GEOLOGY OF JONES COUNTY.

BY

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INTRODUCTION.

SITUATION AND AREA.

Jones county is in the second tier of counties west of the Mississippi river, and is partly included in that conspicuous eastward extension of the state known as Cromwell's Nose. A very important area was added to Iowa by the deflection of the Mississippi from its southerly course near the mouth of the Turkey river, from which point the great stream makes a broad sweep to the east, and then, bending more abruptly to the west, returns to the meridian from which it departed, near Muscatine. A part of Jones county lies east of this meridian.

Clinton and Jackson counties separate Jones from the Mississippi river on the east, on the north lie Dubuque and Delaware, Linn bounds it on the west and Cedar county on the south. Jones county embraces sixteen congressional townships, and, making no allowance for convergence of north and south lines, or for possible errors in surveys, it contains 756 square miles.

PREVIOUS GEOLOGICAL WORK.

The structural features of Jones county, whether considsidered economically or from a purely scientific point of view, have long attracted the attention of geologists, and much has been written concerning various phases of the geological phenomena which the county presents. No exhaustive description of these phenomena has, however, been attempted. The writers on the one hand have dealt with a narrow range of geological facts, or on the other hand they have treated the region in a general way in connection with the consideration of some larger area.

Reference is made to the geology of Jones county in the following official publications:

1844. David Dale Owen. *Report of a Geological Exploration of part of Iowa, Wisconsin and Illinois.*

The explorations reported on were made in the autumn of the year 1839. In the report, on pages 101–107, the several townships now included in Jones county are briefly described, particular attention being given to the distribution of forests and the quality of the soil. On the maps following page 64 of Owen's report, plates ii and iii, the region now called Jones county is embraced in the area occupied by the Coralline beds of the Upper Magnesian limestone.

1852. David Dale Owen. *Report of a Geological Survey of Wisconsin, Iowa and Minnesota.* No reference is made in the body of this report to any part of Jones county, but on the geological map accompanying the report the townships which now make up the county are included in the territory covered by what he now calls the Pentamerus and Coralline beds of the Upper Magnesian limestone.

1858. James Hall and J. D. Whitney. *Report on the Geological Survey of the State of Iowa.* Volume I, Part 1. Geology.

In this report Jones county is grouped with Scott, Cedar and Clinton, and all four counties are disposed of in the four pages 278–281. There are only a few references to special phenomena in Jones.

1868. Charles A. White. *First and Second Annual Reports of Progress by the State Geologist, Etc.*

On pages 27–30 of this report there is a description of some of the geological characteristics of Jones county, especial attention being given to the quarry stone near what is now Stone City. The paper which forms the basis of this part of the report had been published in the Anamosa Eureka in May, 1866.

1870. Charles A. White. *Report on the Geological Survey of the State of Iowa*, Volumes I and II.

In Volume I of Dr. White's report on the geology of Iowa, pages 183 and 184, there are some references to geological phenomena in Jones county; while in Volume II, pages 309–311, the Anamosa quarries, now known as the Stone City quarries, are somewhat fully described.

1886. T. C. Chamberlin and R. D. Salisbury. *Preliminary Paper on the Driftless Area of the Upper Mississippi Valley.*

The paper cited constitutes pages 205–322 of the Sixth Annual Report of the United States Geological survey under direction of Major J. W. Powell. Jones county lies only a short distance away from the margin of the driftless area, and while not directly named is included in the region covered by the general discussion of marginal drift. Some of the surface characteristics of this county are mapped on plate xxvii, and its indurated rocks are indicated by appropriate coloration on plate xxiv.

1891. W. J. McGee. *The Pleistocene History of Northeastern Iowa.*

McGee's memoir embraces pages 189–577 of the eleventh annual report of the United States Geological survey under the direction of J. W. Powell. In this memoir geological features in Jones county are frequently referred to, particularly the topographic forms, drainage and surface materials. An interesting series of well sections in Jones county is given on pages 529–531.

Short papers dealing with other facts of interest in connection with the geology of Jones county, such as White's description of *Stricklandinia castellana* and Calvin's note on the occurrence of *Goniophyllum pyramidale*, have appeared in various publications.

PHYSIOGRAPHY.

TOPOGRAPHY.

Jones county, in its northeastern part at least, is not very far removed from the southwestern edge of the driftless area of the upper Mississippi valley, and its physiographic features have been determined in no small degree by the heaps of drift and ridges of loess developed, during various stages of advance and retreat, along the thin margin of the Iowan ice sheet. While, therefore, over certain portions of the

county the topography is that of the gently undulating drift plain, only slightly modified by erosion since the retreat of the glacial ice, there are large areas in which the topography is that characteristic of loess covered regions in which the surface is ridged and billowy, with sharply rounded hills separated by steep-sided, V-shaped ravines. There are also regions in which rather low loess covered hills alternate with nearly level intervals of drift from an eighth to a half mile in width. There are one or two well developed alluvial plains along the principal drainage streams, and there are a few examples of deep valleys of erosion in which streams flow between beetling cliffs of limestone.

Drift Plains.—The principal drift plain of Jones county is continuous with the drift of northern Linn and southern Delaware. It occupies all or part of Castle Grove, Cass, Monticello, Wayne and Scotch Grove townships. This plain is terminated on the south by a large area occupied by loess hills developed along the Buffalo and Wapsipinicon rivers near Anamosa. East of Anamosa the loess ridges leave the river and pass north of the valley of Bear creek through the southern part of Wayne and northern part of Jackson township. On the north the plain is bounded by the irregular topography—at first, below Monticello, erosional, but afterward of loess type—along the south fork of the Maquoketa. Another drift plain begins at the foot of the loess ridges south of Fairview and occupies portions of Fairview, Greenfield, Rome and Hale townships. There is a small drift region known as Bowen's Prairie north of the Maquoketa; and more or less isolated areas are found in Wyoming and Oxford townships. The valley of Bear creek in Madison township is occupied by drift, though on both sides of the valley loess covered hills rise to a height of 30, 40 or 50 feet above the general level of the adjacent drift plains. All the larger drift plains are interrupted more or less by the peculiar morainic ridges covered with loess, to which McGee has given the name paha.

Loess Hills.—The fine yellow clay known as loess, often homogeneous, though sometimes more or less sandy, seems to be developed in all portions of the county where the surface is particularly broken and rolling. There are certain peculiarities of surface configuration that have come to be recognized as loess topography, and yet as noted later on, nearly all the evidence at hand supports the view that much of the physiographic irregularity characterizing loess covered regions was developed before the loess was deposited. The thickness of the mantle of loess spread over the pre-loessian surface varies from a few inches to ten or twenty or even thirty feet. It is only where the deposit attains considerable thickness that the true loess topography appears. The deposit occurs on high ridges, or wider areas, that overlook the drift plains or stream valleys. It washes easily, and sharply rounded hills separated by steep-sided gullies combine to render the surface over the wider loess regions a perplexing maze of swelling prominences that seem at first to be arranged without definite order. It would be difficult to find an acre of level ground in many square miles of such areas. The hillsides are too steep for cultivation. Roadways must wind back and forth to follow ridges or descend to lower levels through tortuous ravines. The topography is a complex affair, partly erosional; but even the essential features have been largely determined and modified by the original irregularity of the surface.

McGee in the work already cited calls attention to the fact that the loess in this part of Iowa is found only on the higher levels and never on the much lower drift plains. The constant relation of drift plain to loess ridge, so far as Jones county is concerned, is well illustrated on both sides of the Wapsipinicon river near Anamosa. Directly north of Anamosa, near the northwest corner of section 2, Fairview township, the loess ridge rises to an elevation of nearly 200 feet above the river and overlooks the broad drift plain which lies still farther north. From the summit of the ridge the road

from Anamosa to Cass Center descends until, near the southwest corner of section 22, Cass township, it reaches the drift plain. The difference in elevation between the plain and summit of the ridge is 100 feet. The loess ridges south of the stream near Anamosa are equally as high as those on the north. Near the northwest corner of section 16, Fairview township, the elevation is 230 feet above the river and the descent to the drift plain, a short distance south of Fairview, is more than 100 feet. The river here runs between loess ridges rising fully 100 feet above the level of the adjacent plains. There is no better example anywhere of McGee's paradoxical streams, running in valleys that cleave high ridges and separated from each other by low valley-like divides.

The principal loess areas of Jones county lie along the two branches of the Maquoketa in the northeastern townships. Here they blend practically into one continuous area covering all, or nearly all, of the townships of Richland, Washington and Clay, as well as the northeastern part of Scotch Grove. The area next in importance is four to six miles in width. It begins at the Linn county line, embraces the Buffalo and Wapsipinicon to their confluence at Anamosa and continues below Anamosa for a distance of three or four miles. A ridge of loess continuous with the Anamosa area extends eastward through the southern part of Wayne township, past Amber, almost to Center Junction. The eastern end of this ridge, near Center Junction, is broken up into discontinuous hills, with intervals of drift.

A special type of topography is developed wherever the loess is so thin as to be easily eroded down to the underlying drift. In such localities the hills are low with long, sweeping curves, and the nearly flat-bottomed vales between are relatively broad. The hills are capped with a thin veneer of loess and the gracefully curving valleys expose the drift. The areas exhibiting this type of topography are usually

small, but one such area, several miles in length and width, is found west of Wyoming and south of Center Junction.

The paha of McGee, the peculiar ridges and isolated elliptical hills that often rise abruptly in the midst of a drift plain, are striking physiographic features that are intimately related to the loess hills. The paha are usually heaped up masses of drift covered with loess. Numerous examples of these curious hills and ridges occur in Greenfield township. One of the most striking, rising to a height of nearly a hundred feet above the broad plain at its base, is found in section 31. Others are found in sections 17, 18 and 19. In section 10 is a broad wooded paha, and a still larger ridge of the same type, covered with primeval forests, extends through sections 14, 15, 23 and 24. Almost every township affords a greater or less number of examples of the same peculiar topographic forms. Two loess covered hills are conspicuous west of Olin in Rome township. The beautiful paha west of the railroad, a few miles south of Monticello, have been described by McGee, but others equally interesting must, for the present, be left undescribed.

Alluvial Plains and River Valleys.—There are few alluvial plains in Jones county, and the few there are make but little impression upon the general topography. Below Newport the Wapsipinicon escapes from a rather narrow valley and enters a broad alluvial plain which, however, extends only to a short distance below Olin. A mile or two below Hale the valley again widens, and presents the characteristics of a broad flood plain all the way to the eastern limit of the county. For a short distance near Monticello the Maquoketa runs through a low plain. Elsewhere the three main streams of the county flow in narrow valleys of erosion. These valleys are not infrequently 200 feet in depth, and the walls are in part ridges of loess and in part cliffs of limestone. The North Fork of the Maquoketa in Washington township flows through a rocky gorge that has a depth, measured from the general level of the loess ridges a half mile back from the

stream, of 225 feet. The rocky walls immediately bounding the river channel often rise vertically, or nearly so, for 75 or 100 feet. At intervals these walls are cut by erosion of secondary streams into a series of jutting prominences, and the lateral valleys are often picturesque, deep, rock-walled ravines, damp and shaded at the bottom, and having the sides diversified with salient crags, castles, supporting buttresses and other rock masses that have been wrought by the active agents of rock decay into all conceivable fantastic shapes.

The South Fork of the Maquoketa flows in a rock-bound gorge from a short distance below Monticello to the Jackson county line. The valley, taken as a whole, is wider than that of the North Fork and the lateral ravines are also broader. The general features, however, are the same; and crag and castle and wooded rocky bluff give pleasure to the general observer as well as stimulate the interest of the student of topographic forms. One of the rocky promontories left between two deeply excavated secondary ravines, is locally known as Eagle Rock. Eagle Rock is situated on the left bank of the stream about a mile above Canton. It rises to a height of about 150 feet above the water in the channel. Its eastern face is nearly vertical, and a short distance from the river the ravine on its eastern side terminates in a rocky amphitheater. On the west side of Eagle Rock is a broad lateral valley carrying a small tributary stream. Eagle Rock and its adjacent valleys illustrate the general character of the topography bordering this river throughout the greater part of its course in Jones county. Everything betokens long continued erosion. At least the period required to produce the observed effects must antedate both drift sheets and is probably comparable to the length of time required to produce the physiographic characteristics of the driftless area.

The valley of the Wapsipinicon varies from a rather narrow and partly rock-walled gorge above Anamosa to a broad plain, bordered by low rounded hills, between Newport and Olin. At Stone City the limestone rises in the sides of the

valley to a height of ninety feet above the stream, while a short distance back from the river, as, for example, near the northwest corner of the Nw. ¼, Nw. qr. of Sec. 15, Fairview township, the upper beds of limestone have an elevation of about 150 feet above the water at Anamosa, and nearly fifty feet above the level of the drift plain on either side of the loess covered area. Between Olin and Hale the valley becomes narrow and is bounded by limestone cliffs or swelling prominences of loess that repeat, but on a smaller scale, the characteristics of the valley above Anamosa. The broad plain between Newport and Olin has its characteristics repeated in the plain above and below Oxford Mills.

The valley of the Buffalo so far as its course lies in Jones county, resembles that of the Wapsipinicon near Anamosa.

The valley of Bear creek is at first a broad shallow depression in the drift plain, with some loess-capped hills rising above the plain at some distance on either side. Below Wyoming, however, the stream enters a narrow rock-bound valley bordered with wooded hills that exhibit the typical loess topography; and these characteristics persist to beyond the Jackson county line.

There are some minor topographic areas, but the whole topography of the county, over larger and smaller areas alike, is to be interpreted in the light of effects of aqueous and glacial action produced along the attenuated and much lobed and incised border of the Iowan ice sheet, the whole modified more or less by subsequent erosion. Over the larger drift plains erosion has produced scarcely any effect since the Iowan glaciers retreated from the region. Over areas deeply covered with loess, erosion in combination probably with wind action has given rise to the rounded hills and gully-like ravines that divide the surface into such a tangled topographic maze. The drift deposited by both Kansan and Iowan ice sheets was in some places very thin, and so it has been possible for both branches of the Maquoketa, and probably the Wapsipinicon above Anamosa, to return to

their old channels, and by a little scouring to restore some of the features of the preglacial topography.

DRAINAGE.

The drainage of Jones county is quite as unique as the topography. Like the topography it has been determined by the anomalous distribution of drift and loess along the lobed border of the Iowan ice. The Wapsipinicon is the largest river, and it pursues a much longer course within the limits of the county than any other stream; but the area it drains, so far as relates to Jones county, is less than that drained by the South Fork of the Maquoketa. Apart from the Buffalo, which brings drainage waters from Buchanan, Delaware and Linn counties, the Wapsipinicon receives from the north no tributaries of sufficient consequence to be worthy of name. The natural drainage area of the river is encroached upon by Bear creek, an affluent of the Maquoketa. The valley of Bear creek is nearly parallel to that of the Wapsipinicon; for a long distance the streams are not more than a few miles apart, and so the drainage area tributary to the Wapsipinicon is reduced on the north side to a narrow belt only a mile or two in width. The portion of Jones county south of the Wapsipinicon, as far east as Olin, is drained by Walnut creek, but below Olin the streams entering from the south are insignificant.

Bear creek is also nearly parallel to the Maquoketa, but the distance between the two streams will average ten or twelve miles. All the valley of Bear creek and all the intervening region drains into the Maquoketa. This intermediate area is traversed by Mineral creek, which joins the primary stream a few miles below Canton. Kitty creek flows into the Maquoketa near Monticello. Its valley is for some distance nearly parallel to that of its primary, but its flow is in the opposite direction. Grove creek drains the northwest corner of the county, and Farmers creek in the northeast passes down through the center of Washington township

to join the Maquoketa near Clay mills. Farmers creek encroaches on the area belonging to the North Fork of the Maquoketa as Bear creek encroaches on that of the Wapsipinicon, and reduces the surface tributary to the North Fork to a strip a mile or two in width. The Makoqueta proper receives the drainage of nearly three-fourths of the entire county.

The North Maquoketa and White Water creek, with insignificant tributaries that flow only when recent rains or melting snows furnish favorable conditions, drain a small area in the northeastern corner of Washington township.

STRATIGRAPHY.

General Relations of Strata.

The geological formations of Jones county represent three systems. Only two systems, however, are developed to an extent that would command general attention, and they are widely separated from each other in point of time. The indurated rocks belong chiefly to the Silurian system; the superficial deposits belong chiefly to the Pleistocene. Belonging to the indurated rocks are some inconspicuous fragments of Carboniferous strata, and among the superficial deposits are beds of residual clay or geest of pre-Pleistocene origin, but referable to no particular series.

