinois, to the east side of section 30 in Fairfield township, a distance of about twenty

miles. The strata involved in the deformation embrace the Maquoketa shale and the overlying beds of Niagara limestone.

The maximum measured height of the arch was in sections 29 and 30 of Fairfield township. At each of these points the aneroid readings gave the elevation of the upper layers of the Maquoketa as 175 feet above the corresponding layers in the vicinity of Preston. Readings at two different points in sections 22 and 23 of Van Buren township gave the altitude of the uppermost Maquoketa layers as 90 and 115 feet respectively above the equivalent layers near Preston. At some points over this arched belt, where the upper layers of the Maquoketa beds were best exposed, they seem to have been thrown into a series of small crumples at the time the main arch was raised. Where well exposed the layers are crossed by two series of small parallel fissures. These fissures are six to twenty-four inches apart and extend for a distance of one to three or four feet. Those of one series have a direction nearly at right angles to those of the other. When the Niagara layers were seen in an apparently undisturbed position against the inclined Maquoketa beds, the angle of dip was about thirty degrees. Between different points, and sometimes in the same outcrop, the dip varies widely as regards both direction and inclination. A portion of this variance is probably due to the fact that the Niagara limestone creeps or settles on the shale when inequality of support results from differential erosion.

Unconformities.

A number of breaks in the geological record occur in Jackson county as is shown by the presence of unconformities. Between the deposits of the Galena and those of the Maquoketa no line of unconformity was found, yet the abrupt change in the character of the materials, and the variable nature of the Galena surface upon which the Maquoketa rests at different points in the state, suggests a possible, though undiscovered, break.

At one or two points the Niagara limestone was seen in such relations to the Maquoketa shales as to indicate that the Niagara layers occupied a channel eroded in the Maquoketa beds previous to the deposit of the limestone. This would imply a discontinuity of sedimentation.

The deposits of the Des Moines stage were laid down over a much carved and deeply eroded surface. Remnants of these

in the form of outliers are generally found occupying depressions that are bordered at no great distance by older strata. In our area the Niagara limestone usually forms the basin in which are found the Des Moines beds. At one point, in Fairfield township, the Des Moines sandstone rested unconformably against a bank of Maquoketa shale.

The Kansan drift was spread unconformably over the pre-Kansan surface; the Iowan drift was laid down unconformably upon the Kansan; and the mantle of loess rests unconformably upon long leached, strongly oxidized and deeply eroded materials of widely varying age.

ECONOMIC PRODUCTS.

Soils.

The product of the soils of Jackson county, like that of other portions of our favored state, will always be the greatest source of wealth to her intelligent and prosperous people. The total value of the annual products of the farms of the county as given in the census for 1905, aggregates 3,672,597 dollars. This sum is half a million dollars greater than the value of the total coal, clay and stone production of the county of Iowa ranking first in the output of those minerals. It is nearly double the value of all the mineral production of the county ranking second in its output.

The product of the farms of Jackson county for the year indicated by the 1905 census, would purchase more than one-third of all the gold mined in Alaska during that same period. Its value equals nearly one-half of all of the silver output of Colorado during that same year. It would buy nearly three times the crude petroleum produced by the famous Beaumont oil field of Texas during this year, and more than one-half of the Beaumont production during 1902, the year of its greatest prosperity.

Building Stone.

Practically all of the building stone produced in Jackson county is used within its borders. The building stone quarries are all small and are worked intermittently. The rocks of every stage that outcrops in this area contribute a small supply.

Galena limestone.—Small quarries have been operated in the upper portion of the Galena limestone at a number of points in Tete des Morts township. In the village of St. Donatus considerable stone has been quarried from these layers. A small

quarry is at present worked in the south bank of Morts creek near the center of section 13 of Prairie Spring township. A limited quantity of this stone has been taken out near the middle of the north half of section 15; in the northeast quarter of section 24; and in the southeast quarter of section 36. Perhaps the largest quarry in the Galena beds works the upper layers near the top of the north bluff at the junction of Morts creek with the Mississippi river. A large amount of Galena limestone has been taken out of the bluff in the vicinity of Gordon's Ferry station, and used in the construction of wing dams along the river.

Maquoketa beds.—The transition beds from the Maquoketa to the Niagara have been quarried locally at Bellevue, and at a few other points in the northeastern portion of the county. The material is impure limestone. When exposed to the atmosphere this material soon crumbles into small bits and does not prove a durable stone.

