GEOLOGY OF MITCHELL COUNTY.

BY

SAMUEL CALVIN.

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INTRODUCTION.

GEOLOGICAL, TOPOGRAPHICAL AND GEOGRAPHICAL RELATIONS AREA.

Mitchell county is bounded by areas on which geological reports have already been made. The geology of Howard is published in the present volume, that on Worth county appeared in volume X, and in volume VII the geology of Cerro Gordo county is discussed. From what is known of the geological structure of the counties adjoining Mitchell on the east and west, it might readily be inferred that, so far as relates to the stratigraphy of the indurated rocks, our territory lies wholly within the area occupied by formations belonging to the Devonian; and in its relations to the mantle of loose, soil-making materials, it is included in the area of the Iowan drift. Mitchell county is not traversed by the margin of any important geological formation, though in the drift series there are some interesting and significant islands of loess-covered Kansan which merge with rather indefinite limitations into the Iowan plain. These islands are parts of a series of small, loess-covered patches—surrounded by Iowan drift and separated by many miles of intervening Iowan plain from typical regions of loess—which are known to occur along the valley of the Cedar river from Mitchell county to beyond Cedar Rapids in Linn.

The region to be discussed in the present chapter is related in an interesting way to one of the larger topographic features of

the state, which affects a number of the adjacent counties. It is possible that this topography may have had something to do with the genesis of the anomalous loess islands noted above. In the report on Chickasaw county reference is made to the fact, pointed out by McGee in 1891, that the water courses of a part of northeastern Iowa, instead of following the general inclination of the surface, take a direction nearly at right angles to the predominant slope. Between the high divide on which Bonair, Cresco, Ridgeway and Calmar are located, and the Cedar river, the inclination of the surface is greatest toward the southwest, and yet all the streams of the intervening area are flowing toward the southeast. Osage, located on the Iowan plain ninety feet above the level of the Cedar river, is about 140 feet lower than Cresco. A line drawn between the two points would cross the drainage courses nearly at right angles. Along a line practically parallel to that just mentioned we get the following altitudes: Calmar 1263, New Hampton 1169, Charles City 1024. Farther south a similar line gives: Donnan 1151, Sumner 1060, Waverly 948. A nearly parallel line still farther south shows the following significant series of altitudes: Arlington 1113, Oelwein 1049, Fairbank 1000, Dunkerton 945, Dewar 889, Waterloo 841. The unusual behavior of the streams northeast of the Cedar is more strikingly illustrated when other facts are taken into consideration. For example, Devon in Chickasaw county, on the summit of a high divide, has an altitude of 1194 feet. A line drawn from Devon to Oelwein is approximately parallel to the drainage courses, the distance is thirty-nine miles, and the difference in elevation between the two points is 145 feet. In the direction of the drainage the surface has an average slope per mile of less than four feet. On the other hand, from Oelwein to Waterloo, along a line at right angles to the courses of the streams, the distance is twenty-six miles, the difference in elevation is 208 feet, the average gradient in this direction is eight feet to the mile. Riceville and Independence are both located on the Wapsipinicon river, they are about seventy miles apart, the difference in elevation between the two is 308 feet, the average gradient per mile in a straight line is less than four and a half feet. A line from Calmar to Charles City does not lie quite in the direction of the greatest

slope, and yet the average fall per mile from one point to the other is more than six feet. Investigations sufficiently comprehensive to cover the entire area under discussion show that the streams are not following courses coincident with the greatest inclination of the surface.

That the Cedar river occupies the bottom of a broad trough extending from Winneshiek county on the east to Kossuth county on the west, will be apparent if, in connection with the facts already given, the following series of altitudes from Charles City westward be taken into consideration: Charles City 1024, Nora Springs 1064, Mason City 1132, Clear Lake 1241, Garner 1223, Britt 1235, Wesley 1258, Algona 1194. The one break in the gradual rise from Charles City to Wesley is due to the fact that Clear Lake is located in the irregular ridge which constitutes the marginal moraine of the Wisconsin drift lobe. Algona is located in the valley of the Des Moines river, the next important stream west of the Cedar; its elevation, however, is 170 feet greater than that of Charles City. West of the Cedar the southeastward flowing streams follow the direction of the general slope of the surface. Mitchell county lies in the bottom of this great Cedar river depression, and to this fact it probably owes some of its most striking geological characteristics.

In making inquiry concerning the cause of the peculiar behavior of the streams between the Cedar river and the Cresco-Calmar ridge, certain facts are worthy of consideration. During late Tertiary time Iowa stood low with reference to sea level; it was reduced to a peneplain, and the sluggish streams flowed in shallow channels upon a nearly level surface. It may be conceived, however, that the direction of the drainage courses was a consequence of original slopes. About the beginning of the Pleistocene, but before the advent of the first invading glaciers, the whole country was elevated. This was particularly true of northeastern Iowa, which was lifted through 600 or 700 feet. The movement, however, was not uniform, but was greatest near the Mississippi river, and least along the line where now flows the Cedar. In this way the old peneplain was tilted toward the southwest. The upward movement was slow. As it progressed the streams were quickened and energized, and corrasion kept

pace with the uplift. Among other lines of evidence the deeply intrenched meanders of the Upper Iowa, or Oneota river, in the western part of Allamakee county, attest the fact that the region is an elevated peneplain. During the slow process of elevation all the streams held to their original courses and deepened their channels without being diverted from them, notwithstanding the great change which took place in part of the area in the direction of the predominant slope.

It is true that the rock-cut channels of the anomalous streams discussed above, excavated as they were before the earliest ice invasion of the region, were choked with glacial detritus; and it is also true that the modern streams of this peculiar region flow in broad sags and shallow trenches in the surface of the drift. But after the withdrawal of each of the successive ice sheets which affected northeastern Iowa, the preglacial valleys still expressed themselves in depressions in the mantle of drift, sufficiently pronounced to determine the course of the subsequent streams. The great trains of Buchanan gravels, described in the reports on Howard and Chickasaw counties as occurring in all the valleys of this part of the state, show that the present water courses have been the principal lines of drainage at least since the time of the melting of the Kansan ice. Each valley was in fact a trough before even the Kansan drift was deposited. The courses of the post-glacial streams seem to have been determined by preglacial erosion.

In its geographical relations Mitchell belongs to the northern tier of counties in Iowa. Its northern boundary is the north line of the state. It has Howard county on the east, Floyd on the south, and Worth and Cerro Gordo on the west. It is traversed by the axis of the great Cedar river trough, a geographic and topographic feature of more than usual importance. Townships belonging to the four ranges, 15, 16, 17 and 18 west of the fifth principal meridian, are embraced between its eastern and western boundaries. From south to north, within the limits of the ranges named, the county includes the north half of township 97, and all of townships 98, 99 and 100. Township 100 is less than five miles in length from north to south; sections 1 to 6 are absent, and sections 7 to 12 are fractional. From the number of sections in-

cluded in the county the theoretical area would be 480 square miles, but owing to the fact that all the townships fall below the standard dimensions both in length and width, the actual area is less than the theoretical.

PREVIOUS GEOLOGICAL WORK.

Compared with other prairie counties in northeastern Iowa the number of rock exposures in Mitchell is unusually great, and in point of interest many of these exposures are rarely excelled in any part of the state. Notwithstanding all this, Mitchell county has heretofore been practically neglected by official geologists. The pioneer investigations of Owen, conducted in the valleys of the Cedar river and its tributaries, on the limestones and shales making up the geological unit which he calls the *"Formation of Cedar and Part of Lower Iowa River, Belonging to the Devonian Period,"* were evidently not extended as far north as the county we are considering. In the *Geological Survey of Wisconsin, Iowa and Minnesota*, page 80, speaking of the range, extent and bearings of the deposit under discussion, he says: "The formation ranges, with a northwesterly curve, up the valley of the Cedar river; forming a belt, averaging, at first, some twelve or fifteen miles only in width, but gradually enlarging, until, when in latitude 43°, it disappears under the drift of Northern Iowa, it attains a width of from thirty to thirty-five miles." The parallel of 43° passes through the southern part of Floyd county, four or five miles south of Charles City, and Owen seems to have taken it for granted that there are no natural outcrops of Devonian limestones north of that line. A personal examination of the region would have shown the conclusion to be not well founded.

Whitney, in Hall's Geology of Iowa, volume I, part I, makes brief reference to the drainage of Mitchell county on page 306, and on page 311 there are detailed sections of beds exposed near the old town of Newburg, not far from St. Ansgar. White's report on the Geology of Iowa, published in 1870, makes no reference to the county under discussion.

The topography of Mitchell county, its isolated loess deposits and its Iowan bowlders, are discussed with some fullness by McGee in his *Pleistocene History of Northeastern Iowa*, and in

the same memoir the detailed sections of an interesting series of wells in this county, are given on pages 515 and 516.

PHYSIOGRAPHY.

TOPOGRAPHY.