The Silurian strata, while exhibiting many stratigraphic and local variations, are all lithologically and paleontologically intimately related. Throughout the whole thickness of the beds exposed in this county the rocks are dolomitic limestones, and the fossil fauna, however much it may vary in different localities and in different beds, is always and everywhere characteristic of the Niagara series. The lower beds contain such forms as *Halysites catenulatus* Lin., *Favosites favosus* Goldfuss, and *Pentamerus oblongus* Sowerby. The uppermost beds of Niagara seen in this county have so far furnished no fossils, but the Anamosa quarry stone lying next

below them has yielded specimens of *Dalamites verrucosus* Green, and *Calymene niagaransis* Hall. This last species occurs in the Williams quarry in the northeast corner of Fayette county only a few feet above the Maquoketa shales, while at Stone City, in Jones county it is found, though very sparingly, in the building stones which lie at least 250 feet higher in the geological column. The whole assemblage of strata between the top of the Maquoketa shales and the base of the Devonian is referred to the Niagara.

The taxonomic relations of the geological deposits of Jones county, as provisionally adopted, are shown in the following table.

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Cenozoic.	Pleistocene.	Recent.		Alluvial.
		Glacial.	Iowan.	Loess.
				Second Till.
			Aftonian?	Buchanan gravels.
			Kansan.	First Till.
Paleozoic.	Carboniferous.	Upper Carboniferous.	Des Moines	
	Silurian.	Niagara.	Bertram.	
			Anamosa.	
			Le Claire.	
			Delaware.	

Geological Formations.

NIAGARA SERIES.

Though the great beds of dolomite, which may be referred to the Niagara series, represent deposition during a single geological epoch, and so in a certain sense constitute a single stratigraphic unit, they are yet divisible into four more or less perfectly defined stages.

DELAWARE STAGE.

The lower stage of the Niagara has a thickness of about 200 feet. *Pentamerus oblongus*, *Halysites catenulatus*, *Favosites favosus*, *Ptychophyllum expansum*, *Strombodes mamillaris* and a large number of other species, are the characteristic fossils. *Halysites catenulatus* begins near the base of this stage. At first the corals are all small, a few inches only in diameter, and the individual corallites rarely have a diameter exceeding one-sixteenth of an inch. Among the residual products of erosion derived from other phases of the Delaware stage there are, on section 6, Scotch Grove township, weathered fragments of coralla of this same species five feet in diameter, three or four feet in depth, and made up of corallites measuring fully one-eighth of an inch. Pentamerus crowds the beds at various levels and shows a great number of interesting variations. The strata through which these fossils range compose the coralline beds of the Upper Magnesian cliff limestone, as that term is used in Owen's report on work done in the fall of 1839. They comprise the coralline and Pentamerus beds of the Upper Magnesian limestone, as indicated on the map accompanying the report of the same author in 1852. This division is the equivalent of the Niagara limestone of the report of Hall and Whitney, but it embraces only part of the Niagara of Dr. C. A. White.

Prof. A. G. Wilson has recently written on the Upper Silurian in Northeastern Iowa*, arranging the strata of the formation considered in five divisions. Divisions one to four of Professor Wilson's paper, collectively, make up the lower stage as here defined, a stage that embraces all the sediments lying between the summit of the Maquoketa shales and the top of the Pentamerus and Coralline beds that furnish *Strombodes mamillaris* Owen, *Strombodes pentagonus* Owen, *Strombodes gigas* Owen, enormous coralla of *Halysites catenulatus* Linnæus, and equally ponderous masses of *Diphphyllum multicaule* Hall.

*American Geologist, Vol. XVI, p. 275. 1895.

There is no one locality where all the phases of this lower division of the Niagara may be seen in a single section, but all may be studied within the limits of Delaware county, and for this reason it is proposed to call it the Delaware stage. The four divisions of Professor Wilson, so far as they can be delimited, may rank as sub-stages. The Delaware stage contains large quantities of chert, and silicification of the corals is very general, while silicification of the brachiopods is not infrequent.

LE CLAIRE STAGE.

The second stage of the Niagara is represented by the Le Claire limestone of Hall, and may, with propriety, be called the Le Claire stage. Strata of this stage are well developed at Le Claire, in Scott county. They are seen in the same stratigraphical relations at the lime kilns on Sugar creek, and near the quarries at Cedar Valley, in Cedar county. They occur beneath the quarry stone at Stone City, and near Olin and Hale, in Jones county, and they are also seen at many points west of the Jones county line in Linn. Indeed, they are somewhat generally, though by no means universally, distributed in the east central part of Scott, southwestern parts of Clinton, western Cedar and the southern parts of Jones and Linn. They seem, however, to be limited to the southwestern corner of the Niagara area, There are no indications of them in the northeastern part of Jones. A line drawn from the mouth of the Wapsipinicon through Anamosa would mark approximately their northeastern limit.

The Le Claire limestone is generally a massive or heavy bedded, highly crystalline dolomite. It contains scarcely any chert, and in its lower parts there are very few fossils. There are occasionally a few specimens of Pentamerus of the *P. occidentalis* type, and the principal coral is a long, slender, tortuous Amplexus, which is represented only by casts of the vacant or hollow parts of the original corallum. On account of the complete solution of the original structure the

spaces occupied by the solid parts of the coral are now mere cavities in the limestone. In the upper part of the Le Claire stage, small brachiopods abound. They belong to the genera Homeospira, Trematospira, Nucleospira, Rhynchonella, Rhynchotreta, Atrypa, Spirifer, and probably others. In most cases the fossils have been dissolved out, leaving numerous cavities. The calcareous brachial apparatus of the spire-bearing genera is often perfectly preserved, and is the only portion of the original structure represented. No statement can well give any idea of the numbers of these small shells that crowded the sea bottom near the close of the Le Claire stage, nor of the corresponding number of minute cavities that are now so characteristic a feature of this portion of the Le Claire limestone. In some localities in Cedar county, the small brachiopods of this horizon are represented by very perfect casts that were formed by a secondary filling of the cavities left by solution of the original shell. The external characters are thus fairly well reproduced.

Compared with the beds of the Delaware stage, the Le Claire limestone as a rule lies in more massive ledges, it is more completely dolomitized and its fracture surfaces exhibit a more perfectly crystalline structure. It contains an entirely different fauna, a fauna in which small rhynchonelloid and spire-bearing brachiopods are conspicuous. Its fossils are never silicified, and in marked contrast with some portions of the Delaware, its upper part at least is notably free from chert. The Le Claire limestone is the lime burning rock of Sugar creek, Cedar Valley, Port Byron, and Le Claire. Wherever it occurs it furnishes material for the manufacture of the highest quality of lime.

The Le Claire limestone is, in some respects, unique among the geological formations of Iowa. In the first place, it varies locally in thickness, so much so that its upper surface is exceedingly undulating, the curves in some places being very sharp and abrupt. In the second place, it differs from every other limestone of Iowa in frequently exhibiting the

peculiarity of being obliquely bedded on a large scale, the oblique bedding often affecting a thickness of fifteen or twenty feet. (Plate i.) The phenomena suggest that during the deposition of the Le Claire limestone the sea covered only the southwestern part of the Niagara area; that at times the waters were comparatively shallow, and that strong currents, setting sometimes in one direction and sometimes in another, swept the calcareous mud back and forth, piling it up in the eddies in lenticular heaps, or building it up in obliquely bedded masses over areas of considerable extent. The oblique beds observe no regularity with respect to either the angle or direction of dip. Within comparatively short distances they may be found inclining to all points of the compass. Again the waters at times were quiet, and ordinary processes of deposition went on over the original sea bottom, the beds produced

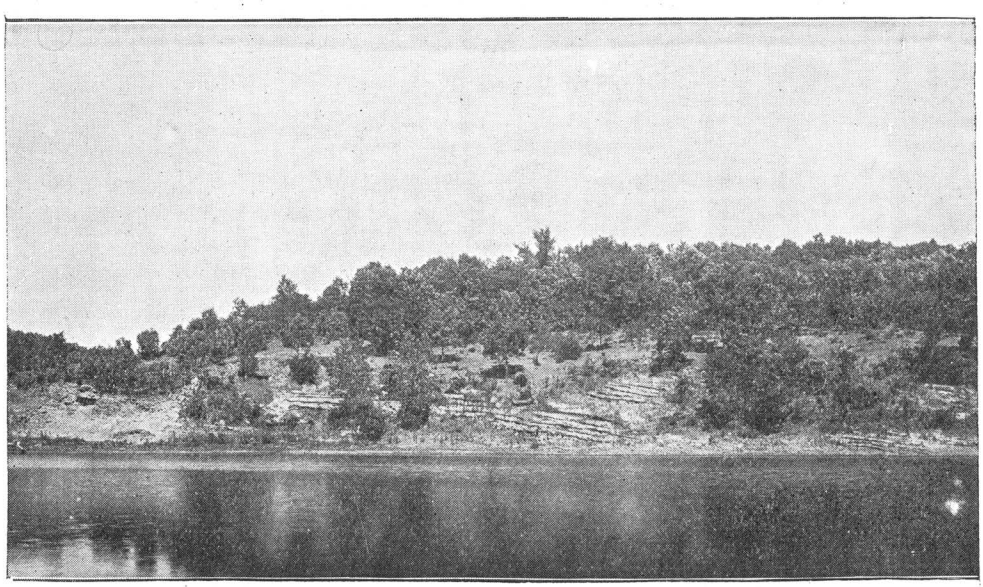
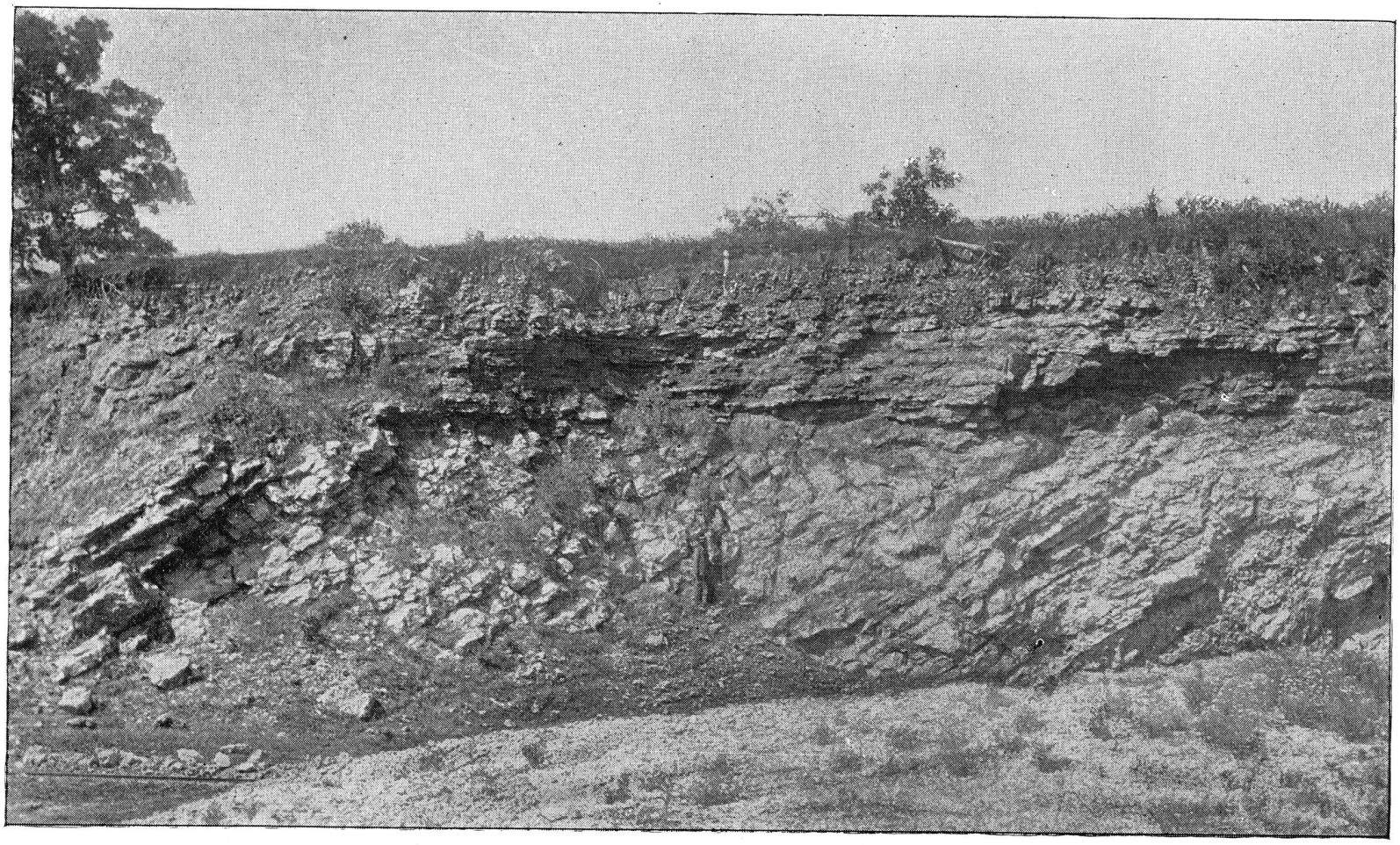


FIG. 1. Inclined, undulating beds of the Le Claire stage near Newport, Jones county, Iowa.

under such circumstances conforming to the undulating surface on which they were laid down. In some cases these beds were horizontal, as in the upper part of the section illustrated in plate i, while in other cases they were more or less flexuous and tilted, as seen in the left bank of the Wapsipinicon above Newport.



TILTED SILURIAN STRATA.

Professor Hall accurately describes some of the variations in the inclination and direction of dip in the Le Claire limestone, as seen at Le Claire,* but he assumes that the inclination of the beds is due to folding and uplift subsequent to their deposition. On this assumption, the Le Claire limestone would have a thickness of more than 600 feet, whereas the maximum thickness does not exceed eighty feet, and the average over the whole area is very much less. Prof. A. H. Worthen† studied this limestone at Port Byron, Illinois, and Le Claire, Iowa, and describes it as "presenting no regular lines of bedding or stratification, but showing lines of false

FIG 2. Exposure of gently folded Le Claire limestone below bridge southeast of Hale.

bedding or cleavage at every conceivable angle to the horizon." He assigns to these beds a thickness of fifty feet, but offers no explanation of what he calls false bedding or cleavage. In White's report on the geology of Iowa,‡ the oblique bedding seems to have been taken as evidence that a line of disturbance crossed the Mississippi river at Le Claire with a direction nearly parallel to the Wapsipinicon valley. This

*Rept. on the Geol. Surv. of the State of Iowa, Hall and Whitney, vol. I., part I., pp. 73-74 1858.

†Geol. Surv. of Ill., vol. I, p. 130, 1866.

‡Report on the Geol. Surv. of the State of Iowa; Charles A. White, vol. I, p. 183, 1870.

apparent disturbance was last recognized about three miles west of Anamosa. The angle of dip, it is said, reached in some places twenty-eight degrees with the horizon. McGee, in discussing the regular deformations of northeastern Iowa,* quotes Dr. White on the Wapsipinicon line of disturbance, and accepts the observations on which the statement is based as evidence of a synclinal fold extending from Le Claire to Anamosa. White's observations appear to have been made only at the two points mentioned. At both places the strata seem to be inclined at a high angle. On the assumption that the inclination of the strata indicates orogenic disturbance, the conclusion that the disturbed beds were parts of the same fold was very natural. There is, however, no fold, nor is there any line of disturbance. In the whole Niagara area southwest of the line which marks the limit of the Le Claire limestone, the phenomena seen at Le Claire and west of Anamosa are repeated scores of times and in ways that defy systematic arrangement. The beds incline at all angles from zero to thirty degrees, and even within short distances they may be found dipping in every possible direction. Twenty miles southwest of the line supposed to be traversed by the synclinal fold, for example at the lime kilns on Sugar creek, along the Cedar river above Rochester, at Cedar Valley, as well as at many intermediate points distributed promiscuously throughout the area of the Le Claire limestone, the beds stand at a high angle, and the multiplicity of directions in which they are inclined, even in exposures that are relatively near together, is wholly inconsistent with the idea of orogenic deformation. The beds are now practically in the position in which they were laid down in the tumultuous Niagara sea. The principal disturbances they have suffered have been the results of epeirogenic movements which affected equally the whole region over which these limestones are distributed, as well as all the adjacent regions of the Mississippi valley.

*Pleistocene History of Northeastern Iowa, p. 340. 1891.

The Le Claire limestone is sharply set off from the deposits of the Delaware stage by its hard, highly crystalline structure, its freedom from chert, its easily recognized fauna, and its record of anomalous conditions of deposition. In the field the distinctions between the Le Claire and Anamosa stages are even more easily recognized, though faunally the two stages are intimately related. In the Anamosa stage oblique bedding is unknown; lithologically the rock is an earthy, finely and perfectly laminated dolomite, not highly crystalline in its typical aspect, and too impure for the manufacture of lime. It may be quarried in symmetrical blocks of any desired dimensions, while the Le Claire limestone breaks into shapeless masses wholly unfit for building purposes. The quarry beds of the Anamosa stage are quite free from

FIG. 3. Top of cliff at Clay Mills, illustrating character of bedding below the building stone layers of the Delaware stage.

fossils, but along the Cedar river in Cedar county, the brachiopod fauna of the upper part of the Le Claire reappears in great force in a stratum four feet in thickness, up near the top of the formation. The beds of the Anamosa stage are very undulating and dip in long graceful, sweeping curves in every possible direction. The knobs and bosses and irregular undulations developed on the sea bottom as a result of the peculiar conditions prevailing during the Le Claire age,

persisted to a greater or less extent after the age came to an end, and it was upon this uneven floor that the Anamosa limestone was laid down. The puzzling flexures of the Anamosa limestone and the puzzling variations in altitude at which it occurs were largely determined by irregularities in the upper surface of the Le Claire formation.