Hopkinton stage.—A number of small quarries for building stone are worked in beds of the Hopkinton stage. A small quantity of stone for local use is taken from the ledge near the middle of the north side of section 24, and from a quarry near the middle of section 20, in Iowa township; from near the middle of the southwest quarter of section 30 of Union township; from near the middle of the south side of section 10 of Butler; and from the middle of the east half of section 21 in Otter Creek township. At a number of other points small quarries have been occasionally worked. The stone from this horizon is generally too massive to be readily quarried or dressed into usable shape. When the materials are in layers the beds contain so much chert in the form of bands and enclosed nodules that the ledges can not be profitably worked on a commercial scale.

Gower stage.—The local demand for building stone in the north-western portion of the county is supplied from the quarries in the Gower beds. These rocks are known to occur in our area over only about one square mile, in sections 9 and 10 of Brandon township. Occasionally they appear capping the west bluff of the North Fork of the Maquoketa river, along the west side of section 10, but they do not appear in the east bank.

Mr. John Archibald has formerly taken out a considerable quantity of stone from a ledge near the middle of the east side of section 9 of Brandon township. One-fourth of a mile south of the Archibald quarry the corresponding layers are worked on land owned by Mrs. P. J. Eads.

At the present time the greater portion of this stone is furnished by Mr. J. N. McCullough, from a quarry near the middle of the south side of section 9. The stone from this horizon occurs in even layers, two or three inches to as many feet in thickness. The material is a sub-granular, yellow colored and fairly durable magnesian limestone. The various layers can be quarried easily, and furnish dimension blocks one foot or more in thickness and flagstones of almost any size desired. The Gower beds yield much the best quality of stone for building and general construction purposes that is found in the county.

Des Moines sandstone.—Where the beds of Des Moines sandstone are thick the sand grains have often been cemented together by an interstitial deposit of iron oxide, so that the layers are much indurated. In such beds small quarries have been worked at a number of points in the county. The most important of these are in the Monmouth outlier in sections 31, 32 and 33 of Monmouth township. Considerable stone has also been taken from the Carboniferous outliers in the north half of section 29 of Fairfield township.

Lime.

Jackson county furnishes more than three-fourths of all the lime produced in Iowa. The value of the lime output for 1904 aggregated $69,550.00. The rock used for manufacture into lime is a dolomite, and comes from a zone about sixty feet in thickness which includes the upper thirty or forty feet of the *Pentamerus oblongus* ledge and the overlying beds containing such characteristic fossils as *Cerionites dactylioides, Caryocrinus ornatus* and Culicocrinus sp. The Hurst quarry section given on page 615 is representative of the lime quarry beds in Jackson county. A. Hurst and Company have operated a large lime burning plant at Hurstville for many years. Quarries are worked on both sides of the river and tracks are laid in such a manner that the loaded cars are brought by gravity to the foot of the incline up which they are drawn by horses to the top of the kilns. The plant is equipped with four patent continuous draw kilns. Each kiln is thirty-five feet high, six by eight feet in cross section, and has a daily capacity of 125 barrels. The lime is barreled and shipped over the Chicago, Milwaukee and Saint Paul railroad to various points in Iowa and all the adjacent states. Wood is exclusively used for fuel, one cord of soft wood burning 28 barrels of lime, or a cord of hard wood burning about 33 barrels.

The Maquoketa Lime Company operates a quarry at Pin Hook, one mile west of Maquoketa. This plant is also owned and managed by Alfred Hurst and Company, of Hurstville. At this point there are three kilns similar in kind and capacity to those at Hurstville. The stone is from the same horizon and the lime is essentially like that produced at the Hurstville plant. The output of the Pin Hook kilns is loaded on cars at a switch about one mile south of the quarry and is shipped