In general the surface of Mitchell county is a gently undulating plain, such as everywhere characterizes typical areas of the Iowan drift. In this county there are only a few streams of sufficient importance to produce any marked effect upon the topography, but the few there are flow in valleys of unusual depth when compared with other streams traversing the Iowan plain. Accordingly the characteristic features of the drift plain are found in broad, unbroken belts between the principal water courses. A typical bit of Iowan topography occurs northeast of the Wapsipinicon river; another belt, five to eight miles in width and ex-

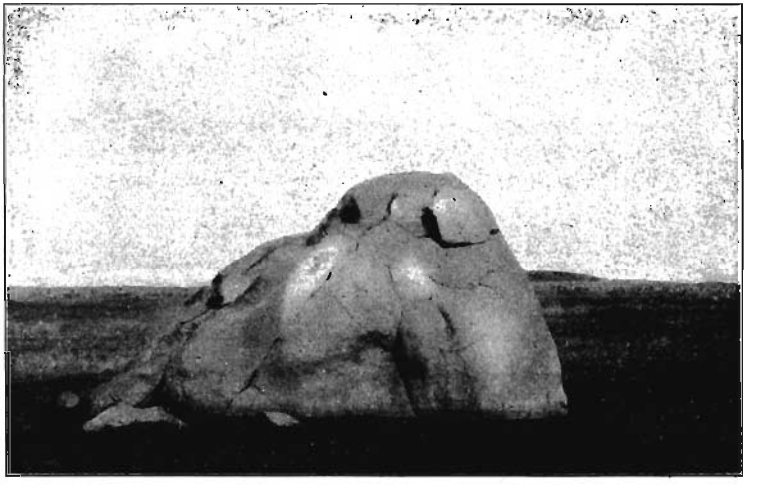

FIG. 42. An Iowan bowlder two and a half miles northeast of O age. This, the largest bowlder seen in Mitchell county, is surrounded by a typical phase of the Iowan drift plain. The level, unbroken surface extends to the horizon.

tending the whole length of the county, lies between the Wapsipinicon and the Little Cedar river; the most extensive belt of characteristic and unbroken Iowan is that which occupies the

area between the Little Cedar and the Cedar, while west of the Cedar there is a very typical portion of the Iowan drift plain, broken into subordinate parts by Rock creek and Deer creek. In the central portions of the Iowan belts, or anywhere outside the immediate influence of the deep stream valleys, there are areas, extending in all directions to the horizon, which are seemingly as level as a floor. (Fig. 42). Along the streams, however, there are narrow belts where the drift is thin, where large bowlders of Iowan types show that the Iowa ice did once occupy the surface, but where the amount of detritus left by the latest ice invasion was insufficient to develop the representative topography of the ideal Iowan plain. In such regions the surface is usually strongly

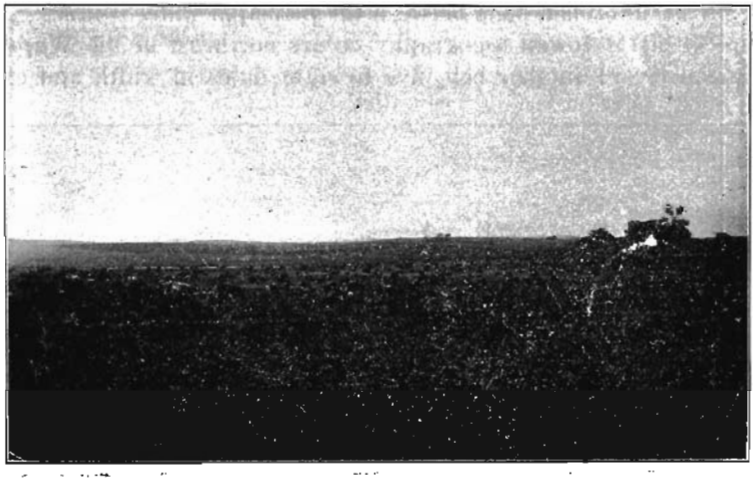

FIG. 43. Undulating surface in areas of thin Iowan drift near the streams. The view was taken in section 4, township 97, range 17.

undulating as shown in figure 43. A concrete illustration of an area of thin drift, with undulating surface and protruding knobs of rock, may be found northwest of Mitchell, in sections 1 and 12, township 98, range 18. A very marked example of a region of thin Iowan, through which the pre-Iowan erosional topography still expresses itself, is seen in sections 22, 23, 26 and 27, Newburg township, a short distance west of St. Ansgar. The same type of topography is illustrated over and over again on both

sides of the Cedar river, from one end of the county to the other. Similar areas occur along the Little Cedar and, to a less extent, along the Wapsipinicon.

Probably the most surprising feature of the topography of Mitchell county is the great depth of the trenches in which the principal rivers flow. The valley of the Cedar, especially, departs widely from the type of valley usually seen in regions of Iowan drift. There are really two types of Iowan valleys. One is illustrated by the course of the Wapsipinicon and its several branches, as well as by Crane creek and some other streams, in Howard and Chickasaw counties. Here the streams follow broad, shallow sags in the surface, due to the fact that preglacial trenches were only partly filled with glacial detritus. The old valley which Crane creek still follows at Lawler in Chickasaw county, is filled with drift to a depth of 135 feet, and yet the stream flows in a broad sag which was determined by preglacial rock erosion. The other type of Iowan valley is illustrated in the narrow, shallow trench which accommodates the Shell Rock river in Worth and Cerro Gordo counties. This simple trench, which is illustrated in figure 12, page 128, volume VII of the reports of the Iowa Geological

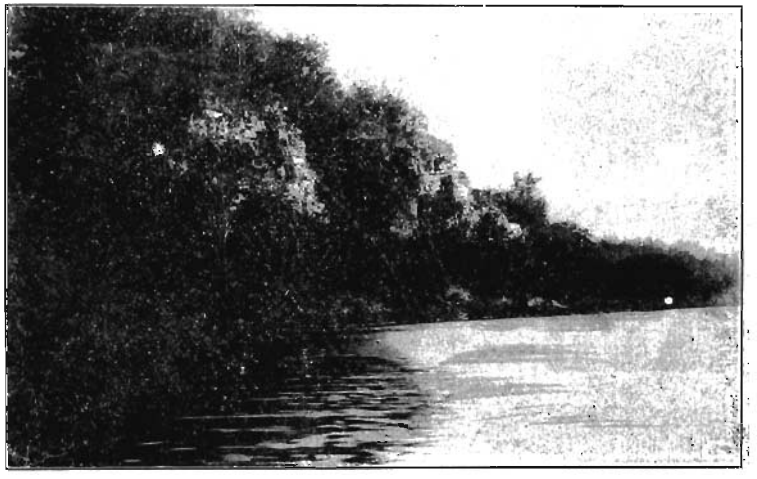

FIG. 44. Precipitous rocky cliffs along the valley of the Cedar river, showing preglacial characteristics. View north of the southeast corner of section 21, township 98, range 17, two miles west of Osage.

Survey, seems to be due wholly to post-Iowan erosion. The same type of stream valley is shown in figure 45 in this report. The valley of the Cedar river in Mitchell county is unlike either of these types. Its depth and width are due largely to preglacial erosion, and the preglacial characteristics persist. There has been no permanent filling of the valley with drift. In type, this water way is allied to the water ways of the Driftless Area. There are the original precipitous rocky cliffs (Figs. 44, 49 and 51) rising vertically from sixty to eighty feet, and the total depth below the level of the upland plain ranges from ninety to 120 feet. The sides of the Cedar river valley are cut by deep erosion trenches, recalling the topography of the Driftless Area, or areas of thin Kansan drift; and the tributaries, few and insignificant though they are, enter the main stream through rock cut troughs or gorges. The valley of the Little Cedar resembles that of the Cedar in a small way. The valley of the Wapsipinicon conforms more closely to the Iowan type. In sections 8, 16 and 17, township 97, range 17, Rock creek flows in a channel with precipitous limestone walls, while in section 12 of the next township west, it is flowing on the surface of the Iowan drift at about the level of

FIG. 45. Rock creek in the southwest quarter of the northeast quarter of section 12, township 97, range 18, showing the usual type of stream in the Iowan drift; the water flows in a shallow trench only a few feet below the level of the cultivated fields.

the cultivated fields (Fig. 45). Near its mouth the channel of Rock creek is preglacial; out on the plain beyond the influence of the deep valley of the Cedar river, the channel has all the characteristics of a young, post-Iowan stream.

Preglacial characteristics are best developed in that part of the Cedar river valley lying between section 1, township 98, range 18, northwest of Mitchell, and section 1, township 97, range 17, south of Osage. Here the valley is deeper, the cliffs of limestone higher, and the mantle of loose soil materials covering the underlying Devonian rocks thinner than anywhere else. Here, too, adjacent to the valley, are a number of high points and plateaus rising more or less conspicuously above the level of the Iowan plain. As in the case of similar highlands near the Iowan border, these prominent areas are free from Iowan drift and covered with loess. On the outer margins of these areas the loess blends without very definite borders into the Iowan plain; on the inner side the loess descends almost or quite to the level of the river. One of the larger loess-covered areas occurs between Osage and the river, being best developed southwest of the city, in sections 26, 27, 34 and 35, township 98, range 17. This area is large enough to afford a typical illustration of loess-Kansan topogra-

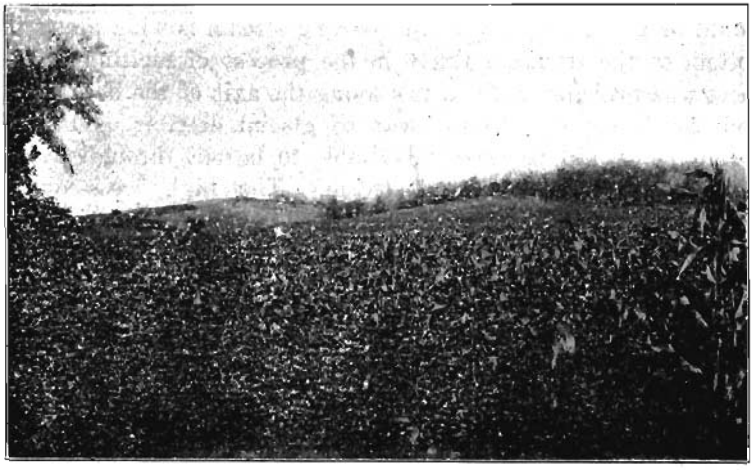

FIG. 46. Loess-Kansan topography in the southern part of the Osage-Mitchell loess island, in the northeast quarter of section 35, township 98, range 17.

phy (Fig. 46), such as occurs anywhere immediately outside of the Iowan margin. Another loess area characterized by the usual loess-Kansan, erosional topography, occurs on the west side of the river, west and northwest of Mitchell.