ANAMOSA STAGE.

The typical phase of the Anamosa stage is well illustrated in the beds that furnish the quarry stone at Stone City. Deposits of this stage, however, were first noted in Iowa at Le Claire and were correlated by Hall with the Onondago Salt Group of New York.* Since Hall's work in Iowa was completed these beds have been studied by White at what is now Stone City,† by Houser at various localities in Scott and Cedar counties‡ and by Norton in Linn county.§ McGee's description of the building stones from the Niagara of Iowa applies in part to the Anamosa limestone.‖ All the writers mentioned, except Professor Hall, refer the Anamosa beds to the Niagara. The rocks of this stage, excepting a few favored localities such as Mount Vernon and Cedar Valley, are remarkably destitute of fossil remains. At Le Claire recognizable fossils are practically wanting and Hall made his determination of the age of the formation on lithological grounds alone.

The quarries at Stone City are about four miles west of Anamosa. When they were first opened Anamosa was the nearest railway station and on this account they became generally known as the Anamosa quarries. The stone was shipped to many points in Iowa and even beyond the limits of the state, and became known among architects and engineers as Anamosa limestone. Under this name it was discussed in trade

*Rept. on the Geol. Surv. of Iowa; Hall and Whitney, vol. I, part I, pp. 76-80. 1858.

†Rept. on Geol Surv. of the State of Iowa, vol. I, p. 184; vol. II, pp. 309-311. 1870.

‡Iowa Geol. Surv., vol. I, pp. 203-207. 1893.

§Ibid., vol IV, pp. 127, 130, 184, etc., 1895. In the text of Prof. Norton's report on Linn county these strata are called the Mount Vernon beds.

‖Tenth Census of the U. S., vol. X, Building Stone, p. 263, 1883. Iowa Geol. Surv., vol. I, pp 30-32. 1893.

journals as well as in the newspapers wherever reference was made to the product of these quarries. The name has also been used in some of the minor publications of the survey. While therefore the beds of this particular stage do not occur at Anamosa, it seems best to retain a name so long and so firmly established, a name that has a definite meaning over an area as wide as that in which this quarry stone finds a market; and therefore it is proposed to recognize these beds as the Anamosa stage of the Niagara series, and to call the rock belonging to this particular horizon, wherever found, the Anamosa limestone.

The Anamosa limestone varies locally; but in general it is composed of evenly bedded, perfectly laminated layers of

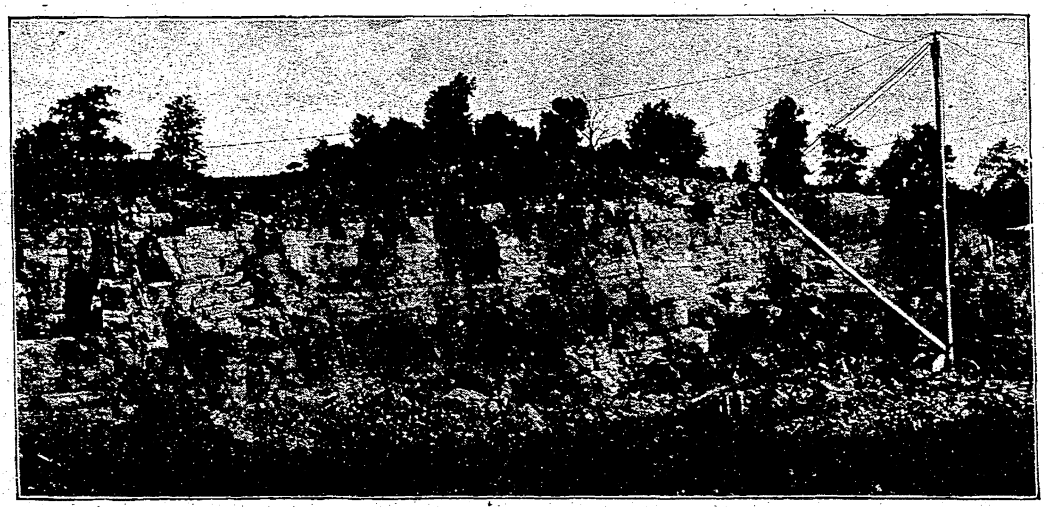


FIG. 4. Beds of the Anamosa stage in the western part of Champion quary at Stone City, showing the moderately strong eastward dip at this locality.

rather impure dolomite that in color ranges through shades of buff, to gray on the one hand, and almost white on the other. In many cases the beds are practically horizontal, but they more commonly exhibit long sweeping undulations due to the uneven character of the floor upon which they were deposited. At the Penitentiary quarry the strata dip to the northwest at the rate of 100 feet to the mile, and at the west end of Champion quarry No. 1, the beds for several rods incline to the east at even a greater angle. Furthermore the

same bed varies in thickness, the variation ranging from six to eighteen inches in less than a quarter of a mile. In general, however, the curves of flexure are so gentle and the changes in thickness of individual beds so gradual that within the dimensions of any block of stone that may probably be called for or could possibly be handled, the lamination planes are true and parallel.

The planes of lamination are at the same time the bedding planes of the Anamosa limestone. The formation as seen in Jones county is not divided into definite layers separated by partings of clay or softer limestone, but for a thickness of many feet the rock presents all the appearance of a single finely laminated bed. Such a bed, however, is not throughout of uniform texture, but is made up of parallel bands differing from each other in minor characters. There are certain planes along which the union of contiguous laminæ is weaker than elsewhere, and it is along these weaker planes that the rock tends to split when it is quarried. The quarrymen recognize these particular planes and divide the quarry somewhat arbitrarily into beds varying from three or four to thirty-six inches in thickness. It is sometimes possible to work two or more of the beds recognized by quarrymen together when blocks thicker than either bed alone are wanted; and on the other hand any of the beds may be split or "capped" when stones for flagging or thinner slabs for any other purpose are desired.

At Stone City this limestone has a thickness of sixty feet, and is divided by a porous, worthless ledge into two nearly equal parts. The lower thirty feet is known as the "gray limestone;" the beds in the upper half of the formation are described as the "white limestone." The most valuable quarry stone comes from the lower or gray limestone. In the upper beds the cleavage along the lamination planes is more perfect than in the beds below, for which reason the rock in this part of the quarry tends to split into thin slabs, and long exposure to the weather reduces it to chip stone. The

unweathered ledges of this upper limestone, while unsuited to many architectural purposes, serve well for ordinary masonry, for, if the blocks are properly quarried and are laid in the wall on the "quarry face" with only the edges of the laminæ exposed to the weather, they will last indefinitely. On the other hand the lower beds furnish excellent material for almost any kind of structure in which stone may be employed. There are ledges that will furnish massive blocks suitable for bridge piers; and there are beds compact, fine-grained, and imperfectly laminated that afford dimension stone suitable for cutting into forms befitting the higher grades of architectural work.

In the lower division of the formation there are some planes along which the rock is vesicular, the cavities though rather indefinite in shape, being evidently produced by solution of small brachiopods similar to those characteristic of the Le Claire. Occasionally there are cavities of larger size, one, two or three inches in diameter. Some of these are lined with crystals of calcite, some are studded with minute crystals of quartz, and there are others in which both minerals occur. The upper white limestone furnishes many interesting, almost agate-like concretions of chert.

Joints at intervals intersect the beds of the Anamosa limestone, but on the whole they are few and distant. They occur more frequently in some quarries than in others; and as a rule they cut through the whole thickness of the formation in a nearly vertical direction. These joints facilitate the work of quarrying, in many cases rendering the use of a channelier unnecessary, and yet are not so numerous as to interfere with the getting out of blocks of any desired dimensions. There are some indications that the joints are not all of the same age. Those of more recent origin are still but a fraction of an inch in width and have the walls undecayed; in those that bear signs of greater age the fissures have been widened by water and other agents chemically active in rock destruction, the walls show decay for some distance from the

vertical surface, and the spaces are occupied with a ferruginous residual clay which the miners of lead regions recognize as "crevice dirt," but which in some recent geological literature is known as geest.

BERTRAM STAGE.

Above the perfectly stratified beds of the Anamosa stage there occurs an irregularly bedded, non-fossiliferous rock of unknown thickness, which may be correlated with the Bertram beds described by Professor Norton*. The Bertram limestone is a yellowish dolomite without lamination planes, and quarrying in shapeless masses of no possible utility. "Bastard stone" is what the quarrymen call it. At Stone City it appears at the top of the Anamosa quarries belonging to Mr. John Ronen. A greater thickness of it is exposed in the same relation to the quarry stone in the quarry known as Champion No. 2, belonging to Hon. John A. Green. In Senator Green's Champion No. 1, some beds of this stage have been exposed by recent stripping. As the work of quarrying progresses the exposed thickness of the Bertram beds is certain to increase. At Champion quarry No. 2, for example, the upper surface of the Anamosa stage rises about fifty-five feet above the level of the Wapsipinicon river, but the bluff at the foot of which the quarry is opened, has an altitude of 180 feet above the same level. While the bluff is covered with a thick mantle of loess, there is yet room for a hundred feet of indurated rock above the level of the Anamosa limestone.

CARBONIFEROUS SERIES.

DES MOINES STAGE.

In the southeastern part of section 24, Fairview township, a great many loose fragments of coal measure sandstone were found in the side of a small ravine. The sandstone was not seen in place, although it was evident that the original ledges were not very far away. The region is thickly covered with

*Iowa Geol. Surv., vol. IV, p. 135 et seq.

loess and drift; it is also wooded and densely overgrown with underbrush; the geological structure is quite effectually concealed. The blocks of sandstone were associated with exposures of tile clay that were manifestly secondary deposits derived by ordinary erosion or by glacial action from beds of Carboniferous shales. McGee mentions a bed of pebbly ferruginous sandstone three miles northeast of Oxford (probably Oxford Junction), in Jones county.* The relations of the deposit are somewhat uncertain, although it is quite probable that the bed in question belongs to the age of the Iowa coal measures. Outlying fragments of coal measure strata are not uncommon in Jackson, Cedar, Linn, Johnson, Scott and Muscatine counties.

During all the time represented by the Devonian and Lower Carboniferous beds of Iowa, Jones county was dry land. The forces that elevated the continental masses had lifted this part of the strata above sea level. The shore line at first passed through the southeastern part of Cedar, the northeastern part of Johnson and the eastern part of Linn. The sea, however, gradually retreated toward the south and west, the shore line became more and more remote from Jones county, until, toward the close of the Lower Carboniferous, probably the whole of what we now call Iowa had become a part of the continent. About the time the coal measure epoch was inaugurated the whole southern and western portions of the state subsided and were largely covered by the encroaching Carboniferous sea. This sea spread sandstones, shales and conglomerates as far north as Rockville in Delaware county. Such Carboniferous deposits were spread over the whole of Jones, but the deposits were thin, the sea soon again retreated, and subsequent erosion has removed nearly every vestige of these later sediments. Notwithstanding the lack of evidence from direct observation, it is still very probable that numerous outliers of Carboniferous strata are concealed beneath the superficial deposits of this county.

* Pleistocene History of Northeastern Iowa. Eleventh Ann. Rep. U. S. Geol. Surv., p. 305.

GEEST.

The superficial deposits of Jones county fall naturally under two heads, (1) geest and (2) Pleistocene beds. The geest is a product of secular rock decay. In this county it is composed chiefly of the insoluble constituents of dolomitic limestones, though it may contain some residual material derived from the decay of Carboniferous sandstones and shales. Neglecting the small portion of possible Carboniferous origin, the history of Jones county geest may be briefly summarized. At the close of the Silurian or early in the Devonian the region, which had previously been covered by the sea, was elevated above tide level. The surface layers of limestone were promptly attacked by the "weather." Moisture, atmospheric gases, and all other agents that work silently and unobtrusively in causing rocks to crumble, combined to bring about disintegration of the exposed beds. Surface waters carried away the soluble constituents, and the insoluble clayey and ferruginous portions, reduced to an incoherent layer of soil, remained. Excepting the short period represented by the invasion of the Carboniferous sea, the work of rock disintegration and removal of soluble constituents has progressed uninterruptedly from the first elevation of the region till the present. This work was interfered with more or less by the incursions of Pleistocene ice and the consequent distribution of a protective covering of drift, but in some localities it is progressing to-day as rapidly as ever. Geest cannot be referred to any particular geologic age.

The geest of Jones county is a dark colored ferruginous clay, which usually contains fragments of chert. In places it is largely made up of chert, for the finer clay is more easily removed by ordinary erosion, and so has been carried away by the mechanical effects of water, while the chert fragments, too large for transportation, have been left. At times the geest contains many silicified fossils, and the most satisfactory specimens of corals and brachiopods are often derived from this source. All the fossil remains found in the geest,

as well as all the chert which it contains, were originally distributed through beds of limestone that have slowly disappeared as a result of ceaseless energy on the part of agents concerned in producing rock decay. A typical example of fossil-bearing geest occurs on the land of Mr. James Delay, in section 3 of Castle Grove township. The residual material is here only about a foot in thickness, but it abounds in well preserved silicified specimens of *Pentamerus oblongus* Sowerby, *Stricklandinia castellana* White, *Zaphrentis stokesi* Edwards and Haime, and *Favosites* (*Astrocerium*) *hispidus* Rominger. In the road that runs north and south through the middle of this section the geest is exposed in rain cut channels at the sides of the driveway, and contains a few specimens of *Pentamerus oblongus* mingled with great numbers of angular fragments of whitish chert. In section 6 of Scotch Grove township the residual products resulting from the decay of beds of limestone of unknown thickness contain three species of Favosites, two of Lyellia, two or three Heliolites, one Syringopora, three Strombodes, many Stromatoporoids, gigantic coralla of Halysites and Diphyphyllum, together with beautifully preserved specimens of Cladopora, Goniophyllum, Amplexus, Zaphrentis and a very large explanate Streptelasma.

PLEISTOCENE DEPOSITS.

The superficial deposits of Pleistocene origin are somewhat complex. They embrace (1) two sheets of till known respectively as the Kansan and Iowan drift; (2) some beds of water-laid sands and gravels that are probably interglacial or Aftonian in age; (3) beds of loess clays and associated sands that overlie both first and second till and are connected genetically with events taking place between, and in front of, the ice lobes developed along the attenuated margin of the Iowan glaciers, and (4) alluvial beds of clay, sand and gravel of more recent origin, deposited on the flood plains of the streams.

The Kansan drift is quite generally concealed by the newer till. It is seen, however, in a few natural exposures where rain wash has cut through the thin Iowan drift, or in places where the second drift has been bodily removed. The newer till, if present at all, is very inconspicuous around Center Junction, and there are here many characteristic exposures of the lower or Kansan drift. The Kansan drift is fundamentally a blue clay, but its upper surface, as seen near Center Junction, is dark reddish-brown, the color being due in part to the oxidizing effect of the atmosphere, and in part to the effect of growth and decay of many successive generations of plants. Below the superficial oxidized portion the blue color predominates. The boulders of the older drift are small, usually are striated, and consist largely of greenstone. All the distinguishing features of the Kansan drift are well seen in railway cuts and in channels by the roadsides, not only in the region indicated, but at many other points in Jones county.

The Kansan drift varies in thickness from zero on bald rocky prominences to more than 200 feet in old preglacial valleys. While fundamentally a blue clay, it contains many bands of sand and gravel which possess no small degree of economic importance since they are the source of water supply in wells of moderate depth. Near Center Junction the drift is more than 200 feet in thickness, but usually farm wells reach a supply of water in gravel beds seventy-five or eighty feet beneath the surface.

In all surface wells of any considerable depth the blue clay of the Kansan drift is reached, and it is from wells that the facts relating to its distribution and general characteristics have chiefly been learned. A short distance west of Amber the railway cuts through a hill of superficial deposits which show the following section.

		FEET.
3.	Loess ---------- 4 to	5
2.	Yellow till with rather large pebbles and small boulders (Iowan drift) ----------	10
1.	Blue clay with small pebbles, clay somewhat stratified (Kansan drift) ----------	12

The section is instructive as showing the stratigraphic relations of the three prevailing types of superficial deposits. At the same time it shows the usual characteristics of the Kansan drift. In the central part of the cut the clay is blue, imperfectly stratified and is charged with rather small, fine-grained, greenish colored boulders. Toward the sides of the cut the Kansan drift comes near to the surface. It shows the effect of oxidation in its dark brown color. Its materials have been mingled more or less with the lower portion of the overlying thin layer of Iowan drift, so that it becomes impossible to draw a definite line between the newer and the older deposits. The mingling of elements of the two tills along their line of contact is, as might be expected, a very common occurrence.