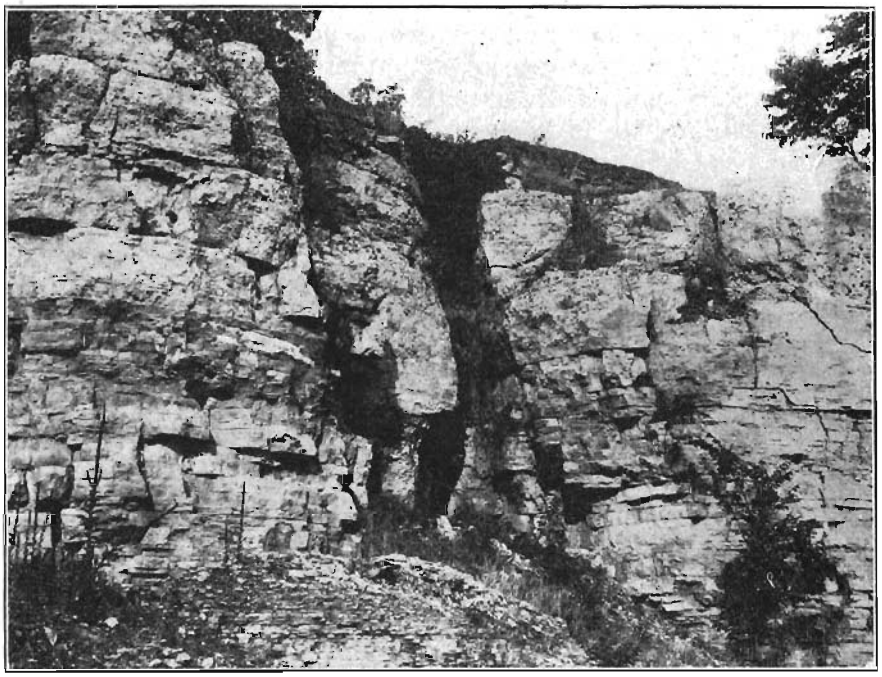

Fig. 78—Ledge of Niagara limestone in the east bank of the Maquoketa river, section 12 of South Fork township. This stone is excellent for lime burning.

over the Chicago and North-Western railroad. A large tract of timber near Green Island is owned by the Hurst company and furnishes the wood for lime burning on this extensive scale.

Joiner's lime works is located near the middle of the south half of section 20 in South Fork township. The plant is equipped with two patent continuous kilns having separate capacities of about 100 barrels. The lime is shipped over the Chicago and North-Western railroad.

The Keystone Lime Company's plant is located near the middle of the west side of section 32 in Monmouth township.

They have one patent kiln with a daily capacity of 100 barrels. The product is generally sold in bulk to contractors, a large portion of the output finding a market in Cedar Rapids.

Mr. Charles Hyler of Bellevue burns from 1500 to 1700 barrels of lime per year. The kiln is located a short distance south of the town. The stone comes from the upper transition beds of the Maquoketa and from the overlying Niagara ledge.

All of the lime marketed in the county is made from dolomite. The lime burning plants are in operation during nine or ten months of the year. Work is usually discontinued for a short time in midwinter. The patent kilns such as are used in the county can be fired continuously, the lime being drawn at intervals of six to twelve hours. Wood is the only fuel at present used in burning the product. Coal is not satisfactory for this purpose, as it is difficult to make an even burn with coal, and the color and the slacking qualities of the lime are also impaired by its use.

Sand.

Abundance of sand suitable for use in common mortar, plaster and cement is found along the channel of the Maquoketa river and its branches. Locally sand is also taken from the beds of Farmers creek, Deep creek and other streams. A bank of sand twenty-two feet in height has been extensively worked near the southwest corner of section 18 in Maquoketa township.

Clays.

Three plants for the manufacture of the more common clay goods are operated in the county. Surface clays are exclusively utilized as a source of the raw materials.

Preston.—The only plant in the county that manufactures drain tile has been operated at Preston, by Mr. Charles Beamer, for a number of years. A Brewer stiff-mud tile machine is used, and the tile is air dried. The burning is made in a single round, down-draft kiln, having a capacity of 16000 to 17000. Tile varying in size from three to six inches is produced. The clay used is a modified alluvium that occurs over the surface in the old Goose Lake channel. No brick are manufactured. The demand is largely local, a part of the output being marketed in Lost Nation.

Maquoketa.—The Maquoketa Brick Company operates a brick the south part of Maquoketa. One Anderson soft mud brick machine is used. There are two square kilns of 200,000 capacity each. Loess clay is the raw material. At present only

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF JACKSON COUNTY, IOWA.

BY T. E. SAVAGE. 1906

LEGEND
GEOLOGICAL FORMATIONS

Des Moines		Pennsylvanian
		Devonian
Niagara Gower and Hopkinton		Silurian
Maquoketa		Ordovician
Galena-Platteville		Ordovician

INDUSTRIES

Clay Plants	▲
Lime Kilns.	⊙
Quarries	⚒

Scale 1/125,000
1 ½ 0 1 2 3 4 5 Miles
1 ½ 0 1 2 3 4 5 Kilometers

R.III E. R.IV E.

R.I E. R.II E.

T. 87 N.

T. 86 N.

T. 85 N.

T. 84 N.

PRAIRIE SPRING
TETE DES MORTS
BUTLER
OTTER CREEK
RICHLAND
BELLEVUE
BRANDON
FARMERS CREEK
PERRY
JACKSON
WASHINGTON
MONMOUTH
SOUTH FORK
MAQUOKETA
FAIRFIELD
VAN BUREN
IOWA
ZONE

STATE OF ILLINOIS
MISSISSIPPI RIVER

R.I E. R.II E. R.III E. R.IV E. R.V E. R.VI E. R.VII E.