Why these loess islands and these unique preglacial features of a river valley, so strangely out of place in the midst of an Iowan plain? It may not be possible to give a satisfactory answer to these questions. It will be remembered, however, that the Cedar river occupies the bottom of a broad trough which affects the surface on a large scale. This great depression is nearly 250 feet in depth; it has Calmar in Winneshiek county on one margin and Wesley in Kossuth county on the other. The geographical position of the phenomena demanding explanation would suggest some possible causal relation between them and events taking place along the bottom of the Cedar river depression during the successive glacial invasions of northeastern Iowa. It is conceivable that the surface of the glaciers, particularly of the thin Iowan glaciers, dipped from both directions toward the bottom of this trough, much as the general land surface does today, but without the corrugations which determine the courses of the modern streams on the sides of the great depression. Under certain conditions of ice melting the waters resulting from surface ablation would be gathered together in a strong stream flowing along the bottom of the trough. Early in the process of melting the ice sheet was probably split in two along the axis of the depression, and the valley was swept clean of glacial detritus. The thin Iowan ice would be especially liable to be cut through by the action of the vigorous axial stream. The high loess-covered knobs and plateaus may never have been overflowed by the Iowan glaciers; in fact the more prominent of these certainly show no traces of Iowan drift. They received their mantle of loess in the same way that other extra-marginal areas were loess-covered at the time of culmination of the Iowan stage.

DRAINAGE.

Mitchell county is drained by three principal streams, the Cedar, the Little Cedar and the Wapsipinicon. Each of these rivers is almost entirely devoid of permanent tributaries so far

as this county is concerned. The larger water courses are bordered by broad belts of prairie land, the surface of which is drained by the flow of storm waters along shallow depressions that scarcely break the level monotony of the Iowan plain. Rock creek and Deer creek, west of the Cedar river, are the most important of the minor streams. A few sections are drained by Spring creek, which joins the Cedar from the northeast, near the south line of the county.

Altitudes.—The following short table from Gannett's Dictionary of Altitudes, showing the relation of a few of the more important points in the county to sea level, is not without significance. The first four places are located near the axis of the Cedar river trough, but are up on the Iowan plain, not in the river valley. Carpenter, on the level plain west of the Cedar, may be compared as to altitude with St. Ansgar; but more significant is the comparison which may be made of Riceville in the Wapsipinicon valley with Osage on the upland plain, ninety feet above the Cedar river.

	FEET.
Otranto	1,178
St. Ansgar	1,175
Osage	1,163
Orchard	1,090
Carpenter	1,198
Riceville	1,229

Between Otranto and Orchard, parallel to the axis of the valley, the fall is 4.5 feet to the mile; between Riceville and Osage, at right angles to the drainage, the average fall per mile is 4.7 feet.

STRATIGRAPHY.

General Discussion.

Mitchell county offers no great variety of geological formations. Only two systems are represented, the Devonian and the Pleistocene. In the Devonian but a single stage is recognized, the Cedar Valley stage of the Middle Devonian. There are natural exposures of two stages of the Pleistocene, the Kansan and the Iowan. In some well sections there are indications of the pre-

Kansan drift. Devonian limestones come to the surface along all the principal streams. In the Cedar river valley there are exposures at intervals from Orchard to Otranto. There are outcrops of Devonian near McIntire in the eastern part of the county and near Carpenter in the west. In the central part stone is quarried at numerous points near Brownville, Little Cedar and Staceyville. Notwithstanding the great number and wide distribution of the rock exposures, the aggregate thickness of the Devonian strata seen in the county does not exceed ninety feet. There are a number of vertical cliffs within a few miles of Osage —in sections 21, 27, 28 and 34, township 98, range 17—which individually show practically the whole succession of the Devonian beds seen in the entire county.

The larger stream valleys of the county are about parallel to the strike of the strata, and northeast of the Cedar river the slope of the surface conforms very closely to the general southerly and southwesterly dip. The same beds which are quarried at Orchard

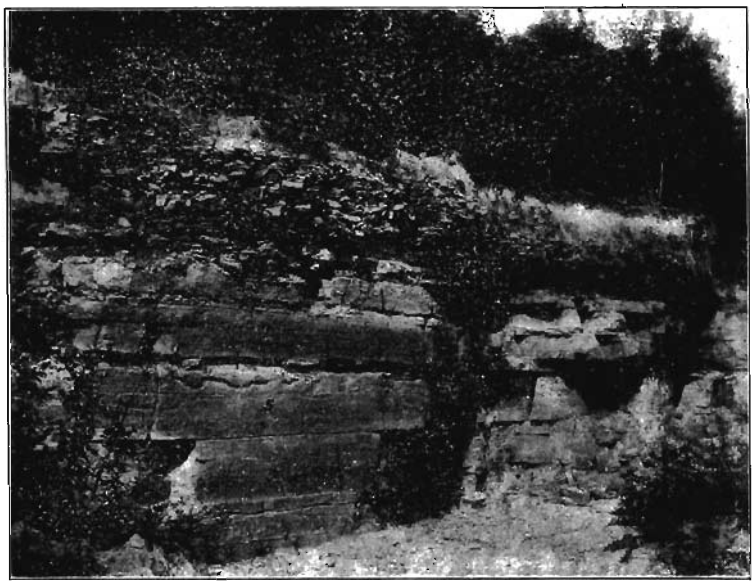

FIG. 47. The Lewis lime quarry, in the southeast quarter of section 27, Osage township, one and one-half miles southwest of Osage.

are quarried near St. Ansgar; the quarrystone beds at McIntire are the same as those burned for lime southwest of Osage. Each exposure examined throughout the whole county proves to be in some measure, a repetition of every other. One striking feature of the geology of Mitchell county is the extraordinary development of the fine-grained, whitish, lithographic beds which mark a very definite and easily recognized horizon in Howard, Chickasaw, Cerro Gordo and other counties as far south as Johnson. Here the lithographic zone is much thicker than usual, the bedding is more regular (Figs. 47 and 48), and the texture of the

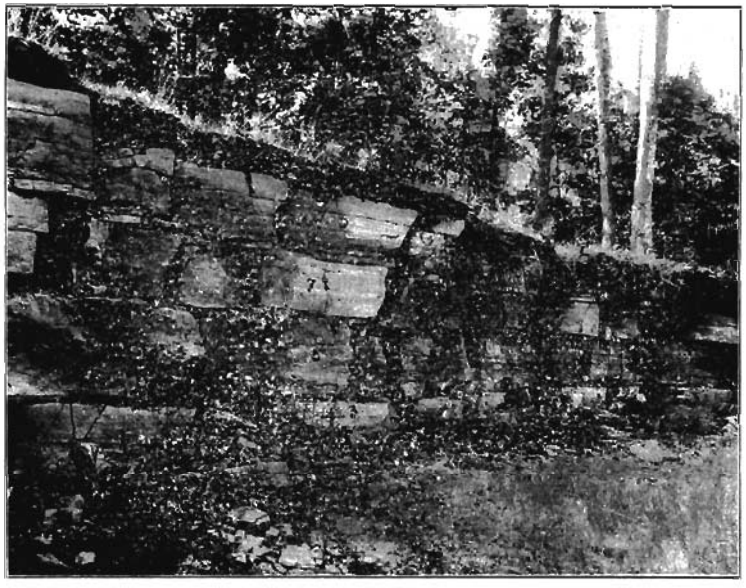

FIG 48. Lithographic beds in the Gable quarry in the northwest quarter of the southeast quarter of section 27, township 98, range 17.

stone is very much finer. The lithographic horizon is the highest represented in the county. The beds resist solution and weathering remarkably well, and they crop out in nearly all parts of the county on hill slopes, or even on level plains wherever the drift is thin. All the strata belonging to the horizon of the Salisbury quarry and other quarries about Vernon Springs and Cresco in

Howard county, are absent from Mitchell, or are represented only by beds of waste overlying the lithographic zone.

SYNOPTICAL TABLE.

The following table shows the taxonomic relations of the geological formations of Mitchell county:

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Cenozoic.	Pleistocene.	Glacial.	Iowan.	Loess.
				Iowan till.
			Kansan.	Buchanan gravel
				Kansan till.
Paleozoic.	Devonian.	Middle Devonian	Cedar Valley.	

Devonian System.

TYPICAL SECTIONS.

The Lewis Lime Quarry.—In the southeast ¼ of section 27 and the northeast ¼ of section 34, Osage township, there are many quarries and natural outcrops which together afford a very complete section of the upper part of the Devonian as it is developed in Mitchell county. A large quarry (Fig. 47) on the land of J. H. Brush, operated by George Lewis in the production of building stone and the manufacture of lime, gives the following standard section of the lithographic zone:

		FEET	IN.
10.	Dark brown residual clays with some granular, calcareous, residual material resembling fine sand, and many weathered chips of limestone	4	
9.	Firm, whitish, fine-grained ledge of concretionary lithographic limestone containing a number of obscure stromatoporoids		10
8.	Parting of shaly, fossiliferous limestone; fossils mostly in the form of comminuted brachiopod shells, among which some small Spirifers and Cyrtinas are recognizable		3

		FEET.	IN.
7.	Hard, fine-grained lithograpic limestone with lamination planes well defined in some places, less perfectly defined in others, and with a tendency to split up into individual layers of varying degrees of thickness	1	2
6.	Marly shale		3
5.	Heavy ledge of fine-grained lithographic stone dividing into two parts, the upper ten, the lower seventeen inches in thickness. The lower five inches is very fine and homogenous in texture and tends in places to separate as a distinct layer	2	3
4.	Thin shaly parting		1
3.	Ledge of fine-textured lithographic stone in three parts, eight, seventeen and a half, and three and a half inches respectively	2	4
2.	Shaly parting		1
1.	Coarser and less perfect lithographic stone in two parts eleven and nine inches thick	1	8

Beds 3, 5, 7 and 9 are fine-grained and light colored, break with conchoidal fracture, and would all be classed as lithographic limestone. It is the upper eight inches of No. 3 and the lower five or six inches of No. 5 that are fine enough and homogeneous enough to give promise of possessing commercial value as serviceable lithographic stone. All the beds are checked and jointed on an extensive scale, and this renders it difficult to obtain blocks of usable size for lithographic purposes. A few yards southeast of the quarry described, the beds lying below No. 1 are exposed so as to afford the following general section in which minor details are omitted:

		FEET.	IN.
6.	Impure dolomitic limestone varying in texture, layers ranging in thickness from two to fourteen inches	8	
5.	Heavy lithographic ledge, light gray in color, with fine texture, includes great numbers of minute, rhomboidal crystals of calcite	2	2
4.	Calcareous shale		6
3.	Argillaceous limestone decomposing rapidly by exposure to weather, upper four or five inches more resistant	2	
2.	Series of irregular courses of grayish, magnesian limestone, varying laterally in color and thickness in the same layer		4

		FEET.	IN.
1.	Soft, yellow, earthy, regularly bedded magnesian limestone in five layers which are 5, 14, 8, 5 and 14 inches in thickness respectively, layers separated by shaly partings, total thickness exposed	4	6

In the immediate vicinity of the Lewis quarry there are many rock exposures in the steep bluffs along Sugar creek, and quarries have been operated at a number of points. Beyond the slight variations in individual layers which may always be expected, there is nothing in all the exposures essentially different from the several members of the two sections already described. For example, in some parts of the quarry of L. D. Green, located on the south side of the ravine followed by the wagon road in the northeast ¼ of section 34, the equivalent of the upper part of No. 3 in the Lewis quarry divides along definite lamination planes into thinner portions varying from half an inch to two inches in thickness. The texture seems to be even finer and better adapted to high grade lithographic work than in the quarry first noted. Some of the other layers, notably the equivalent of No. 7, show a tendency to divide into thin laminæ.