A shallow well near the center of section 20 in Fairview township may stand as the type of a very large number distributed throughout the drift covered portions of the county. This well was dug just outside the margin of the loess which is developed along the Wapsipinicon river. It shows the following section:

		FEET.
5.	Black loam or vegetable mould ----------	1
4.	Yellow clay of Iowan stage ----------	8
3.	Dark brownish band, upper portion of Kansan stage	4
2.	Blue clay, unoxidized portion of Kansan stage ----------	12
1.	Sand in which occurs an abundance of water ----------	½

Below number 1, a test with an auger shows a recurrence of blue clay. The water-bearing sand is interbedded with the characteristic clays of the Kansan stage. No. 3, is quite ferruginous and highly oxidized at top. Lower down it passes into the blue clay of No. 2. In many wells the yellow till of Iowan age has a thickness of fifteen to twenty feet. Between

the two tills the well-diggers often encounter trunks and branches of trees, the remains of an old forest that occupied the region during the long interval which separated the two glacial periods recorded by the Kansan and Iowan drift.

The Iowan till is superficial over the larger part of the drift plains already noted in describing the physiography of the county. Its thickness rarely exceeds twenty feet, and usually it is much less. Compared with the Kansan till it presents the following differences: (1) It is very much thinner. (2) It is yellow in color, while the Kansan clays are blue. (3) It contains large boulders. Boulders exceeding a foot in diameter are rare in the Kansan drift. In the Iowan drift boulders six or eight feet in diameter are common, and great masses measuring twenty feet in some of their dimensions, are not infrequent. (4) The larger and more characteristic boulders of the Iowan drift are composed of coarsely crystalline, light colored granite; the characteristic boulders of the Kansan drift are fine-grained, dark colored greenstone. (5) The small boulders of the Iowan drift are less frequently striated than in the Kansan. (6) The second till contains a much smaller proportion of fragments of local origin. (7) The Iowan ice sheet rode over the older surface materials without disturbing them to any considerable extent; the Kansan ice sheet cut down to bedrock and recorded the direction of its movement in striæ engraved on the native limestone ledges.

Between the two drift sheets in Buchanan county there are occasionally beds of yellowish, stratified, generally cross-bedded sands and gravels that may be Aftonian in age. It is proposed to call them the Buchanan gravels.* Yellow stratified sands and gravels of similar appearance occur at many points in the Pleistocene deposits of Jones county. They may, possibly, be referable to the same age as those of Buchanan county, but their relations to the sheets of till have not

* *The Buchanan Gravels: An Intergladial Deposit in Buchanan County, Iowa*, by Samuel Calvin. Am. Geologist. vol. xvii, p. 76. 1896.

been definitely determined. Typical exposures of such Pleistocene sands are seen along the border of the "second bench" or upper flood plain of the Wapsipinicon river in the Ne. qr. of section 14, Fairview township. Wherever these gravels occur they furnish the best of materials for the improvement of clay roads.

The loess is a fine yellow clay having nearly the same color as the Iowan drift. It is fairly homogeneous in composition, the differences which it presents being due to varying proportions of sand mixed with the clay. Loess contains neither pebbles nor boulders, a fact which distinguishes it from the yellow clay of the second till. It is one of the most important Pleistocene deposits of Jones county, for fully half the area is occupied by beds of this peculiar formation. The largest continuous loess covered region occupies a space of more than a hundred square miles in the northeast corner of the county and embraces all of Washington and Clay townships with portions of Richland, Scotch Grove and Wyoming. The area next in importance has a width of from two to four miles on both sides of the river at Anamosa. Ridges of loess extend with some interruptions through the southern part of Wayne and the northern part of Jackson and Madison townships, and connect the Anamosa with the northeastern area. In the central and southern parts of Jackson and Madison townships narrow ridges of loess alternate with flat bottomed intervales covered with Iowan drift. Southeast of Hale is a loess area embracing quite a number of square miles; west of Olin there are high ridges covered with the same formation; while in Greenfield township there are numerous conspicuous paha ridges capped with loess. The northwestern part of Jones county is comparatively free from loess. The gently undulating surface studded with conspicuous boulders of gray granite, announcing as it does the universal presence of the Iowan drift, is, even here however, occasionally broken by loess covered paha ridges. Such a ridge, having a length of several miles, crosses obliquely the north line of Cass

township in section 4, and McGee's Monticello paha occurs in the south half of section 33 of Monticello township.

McGee has called attention to the peculiar hypsographic distribution of the loess in this part of Iowa.* It not only overlies the drift, but it seems preferably to be distributed on plateaus, crests of rock, and morainic ridges of till that rise conspicuously above the level of the average drift plain. Reference has already been made to the fact that the summits of the loess covered ridges on both sides of the river near Anamosa, rise to a height of one hundred feet above the level of the adjacent regions which are covered with Iowan drift. All the isolated, loess-capped paha ridges have an elevation of from forty to sixty feet above the neighboring boulder-dotted plains, and the large loess area in the northeastern part of the county is a plateau having an average elevation of sixty or seventy-five feet above the drift covered areas that interdigitate with its lobed or sinuated margin.

In the case of isolated ridges and minor areas of loess there is evidence that many of the peculiarities of the present topography were developed before the loess was deposited. Around Anamosa there are ridges of limestone that would rise above the level of adjoining areas if all the loess were stripped from their summits. As McGee has pointed out, the river flows in a gorge which cleaves a rocky ridge, and the presence of this ridge seems to have been an important factor in bringing about the deposition of the loess. The Monticello paha is simply a mantle of loess spread over a prominent crest of rock that, before it was concealed by the fine yellow loess silt, stood out conspicuously above the general level. At the northwestern end of the paha the rocks are still exposed in a number of bold precipices twenty to twenty-five feet in height. A short distance southwest of the main paha ridge there is a second rocky crest, but smaller and lower than the first. This crest is bare even of drift for a length of thirty rods, but at its southeastern end it passes under a veneer of

* Pleistocene Hist. of Northeastern Iowa, Eleventh Ann. Rept. U. S. Geol. Surv., p. 301.

loess which eventually blends with the loess of the larger ridge. Within the distance of half a mile to the southwest there are many less prominent knobs and bosses of rocks which are bare toward the southwest but covered with soil on the southeast. They were not prominent enough to bring about the conditions necessary for the deposition of loess.

A typical illustration of loess distribution may be seen one and a half miles south of Center Junction. The surface is ridged and rolling, and superficially the ridges, particularly on their summits, are made up of loess. But the roadway is cut into some of the ridges far enough to show that the loess is insignificant in amount, and that it forms only a thin veneer over the summit of ridges of drift. The drift is mainly of the Kansan type, with brownish, ferruginous clay containing many small, dark green, fine-grained and usually striated boulders. The ridges, however, were present before the loess was laid down. The loess simply accentuates some features of a pre-existing topography.

That the major topographic features of Jones county were developed before the deposition of the loess is well shown at a number of points. Even the river channel between Stone City and Anamosa, which is cut 120 feet below the average level of the drift and 220 feet below the summit of the loess that crowns the walls of the valley is not only pre-loessal, but is preglacial. Both loess and drift, in beds undisturbed since first deposited, come down on the sides of the valley practically to the present level of the water. At Senator Green's Champion quarry No. 1, undisturbed loess overlies a thin bed of Kansan drift. Near the fair ground, northeast of Anamosa, and about 40 feet above the river there are exposures of drift. Three-fourths of a mile north and 65 feet higher, the loess has been eroded down to the drift, and exposes a large gray granite boulder of the Iowan type, and yet this point is 120 feet below the summit, which the road finally surmounts near the southwest corner of section 30, of Wayne township.

Beds of alluvium or river silt have been deposited on the flood plains of all the streams. In the table of geological formations on page 48 alluvium is referred to the recent epoch. The formation has been in progress of deposition ever since the withdrawal of the second ice sheet. Some of it dates only from the latest overflow, but by far the most important part of it is but little, if any, younger than the loess. The flooded streams carrying torrents of water from melting glaciers carried also enormous loads of gravel, sand and fine glacial silt, and these materials, deposited upon the overflowed plains, furnished the larger portion of the present alluvium.

Bodies of alluvium of sufficient importance to deserve special notice are found at only a few points in the county. Monticello has been built on the margin of an alluvial plain that extends up the valley of Kitty creek for some distance on the one hand and up the valley of the Maquoketa to beyond the Delaware county line on the other. The thickness of the deposit varies from a foot or two at the margins to more than thirty feet in the axial parts of the valleys. At the base the deposit is composed of gravel. This is covered by sand, and on the sand rest beds of stratified clays of excellent quality for the manufacture of brick and tile. The broad flood plain that extends from Newport almost to Hale is occupied with alluvial deposits. These deposits are often very sandy, but in the neighborhood of Olin they contain tile clays of demonstrated excellence. Oxford Mills and Oxford Junction stand in the midst of a plain covered with alluvium.

Typical Exposures.

A large proportion of the rock exposures in Jones county belong to the Delaware stage of the Niagara. The characteristics of the different beds of this stage are, however, very inconstant; and the strata of the same horizon vary locally to such an extent as to make the correlation of the several exposures exceedingly difficult. The contact of the Niagara

with the underlying Maquoketa was not seen. The lowest beds observed lie at least sixty feet above the line of junction between the two formations. At this lowest observed horizon the dolomitic limestone is sometimes crowded with casts of large individuals of *Pentamerus oblongus* Sowerby. In the valley of the North Maquoketa near Cascade, a few feet above the level of the river, there are Pentamerus beds with cherty partings, in which the fossils are unusually perfect. As a result of conditions somewhat unusual in our Iowa dolomites, many of the individuals retain portions of the original shell. Pentamerus beds, alternating with some coral-bearing and many unfossiliferous layers, are found in the bluffs up to a height of sixty feet above the level of the river. The horizon of small silicified colonies of *Halysites catenulatus* and *Syringopora nitella* occurs below the middle of this section, and the corals named range through ledges that together have a thickness of eight or ten feet. The coral beds are followed by one foot of Pentamerus-bearing limestone and twelve feet of coarse limestone without fossils. Higher up is a third Pentamerus bed, above which the rock becomes massive for fifteen to twenty feet, and shows no fossils. Above these massive beds the strata are again crowded with Pentamerus, but the individuals are smaller, and many belong to the species *Pentamerus pergibbosus* Hall and Whitfield. Associated with *P. pergibbosus* are *Cerionites dactylioides* Owen, *Caryocrinus ornatus* Say, and *Leptæna rhomboidalis* Wilckens. In other portions of the county there often occur, above the horizon of Cerionites, massive barren ledges of variable thickness, followed by some twenty or thirty feet of evenly bedded building stone.

The forgoing facts are not derived from any one section. They are offered as a generalized statement of what may be learned by combining the observations on a number of different exposures. They illustrate the succession of beds for the lower 200 feet of the Delaware stage. The difficulties in the way of correlation of the numerous outcrops of this stage arise from the fact that, during the progress of deposition of

the limestone, the types of life were not uniformly distributed over the bottom of the Niagara seas. At any given time there were areas supporting vigorous colonies of certain species, but the assemblage of species differed more or less in different localities, and there were at the same time intervening areas over which living forms were very sparsely distributed, or from which they were entirely absent.

The exposures of Le Claire limestone in Jones county are neither numerous nor conspicuous. Isolated masses of this limestone, when free from fossils, and so situated as not to show its relations to the Delaware and Anamosa stages, cannot be distinguished from certain heavy bedded, highly dolomitized, unfossiliferous portions of the lower stage. Beds of the Anamosa stage have pronounced lithological characteristics which render them easily recognized, but the Bertram beds can only be distinguished by their stratigraphical relations to the Anamosa.

Without in all cases entering into details of sections, which would not be instructive, or attempting to correlate the several exposures, which would often be impossible, the more important and instructive of the rock exposures in the several townships may be briefly noted.

CASTLE GROVE TOWNSHIP.

Characteristic exposures are found in Castle Grove township, along Grove creek, Silver creek and West creek. In the northeast quarter of section 3, the soil is thin in places, and on the north side of Grove creek weathered masses of dolomite belonging to the Delaware stage appear on the surface. South of the creek, in the same quarter section, a quarry was formerly worked, and furnished a fairly good quality of stone for ordinary purposes. Interbedded with the limestone in this quarry are many bands of chert. Overlying the quarry stone is a layer of dark, ferruginous, residual clay, or geest, resulting from secular decay of overlying beds of limestone. This geest contains beautifully preserved

silicified specimens of *Pentamerus oblongus subrectus* Hall var., *Stricklandinia castellana* White, *Favosites* (*Astrocerium*) *hispidus* Rominger, and *Zaphrentis stokesi* Edwards and Haime. At the point where the quarry is opened the soil is composed wholly of geest, with a thin layer of vegetable mould. Till seems to be entirely absent, and yet lying on the surface of the geest or partly imbedded in it, there are a few rather small erratic boulders. The amount of detritus left by the ice sheets was in many places exceedingly small.

North of Grove creek, in the southwest quarter of section 2, the scant soil is insufficient to conceal a great number of dolomitic ledges which crop out on a gently sloping hillside facing the south. Some of the badly weathered masses are in place, but many seem to be strewn irregularly over the surface. The most conspicuous fossils here are very large internal casts of *P. oblongus sinuatus* McChesney var. Some of the beds at this locality when first laid down included gigantic coralla of a slender stemmed Diphyphyllum. The coral, however, was not subsequently silicified, and it has been entirely removed by solution leaving sinuous, anastomosing, closely crowded, tube-like channels which pass vertically through ledges many inches in thickness. About fifteen feet below the level of the large sinuated Pentamerus the beds contain silicified fossils; and Pentamerus of the ordinary type, together with *Alveolites interstinctus*, *Lyella americana*, *Favosites niagarensis* and other corals, occur in cherty masses upon the surface. Stricklandinia is present in beds immediately beneath the coral-bearing horizon. Other exposures in this township are found in section 24.

MONTICELLO TOWNSHIP.

In section 19 of Monticello township there are outcrops of the Delaware stage, the chief interest of which lies in the fact that a stratum about twenty feet in thickness, made up of cemented segments of crinoid stems and containing but little magnesium carbonate, lies in the midst of unfossiliferous

dolomite. This crinoidal bed, so strikingly different in its fossil contents and chemical composition from any of the ordinary phases of the Niagara, occurs in adjacent sections of Monticello and Castle Grove townships and in section 4 of Wayne, but was seen nowhere else in the county.

In sections 32 and 33 of Monticello township, rough, jagged, worn masses of Niagara illustrate in a typical way the effects of weathering on this formation. Around the northern foot of the Monticello paha the exposures assume the form of weather-corroded cliffs, twenty-five or thirty feet in height. Southwest of the paha the rocks project above the general level in the form of sharp ridges, trending southeast, and probably ten feet in height. West of the road which runs past the foot of the paha a few small quarries have been worked to supply local needs. The rocks here are generally without fossils. Specimens of a small tubed variety of *Favosites favosus*, an unrecognizable silicified Stromatoporoid and rocks containing tube-like channels, from which stems of Diphyphyllum have been removed by solution, occur very sparingly. The rock generally has an earthy fracture quite unlike that of the semi-crystalline portions of the formation composed of pure dolomite.

In the bluffs that border the river bottom east of the mouth of Kitty creek, there are exposures which contain a fauna characteristic of the horizon of *Pantamerus pergibbosus*. The rocks are badly weathered, are intersected by numerous fissures, and contain a great many cavities. The fossils, which are all in the form of casts, embrace *Favosites forbesi* or a related spherical species, *Halysites catenulatus*, a species of Thecia, *Cerionites dactylioides*, *Saccocrinus christyi*, another crinoid related to Hexacrinus, *Pentamerus pergibbosus*, *Spirifer eudorus*, and an undetermined Orthoceras. From two to three miles northeast of Monticello, in the southeast of section 11 and in adjoining parts of 13 and 14, there are many outcrops; and in the ravine followed by the road running between 11 and 14 the *P. pergibbosus* horizon is exposed. Fossils are more

numerous than in the bluffs east of Monticello, and among the other forms belonging to this horizon there are casts of *Eucalyptocrinus crassus*. South of the road the hill rises fifty feet above the level of the *P. pergibbosus* beds. The surface is strewn with detached rock fragments and diversified with numerous small outcrops of ledges in place. The rocks are generally barren, but a few colonies of Halysites and Syringopora were observed in the loose masses scattered over the surface. Near the summit of the hill the evenly bedded building stone layers of the Delaware stage have been quarried on a small scale.

One and one-fourth miles northeast of Monticello a quarry has been opened in the quarry stone portion of the lower stage. The rock here is rather soft and as usual furnishes no fossils. This quarry stone horizon of the Delaware is quite constant about 200 feet above the base of the formation, and twenty, thirty or forty feet above the beds that furnish *P. pergibbosus* and Cerionites.