TRI CITY LITHO. CO DAVENPORT IA.

ordinary construction brick is produced, but plans are being made to manufacture pressed brick in the near future. The plant near the Chicago and North-Western railway station, in output is sold in Maquoketa and neighboring towns.

For a number of years common brick has been manufactured at Maquoketa by Mr. George Becker. The clay is a mixture of loess and alluvial material. Seven kilns of 100,000 capacity are usually burned each year. The home market takes a large share of his production.

Water Supplies.

Over all the northeastern portion of the county the numerous springs that issue at the upper surface of the Maquoketa shale furnish a perennial supply of excellent water. The Maquoketa river and the North and South Forks bring abundance of water to the regions through which they flow. All of the larger creeks of the area are permanent streams and carry stock water of the finest kind. Much of the potable water is obtained from shallow wells which range in depth from twenty or thirty to three hundred feet. The water supply for the town of Sabula is obtained from a well 973 feet in depth.

The curb of the well is a short distance below the horizon of the base of the Niagara limestone in which massive dolomite the river has here cut a gorge more than one hundred feet deep. In the first one hundred and sixty three feet the drill passed through unconsolidated sand and gravel which represents the pre-glacial channel of the Mississippi river, excavated in the Maquoketa and the upper beds of the Galena. The thickness and elevation above tide at the base of the formations penetrated are given by Norton as follows:*

		THICKNESS FEET.	ABOVE TIDE FEET.
7.	Alluvium, filling ancient channel	163	419
6.	Platteville-Galena	212	207
5.	St. Peter	75	132
4.	Upper Oneota	125	7
3.	New Richmond	25	−18
2.	Lower Oneota	175	−193
1.	St. Croix, penetrated	198	−391

It will be seen from the above table that the drill entered the St. Croix sandstone. When the well was completed the discharge measured 720 gallons a minute. The pressure of thirty-two pounds is sufficient to furnish water and fire protection to all parts of the town.

Below is given an analysis of the water of this well, made by J. B. Weems in 1896, the year after the well was completed.

*Norton: Artesian wells of Iowa, Iowa Geol. Surv., Vol. VI, p 259.

ANALYSIS.	GRAINS PER U S GALLON.	PARTS PER MILLION.
Calcium carbonate ($CaCO_3$)	7.764	133 857
Magnesium carbonate ($MgCO_3$)	.522	9 000
Magnesium bicarbonate ($Mg H_2 (CO_3)_2$	10 374	178 857
Sodium carbonate ($Na_2 CO_3$)	605	10.428
Sodium sulphate ($Na_2 SO_4$)	1.756	30 286
Alumina ($Al_2 O_3$) and Ferric oxide ($Fe_2 O_3$)	.331	5 714
Silica ($Si O_2$)	.174	3 000

Maquoketa.—The Maquoketa city water supply is obtained from a large well put down in the flood plain bordering the South Fork of the Maquoketa river. The well is located on the south side of the river in the northeast part of the town. It is thirty feet in depth, entirely in sand and gravel, and has a diameter of twenty-two and one-half feet. From the well a line of twenty-four-inch tile, without flanges, is laid up the valley for a distance of 600 feet, parallel with the course of the stream. The well is about 600 feet from the immediate bed of the river and the tile approaches within 100 feet of the stream at the nearest point. The water-works are equipped with one Worthington compound duplex pump, having a capacity of 1,500,000 gallons in twenty-four hours, and one Blake duplex pump with a daily capacity of 750,000 gallons. Since the tile was put in the well has furnished an ample supply of water for all the needs of the city. The stand pipe is 100 feet high. It stands on a hill about 140 feet above the curb of the well and furnishes a good water pressure throughout the town.

Following is a copy of an analysis made by Mr. Floyd Davis, of Des Moines, of a sample of water from the well of the Maquoketa city water works. The report bears the date of October 4, 1897:

	PARTS PER 1,000,000
Total solids	399 000
Loss on ignition*	76 000
Chlorine	18.500
Free ammonia	.060
Albuminoid ammonia	.070
Oxygen consumed (Kubel)	1.900
Nitrogen in nitrites	none
Nitrogen in nitrates	9.800

*No change in color, slight acid odor

ACKNOWLEDGMENTS.

Among the persons who aided in the prosecution of the field work on which the foregoing report is based the writer desires to acknowledge the generous assistance of Mr. Harvey Reid, of Maquoketa, whose extensive knowledge of local geology and geography, and whose unfailing enthusiasm in the work made his help especially valuable. Professor Calvin has also been a helpful advisor in the field, and has identified many of the more difficult fossils in connection with the stratigraphical study. To the above and to all others who contributed towards the success of the work, the most cordial thanks are extended.