It were scarcely possible or desirable to describe all the outcrops and artificial openings in this locality. The lithographic beds are quarried at an opening on the land of Dr. W. H. H. Gable in the northwest ¼ of the southeast ¼ of section 27, about half a mile northwest of the Lewis quarry. The layers worked embrace Nos. 3, 5, 7 and 9 (Fig. 48). There is no waste above No. 9, the stripping consisting of a very thin layer of humus. The remarkable durability of the fine-grained beds is well illustrated by the scarcely perceptible effects produced by weathering and solution on bed No. 9, notwithstanding its proximity to the surface. Checks and joints are more numerous here than at the Lewis lime quarry, due probably to greater exposure to alternations of temperature, but otherwise the ledges present no essential differences. Southwest of the Gable quarry there is a steep bluff facing the river and showing the succession of beds below the lithographic zone. A little more than one-fourth of a mile east of the Gable quarry, the underlying dolomitized beds have been quarried to some extent, in the south bank of Sugar creek.

A quarry worked for lime and building stone by Mr. Ritter is located near the east line of the southeast ¼ of section 27, north of the Osage road. The section includes all the beds seen in the Lewis quarry. The characteristics are those usual to the horizon of the lithographic stone. The ledges above No. 3 are in part split up into a number of thinner layers, as in the Green quarry. A short distance west of the city limits of Osage, near the center of section 26, there is a quarry showing the lithographic zone. The section is the same as at the Lewis quarry except that the lower part of No. 3 is very shaly, the upper, fine-grained part of 3 is 9½ inches thick, the upper part of No. 5 thins out to zero at one place and 7 and 9 are blended into a single layer. The lithographic stone is again exposed west of the bridge over Sugar creek, in the southeast ¼ of section 22, township 98, range 17. Some quarrying has been done on opposite sides of the road, both in section 22 and section 27. The layers of the Lewis quarry, excepting 8, 9 and 10, are present and show the usual characteristics. The limestone is here overlain by three feet of fine silt-like loess.

The Chandler Cliff Section.—There are some picturesque bluffs on the east side of the river, in the southeast ¼ of the southeast ¼ of section 21, directly west of Osage, which afford the following section:

		FEET.	IN.
26.	Residual clay in which thin, weathered slabs and flakes of limestone are embedded, part of mantle of waste	4	
25.	Coarse-grained, rough, weathered, magnesian limestone		6
24.	Firm, fine-grained, lithographic ledge, somewhat concretionary and containing imperfectly preserved stromatoporoids, the equivalent of 9 of Lewis quarry	1	
23.	Partly decayed and partly shaly layer, the equivalent of numbers 6 and 8 of the Lewis quarry. No. 7 has thinned out and is not represented in this section	1	
22.	Fine, light-colored, lithographic bed, equal to No. 5 of Lewis' quarry. The bed as usual shows two divisions which are separated by a peculiar suture-like joint due to the interlocking of small prominences from the apposed surfaces. This interlocking joint is seen in all the exposures of this vicinity between the two parts of No. 5. The interlocking denticles show stylolitic structure	2	

		FEET.	IN.
21	Shaly parting		1
20.	Lithographic limestone in three parts: No. 3 of the Lewis quarry; upper part as usual very fine-grained and homogeneous	2	6
19.	Shaly parting		2
18.	Fine-grained, lithographic stone equivalent to basal member of the Lewis quarry	1	
17.	Coarse dolomitic layer	1	
16.	Fine-grained, laminated layer	1	
15.	Coarse, granular dolomite in beds ranging from six inches to a foot in thickness	4	
14.	Shaly parting		6
13.	Bed with lithographic nodules embedded in granular matrix	1	2
12.	Heavy layer which is dolomitic below and partly lithographic above. The lithographic portion is joined to the coarser dolomite by a wavy and irregular line	1	2
11.	Shaly band, variable in thickness, averaging about		6
10.	Heavy layer of crystalline dolomite	1	6
9.	Shaly parting		2
8.	Thick layer of limestone, coarse and granular at the base, upper six inches partly lithographic	1	6
7.	Hard, light gray, lithographic stone	1	1
6	Shaly decayed limestone	1	
5.	Light gray, crystalline limestone, good building stone	1	2
4.	Evenly bedded, yellowish dolomite, good quality, quarried for building stone at many points in the county, layers ranging up to a foot or more in thickness, no fossils	9	
3.	Irregularly and indefinitely bedded dolomite, much checked and cut by joints, carries numerous casts of *Athyris vittata* and other species characteristic of the same horizon. This member will be referred to in subsequent parts of this report as the Athyris zone	12	
2.	Two heavy, irregular, non-laminated, dolomitic beds, containing many shapeless cavities lined with calcite	5	
1.	Magnesian limestone, partly dolomitic, in regular layers	15	

The coarse, heavy, structureless beds of number 2 are quite constant over an area of considerable extent, and they afford a good datum line on account of the ease with which they can be recognized in all the cliff exposures from above Mitchell to three

or four miles below Osage. Number 3 is also very persistent, the most characteristic fossil in all the sections along the Cedar river being *Athyris vittata*. Numbers 4 and 5 are the most important of the building stone beds in the county. They are quarried at Orchard near the southern boundary, and near St. Ansgar in the northwestern quarter. The upper part of number 12 and the whole of 13 appear to be the equivalent of the thick lithographic bed with calcite crystals, numbered 5 in the section below the level of the Lewis quarry. This seems to be a very variable member of this part of the Devonian section, for at the Frank Nickerson quarry, on the river bluff a little more than a mile and a half south of Osage, it is divided into three distinct parts with a thin band of coarse dolomite between the upper part and the one next below. The equivalents of the Lewis quarry beds are noted in giving the details of the several members from 18 to 24 inclusive. In this section there is more of the limestone overlying the lithographic beds than was seen at any other point in the county.

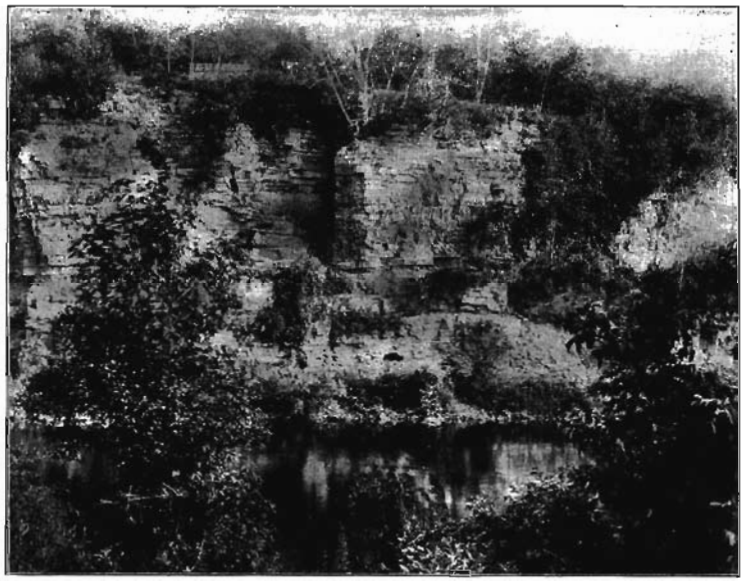

FIG 49. Cliff below the wagon bridge in the northeast quarter of section 28, township 98, range 17. There are folded and brecciated beds at the base of the cliff; the lithographic limestone appears at the top.

In the northwest ¼ of section 28, township 98, range 17, one-fourth of a mile below the electric power plant and two miles west of Osage, there is an interesting cliff (Fig. 49), which shows beds ranging down fifteen or twenty feet below No. 1 of the Chandler cliff section. These lower beds have been deformed and crushed on an extensive scale, the crushing having taken place before the overlying beds of the Chandler cliff were deposited. One of the larger and flatter of the arches into which the beds were thrown appears to the right of the middle of the view. The crushing and folding have been more energetic, or at least more effective, on each side of the arch. Immediately to the left the crushing seems to have been more perfect than elsewhere in this exposure, and the broken fragments of the original beds, ranging from a fraction of an inch to more than a foot in diameter, are now standing at every possible angle (Fig. 50). In some cases a certain amount of continuity may be traced from fragment to fragment of the same bed, the pieces showing very clearly that they are the constituent parts of a collapsed arch, but in general the displaced and

FIG. 50. Near view of the crush breccia at the base of the cliff shown in figure 49.

broken portions of the several beds are promiscuously jumbled together in perfect disorder. The matrix is composed of very finely comminuted fragments of the original beds mixed with finer, gray, granular, argillaceous limestone. It is probable that the entire matrix is detrital. Toward the right of the view there are several small arches, sharply curved and more or less broken. This section shows all the strata from the crushed zone up to the lithographic bed No. 7 of the Lewis quarry.