Other exposures occur along the Maquoketa in sections 23, 25 and 26 of this township; and in the southern parts of 35 and 36 there are many stony hills and outcrops, the beds of which furnish no fossils nor do they show any characteristics by which they could be referred to a definite horizon.

RICHLAND TOWNSHIP.

Richland township is largely covered with loess. The rock exposures are limited to the bluffs along the Maquoketa river in sections 30 to 35, and to the valleys of some small streams in the neighborhood of Bowen's Prairie. Along the river there are cliffs of limestone thirty to forty feet in height, and composed of massive beds intersected with numerous joints and fissures. The foot of the cliffs is often undermined for a distance of ten or fifteen feet, and cavernous recesses have been excavated, by weathering, in their vertical faces. Fossils are rare, but the horizon is clearly indicated by the presence of Cerionites and *P. pergibbosus* eight or ten feet above the level of the water.

There are some exposures near Bowen's Prairie; and in the bed of the small creek east of the schoolhouse and cemetery the rocks contain many small individuals of *Pentamerus oblongus*. The horizon is lower than the *P. pergibbosus* beds.

WASHINGTON TOWNSHIP.

Rocks are exposed in the valleys of all the streams in Washington township. Along White Water creek and the North Maquoketa, the sides of the valleys are quite precipitous, sometimes standing in vertical cliffs. More frequently, however, they take the form of steep bluffs, that here and there expose moss-covered walls of rock, ten, twenty or thirty feet in height; while elsewhere the rock is concealed by soil and talus which support gloomy forests of oak and maple. Mosses, ferns and trailing vines conceal immense detached masses of limestone, that, in the erosion of the valleys, were undermined and rolled down from some higher levels. An exposure typical of a large number along the North Maquoketa is seen in the walls of the gorge, down which the road winds on its way to the ford in the northeast quarter of section 26. The rocks are not very fossiliferous, but the section shows various phases of the Pentamerus and Cerionites beds up to the evenly-bedded quarry stone of the Delaware stage which here occurs 150 feet above the level of the river. The paucity of corals in this section, and the absence of silicified fossils of any kind, are in striking contrast with what occurs in many other places at the same horizons. Even Pentamerus is scarce, while only a few miles away there are beds at the same stratigraphic level composed entirely of crowded individuals of *P. oblongus*. The county furnishes many equally striking illustrations of local variations in the distribution of the Niagara fauna or in the dolomitization and other processes that have affected the Niagara limestone since its deposition.

Exposures of the quarry stone beds on Farm creek, in section 28, furnished the material used in the erection of Saint Peter's church and other buildings at Temple Hill.

CASS TOWNSHIP.

Cass township has a number of interesting rock exposures along Buffalo creek and its tributaries in sections 29–34. The cliffs of massive bedded dolomite are mostly of the Le Claire stage, but in section 33 the building stone beds of the Anamosa stage are well developed. Two large quarries are operated near the south line of the southwest quarter of 33. One is the Penitentiary quarry or State quarry, owned by the state and worked by convict laborers; the other is the Johnellen quarry, owned and operated by Hon. J. A. Green. The two quarries are in fact continuous, and present a frontage of nearly a quarter of a mile. The quarry face is a curve, describing the quadrant of a circle, trending at first toward the west at the east end of the State quarry, and finally trending north at the north end of the Johnellen quarry. The strata dip toward the northwest. Fully twenty feet of Le Claire limestone are exposed above the railway grade at the east end of the State quarry, but for a few rods the beds dip at a steep angle, and the base of the Anamosa stone soon reaches the level of the tracks. The inclination is afterwards more gentle, but at the north end of the Johnellen quarry the base of the quarry stone is twelve or fifteen feet below the level of the railway. A short distance northeast of the last point the upper surface of the Le Claire beds rises even above the level of the top of the quarries just noted, and the Anamosa stone has disappeared as a result of erosion. The floor of the sea at the beginning of Anamosa time was exceedingly uneven.

The Le Claire limestone along the Buffalo would furnish excellent material for lime.

WAYNE TOWNSHIP.

Rock exposures in Wayne township are confined to its northern part. The central part of the township is occupied by gently undulating drift, and its southern portion is traversed by morainic ridges capped with loess. There are

unfossiliferous, characterless exposures of rock in section 1, but the most conspicuous outcrops occur in sections 4 and 5. On both sides of the valley of Kitty creek, in the west half of section 4, there is an area, more than 200 acres in extent, over which the surface is broken and hilly, the depressions are occupied by a thin soil, and the eminences are in the main projecting weather-beaten crags of dolomite. The surface is largely strewn with displaced fragments. Similar conditions prevail in the eastern part of section 5. This area in Wayne is continuous with the area of rock exposures west and north of the Monticello paha in Monticello township. The rocks represent some of the multitudinous phases of the Delaware stage. In places they are massive. Elsewhere they lie in layers thin enough to be easily quarried, but they are rendered almost useless by the presence of large quantities of chert. Half way between the center and the northwest corner of section 4 the imperfectly dolomotized crinoidal limestone already noticed is exposed. Tubular cavities left by solution of coralla of Diphyphyllum are seen occasionally in the dolomitized portions of the exposures. More rarely silicified stems of Diphyphyllum occur, and there are occasional specimens of *Favosites favosus*. The rock has been quarried at a few points, and the loose masses with which the surface is encumbered have been used in building miles of fences.

A small cut on the railway, one mile northeast of Langworthy, shows well one phase of the Delaware stage. There are no signs of true bedding. The rock is cleft and fissured in every possible direction and if quarried would come out in shapeless pieces. Furthermore the rock is not uniform in character for any distance in any direction. A part of a given block defined by the irregularly disposed fissures may be hard, crystalline dolomite, while the rest of it is soft, yellow, granular and earthy. Fossils are scarce. The few observed belong to the general Diphyphyllum, Favosites and Rhynchonella.

SCOTCH GROVE TOWNSHIP.

The whole course of the Maquoketa river, so far as it lies in Scotch Grove township, is bordered by bluffs of dolomite belonging to the lower two-thirds of the Delaware stage. Along the great loop of the river in section 5 the cliffs include beds containing *Pentamerus pergibbosus* and *Cerionites dactylioides*. The faces of the cliffs are worn into caverns. There are re-entrant recesses due to widening of fissures, and there are threatening masses which overhang the receding, softer and more easily eroded basal portions of the ledges.

In the southwest quarter of section 6, and on both sides of the road that passes diagonally through section 7, there are, in the thin-soiled, stony fields, many rocky exposures of the same type as those seen in the adjacent parts of Wayne and Monticello townships. In general the rock is barren of fossils, but about one mile northeast of Scotch Grove, in section 7, there are masses containing the tubular spaces left by solution of stems of Diphyphyllum, indicating the growth in this locality of gigantic coralla many feet in diameter. Along the west side of section 5, and in the east half of section 6, the surface is strewn with silicified corals belonging to a great number of species. The elevation is about the same as that of the barren, or nearly barren, beds only a mile or two to the west. Among the silicified corals are enormous coralla of *Diphyphyllum multicaule* comparable in size to the corals that have disappeared by solution northwest of Scotch Grove, and doubtless belonging to the same species. In this locality it seems the growth of corals was very luxuriant and the conditions for their preservation by the substitution of silica for the original calcium carbonate were usually favorable. In the other locality, only a mile or so away, life was absent except in a few favored spots, and the metasomatic or pseudomorphic changes essential to the preservation of the skeletal parts failed because the necessary conditions were not present. The corals scattered over the surface in the western part of section 6 are part of the residual products resulting

from decay of layers of dolomite that have been removed from the region. They are constituent parts of the geest. Similar corals are wholly or partly embedded in residual soil, and the same species occur in silicified condition in the undecayed, underlying ledges of dolomitic limestone. Along with the corals the undecayed beds often contain numerous internal casts of *Pentamerus oblongus*, some of which are silicified, though the majority are not. The assemblage of corals in this interesting locality embraces the following species:

Heliolites megastoma McCoy.
Heliolites interstinctus Linnæus
Lyellia americana Edwards and Haime.
Lyellia, undescribed species.
Halysites catenulata Linnæus.
Syringopora annulata Rominger.
Springopora verticillata Goldfuss.
Favosites favosus Goldfuss.
Favosites niagarensis Hall.
Favosites (*Astrocerium*) *hisingeri* Edwards and Haime.
Favosites obliguus Rominger
Alveolites undosus Miller.
Cladopora laqueata Rominger.
Zaphrentis stokesi Edwards and Haime.
Streptelasma patula Rominger.
Amplexus shumardi Edwards and Haime.
Ptychophyllum expansum Owen.
Strombodes gigas Owen.
Strombodes pentagonus Goldfuss.
Strombodes mamillatus Owen.
Goniophyllum pyramidale Hisinger.

Besides the species mentioned, there are large silicified Stromatoporoids, forms related to Diphyphyllum, with stems three-eighths of an inch in diameter and growing embedded in *Favosites hisingeri*, a very large, wheel-shaped Streptelasma, related to *S. patula*, half an inch in length, and more than two inches in diameter, an encrusting species of Thecia, and a

number of others that have not yet been studied. While most of the species occur elsewhere, no other locality affords evidence of such luxuriance of coral growth as is witnessed here. Nearly all the species are represented by coralla of unusual size. Gigantic masses of Halysites that are evidently mere fragments of the original coralla, are five feet in length, four feet in width and three feet in thickness; and there are many fragments of colonies of Diphyphyllum equally as large. The conditions favoring the exceptional growth and perfect preservation of the corals were limited to a relatively small and sharply defined area. We have here another striking example of definitely localized conditions.

CLAY TOWNSHIP.

The principal rock exposures in Clay township are found in the bluffs along Farm creek and the Maquoketa river, and in the lateral gorges that open into the valleys of these two streams. At the bridge, a short distance southwest of Clay Mills, there are massive beds without signs of stratification, crowded with casts of beautifully preserved, medium sized individuals of *Pentamerus oblongus*. The Pentamerus beds have here a thickness of about thirty feet. They are almost wholly free from silica, and they contain no conspicuous corals. Above the Pentamerus beds there are weathered ledges of dolomite, bearing few fossils, and having a thickness of fifty to seventy-five feet. Immediately west of the village of Clay Mills the dolomitic cliffs have an altitude of 145 feet above the bed of Farm creek, and 150 feet above the Maquoketa river. The lower fifty feet at the base of the cliff, including the prolific Pentamerus beds seen at the bridge, are concealed by talus. Above the talus slope the ledges form a vertical wall ninety-five feet in height. (Fig. 3.) The structure of similar cliffs may be studied east of the village, along the road which, taking advantage of a favorable arrangement of the talus, follows close to the foot of the vertical wall and gradually attains the summit of the bluff. Pentamerus is

found sparingly up to fifty or sixty feet above Farm creek; there are a few traces of feeble colonies of Halysites; but fossils of every kind are rare above the horizon of the Pentamerus beds at the river, and none of the species are silicified. At the summit of the bluff, about a quarter of a mile east of Clay Mills, the road reaches the level of the quarry-stone of the Delaware stage. The quarry beds, horizontally and evenly stratified, vary from three to fifteen inches in thickness, and are much superior in quality to beds of the same horizon in many other localities. Eagle rock is a conspicuous rocky promontory facing the river in the southwest of section 13. It has an altitude of 150 feet above the water near its base. It shows essentially the same succession of beds as seen at Clay mills, and its summit is capped with layers of evenly stratified building stone. The road, which winds diagonally through section 15, follows a deep ravine with high, rocky walls. The walls exhibit the same characteristics as the sections already noted, and include all the ledges, from the prolific Pentamerus horizon up to the building stone beds. But in none of these sections is there anything to correspond to the coral beds of section 6 in Scotch Grove township. A few small, silicified corals were found free in the bed of a creek in the northwest of section 15 of Clay township; but although the creek bed should have contained residual products from probably 200 feet of limestone removed by erosion, silicified fossils, or even fragments of chert, were so few in number and so small in size that they could be found only by careful search. This region probably never supported more than a few feeble colonies of corals at any given time, and only a small proportion of these was preserved by the substitution of silica for the original material.

The exposures at and near Clay Mills and at Eagle Rock are typical of the majority of exposures occuring in this township. In the southeast of section 24, however, corals were more plentiful than near Clay Mills, and some ledges in the dry bed of an intermittent creek furnish small silicified

specimens of *Favosites favosus*, *F. hisingeri*, *Lyellia americana*, *Heliolites interstinctus* and *Halysites catenulatus*. Besides the species named there are two species of Zaphrentis, one Rhynchotreta, the common Pentamerus, and a large species of Straparollus more than four inches in diameter. The poverty of the fauna at this locality was one of its most striking characteristics.

FAIRVIEW TOWNSHIP.

Fairview township is the center of the building stone industry for Jones county. The great shipping quarries of this township are located in sections 5 and 6. The quarries are worked in beds of the Anamosa stage, and it is in these quarries that the typical exposures of this stage are found. The original quarry which produced building stone on a commercial scale for other than local markets, was called the Anamosa quarry, and the special kind of rock which it furnished became known in the building trade as Anamosa limestone. Under this name it is still known, and the name is to be perpetuated by calling the particular geologic horizon in which these great quarries were opened, the Anamosa stage. The evenly bedded quarry stone of the Anamosa stage has already been described. In sections 4, 5, 6, 7 and 8 of this township it overlies massive beds of the Le Claire. The Le Claire beds, however, are not very thick and at the mill near Anamosa the Wapsipinicon river has cut down into the thin cherty beds of the Delaware stage. The bluffs, however, from Stone City to the center of section 13 are largely of Le Claire limestone.

Gold Hill quarry, the property of F. S. Brown & Co., is located near the western edge of section 6. All the ledges exposed in this quarry belong to the Anamosa stage. About eighty rods southeast of Gold Hill is Champion quarry No. 1, belonging to Hon. J. A. Green. Mr. Green takes out the laminated stone down to the massive beds of the Le Claire. Between the level of the river and the thin layer of drift overlying

the rock at Champion quarry No. 1, the following section is exposed:

		FEET.
5.	Remnants of a non-laminated, yellow magnesian limestone, Bertram stage	2 to 3
4.	White limestone of the Anamosa stage, much decayed and broken into small fragments in the upper part	30
3.	Gray limestone of Anamosa stage	30
2.	Heavy bedded limestone, forming in places vertical walls above level of railway track, Le Claire	15
1.	Slope from level of railway track to river, unexposed	25

The Stone City quarry, one-fourth of a mile east of the center of section 6, is owned by H. Dearborn & Sons. The quarry stone is worked down to the non-laminated Le Claire, which everywhere forms the floor on which the Anamosa limestone was deposited. The section in its general details is the same as that on the property of Mr. Green. The upper surface of the Le Claire, as already noted, is very uneven, and here slopes to the east. In the Anamosa quarries owned by Mr. Ronen, and located in the western part of section 5, the floor on which the quarry stone rests descends below the level of the railway tracks, and at Mr. Green's Champion quarry No. 2, one-fourth of a mile southeast of Ronen's, the lower Anamosa beds pass beneath the level of the river. Farther east the Anamosa limestone again rises, and in section 4, to use the quarryman's expression, "throws itself out of the ground." The Anamosa stone is seen in its normal relations to other geological formations at a number of points in the walls of the valley of the small creek which flows through sections 7 and 8.

There are some peculiar phases of the Le Claire limestone along the river, between Stone City and the east line of the township. Some of the characteristics are illustrated in the bold cliff in sections 13 and 24. Near the center of 13 is an exposure twenty-five feet in height which, as usual in this region, shows no definite bedding planes. The rock near the base of the cliff is very much fractured, and broken into small,

angular bits in such a way as to impart a close resemblance to limestone breccia. There are crevices in the lower part of the exposure, and a large amount of work has been done in developing and exploring them, in the hope of finding lead ore. Prospecting for lead has been carried on in corresponding beds in sections 14 and 24. In the upper part of the exposures the rocks are more solid. The only fossils noted were the impressions of a small Zaphrentis, diminutive colonies of Favosites and a small brachiopod resembling *Rhynchonella whitei*. The rocks are free from chert, and the fossils are represented by cavities left as a result of solution of the original organic structures.

JACKSON TOWNSHIP.

Ledges of Le Claire limestone, similar to those seen in sections 11, 13, 14 and 24, of Fairview, are continued along the river in Jackson township, as far as Newport in section 33. Above the mill dam, near Newport, the ledges exhibit fairly defined bedding, and may be quarried with some success for rough masonry. In the left bank of the river, above the dam, the beds are folded into a long, sweeping, double curve, more than 300 feet in length. The steepest part of the curve dips to the northeast at an angle of twenty degrees.

A small area, near the center of section 22, is occupied by beds of the Anamosa stage overlying the Le Claire, and at what is called Slife's ford, in the southwest of 26, the river has cut its channel in the upper layers of the Anamosa limestone. Quarrying has been done on a limited scale at both the points mentioned.

MADISON TOWNSHIP.

Madison township has no rock exposures. The entire surface of the township is covered with loess and drift. South of Center Junction the indurated rocks are covered with superficial deposits to a depth, in places, of 200 feet. The greater part of the township was, in preglacial times, occupied by a broad, deep valley.

WYOMING TOWNSHIP.

Rock exposures occur in Wyoming township, in the valley of the small creek followed by the Chicago & Northwestern railway, in sections 3 and 15. There are other exposures in the hills bordering the valley of Bear creek, in the southeastern corner of the township. In the northern sections the

FIG. 5. Monument of Niagara limestone, Delaware stage, 80 rods north of southwest corner of section 35, Wyoming township.

stone is generally coarse in texture, very vesicular, and breaks in irregularly shaped masses. The bedding is not very definite, and the layers often seem to be more or less flexed and tilted. In section 9, Ne. qr., Se. $\frac{1}{4}$, there are even horizontal beds of quarry stone of the Delaware stage, overlying the rough vesicular ledges that outcrop lower down in the sides

of the valley. In the southeastern corner of the township, the beds are also of the Delaware stage. Eighty rods north of the southwest corner of section 35, there are exposures on the hillsides, high above the bottom of the valley of Bear creek. One of the interesting phenomena of the locality just mentioned, is a column of limestone eight feet in diameter, and rising above the general surface about sixteen feet (Fig. 5.) The soil is thin, but what there is is chiefly drift, and boulders are scattered over the hillside all around the column. The column is the result of unequal erosion of the limestone. It evidently stood there before the drift was laid down. How it escaped destruction by the glacial ice that deposited the boulders now lying around its base, is a question not easily answered. The exposures in Wyoming township belong to the upper part of the Delaware stage. Fossils are rare. In the vicinity of the monument described above, there were traces of Halysites and Cœlospira.

GREENFIELD TOWNSHIP.

There are very few rock exposures in Greenfield township. The drift is in places more than 100 feet in thickness, and the surface, more than in any other township, is diversified with paha ridges. The rocks, however, come to the surface at a few points along Walnut creek. The exposures seem to be wholly confined to the northwest quarter of section 15. All belong to the Le Claire stage, and the oblique bedding peculiar to this stage is one of their prominent characteristics. Altogether there is a thickness of twenty-five feet exposed, and the oblique beds, which are confined to the lower part of the exposure, are inclined to the east at an angle of 28°. Among the uppermost ledges there are some that contain numerous cavities from which small costate, Retzia-like shells have been removed by solution. The same kind of cavities is very characteristic of the strata overlying oblique beds of Le Claire limestone at many points beyond the limits of Jones county.

ROME TOWNSHIP.

The most important rock exposures in Rome township occur southeast of Olin in the valley of Sibyl creek. Mr. A. Rummel has opened a quarry in typical beds of the Anamosa stage, not far from the township line, almost directly east of the center of section 24. The thickness of the beds worked in this quarry is about thirty feet. The lamination planes occur as usual in the Anamosa limestone, but there are no planes separating the mass of sediments into distinct layers. The whole exposure is practically one continuous ledge that may be split with almost equal facility along any one of the numerous planes of lamination. The creek near the base of the quarry cuts down into non-laminated beds belonging to the Le Claire stage.

HALE TOWNSHIP.

A short distance east of Rummel's quarry, in section 19 of Hale township, there are several exposures of Anamosa limestone underlain by beds of Le Claire. At two or three points quarries have been opened, the most extensive being that on the land of Mr. A. J. Dolby. The stone is very similar to that in the Rummel quarry in Rome township, except that it is more definitely divided into layers, and that nodules of chert are very numerous. On the slopes below the level of the quarries there are exposures of Le Claire limestone containing casts of the species of Amplexus that is so marked a characteristic of this formation at many of its typical localities in Cedar and Scott counties.

There are undeveloped beds of Anamosa limestone in the northwest quarter of section 20, and deposits of the same stage occur on both sides of the river near Hale. The highly crystalline dolomite of the Le Claire stage, suitable for lime burning, is exposed in a number of places on the land of Mr. J. R. Clay in the western half of section 15. At the bridge over the Wapsipinicon southwest of Hale, there are bluffs of massive Le Claire limestone fully twenty feet in height. (Fig. 2.)

The imperfectly defined lines of bedding show the anomalous folds and dips that so generally mark this particular horizon. For purposes of lime burning the rocks at this point are unexcelled, but, although lime has been made here on a small scale, there is none manufactured at present.

East of Hale, near the center of section 11, the Anamosa beds are somewhat extensively quarried. The quality of the stone is better than that near Olin. The beds show the effect of having been deposited on an uneven floor. The layers are all somewhat warped. North of the center of the quarry they slope in all directions from a dome-like arch, but before reaching the north end of the working the dip is reversed. On the south side of the dome the dip is steeper than on the north, and is continuous as far as the quarry has been opened. The total exposure here has a thickness of about thirty feet. The lower beds of the Anamosa stage have not yet been taken out. On the south side of the river, about eighty rods east of the center of section 15, the John Clay quarry exposes from twenty-five to thirty feet of Anamosa limestone. The quarry stone is taken out down to the upper surface of the Le Claire. Near the middle of the west line of section 14 there is another quarry belonging to A. Ballou, which affords the following section:

		FEET.
5.	Soil and geest only a few inches	--
4.	Anamosa stone of usual quality, ledges varying in thickness from five inches to two or three feet	25
3.	Unlaminated ledges of Le Claire limestone, nearly uniform in thickness, good bridge rock	2¾
2.	Massive coarse Le Claire limestone without partings	8
1.	Unexposed to level of water in river	6

A few rods east of the Ballou quarry another opening has been made and worked on a small scale. The usual features are shown, the only point of interest arising from the fact that owing to the irregularities attending the deposition of the Le Claire, the base of the Anamosa formation descends below the level of the roadway, a descent of at least eleven

feet in as many rods. The last two quarries are opened in the side of a wooded bluff seventy-five feet in height. The beds overlying the Anamosa are not exposed, but it may be assumed that they belong to the Bertram stage and possess the characteristics of this formation as developed near Stone City.

OXFORD TOWNSHIP.

The exposures in Oxford township are not very numerous. The Delaware limestone, with casts of the ordinary type of *Pentamerus oblongus*, comes to the surface in the level plain within the limits of the town of Oxford Junction. One and a half miles further north, sixty rods south of the center of section 10, and only a few feet higher than the Pentamerus beds at Oxford Junction, there is an exposure of Anamosa limestone underlain by heavy beds of Le Claire.

Unconformities.

The peculiar conditions attending the deposition of the Le Claire limestone, described on preceding pages, have produced a great number of apparent unconformities. Horizontal beds of Le Claire seem to rest on the edges of inclined strata of the same age (plate i), and the inequalities of the sea bottom at the close of the Le Claire produced many anomalies in the position and relation of the Anamosa beds. It often looks very much as if the surface of the Le Claire formation had been deeply eroded before the Anamosa beds were deposited. The appearance is not wholly deceptive, for the materials of the Le Claire were scooped out in some localities and were irregularly heaped up in others immediately before the opening of the Anamosa stage. The erosion, however, was not subaerial. All the observed effects were produced beneath the water as the result of vigorous currents acting on the bottom of a shallow sea. At many points along the South Atlantic coast of the United States analogous effects are now being produced by storm-driven currents acting on submerged sands.

True unconformity occurs between the Niagara and the Carboniferous. The region was elevated above the sea near the beginning of the Devonian and was subjected to subaerial erosion during all the stages of the Devonian and Lower Carboniferous. It was not indeed until probably the middle of the Upper Carboniferous that the sea returned to deposit a new series of sediments upon the deeply eroded surface of the Silurian. The time during which the Carboniferous sea occupied the county was, geologically speaking, very short, and nearly all the sands and shales which accumulated above the Niagara dolomite have been carried away by subsequent erosion.

The Pleistocene deposits rest unconformably upon all the indurated rocks, the two drift sheets are unconformable, the loess is unconformable on the Kansan drift, and the alluvium occupies valleys of erosion that have been cut in all the deposits preceding it in point of age.

Deformations.

That examples of deformation of strata occur within the limits of Jones county is scarcely to be doubted; but if such do occur, they are so completely disguised by the anomalies of deposition consequent on conditions existing during the progress and at the close of the Le Claire stage, that it has not been possible to recognize them with any degree of certainty.

ECONOMIC PRODUCTS.

SOILS.

From an economic standpoint the soils of Jones county easily outrank in importance all the other geological formations. These soils fall naturally into four divisions, namely: residual soils or geest, glacial soils or drift, yellow clay soils or loess, and alluvial soils which may consist of clay or sand, or varying admixtures of these two materials. The history, origin and distribution, and some of the physical characteristics

of each of these types of soil have already been discussed. It remains only to note briefly their relative importance judged from an agricultural point of view.

The residual soils of the county are comparatively unimportant. The area exclusively occupied by them is small. Where they prevail the soil is thin and is usually insufficient to conceal the indurated rocks of the region. Weather beaten crags project above the surface, and the scant soil is encumbered with numerous rock-masses detached by the processes of disintegration. Sections 2 and 3 of Castle Grove, 19, 33, 34 and 36 of Monticello, 4 and 5 of Wayne, 5, 6 and 7 of Scotch Grove township afford numerous typical illustrations of residual soils.

The drift soils, on the other hand, are the most important and valuable of all the classes named. In the drift covered portions of the county the indurated rocks are usually effectually concealed by a mantle of glacial detritus that is, in places, more than 200 feet in depth. The efforts of ants, earthworms, gophers, and other burrowing animals, that, during all the years since the retreat of the Iowan ice, have been effective in carrying the fine-grained portion of the deposit up to the surface, aided as these have been by rains and frosts and vegetable growth and decay, have resulted in developing upon the surface of the drift a mellow loam, rich in organic matter and so constituted physically as to offer advantages of easy cultivation coupled with the assured hope of generous harvests. The drift occupies certain plains already described under the head of physiography. The limits of the drift plains circumscribe the regions in which wealth is, on the whole, accumulating most rapidly with least effort. The drift covered regions are everywhere characterized by masses of gray granite, and so the distribution of boulders is practically coextensive with areas marked by the highest degree of agricultural prosperity.

The loess soils are represented by the surface materials covering the hills of yellow clay, on both sides of the river,

near Anamosa. They are illustrated on even a larger scale in the broken, rolling, hilly regions of Clay, Washington and Richland townships. Before the settlement of the county the drift plains were prairies supporting annually a wealth of grass. The yellow loess hills, on the contrary, were wooded, and supported groves of white oak, basswood and poplar. The loess washes easily, and the fields into which these wooded clay hills have been transformed are often deeply gashed and gullied by recent rains. The soil is poor and difficult of cultivation, and the farmsteads of loess regions are often sadly wanting in signs of comfort and prosperity.

Alluvial soils are found in the river valleys. The areas occupied by such soils have been described in connection with the subject of alluvium. Alluvial soils rank, in fertility and ease of cultivation, with those of the drift.

BUILDING STONES.

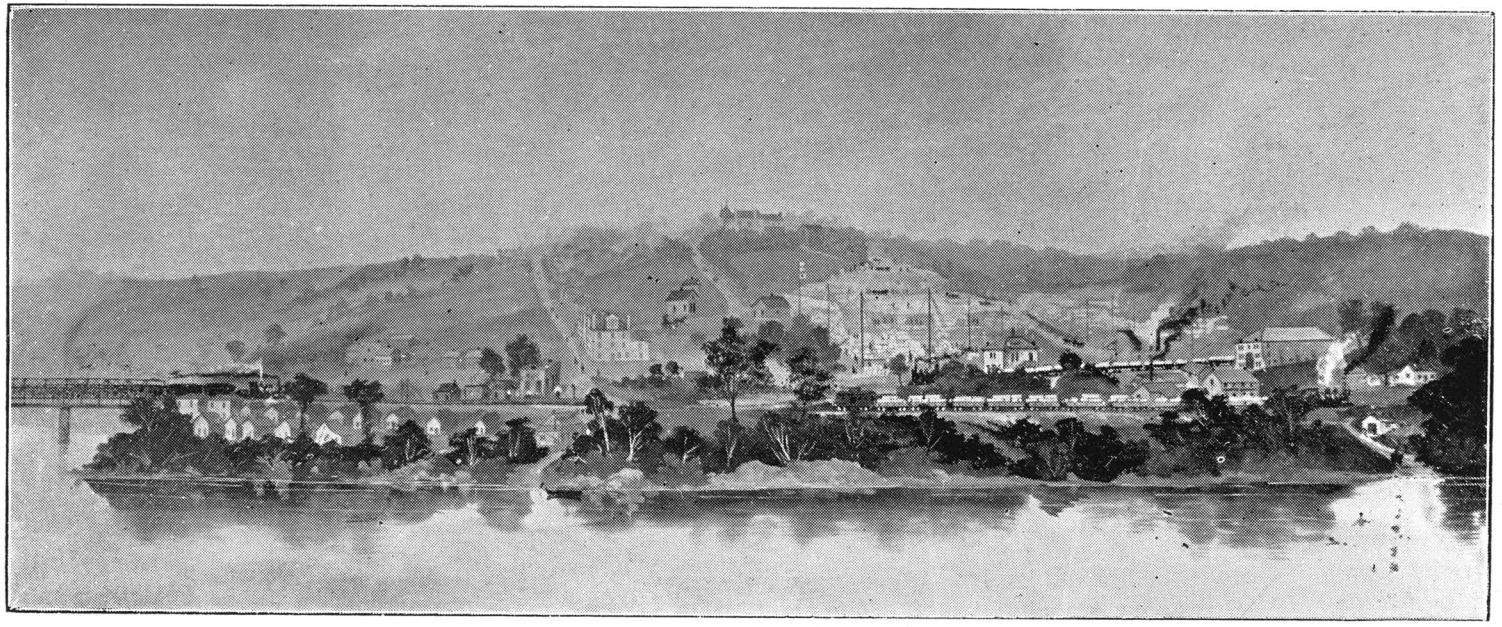
Each stage of the Niagara furnishes constructive materials that may be used in some grade of masonry; but the Anamosa stage and the evenly bedded horizon near the top of the Delaware, furnish the only building stones worthy of present consideration. The building stone beds of the Delaware stage afford some excellent material, particularly in the neighborhood of Clay Mills, Canton and Temple Hill. Near Clay Mills the ledges vary from three to fourteen inches in thickness. The stone is generally of good color, it is firm, compact, without laminæ, and, in the most trying situations, it resists admirably the action of the weather. All the exposures of the Delaware stage building stone are unfortunately located, so far as relates to facilities for transportation. Their only use for many years to come will be the furnishing of building material to supply local demands. Their distribution and stratigraphic position have been already noted.

The quarry industries of Jones county, so far as these are conducted on a scale of commercial importance, are all dependent on the evenly bedded, finely laminated strata of

the Anamosa stage. The most important quarries of this stage are located near the western border of the county, in Fairview and Cass townships. The several quarries in this important group were mentioned and some of their characteristics discussed in the discriptions of the typical exposures of the county.

The evenly bedded stone in the river bluffs west of Anamosa early attracted attention. The first extensive use of it was made by the United States army in constructing military roads while Iowa was yet a territory. Some of the old bridge piers built under the direction of the military engineers, are still standing and bear conclusive testimony to the durability of stone from this horizon. For some time the quarries were worked on a small scale and supplied only a local trade, but the market widened as the qualities of the stone became better known, and long wagon hauls were made in order to secure this material for use in structures of sufficient importance to justify such expensive methods of transportation. In 1852 stone was hauled from what is now Stone City to Mount Vernon for use in construction of one of the first buildings belonging to Cornell College.

Shipments by rail began from this locality in 1859, and since that time the stone industry of the region has steadily increased. From supplying a very restricted local trade, the business of quarrying and shipping stone has grown until it now reaches markets distributed throughout Iowa, Illinois, Wisconsin, Minnesota, South Dakota, Nebraska, Kansas and Missouri. Many of the most important structures in the several states named are built of Anamosa stone. It competes in Chicago and Minneapolis with the product of quarries more advantageously located, so far as distance is concerned. All the important railways of the northwest have used Anamosa stone in the construction of bridge piers. The stone has been used extensively in erecting the shops and other buildings at the Rock Island Arsenal. Iowa and Nebraska have both used it in building hospitals for the insane. It



ENVIRONS OF STONE CITY. VIEW FROM THE NORTH SIDE OF THE WAPSIPINICON, SHOWING SOUTH WALL OF THE CANYON-LIKE GORGE IN WHICH THE RIVER FLOWS.

meets the requirements of all grades of architectural work, from the humblest to the highest. As architects and engineers become better acquainted with its merits, the stone finds an ever widening market. From the limited shipments in 1859 the stone industry of this locality grew until in 1887 nearly 9,000 car loads were sent out. The total shipments from 1859 to November, 1895, amount to 156,229 cars, which, at the low average of twenty dollars per car, gives an aggregate value of $3,124,580. The future of the stone industry around Stone City depends wholly on the extent of the markets that can profitably be reached from this as a distributing center, and on the extent to which stone will be employed in building the homes and business palaces and new structures of every kind that give tangible expression to the increasing wealth and growing sense of architectural beauty throughout this great northwest. No possible demand can ever outrun the supply. The geological structure indicates beyond question the presence of inexhaustible stores of quarry stone easily accessible. So long, therefore, as stone is used in construction, the business of quarrying and shipping from Stone City is one of assured permanence.