Near the northwest corner of section 1, and the northeast corner of 2, township 97, range 17, there are some fine precipitous rocky bluffs showing the equivalent of the brecciated zone at the base, overlain by the successive members of the Chandler cliff section. The lithographic layers, differing but slightly from the corresponding beds at the Lewis limekiln, have been quarried on the brow of the hill, on land belonging to Mr. Nickerson. The Wilkin brothers have a large quarry, or series of quarries, in section 1, at which point the beds equivalent to 5 and 7 of the Lewis section are more than usually laminated. The beds of the crushed zone at the bottom of the cliff, show rather gentle folding, the folds being broken and brecciated at only a few points, and these of limited extent. A rather majestic looking cliff on the south side of the river, near the center of section 34, township 98, range 17, repeats the details of the Chandler section; and another cliff south of the center of section 28, affords nothing but a repetition of the same details. At the last named point the crushed zone is concealed by talus. Another similar cliff belonging to the Chandler group, occurs on the south side of the river, south of the middle of section 21.

Rock Exposures Near Orchard.—The Devonian limestone lies within a few feet of the surface of the upland plain in and around Orchard. The Bartlett quarry in the eastern edge of the village is simply a pit sunk below the level of the plain. Only the upper lithographic beds are here exposed, and they contain the usual stromatoporoids seen in No. 9 of the Lewis quarry. A short distance above the railway bridge over Spring creek, there is a quarry in the low bluff of the stream, beginning at the level of the water. The horizon is that of the evenly bedded dolomite, No. 4 of the Chandler section. The quarry is capable of furnish-

ing good building stone and some fairly good dimension stone. The lowest course is fifteen inches in thickness. Quite an amount of six inch and nine inch ashlar stone could be obtained. The relation of the lithographic stone to the surface of the upland plain is about the same here as it is around Osage and St. Ansgar, but owing to the fact that the smaller stream has accomplished less in the way of erosion, the Athyris bed and all the lower members of the Devonian section lie below the level of the valley of Spring creek.

With the Orchard exposures should be classed the natural outcroppings on the opposite side of the Cedar river, two miles west of Orchard, near the southeast corner of section 12, township 97, range 17. The beds exposed here are the same as those seen at Orchard. The magnesian layers below the lithographic zone are very much broken up by weathering, some being reduced to mere chips.

Exposures Near Mitchell.—An imposing cliff of limestone (Fig. 51) composed wholly of strata lying below the horizon of the

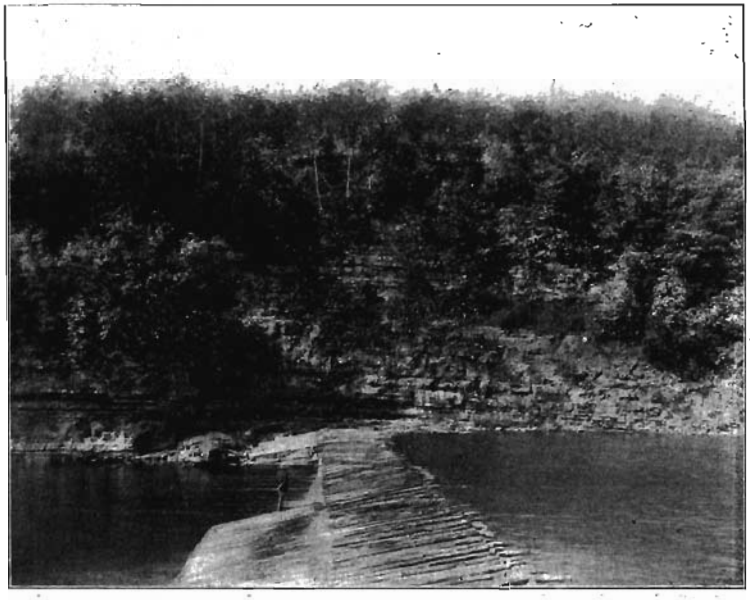

FIG 51. Precipitous, rocky cliffs at Mitchell.

lithographic beds of the Lewis quarry, is seen at the west end of the mill dam at Mitchell. At the level of the water below the dam there are two feet of beds belonging to the brecciated horizon. No. 1 of the Chandler section is represented by eleven feet of regularly bedded dolomite which is divided by a six inch band of shale about three and a half feet from the top. The coarse, unstratified bed with calcite-lined cavities, No. 2 at the Chandler cliff, presents the usual characteristics and the usual thickness. The soft yellowish limestone with casts of Athyris is reduced to five feet. This is followed, however, by five feet of harder dolomite in which fossils could not be detected, but which should doubtless be classed as part of the Athyris bed. Above this the evenly bedded quarry stone, No. 4 at Chandler's, has a thickness of fifteen feet, and this is overlain by three heavy ledges of hard dolomite which would furnish excellent material for bridge piers or for lime burning. Quite an amount of stone has been taken out here toward the top of the bluff at the horizon of No. 4. A number of other quarries have been operated within a mile of Mitchell. There is one, for example, west of the river in the northwest ¼ of section 8, and there are quarries on both sides of the river in the southwest ¼ of section 5. All make use of the evenly bedded stone belonging to the horizon of No. 4 at the Chandler cliff.

St. Ansgar Exposures.—Near the northeast corner of section 35, township 99, range 18, a mile and a half south of St. Ansgar, two quarries have been opened at points only a few rods apart. In both the stone is highly magnesian, in general dolomitic. The lower beds of the north quarry are rich in casts of brachiopods, *Athyris vittata* being the most common and the most characteristic. Casts of *Spirifer subvaricosus* are not uncommon, and in one of the layers *Atrypa reticularis* is plentiful. The fossils indicate at once the horizon of the Athyris bed at Chandler's cliff. In both of these quarries it is the evenly bedded dolomite, No. 4, above the Athyris horizon, that is worked. The south quarry is operated by C. H. Sherman of St. Ansgar, and is producing a durable stone, excellent for rough masonry. The range of the beds from two to thirty inches in thickness makes it possible to select stone suited to any desired purpose. One mile south of the quarries noted above, near the northeast corner of section 2, town-

ship 98, range 18, the road is cut through ledges of the lithographic zone. Between the Athyris bed at the quarries near the bridge south of St. Ansgar and the lithographic beds one mile farther south, the difference in level is thirty-five feet. The equivalents of 3, 5, 7 and 9 of the Lewis quarry are readily recognized. The stromatoporoids of No. 9 are better preserved than those of the corresponding bed near Osage and Orchard. They are also more numerous, and the individual colonies are larger; and yet they fall far short of the enormous development which the stromatoporoids of this bed attain near Nora Springs and Mason City. While the characteristics of the lithographic beds are probably more constant over wide areas than those of any other zone in northeastern Iowa, at this exposure, two and one-half miles south of St. Ansgar, the several layers vary in the most unexpected manner within a very short distance. At the north end of the exposure the beds are of the usual unaltered lithographic type; toward the south end, not more than thirty feet away, the section involving the very same beds is nearly all dolomite. In the dolomitized parts of No. 9 the stromatoporoids are represented by rough, spongiose masses from which the original structures of the fossils have been wholly or partially dissolved.

In the road one-fourth of a mile directly west of St. Ansgar, the Athyris bed, with its usual association of fossils, is well shown; and the quarry located above the bridge and west of the river, three-fourths of a mile southwest of the town, is worked in the dolomite which lies above the Athyris zone. There are exposures in the east bluff of the river north of the bridge at Newburg, which show the Athyris bed and the overlying dolomite. In the small gullies eroded in the sides of the bluff, blocks of lithographic stone occur with other waste material near the level of the upland, but no lithographic beds were here seen in place. The strata here dip to the north, and the Athyris beds disappear below the level of the water in the mill pond, near the center of section 14. It seems probable that it is these exposures east of Newburg that Whitney describes on page 311 of Hall's report on the Geology of Iowa. The Spirifer which Whitney mentions as resembling *Spirifer mucronatus* is doubtless the *Spirifer subvaricosus* of the Athyris zone, found near the southern end of the exposure.

The surface markings of the two Spirifers are very much alike.

There are a number of stony hills with rock near the surface, in sections 12 and 13, township 99, range 18, from one to two miles north of St. Ansgar. In section 13 the railway follows the base of a stony escarpment which sets off the upland prairie from the Cedar river valley. One-eighth of a mile north of the bridge over Turtle creek in section 13, there is an exposure that has been quarried. The rock is evenly bedded and seems to be the equivalent of the quarry stone south of St. Ansgar, the equivalent of No. 4 of the Chandler cliff section.

There are some good exposures in the vertical bluffs on the west side of the river, in the northeast ¼ of section 3, township 99, range 18. Stone has been quarried at a number of points. Quarrying begins at the top of a talus slope, fifteen feet above the base of the cliff. The breast of the quarries includes twelve feet of heavy, non-laminated, vesicular dolomite which is overlain by four feet of laminated beds which may be split into thinner slabs as desired. The upper part of the Athyris zone is here included in the workable quarry beds, the layers of this zone being much firmer, and the bedding more regular, than is the case farther south. The fossils are represented by cavities rather than casts. Three-fourths of a mile below, and on the opposite side of the stream, is the Hanson quarry which works only the laminated beds of the section described above, together with the uppermost portion of the heavier, vesicular beds beneath.

Otranto Exposures.—Only the lower members of the sections around Osage are represented near Otranto. The highest beds exposed in this region belong to the Athyris horizon, and these differ somewhat in texture, color and fossil contents from the corresponding beds farther down the river. In the southeast ¼ of the southwest ¼ of section 28, township 100, range 18, there are outcrops of the Athyris zone in the form of soft, granular, cream-colored limestone which breaks up into irregular, shapeless pieces on weathering. The beds are quite fossiliferous. *Atrypa reticularis* is the most common, but the typical *Athyris vittata* is not rare. Directly north of the last point, in the southeast ¼ of the northwest ¼ of the same section, there is a quarry from which a considerable amount of stone has been taken out. The rock is

soft, yellow, coarse-grained, very vesicular and rich in casts of *Atrypa reticularis*. There are also casts of *Athyris vittata*, and *Dielasma iowensis*, a species occurring in some places very abundantly at this horizon, appears more rarely. There runs through this quarry a band of dark shaly carbonaceous material which has been mistaken by the quarrymen and others for indications of coal. There is an opening near the mill at Otranto showing the same vesicular, yellow limestone seen at the quarry just described. The same stone appears in the bluff a short distance above the Otranto bridge. It crops out at a number of places along Otter creek northeast of Otranto, a good exposure occurring a short distance north of the southeast corner of section 15, Otranto township.