GOLD HILL QUARRY.

Gold Hill quarry is situated within 600 feet of the west line of Jones county, in Fairview township (Sec. 6, Nw. qr., Sw. ¼). It belongs to F. S. Brown & Co., and is operated in conjunction with the Crescent quarry, which belongs to the same company, and is located west of the line in Linn county. During 1895 the Gold Hill property in Jones county was practically idle, the company finding it more convenient to fill orders for the particular grade of stone called for from its quarry in Linn county.

The quarry stone at Gold Hill is overlain by loess varying from a few feet up to fifteen feet in thickness. Beneath the loess is a thin layer of till which contains pebbles and small boulders of types characteristic of the Kansan drift sheet. The drift rests on ferruginous residual clay or geest, which

fills crevices and pockets in the upper weathered portions of the quarry stone, while associated with the geest are masses of grayish powder, sometimes several feet in thickness, representing an early stage of rock decay when only the cement which binds together the constituent grains has been removed by solution.

The equipment of the quarry includes a steam plant which is used chiefly as a pumping station to supply water under necessary pressure for the hydraulic apparatus used in stripping. There are also derricks, horse power hoists, steam channelers, and other devices for quarrying and handling stone. A large force of laborers and stone cutters is constantly employed. Since 1887, when the present company began operating, there has been shipped a total of about 12,000 cars. The largest shipments in any one year were 2,248 cars in 1890.

CHAMPION QUARRY NO. 1.

The Champion quarry, No. 1 (Fig. 6), is the property of Hon. J. A. Green. It is situated a few rods east of Gold Hill,

FIG. 6. View in Champion quarry, Stone City.

and presents essentially the same features as the quarries farther west. As already noted, the quarry beds of this region

are not definitely divided into layers. Throughout their whole thickness they constitute practically one layer very perfectly laminated and capable of being split along almost any one of the numerous lamination planes. The division into ledges is therefore more or less arbitrary. For the purpose of illustrating the manner in which these quarries are divided, the following section from Champion quarry No. 1 is given:

		FEET.	INCHES.
26.	Loess, varying in thickness, maximum	20	
25.	Fine sand associated with loess, the sub-loessial sand of Norton	2 to	6
24.	Drift and residual clay		1
23.	"Shelly stone," the partially decomposed beds of the upper, or white limestone, broken into thin flakes or chips	2 to	10
22.	"White stone" splitting readily into smooth surfaced slabs, used chiefly for riprap		16
21.	"Rotten layer," a soft vesicular ledge of poor quality which separates the gray from the white limestone		2 4
20.	Compact, fine-grained, ledge, good building stone		1 5
19.	Same as 20		1 5
18.	Ledge of good building stone		11
17.	Same as 18		11
16.	Upper bridge stone, coarse		2 6
15.	Inferior layer containing many small cavities lined with calcite		10
14.	Fine-grained building stone		1 1
13.	Ledge containing at base a thin layer of very fine-grained, compact limestone, which cracks into angular fragments under the action of frost (the bands of very fine-grained limestone differing from the ordinary granular dolomite are called "flint" by the quarrymen)		1 3
12.	Ledge with bands of "flint"		1 11
11.	Solid ledge of good building stone		1 4
10.	Compact ledge, best quality afforded by the quarry		1 2
9.	"Wavy ledge" good for ordinary masonry; the laminæ are more or less undulated	2½ to	3
8.	Good building ledge		11

		FEET.	INCHES.
7.	"Flint ledge," compact limestone, breaking into angular fragments on exposure to weather	½ to 1	4
6.	Flagging ledge, easily split	1	4
5.	Ledge containing cavities lined with crystals	1	
4.	Ledge of good building stone		11
3.	Lower flagging ledge	2	
2.	Lower bridge stone ledge, very durable, though occasionally containing cavities lined with crystals	2	4
1.	Ledge that may again be split into blocks convenient for building purposes	3	

Below the quarry stone there are here, as everywhere in this region, massive beds of the Le Claire limestone. The uppermost ledge of the Le Claire at the Champion quarry ranges from two and one-half to three feet in thickness, and was formerly quarried to a limited extent for use in heavy bridge piers.

The machinery employed in the Champion quarry includes a steam channeler, a number of horse power hoists, seven large derricks, circular rubbing beds for dressing stone, a Gates crusher, steam plant containing an eighty horse power engine, besides a pumping station containing pumps and hydraulic engine, used in stripping off the superficial clays and sands. The hydraulic process of stripping was first employed in this region at the Champion quarry. On account of the great saving effected, the expense of removing a given number of cubic yards of earth being less than one-fifth of what it was by the methods formerly employed, hydraulic stripping has been adopted by all the larger quarries.

The Champion No. 1 furnishes crushed stone, riprap, rubble, bridge stone, flagging and all grades of dimension stone. A large force of laborers, machinists and stone cutters finds constant employment; the number of employes on the pay-rolls at any one time has varied from 40 to 460. This quarry is located almost in the very center of the area which, in this locality is occupied by the evenly bedded, laminated stone of

the Anamosa stage. It was opened by Mr. Green in 1869. During the first year 150 car loads were shipped. In 1882 the business had grown to 4,801 cars. The total shipments since the quarry was opened aggregates 47,618 car loads. A number of switches or spurs of railway track lead into the quarry, making it possible to load the stone at the point at which it is quarried.

STONE CITY QUARRIES.

The Stone City quarries (Fig. 7) were opened by Mr. H. Dearborn in 1869. They are now owned and operated by H.

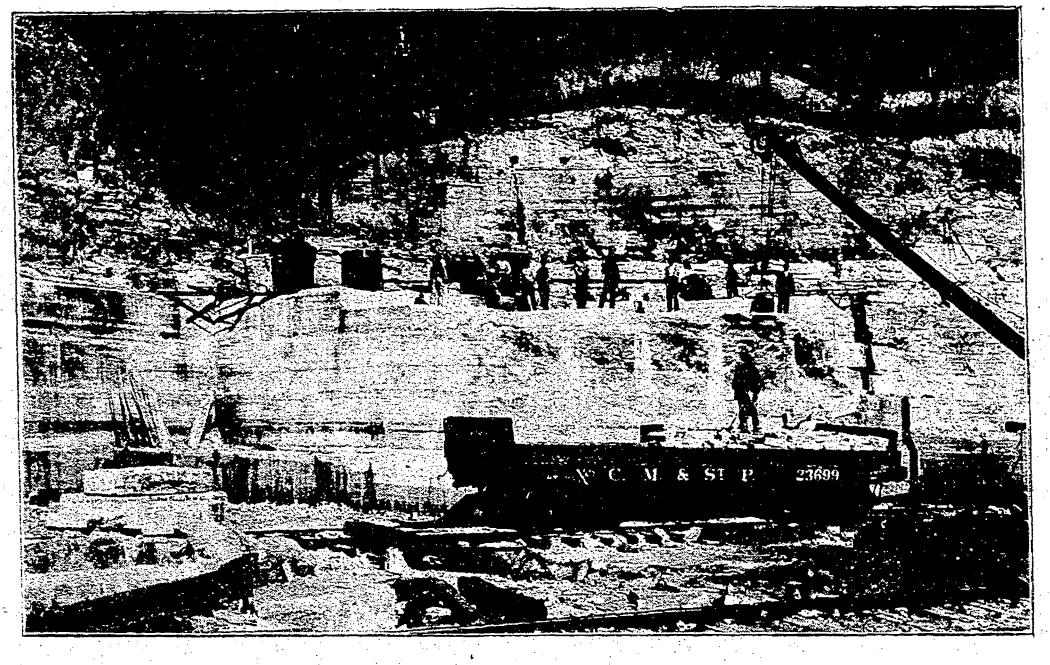


FIG. 7. View in Stone City quarry, Stone City.

Dearborn & Sons. They are located near the middle of the south half of the northeast quarter of section 6, Fairview township. The quarry face forms a long sweeping curve about a quarter of a mile in length and nearly parallel with the sweep of the Wapsipinicon river that here flows close to the foot of the bluffs in which the quarries were opened. The quality of the stone and the succession of ledges are essentially the same as at the quarries already described. Overlying the stone is a bed of loess, sand and drift, with an average thickness of five feet and a maximum thickness of fifteen

feet. Some six or eight feet of stone at the top of the quarry are to be counted with the refuse, the beds being broken into small angular pieces as a result of weathering prior to the deposition of the superficial drift and loess. These quarries expose the whole thickness of the "gray stone" or lower half of the Anamosa beds, above which are serviceable beds of the "white stone," or upper half, having a thickness of ten or fifteen feet. The beds are worked out down to heavy ledges of non-laminated Le Claire. The quarries are capable of furnishing dimension stone from three to thirty-three inches in thickness, and of any desired length and width. Four railway tracks, following the curve of the quarry face, afford facilities for handling cars. The equipment comprises channelers, derricks, steam and horse power hoists, and steam pumps for use in hydraulic stripping. The men employed include the usual grades of workmen, from the common laborer to the most skillful stone cutter, and the number has varied from 20 to 100. The number of car loads of stone shipped from the time the quarries were opened till November, 1895, amounts to 27,432. In one year, 1892, the shipment amounted to 2,765 car loads.

ANAMOSA QUARRY.

The Anamosa quarry was the first in this locality to ship stone abroad, the first shipments by rail being made in 1859. The quarry was opened by David Graham, but its present owner is Mr. J. Ronen, who has opreated it since 1881. The Anamosa quarry is located near the northwest corner of the southwest quarter, section 5, Fairview township. Mr. Ronen's quarry is indeed double, for there are two openings a short distance apart. At the first opening the amount of clay stripping is very small. Beneath the clay there are a few feet of non-laminated worthless rock belonging to the Bertram stage. Then in descending order there follow fragmentary beds of the "white limestone," "shell rock," then the usual succession of ledges down to the lower bridge layer, or No. 2 of the Champion quarry section. Owing to the eastward dip of the

beds at this locality, the lower bridge rock at the second Ronen quarry is too low to be worked, the lowest workable beds being about the level of the "flint ledge," or No. 7 of the section at the Champion. Since 1859 there has been shipped from the Anamosa quarry a total of 28,134 car loads, of which 20,484 cars were shipped by Mr. Ronen since he took possession of the property in 1881.

CHAMPION QUARRY NO. 2.

The Champion quarry No. 2 is now the property of Hon. J. A. Green. Its location is near the center of the southeast quarter of section 5, Fairview township. This quarry was opened by Crouse, Shaw & Weaver in 1866. In 1872 it was sold to the state of Iowa, from which date until 1884 it was worked by convicts from the penitentiary at Anamosa. Afterwards it was purchased by the present owner, who works it on a small scale in connection with the larger quarry, Champion No. 1. At this quarry there are about eight feet of clay to be removed. The Bertram beds have a thickness of from ten to fifteen feet. The full thickness of the "white rock" is exposed. It is somewhat fragmentary or "shelly" near the top, but the lower two-thirds is good. The "gray stone" is not fully exposed. The lower bridge rock lies here beneath the level of the river, and the quarrying is carried down only as far as the "flint ledge," No. 7 of the Champion quarry section. About 15,000 car loads, all told, have been shipped from this opening.

GEM QUARRY.

The Gem quarry is a small opening near the northeast corner of the northwest quarter of section 4, in Fairview Township. Work was begun here in the spring of 1894. The quarry is opened in the bluffs on the west side of the Buffalo creek. At the foot of the bluff runs a spur of the Northwestern railway, which affords the necessary shipping facilities. At this quarry very little stripping is necessary; only a thin layer of soil overlies the quarry stone. In the upper part of

the quarry the stone is soft, but near the base the quality is good, and it shows the usual characteristics of the Anamosa beds in this locality. There is very little machinery used except a derrick and horse power hoist, and only two or three men are employed. The land is owned by James Joslin, but the quarry is at present leased and operated by James Lawrence. About fifty cars have been shipped during the two years that the quarry has been in operation.

STATE QUARRY.

In 1884 the present State quarry, or Penitentiary quarry, was opened. Formerly the stone for the penitentiary buildings at Anamosa was obtained from what is now known as Champion quarry No. 2. In the year named the state bought property on Buffalo creek, in the southwest quarter of section 33, Cass township, and began operating the present quarry. The quarry is worked altogether by convict labor. Above the stone is a bed of loess and drift varying in thickness from a few inches to ten or twelve feet. Below the drift there are a few feet of decayed and broken "shell rock" belonging to the upper part of the "white stone" of the Anamosa stage. Lower in the quarry the ledges present the same features as in corresponding parts of other exposures. The exposure of Le Claire limestone at the east end of this quarry and the strong dip assumed by the beds in accommodating themselves to the uneven upper surface of the Le Claire have been already noticed. Most of the work at this quarry is done by hand. There are seven large derricks for handling the stone, but they are all operated by hand power. The stone is shipped over a spur of the Northwestern railway, which runs up the valley of the Buffalo and accommodates all the quarries in this part of the Anamosa stone basin. About 15,000 cars have been shipped since 1884.

JOHNELLEN QURRY.

The Johnellen quarry lies west of the State quarry, in the Sw. $\frac{1}{4}$ of the Sw. qr. of section 33, Cass township. It is owned

by Hon. J. A. Green, who began operations at this point in 1887. The stripping in this quarry consists of loess, drift, residual clays and decayed fragmentary rock, having an aggregate thickness of from ten to twenty feet. There is a great deal of ferruginous residual clay mixed with the fragmentary stone near the top of the exposure. The same clay has worked down into crevices almost or quite to the top of the "gray stone." The lower beds, or "gray stone," are here of very excellent quality, firm, compact, of pleasing neutral color, and capable of resisting the weather indefinitely. This quarry is not operated on a large scale. The present equipment and force are represented by three derricks, two horse power hoists and half a dozen men. The thickness of the serviceable quarry stone, which exceeds that of any other exposure in this region, the quality of the product, and the fact that the beds extend under several hundred acres belonging to the same owner, make it certain that in the near future the Johnellen will become one of the most extensive and important shipping quarries in this upper portion of the Mississippi valley. About 7,000 car loads of stone have already been shipped from this opening.

OTHER QUARRIES OF THE STONE CITY BASIN.

The quarries enumerated above are the only ones shipping stone by rail from the Stone City basin. There are, however, a number of exposures of Anamosa limestone in the bluffs of the small creek that flows through sections 7 and 8 of Fairview township, and some quarrying has been done on the lands of L. B. Parsons and R. M. Peet. The stone is hauled out by wagon and supplies the demand throughout a large and wealthy farming community between the Wapsipinicon river and Mount Vernon. Only the simplest processes are used in these quarries, and, while exact statistics are not at hand, the amount and value of the stone produced here is by no means inconsiderable.

ANDREW RUMMEL QUARRY.

Mr. Andrew Rummel owns and operates a quarry near Olin, in Rome township. (Tp. 83 N., R. III W., Sec. 24, Ne. qr., Se. ¼.) (Fig. 8.) The quarry is opened in the low bluff on the west side of the valley of Sibyl creek. The stone belongs to the Anamosa stage, and except that it is buff in color, it corresponds well with the "gray stone," or lower portion of the formation as seen near Stone City. There are no definite bedding planes, but the rock cleaves readily along any of the planes of lamination. The surface of the laminæ are not so smooth and true as they are at the corresponding horizon near

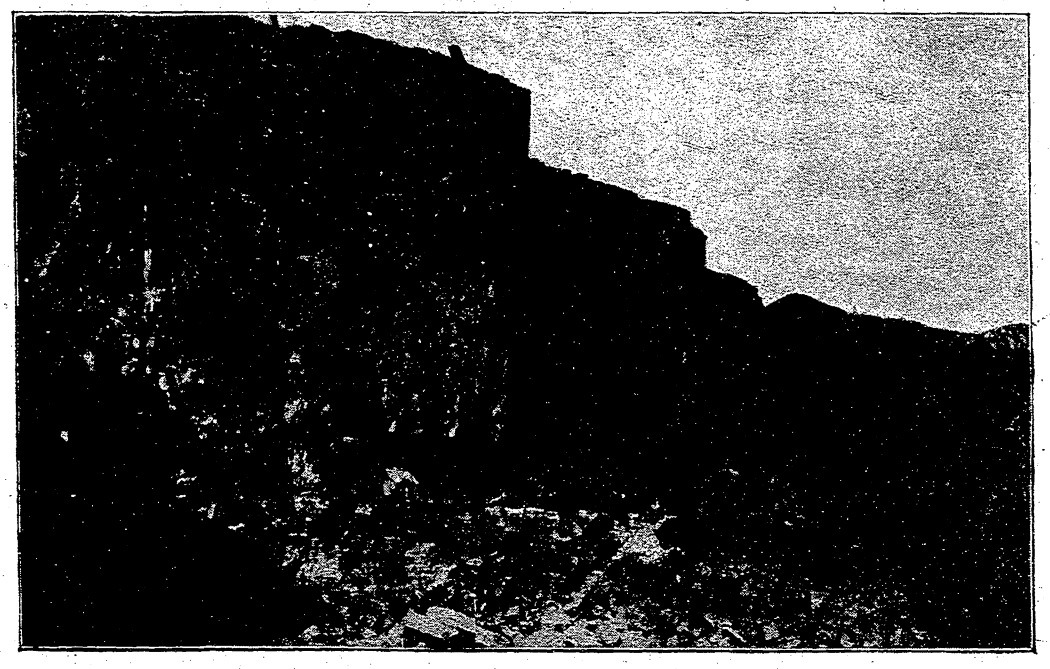


FIG. 8. View in Rummels' Quarry, near Olin.