Exposures West of Cedar River on Rock Creek and Deer Creek.—In the northwest ¼ of the northeast ¼ of section 17, township 97, range 17, a short distance above the bridge over Rock creek, there is a small opening which shows bed No. 3 of the Lewis quarry section, and all the overlying beds up to the mantle of waste and broken stone above No. 9. In all this region the limestone lies very near the surface; it is exposed in natural sections in the low banks of the creek; quarries might be opened at a score of points if the demand for building material justified the labor and expense.

The Gopelrud quarry is located in the northeast ¼ of the northeast ¼ of section 22, township 98, range 18. It is opened along the south bank of Rock creek for a distance of 200 yards. The individual beds vary within short distances, but near the middle of the opening there are at the bottom a number of more or less perfectly lithographic layers ranging from an inch to ten inches and aggregating four feet in thickness. This is followed by a heavy, stromatoporoid bearing bed, two and a half feet thick, in which occur a small branching Favosites, an Alveolites with small tubes resembling *A. rockfordensis*, and some colonies of Diphyphyllum. Above the stromatoporoid bed are two to five feet of granular, decayed dolomite which furnished casts of a Cyrtina. The limestones exposed at this point embrace the lithographic zone, but they show quite an amount of variation in the several members of the section when compared with the standard section

at the Lewis quarry. The stromatoporoid bed, the equivalent of No. 9, is much thicker than it is near Osage, and it has assumed more of the characteristics of this bed as it is developed near Mason City and Nora Springs. The variations in the individual beds recall the interesting section in the roadside two and a half miles south of St. Ansgar. A bed that is lithographic in one place may be changed to dolomite within a few yards; what is a single layer in one part of the quarry may be divided into two or more distinct layers in another part.

Near the middle of the north line of section 8, Newburg township, there is an interesting section in the south bank of Deer

FIG. 52. Folded beds of the brecciated zone in the bank of Deer creek, near the middle of the north line of section 8, Newburg township.

creek (Fig. 52), which affords the best example of complex folding seen in the county. The stone is an earthy dolomite, and is destitute of fossils as far as could be observed. The cliff is from fifteen to eighteen feet in height, and all the beds have been thrown into a succession of undulating folds as shown in the

figure. Although the beds contain no fossils, and no recognized members of the Devonian section of the county are present to indicate their stratigraphic relations, the outcrop may be referred without much hesitation to the horizon of the crushed and brecciated zone in the lower part of some of the sections near Osage. The folds resemble those seen at the base of the cliff below the Wilkin Brothers' quarry. It is only at the brecciated horizon that any indications of crushing and brecciation have been observed in Mitchell county.

Exposures on the Little Cedar.—There are several quarries and exposures within a radius of one or two miles of Brownville. Rock crops out in a section six feet in thickness, in the bank of the river below the mill, but it is all so much weathered that its characters are obscured. A quarry on the Mosher farm, about two miles up the stream, furnished a good grade of heavy stone for the abutments of the bridge at Brownville. The Moss quarry on Beaver creek, in the southeast ¼ of section 30, Jenkins township, is worked in evenly bedded magnesian, or dolomitic limestone. It is opened for a distance of fifteen or twenty rods along the bank of the creek, and the individual beds vary considerably when traced from one part of the quarry to another. Some bluish, non-dolomitic pieces lying loose in the bottom of the quarry show traces of Atrypa and Spirifer, and these were the only fossils observed in the entire outcrop. There are exposures of magnesian limestone below Brownville, as far as the southeast ¼ of the southwest ¼ of section 32 in the southwestern part of Douglas township. Above Brownville the outcrops are more numerous and more important. Stone crops out along the stream for some distance above and below the town of Little Cedar. In the northeast ¼ of the southeast ¼ of section 22, Liberty township, there is a quarry furnishing good range stone from what is the equivalent of No. 4 at the Chandler cliff, the horizon from which comes most of the quarry stone of Mitchell county. Along the north line of the same section the lithographic beds are exposed at the level of the upland prairie. The rock section here evidently repeats the sections near Osage. In the west bank of the river, one-half mile southeast of Stacyville, a quarry has been opened in dolomitic limestone of fairly good quality. The layers range from three to

fourteen inches in thickness. The quarry is overlain by a large amount of decayed stone, particularly on the west side; farther east the stripping includes a fairly well developed bed of rusty Buchanan gravel of late Kansan age, and above this there is a loess-like deposit overlying some glacial bowlders. No fossils were seen in the quarry beds in place, but in some weathered blocks there were traces of Idiostroma, a form occurring at Iowa City below the level of the lithographic zone.

Exposures Near McIntire.—Limestone is exposed at the mill southeast of McIntire. It occurs in even and regular beds ranging from two to fourteen inches in thickness. As in many other cases, however, the stone is variable at the same horizon; any given bed may be unaltered limestone in one place and granular dolomite in another. On the south side of a small ravine south of the mill, a large amount of stone has been taken out. At one point the quarry face shows:

		FEET.	IN.
5.	Loess	6	
4.	Decayed, magnesian, granular limestone	2	
3.	Laminated lithographic stone	3	
2.	Solid, granular, fossiliferous bed containing Stromatopora, Favosites, Atrypa, Spirifer and Cyrtina	1	3
1.	Thin-bedded, partly lithographic stone	2	

In some parts of the exposure the upper portion of No. 2 weathers into thin, irregular, earthy chips; in places it is solid lithographic stone. In the small creek bed between the quarry and the mill there are firm, dolomitic beds below the level of No. 1, six to eight inches in thickness. In a small opening north of the ravine the lithographic characteristics of 2 and 3 are better developed and approach in perfection of fineness and homogeneity some of the best examples of lithographic stone southwest of Osage. The McIntire quarries on the Wapsipinicon, in the northeastern part of the county, include the beds that are quarried near the top of the exposures around Osage and Orchard, in the valley of the Cedar.

GENERAL DEVONIAN SECTION.

		FEET.
8.	Magnesian limestone above the lithographic zone, represented usually by weathered chips	6
7.	Lithographic zone	9
6.	Assemblage of variable beds between the lithographic zone and the evenly bedded quarry stone	15
5.	Quarry stone, No. 4 of the Chandler cliff section	10
4.	Athyris bed	12
3.	Coarse, vesicular bed with calcite-lined cavities	5
2.	Regularly bedded dolomite at base of Chandler section	15
1.	Folded and brecciated zone	15

Pleistocene System.

KANSAN STAGE.

Kansan Drift.—The Kansan stage is represented in Mitchell county by the Kansan till and the Buchanan gravels. Over the greater part of the county the deposits of the Kansan stage have been concealed by the later Iowan; but in the pronounced loess-Kansan areas extending from above Mitchell to below Osage, there is no Iowan drift. This region seems never to have been occupied by Iowan ice. The surface deposits are made up of loess resting on residual clays or on weathered and reddened Kansan till. On the hill south of the west end of the bridge at Mitchell there are good exposures showing the red ferretto zone of the Kansan overlain by a heavy body of Iowan loess. The same relations are shown on the hills west and southwest of Osage. A possible explanation of the absence of Iowan drift, and the development of loess-Kansan characteristics in the axis of the Cedar river trough, is given in connection with the discussion of the topography of this anomalous area. The unweathered blue Kansan till, with splintered fragments of wood from the Aftonian forests, is exposed in wells and other artificial excavations. It underlies the surface over the greater part of the county.

Buchanan Gravels.—Buchanan gravels, laid down, as described in the report on Howard county, in the form of eskers, valley trains and outwash aprons, at the time of melting of the Kansan ice, are extensively developed in Mitchell county. There is a typical pit of the upland phase of the gravels a short distance southwest of Osage, in the northwest ¼ of section 35, township

98, range 17. The deposit is very ferruginous and weather stained. Most of the crystalline pebbles are profoundly altered and decayed. The section shows four feet of very rusty, cross-bedded sand overlain by from four to six feet of coarse, fer-

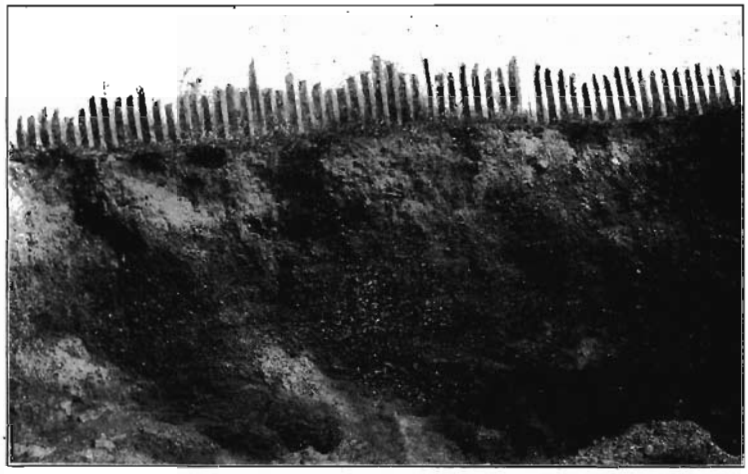

FIG. 53. Pit of Buchanan gravel overlain by Iowan loess, in the northwest quarter of section 35, township 98, range 17.

ruginous gravel (Fig. 53). Along with the northern granites and greenstones are some fragments of the local lithographic limestone, and it is interesting to note that the limestone has suffered less from weathering than most of the crystalline pebbles. Above the gravel is a mantle of fresh Iowan loess. There is no Iowan drift. The pit is located in the midst of an area of pronounced loess-Kansan topography, on a knob which rises eighty feet above the level of the river. Low ground to the south and southeast of the knob has evidently been occupied by Iowan ice. A short distance west of Mitchell is another pit of rusty Buchanan gravel similarly located in a loess-Kansan area which rises conspicuously above the level of the adjacent Iowan plain.

Beds of Buchanan gravel are to be found in every part of the county. Trains of gravel follow the valleys of the Wapsipinicon and the Little Cedar. Along the Cedar river the gravel occurs most frequently, not in the valley, but on the bluffs overlooking

the stream. At Mitchell, for example, old, ferruginous gravel lies on the summit of the cliff illustrated in figure 51. Extensive deposits are also found on the uplands remote from streams. It is not practicable to mention specifically all the outcrops; the deposits seem to be most common in Jenkins and Douglas townships.

IOWAN STAGE.

Iowan Drift.—The yellow clays and large coarse granite bowlders of the Iowan drift are distributed over nearly the entire county. No fresh railway cuts or well sections were seen, from which details relating to thickness could be obtained, but the level or slightly undulating topography, so universal in all the spaces between the major streams, affords trustworthy evidence concerning the geographical distribution of this comparatively young sheet of till. Figure 42 illustrates two characteristics of the Iowan drift—first, the level, unbroken, uneroded plain in which the surface remains precisely as it was left at the time of the withdrawal of the Iowan glaciers, and second, the large, coarse, granite bowlders which in some areas are liberally sprinkled over the surface. Compared with Chickasaw, Bremer and Buchanan counties, large bowlders are very rare in Mitchell. That shown in figure 42 is the largest seen in this county.

Iowan Loess.—The large loess-Kansan area beginning above Mitchell and extending to the southeast ¼ of section 36, township 98, range 17, a mile and a half south of Osage, is covered with a mantle of typical Iowan loess. In accordance with its habit near the Iowan margin, the loess is thickest on the highest points. It is always best developed on surfaces that never received any deposit of Iowan drift, surfaces that were never overflowed by Iowan ice, surfaces that, at the time of loess deposition, were extra-marginal so far as the Iowan glaciers were concerned. The conditions for loess deposition were met, even long distances back from the actual Iowan margin, whenever prominent areas of any kind or size rose above the level of the glacier surface. All the hills south and west of Osage rise above the level of the adjacent Iowan plain, and all are loess-covered. A cut made to accommodate the wagon road in the southeast ¼ of section 27, in Osage

township, reveals a section of rather dark-colored and siliceous, granular loess eleven feet in thickness. A little more than a mile south of main street, Osage, the road between sections 35 and 36 cuts through a heavy bed of typical yellow loess indistinguishable from that occurring around the Iowan margin in Delaware and Dubuque counties. At Mitchell there is a good section of loess a few rods west of the wagon bridge; there is another on the hill slope south of the bridge; other sections, too numerous for specific reference, occur throughout the Osage-Mitchell, loess-Kansan island. By comparing figures 46 and 42, the differences in the topographic features of loess-Kansan areas and the average Iowan plain may be readily appreciated. Typical loess is developed along Spring creek, a very good illustration occurring in the northwest ¼ of section 32, township 98, range 17. Loess also occurs along the Little Cedar at various points between Stacyville and the southern line of the county. There is a small area of loess-Kansan along Rock creek, in sections 8 and 17, township 97, range 17, and there is quite a bed of loess above the rock section at McIntire.

Supra-Iowan Loess.—Some of the loess of Mitchell county is distributed in a manner that is altogether unusual in regions near the actual Iowan margin. Superposition of loess on Kansan drift, or on any drift older than the Iowan, is the relation generally observed, but loess on a level Iowan plain is so unusual as to excite surprise. Nevertheless, in Mitchell county, there are extensive areas of the average Iowan plain covered with a thin veneer of gray or ashen loess, from a few inches to a foot in thickness. A broad belt of this thin loess, three to six miles in width, occurs west of the Little Cedar, a concrete example of which may be seen on the west side of the stream along the line between Lincoln and Douglas townships, and for two miles or more along the same line projected westward in the northern part of Lincoln. A part of the same belt is well shown in the vicinity of Stacyville. West of the Cedar there are a number of areas veneered with the thin gray supra-Iowan loess. An instructive illustration was noted in the south half of section 17, township 98, range 17, where the rain-cut trenches by the roadside showed from eight to ten inches of loess superposed on Iowan till. The gray pebbleless

loess was sharply set off by color and composition from the yellow glacial till with its numerous pebbles and cobblestones. It was set off from the till in another way, for the two deposits are not eroded with equal facility, and an overhanging shelf of loess formed a projecting cornice along the upper part of the walls of the small gullies. The same facts may be observed northwest of Mitchell, some distance away from the borders of the loess-Kansan island. This same type of loess is well developed in the region about Mona. On these loess areas the soil in the cultivated fields shows much lighter in color than the black loam developed on ordinary Iowan drift.

Iowan Terraces.—Sand terraces of Iowan age were seen at intervals along the valley of the Cedar river. Similar deposits may be present in the valleys of the other streams, but none were noted. A broad terrace, rising fifteen feet above the present flood plain of the river, occurs in the northwest ¼ of the northwest ¼ of section 34, township 98, range 17. The sand used in connection with building operations at Osage comes largely from this locality. Cross bedding is a common feature of the deposit. The upper zone for two feet or more is stained with humus, but the rest is clean quartz sand as fresh and unaltered as when it was laid down. The material is young as compared with any phase of the Buchanan gravels. The deposit is to be correlated with the fresh terrace sands of Iowan age occurring along the Iowa river near Iowa City. The difference in age between these young, fresh sands deposited from floods when the Iowan ice was melting, and such old weather stained, ferruginous sands and gravels of late Kansan age as are illustrated in figure 53, is almost immeasurably great. Near the center of section 21 of the same township there is another broad terrace of Iowan sands covering an area of several acres. Like the preceding its upper surface is not more than fifteen or twenty feet above the level of the water in the river.

Deformations and Unconformities.

The folding and crushing seen in the brecciated zone at the base of the Devonian section (Figures 49, 50 and 52) afford the only examples of deformation of geological strata seen in the county. The only unconformities worthy of note are those between the

glacial deposits and the Devonian limestones, and between the eroded surface of the deposits belonging to the Kansan age and the overlying Iowan drift and Iowan loess.

Soils.

The soils of Mitchell county are not very varied, but all possess a high order of merit. One type, the rich black loam developed on the surface of the Iowan drift, is the most widely distributed and covers much more than half of the entire area. On account of its general distribution it may be regarded as the characteristic soil of the county, and in all respects the most important. In point of quality it is equal to the best. This soil is rich in organic matter and in all the forms of plant food that arise as primary or secondary products of organic decay. The Iowan till is also rich in lime carbonate and other soluble mineral substances, a quality which makes this soil especially well adapted to the production of cereals and grasses. Both phases of the loess,—the thick yellow supra-Kansan and the thin gray supra-Iowan,—give rise to soils of excellent quality. All the soils of the county are mellow and easily cultivated, and so are in striking and agreeable contrast with the stiff, intractible clay soils of many less favored regions. The soils will always be the chief source of wealth, agriculture will always remain the principal industry of the county. On these facts the people of Mitchell county may well congratulate themselves. Agriculture is the noblest of callings. Every man engaged in it contributes something to the success and well being of humanity. It offers sure rewards to intelligently directed effort as no other occupation can. It affords an escape from labor troubles and from contact with the vice and poverty and wretchedness that develop to such an alarming extent around some of the great organized industries. It produces the best types of self reliant manhood and womanhood, and this is a contribution to the state and to humanity at large that is better than wealth.

ECONOMIC PRODUCTS.

Building Stone.—Exposures of Devonian limestones and dolomites are unusually numerous in this region when compared with other prairie counties, and so no neighborhood is very far re-

moved from quarries of available building stone. All the quarries and openings of special importance have been previously noted in discussing the typical sections of the indurated rocks. The principal horizons from which building stone is obtained are the lithographic zone and the regularly bedded dolomite numbered 4 in the Chandler cliff section. Southwest of Osage the lithographic limestone is quarried more than any other, while near Mitchell and St. Ansgar it is the dolomite that is worked the most. Along the Little Cedar from Stacyville to Brownville the quarries are mostly operated in the dolomitic horizon, but at McIntire on the Wapispinicon, the lithographic stone is included in the beds from which building material is obtained. West of the Cedar, the quarries on Rock creek work the equivalent of the lithographic zone. The Athyris bed becomes usable and is quarried near Otranto, and there appears no good reason who the dolomite numbered 1 of the Chandler section should not be found as useful as any other. At present there are no shipping quarries in the county. All now worked have been opened to meet the immediate local demand.

Lime.—All the lime at present burned in the county is made from the fine-grained, non-magnesian lithographic stone. The largest producer is Mr. George Lewis who operates a large draw kiln southwest of Osage. Work is not carried on continuously for the reason that the amount produced is governed by the demand in the local market. The lime is of good quality and serves an excellent purpose if used soon after it is burned. It has the disadvantage of all non-magnesian limes in that it air slacks readily, a fact that interferes with its being shipped far or kept in stock for any length of time. Lime is also made by Mr. Ritter one-half mile northeast of the Lewis quarry, the stone used being from the same lithographic horizon. Some of the dolomite which lies below the lithographic stone would make a lime having better shipping and keeping qualities than that now produced. Lime from dolomite is also intrinsically better than that made from pure limestone in the fact that it sets more slowly, sets harder, and makes a firmer bond.

Lithographic Stone.—The beds of the lithographic zone are known to range from Le Roy in Minnesota to Iowa City in

Johnson county, Iowa. In general they lack the fine even grain which would make them useful in lithographic printing; but the band comprising the upper eight or nine inches of No. 3 of the Lewis quarry section is remarkably fine-grained and homogeneous, and test samples of it were sent to the great lithographing establishment of A. Hoen & Co. of Baltimore. Reports of the tests were very favorable, in the language of one communication the stone "is quite as satisfactory for the finer process of lithographic engraving as it is for the ordinary transferring and printing processes." On mailing a few transfer impressions pulled from the sample of lithographic stone submitted for trial, the statement was made that "these impressions are as good as the original would give and, if defective, the defects are due to the original and not to the stone from which they were printed." The lower part of No. 5, as well as the upper part of No. 3, seems to be fine enough for good lithographic work. The only discouraging feature of the case lies in the fact that, so far as the quarries have been opened the beds are badly checked as shown in figures 47 and 48, making it difficult to get slabs of useful size. To have commercial value the quarries should be capable of affording pieces ranging from 30x42 inches up to 42x64. It may be possible that, as the quarries are worked farther in from the surface, the objectionable checks may not be so numerous, and that Mitchell county may add to its industries the production of a high grade of lithographic stone.