Stone City, but are irregularly indurated, apparently as a result of wave action at the time the beds were forming. The strata dip southeast at an angle of 5°.

In quarrying, only the simplest tools are used. Drills, crowbars, wedges, picks, shovels and wheelbarrows make up the equipment, From two to four men are employed, and the annual output amounts to about 1,200 perch. Some stone is hauled to Olin and shipped abroad, but the market is largely local. Very little stripping is necessary. The soil or clay

overlying the stone is only a few inches in thickness. For two or three feet below the soil the beds are broken into chips or spalls by weathering. With better means for quarrying, the greater part of the exposure would furnish marketable stone. The present method of quarrying, however, involves the use of large quantities of powder in a single blast. Drill holes are made six inches in diameter and twelve feet deep. These are filled, or nearly filled, with powder, and the firing of such a blast loosens up great masses which are further separated and removed with pick, crowbar and sledges. The firing of these great blasts shatters the stone badly, rendering much of it worthless, and leaving even the best of it in condition suited for use in only the cheaper grades of masonry. Were the demand such as to justify the expense of putting in improved machinery, stone of high grade for many purposes might easily be obtained.

A. J. DOLBY QUARRY.

East of the Rummel quarry, in Hale township (Tp. 83 N., R. II W., Sec. 19, Nw. qr., Sw. $\frac{1}{4}$), there is a quarry on land belonging to Mr. A. J. Dolby. The beds at present worked in the Dolby quarry lie above those of the Rummel quarry and correspond to the upper half, "white stone," of the Anamosa stage at Stone City. The bedding planes are more obvious than in the Rummel quarry, and chert nodules characteristic of this upper horizon are very common along certain planes. The rock here comes almost to the surface, there being only an inch or two of soil. The usual effects of weathering are seen for a few feet below the upper limit of the strata. A derrick operated by hand power is used for hoisting, but there is no other machinery beyond the hand drills and other inexpensive tools used in ordinary quarrying. It is likely that, by working down to a lower level, a better quality of stone than now taken out would be obtained.

SHOPE QUARRIES.

There are two small quarries on the land of Mr. E. Shope, in the forty acres east of the Dolby quarry. One of these is

continuous with the Dolby quarry, the two quarries together having a combined front of 300 feet in length. The characteristics of the stone are the same as already described in connection with the quarries of this region.

CARTER QUARRY.

About a fourth of a mile north of the Dolby quarry, and in the same section, Mr. William Carter has taken out stone from beds of the Anamosa stage. This quarry has not been worked except on a small scale. With facilities for shipping, this, as well as all the other quarries of the region, is capable of furnishing unlimited amounts of high grade stone.

HALE QUARRY.

Near the center of section 11, Hale township, three-fourths of a mile east of the village of Hale, a quarry has been worked for some years in beds of the Anamosa stage. The north end of this quarry is owned by Murray Brothers, while the south end is on land belonging to Mr. E. Horton. The stone in the Hale quarry is finer than that in the quarries near Olin, but it resembles the Olin stone in the uneven, wave-marked surface of the several beds. The stone comes practically to the surface, there being only a few inches of soil overlying the upper beds. For about six feet at the top of the quarry the stone is much broken and disintegrated, as a result of weathering. Below the weathered portion the rock is solid and shows the characteristic lamination of this horizon. Partings between the beds are inconspicuous. The flexures of the beds and the dip in all directions (quaquaversal dip) forming a low dome near the north end of this quarry, have already been noticed. The quarry supplies local trade only.

JOHN CLAY QUARRY.

The John Clay quarry is located on the south side of the river, near Hale, a short distance east of the center of section 15. It has been worked on only a small scale to supply a limited demand. The quality of the stone is good, and were there better facilities for shipping, quarrying might be carried on

here on a scale that would be limited only by the conditions of the market. The quantity of excellent stone is unlimited.

BALLOU QUARRY.

The Ballou quarry lies east of Clay's, in section 14. The quality of stone is the same as is found generally in the Anamosa stage of this region. While there is an unlimited supply, the demand that can be met by the present conditions of transportation is small. This, like other quarries of the region, is operated intermittently.

OTHER QUARRIES IN THE ANAMOSA LIMESTONE.

East of Ballou quarry is a small opening that has furnished a considerable amount of stone. In sections 26 and 32 of Jackson township there are small quarries to which reference has been made in the description of the typical exposures, and the opening in section 10 of Oxford township has also already been noted.

LIME.

Lime is not made on a commercial scale anywhere in Jones county, although beds suitable for its manufacture occur abundantly in the Delaware and Le Claire stages. Lime was formerly made at points near Anamosa, Stone City, Olin, Clay Mills and Hale. There are Le Claire beds near the quarries on the Buffalo, and there are others near Anamosa and Stone City capable of furnishing material for manufacture into lime of the highest excellence. At the points named the facilities for shipping are good. There are many other equally good exposures of lime burning stone, but they are less favorably situated with reference to easy access to markets.

CLAYS.

The clays of Jones county which are available for use in the manufacture of economic products are loess and alluvium. Both occur in unlimited quantities. The clay products are at present limited to common structural brick and drain tile. Nearly all the brick made in the county are manufactured

from loess; for making drain tile the fine alluvial clays are used exclusively.

OLIN TILE & BRICK COMPANY.

The most important clay-working establishment in the county is that of the Olin Tile & Brick Co., located at Olin, in Rome township. The clay used is obtained from beds of alluvium in the low plain a short distance south of the works. It is blue in color, tough, tenacious, and gives best results when mixed with about one-fifth its bulk of sand. During 1894 the factory turned out about 40,000 brick and 400,000 drain tile. The plant consists of the necessary building to accommodate the machinery and workmen in producing and handling the output, steam-heated drying sheds, and three down draft kilns in which the product is burned. An H. Brewer & Co. No. 6 A machine is used in making both brick and tile. The sizes of drain tile range from three to ten inches inclusive. The markets are largely local, but shipments are made by rail, both east and west, for a distance of forty or fifty miles.

MONTICELLO TILE & PRESS BRICK COMPANY.

The Monticello Tile & Brick factory is owned by Mr. John Gibson. It has been operated for fourteen years. The product consists of drain tile and end-cut, steam re-pressed brick. The present annual output amounts to 300,000 brick and 250,000 tile. Formerly 800,000 brick were made annually. Seven sizes of tile are made, the smallest being 2½ and the largest 8 inches in diameter. The machinery used includes a thirty horse power steam plant, a Brewer & Tiffany tile machine with a capacity of 10,000 daily, and a Mackenzie brick machine of nearly equal capacity. The brick are dried in the open air and the tile in a steam heated drying shed. The drying shed has a capacity of 50,000 tile. It is two stories in height, a Jeffery elevator being used to lift the tile dried in the second story. Mr. Gibson has a very ingenious and convenient system of tracks and switches on which to

handle the cars that carry the product from the machine to the drying shed. The clay used in making brick is a stratified loess. or loess-like alluvium. The bed is ten or twelve feet in thickness. Its location is about twenty feet above the level of the Maquoketa river, at the edge of an old flood plain where the alluvium blends with the true loess. The clay is dug within a few yards of the machine that moulds it into brick.

The tile clay is a true alluvium, blue in color, and has to be hauled from the low plain bordering Kitty creek three-fourths of a mile away.

The clay for both brick and tile needs only to be tempered with water. Both burn to a deep red color. The tile are burned in a circular down draft kiln which has a capacity of 17,000 tile of the smallest diameter. A case kiln is used in burning the brick. The market is chiefly local, though shipments are made by rail to points within a radius of twenty-five to thirty miles.

ANAMOSA BRICK YARD.

Mr. B. F. Smith operates a brick yard at Anamosa. The product at present consists wholly of common, handmade brick. The common, yellow, loess clay is used, tempered with water in the ordinary pug mill. About 600,000 brick is the annual product, and these are all consumed in supplying the local demand.

OTHER CLAY-WORKING PLANTS.

Brick and tile works have been operated intermittently or only for a season or two at other points in the county. The raw material, especially for brick making, is so abundant and so generally distributed that there are few points where some clay product might not be made. A second factory for the manufacture of brick and tile was operated sometime ago at Monticello, but in recent years the works have been idle, and brick were formerly made at a yard, now unused, in Wyoming.

BUILDING SAND.

Bountiful supplies of building sand are found in the sand bars along the streams and in the beds of yellow sand and gravel that were deposited in connection with the yellow clays during the time of ice melting at the close of the Iowan period.

MOULDING SAND.

The sub-loessial sands at Stone City are finer and more argillaceous than usual, and underneath the yellow clay there are from four to six feet of material that has been tested and found to serve excellently as moulding sand.

ROAD MATERIALS.

Outcrops of Niagara limestone are so numerous that few localities are far removed from unlimited supplies of material that may be converted into road metal or macadam. The yellow sands and gravels already mentioned furnish the best of material for the improvement of clay roads, and all sandy stretches of road need only a thin layer of the widely distributed loess clay to render them passable at all seasons of the year.

LEAD.

More or less energy and capital have been expended in Jones county in prospecting for lead ore. The Niagara limestone, which is spread over the entire county, is dolomitic, and the Iowa dolomites are all lead-bearing to a certain extent. The Niagara limestone, therefore, contains some galena or lead sulphide, but there is no evidence to justify the hope that lead ore, in paying quantities, will ever be found in this formation. The ore bodies are all small, aggregating a few hundred pounds at most, and while interesting from a scientific point of view, possess no economic value. Some years ago Mr. James Brown took out 6,000 pounds of ore from a crevice on section 13 of Fairview township, and in the spring of 1895 Mr. W. D. Sheehan obtained 5,000 pounds in section 19 of Jackson township. These bodies of ore are of very

unusual size for this formation, and would probably not be duplicated by the most persistent search in many years to come.

WATER SUPPLY.

The streams of the county furnish a plentiful supply of water in the regions through which they flow. The surface wells that furnished water so abundantly some years ago have very generally failed, and farmers and others have found it necessary to sink wells to water-bearing strata at considerable depth from the surface. The well at Mr. Gibson's tile and brick factory is only 46 feet deep, but the supply seems to be unlimited. The well is bored about 26 feet in Niagara limestone. Near the center of Greenfield township it is found necessary to bore 12 to 15 feet into the rock and the wells are from 75 to 150 feet in depth. Near Center Junction water is found in beds of sand and gravel interbedded with blue clay of the Kansan till, at a depth of from 80 to 100 feet. The deep well at Monticello penetrated to the Saint Croix sandstone at a depth of 1,198 feet.

The permanent water-bearing horizons of which the wells of the county furnish evidence are (1) the Saint Croix sandstone, which may be reached anywhere in the county at a depth of from 1,200 to 1,500 feet, (2) the plane of contact between deep beds of till and the underlying indurated rocks, (3) beds of sand and gravel at some depth from the surface in the blue clay of the Kansan drift. The deep well at Monticello gets its supply from the first named source, the wells near the center of Greenfield as well as many others throughout the county draw from the second, and in the region of very deep drift near Center Junction there are examples of wells deriving their supply from the third source.

WATER POWERS.

The streams of Jones county furnish abundant water power, but these sources of energy have not yet been utilized as they doubtless will be in the future. The saw mills and grist

mills that were important factors during the period of settlement have largely fallen into disuse. On the Wapsipinicon river there are mills at Anamosa, Newport and Oxford Mills. On the Maquoketa the chief water powers are at Monticello and in section 3 of Scotch Grove township. Walnut creek once furnished power to a mill at Olin. At Clay Mills there was a water power on Farmers creek, and the same stream supplied the power for a small saw mill northeast of Temple Hill, in section 28 of Washington township. These smaller streams, however, have recently been dry during the greater part of the year and the mills operated at all have had to resort to steam power.

The water powers at Anamosa and Monticello are now used chiefly in producing electric energy, and it is in this direction that in the future the permanent water powers will all find profitable employment.

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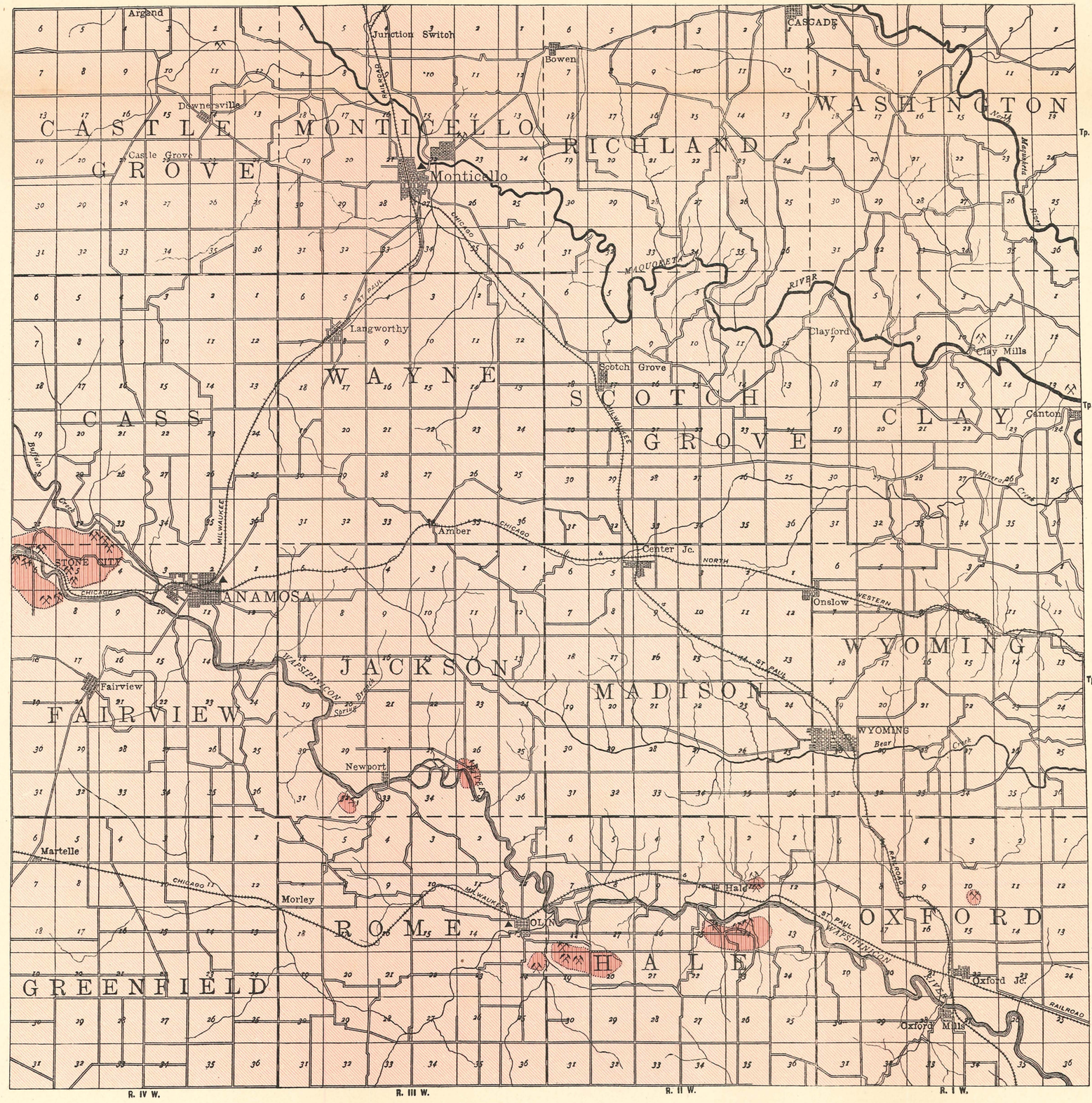

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF JONES COUNTY, IOWA.

BY

SAMUEL CALVIN

1896.

LEGEND

GEOLOGICAL FORMATIONS

ANAMOSA AND BERTRAM

DELAWARE AND LE CLAIRE

INDUSTRIES

QUARRIES

CLAY WORKS

IOWA PRINTING CO DES MOINES, IA.

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