Road Materials.—The general distribution and the great number of rock exposures in the county bring the possibility of using crushed stone for road improvement within reach of almost every neighborhood, and the time will certainly come when many of the more important roads will be covered with macadam. Buchanan gravel is also available in almost every part of the county and offers a means for the improvement of the highways at once cheap and convenient.

Clays.—The Pleitocene deposits contain the only clays seen in the area under discussion. Glacial clay from either of the drift sheets contains so many pebbles as to interfere somewhat with its use in the manufacture of brick, tile and other

clay products, though, in the case of the yellow Iowan drift at least, the difficulties are not insurmountable. On the other hand the loess clays are too siliceous for use. No clay working plants are at present operated in the county.

Iron Ore.—Small beds of limonite are found at various places throughout Mitchell county. A fairly typical example of these deposits occurs a few rods east of the bridge which spans the stream a short distance northeast of the village of Little Cedar. Neither the thickness nor the extent of the ore body at this point could readily be ascertained. By far the most important deposit of iron ore is seen at the top of the bluff, a few rods north of the west end of the bridge at Mitchell. The bed is concretionary, but quite solid. A thickness of sixteen feet is exposed. The ore lies in an old channel cut in the Devonian limestone. There are many quartz pebbles included in it. Masses ranging up to six feet in diameter are found on the steep slope between the bottom of the ore body and the level of the water in the river. The ore at this point is at least pre-Kansan in age, for it is overlain by a bed of typical Buchanan gravel which, in turn, is overlain by the much younger Iowan loess. The lateral limits of the ore body could not be ascertained on account of the heavy mantle of younger deposits which effectually conceal it from view, but concretionary masses of the limonite were seen in the wash by the roadsides on the west side of the river, more than a quarter of a mile back from the bridge.

Coal.—For many years there has been a great deal of interest felt by the people of Otranto in supposed indications of coal The black, carbonaceous band running through the quarry in the southeast ¼ of the northwest ¼ of section 28, township 100, range 18, has been noted on a preceding page. Wells at a number of points in and around Otranto have penetrated this black shale, and hopes of finding workable coal have been aroused and persistently entertained. Near Mona, according to report, a well driller found two inches of coal at a depth of thirty-eight feet, and six inches at a depth of forty feet. It is said that drilling stopped in light shale, but the depth of the light shale could not be ascertained. At less than 100 feet the Maquoketa might be reached. It is needless to say that there

is no coal of commercial importance in strata of Devonian age. Black seams with thin films of real coal are known to occur in the Independence shales at Independence, Iowa, and the same carbonaceous Devonian shale has been encountered at many other points, raising false hopes and leading to no small amount of useless expenditure.

Water Supplies.

The three principal streams of the county are permanent and afford bountiful supplies of stock water to farmers and others living along their banks. Most of the smaller streams are intermittent. For water supplies for all purposes, therefore, the people, over by far the larger part of the county, are dependent on wells. In some localities well water is obtained in seams of sand and gravel in the drift; but in Mitchell county the Pleistocene deposits, over large areas, are unusually thin, and a large proportion of the wells penetrate the limestones to greater or less depths. The area of deepest drift lies between the Wapsipinicon and the Little Cedar, where farm wells range in depth from 200 to more than 300 feet without striking rock. Quite a number of the wells in the deep drift of Jenkins, Douglas and Lincoln townships are reported as flowing. One in the northeast ¼ of section 17, Douglas township, is said to have a pressure of forty pounds to the square inch at a height of five feet above the surface. Between the Cedar and the Little Cedar the limestones generally lie nearer the surface; in some instances they come so near as actually to be exposed by wash in the roads and fields. The drift here rarely exceeds 100 feet in thickness; more commonly it ranges from twenty to sixty. In this region the water supplies are drawn from fissures at varying depths in the Devonian limestones. The well in the southwest ¼ of section 8, Burr Oak township, in which the drill passed through twenty-two feet of drift and went into rock to a distance of 103 feet, is rather an extreme case; but fifty feet in drift and eighty feet in limestone would be fairly typical of the wells of this region.

The city of Osage is supplied with water of excellent quality from an artesian well. The well is 780 feet deep and ends in the Saint Peter sandstone. No systematic record of the boring

was kept until a depth of 490 feet was reached, after which samples were carefully taken and a very satisfactory record is available. Through the kindness of Mayor Humbert the Survey was supplied with a set of samples from which has been compiled the following section of the strata penetrated by the drill:

		THICKNESS.	DEPTH.
14.	Light buff, crystalline dolomite, beginning at a depth of 490 feet, represented by four samples at 490, 520, 530 and 540 feet in depth respectively	50	540
13.	Limestone effervescing freely in cold hydrochloric acid, light gray in color, six samples at 560, 575, 585, 595, 600 and 625	85	625
12.	Yellowish limestone with pyritic crystals and small nodules, two samples at 630 and 640	15	640
11.	Light gray limestone with pyrite, one sample	5	645
10.	Dark gray limestone mixed with small chips of lighter gray from No. 11, some grains of pyrite, one sample	10	655
9.	Dark gray shaly limestone, pyritic, one sample	5	660
8.	Dark gray limestone mixed with chips of green shale	10	670
7.	Greenish shale	5	675
6.	Slaty gray shale with some small flakes of limestone and crystals of pyrite, two samples at 690 and 695	20	695
5.	Dark green shale with a few small bits of limestone and grains of clean, white, water-worn, quartz sand	20	715
4.	Clean, clear, water-worn, quartz sand mixed with some chips of green shale from No. 5, three samples at 725, 740, and 750, sand at 750 a little finer that that above	35	750
3.	Yellowish sand finer than any in No. 4	10	760
2.	Greenish, marly shale with some sand grains and small chips of limestone	10	770
1.	Fine gray sand with well rounded grains, some shale	10	780

In this section numbers 1-4 are Saint Peter sandstone. Numbers 5-13 represent the non-dolomitic phase, and 14 the dolomitized phase, of the Galena-Trenton. In addition to the samples noted in the section above, there are two others that presumably

come from points above the 490 foot level. They are marked No. 1 and No. 2 respectively, but no depth is given in either case. No. 1 is a mixture of light green and dark gray shale which might possibly come from the Maquoketa formation. No. 2 is a light colored limestone.

At St. Ansgar a well was in the process of boring. The drill had reached a depth of 160 feet, the last sixty feet being in the Maquoketa shales.

Water Powers.

Water powers have been developed on all the three principal streams of the county. For example, there are mills on the Wapsininicon at McIntire and Riceville. Mills have been built at Stacyville and Brownville on the Little Cedar. On the Cedar river there are mills at Otranto, Newburg, below St. Ansgar, at Mitchell, and at a point two miles west of Osage. That west of Osage illustrates the manner in which all possible water powers are certain to be utilized in the future, namely, in the development of electrical energy and its transmission to points where it may render service to the inhabitants of town and farm.

SUMMARY.

Mitchell county lies wholly within the Devonian area and within the area properly belonging to the Iowan drift. The valley of the Cedar river is the bottom of a broad trough in the surface of northeastern Iowa, which has Cresco and Calmar on one rim and Wesley in Kossuth county on the other. Northeast of the Cedar the general surface slopes strongly toward the southwest, but the streams of the region—including Crane creek, the many branches of the Wapsipinicon, and the Little Cedar—flow toward the southeast, their courses being nearly at right angles to the direction of the greatest slope. The position of the Cedar river, at the bottom of the great trough, probably explains the unusual preglacial characteristics of the valley and the presence of loess-Kansan islands so far from the actual margin of the Iowan drift.

The indurated rocks are Devonian limestones and dolomites, they all belong to one stage, and the aggregate thickness of all

the beds exposed in the county does not exceed ninety feet. The dip of the strata coincides very nearly with the general slope of the surface, and so practically the same beds are seen at the numerous points where indurated rocks are exposed. The lithographic zone, which is so constant a feature of the Devonian limestones of Iowa, is unusually well developed, and certain parts of these beds are fine grained and homogeneous enough to be used in the better grades of lithographic printing, provided blocks of the desired sizes can be obtained. Quarry stone suitable for rough masonry is abundant and is available in almost every part of the county. Material for lime making is plentiful and of good quality. Workable clays are scarce. There is no possibility of finding coal. It is possible, and highly probable, that in the future quarrying and lime burning will be developed into industries of far greater importance than they have yet attained. With the splendid quality and inexhaustible resources of the soils of the county, agriculture and related industries must always remain the principal occupation of the people, the chief productive source of wealth.

ACKNOWLEDGMENTS.

In prosecuting the field work in Mitchell county the writer was ably assisted by Professor F. M. Arey of the Iowa State Normal School. Without this assistance the work could scarcely have been finished in the time available for operations in the field. Of the great value of the volunteer services rendered by Professor Arey, and of the aid so generously extended by all the citizens of the county with whom the work brought the representatives of the Survey in contact, it is a pleasure to make grateful acknowledgment.

STATE OF MINNESOTA

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF MITCHELL COUNTY IOWA.

BY

SAMUEL CALVIN

1903.

Scale 1:250000

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

CEDAR VALLEY

INDUSTRIES.

QUARRIES

LIME KILNS

CERRO GORDO CO.

FALLS TWP.

UNION TWP. T.98 N.

T.97 N.

BARTON TWP. T.99 N.

T.100 N. TWP.

DEER CREEK TWP.

HANCOCK CO.

OAKDALE TWP. T.100 N.

JAMESTOWN TWP. T.99 N.

AFTON TWP. T.98 N.

T.97 N.

WORTH CO.

OTRANTO

MONA

UNION

STACYVILLE

WAYNE

BAILEY

MEYER

TOETERVILLE

STACYVILLE

McINTIRE

CARPENTER

STANSGAR

DAVID

NEWBURG

LIBERTY

JENKINS

LITTLE CEDAR

DORAN

RICEVILLE

BROWNVILLE

MITCHELL

WEST MITCHELL

CARDIFF

BURR OAK

ROCK

DOUGLAS

OSAGE

NEW HAVEN

CEDAR

ORCHARD

ROCK GROVE TWP. RUDD TWP. FLOYD TWP. CEDAR TWP.

R.XVIII W. R.XVII W. R.XVI W. R.XV W.

FLOYD CO.

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