GEOLOGY OF BUTLER COUNTY

BY

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INTRODUCTION

LOCATION AND AREA.

Butler county, once a part of Bremer and Buchanan counties, was organized in 1851. It was named in honor of General William O. Butler, an officer of the Mexican war and a Vice-Presidential candidate in 1848. It is in the third tier of counties from the Minnesota line and is fourth in order from the Mississippi river. Bremer and Black Hawk counties are on its eastern border. It has Grundy county on the south, Franklin on the west and Floyd on the north. Its approximate area is 576 square miles, divided equally among sixteen civil townships each of which is exactly conterminous with a corresponding congressional township. There is no large city within its bounds, but it has nine thrifty communities with populations ranging from 400 to 1,500 inhabitants. Allison and Bristow are upon upland plains apart from any perennial streams but the other towns are located in the valleys of the principal watercourses. The leading and almost universal occupation of the people is agriculture. Valley and upland alike everywhere respond bountifully to the labors of the husbandman.

PREVIOUS GEOLOGICAL WORK.

Beyond the interest always attaching to a region rich in promise to the future tillers of the soil, there was very little in Butler county to attract the attention of the earlier geologists whose time and purpose did not admit of consideration of details of minor importance.

Mention is made by White in the first volume of his Geology of Iowa, 1870, of "certain important exposures of the Kinderhook formation in the eastern part of Franklin and the western part of Butler counties," without specifying the localities or characteristics of the rocks. Since little or no quarrying had been done in the Lime Creek shales at that time and the natural exposures

were slight and the weathered rock gave little clew to its identity, it is not surprising that the area of these shales was assigned by him to the Kinderhook stage, and that on his map of the state the eastern limit of the Mississippian series was drawn even beyond the eastern border of the Lime Creek shales, thus covering more than one-third of the area of the county. As a matter of fact the area of the Kinderhook stage is confined to Washington township and small fractions of Madison and Monroe townships immediately adjacent to it, while all the rest of the territory previously assigned to the Kinderhook must be regarded as belonging to the Devonian.

McGee in his Pleistocene History of Northeastern Iowa makes brief allusions to the topography of Butler county in common with neighboring counties having similar surface features. Recent writers seem to have added nothing, except incidentally, to the meager record of the above named writers.

PHYSIOGRAPHY

Topography

The present surface of Butler county is the resultant of various agencies, both constructive and destructive, that have been incessantly in operation ever since the land emerged from the waters that covered it during the accumulation of the material of the Devonian and the Carboniferous rocks that form the basis upon which the later agencies have been doing their work.

PREGLACIAL.

The destructive agencies corraded, cut and gouged out the rock surface through the long interval preceding the glacial period, in places meeting with stubborn resistance from rock that, being indurated, not only withstood the wear and tear of running waters, but that in some cases, at least, was little affected by the acids of the atmosphere and waters. Elsewhere the surface readily gave way to the assaults of the various attacking forces. Thus it was widely channeled in some places, sharply trenched in others, or made uneven with ridges, mounds and knobs over broad mesas into which were sunk depressions of varied form and character. During this interval little constructive work was done; at least, little if any, appears to-day. In

fact, few of the erosive effects of that time are anywhere apparent unmodified by the forces that later everywhere wrought so effectually as to obscure almost, or quite, completely, all that had been accomplished previously.

To-day preglacial erosive effects are chiefly to be noted in the general topographic forms of upland and lowland, in the occasional rock outcroppings where the drift material chances to be thin, or in the observance of the depth at which rock occurs in well drillings in different localities, allowance having been made for the varying elevations of the surface where the wells are put down. Nevertheless, there are several instances in the county where preglacial erosion seems to have escaped complete obliteration by the drift deposits.

In the southwestern part of Washington township Beaver creek valley bears little evidence of modification by the drift. It is narrow, with high bluff-sides, especially upon the north, the sloping surfaces of which are made up of the talus from the breaking down of the Kinderhook limestone, numerous pieces of which appear scattered over the lower two-thirds of the bank, and a sinuous line of which can still be detected in place one-third of the distance from the top of the slope. The bed of the stream is very near to the rock. The comparatively slight aggrading that has been done as well as the formation of the talus has been accomplished in recent times. Little that is distinctly the result of the glacial epoch is manifest here.

A north and south valley, with occasional outcroppings of limestone along its middle slopes, cuts the central part of Fremont and Butler townships. This, too, is the product of preglacial stream activity which was much more vigorous than that which can be ascribed to the ordinarily insignificant rivulet that to-day quietly courses over the drift material that partially fills this ancient valley. Had the drift sheets in this part of the county been as heavy as they are in most other localities, here would have been a buried channel discoverable only from the greater depth at which rock would have been reached along its course by the well driller, and the comparatively near approach of rock to the surface elsewhere in its neighborhood.

For a few miles in the immediate neighborhood of Greene the east border of the upland is marked by an abrupt slope to the level of the river plain. Midway of this declivity numerous outcroppings of limestone are seen; they occur at advantageous points in which quarries have been operated, and they readily supply the local demands for building stone in the northern part of the county. Evidently the river at some time here skirted a rocky escarpment as many modern rivers do, but withdrew towards its present channel so long ago that a perfect talus slope has been formed, and the valley has been aggraded to a thickness of thirty feet or more.

In Pittsford township, a mile or more west of Bristow, Otter creek and a small tributary occupy for several miles a deep valley. As is indicated by the face of the quarries that have been opened up along the west side of the valley, the rock has been cut to the depth of twenty-five feet or more, above which the mantle of rock waste rises by less abrupt slope for forty or fifty feet more. The present gradient of the stream bed is evidently very nearly the same as that of the ancient stream, and, as it is quite high, it is manifest that the rock cut runs out quite rapidly. It is very likely, however, that the upper end of this valley was entirely filled with drift material, but the waters of the melting ice sheet, converging at the lower part of it, and rapidly gaining velocity in descending to the level of the plain of the West Fork, swept it clear of all glacial debris. As the glacial waters subsided and normal conditions of water supply obtained again, the irregular deposits of till made new lines of drainage necessary. The Coldwater, a manifestly young stream running at right angles to the course of the preglacial stream some five or six miles north of the open valley, has cut off the territory that made a large stream possible, and the diminutive creek that has succeeded the older one in its lower course, has wrought comparatively little change in all the years that have intervened.

KANSAN AREA.

With a few notable exceptions, most of which have been mentioned under the previous caption, the general surface of Butler county is that of a great drift plain crossed from the northwest

and west by three wide alluvial plains, through which its principal streams flow with easy gradient and consequently with slight erosional effects. The slopes bordering these plains rarely rise abruptly; indeed, in many places it is difficult to determine just where the bounding lines run, so gently do the declivities of the till come down to the alluvial plains. The well behaved streams are content to confine their meanders to the alluvial plains, rarely venturing to trespass upon the slopes of till. A notable and almost sole instance of departure from the rule is at Jerusalem hill, near the point where the West Fork of the Cedar crosses the line between sections 4 and 9, Beaver township. The West Fork here has worked its way well into the till, making a raw, precipitous bank some twenty-five feet high.

New Hartford Recessional Moraine.

Between the West Fork and Beaver creek there are three localities which attract the attention of the most indifferent observer. The largest and most interesting of these constitutes the entire upland region between the above named streams, extending a little north of west from beyond the eastern border of the county in Beaver township to section 9, Albion township, where its distinctive features give way to the ordinary topographic forms of this portion of the county.

Here, apart from the generally recognized Kansan drift area of the state, is a jumble of hills and ridges with their included valleys, not the work of extensive erosion, but rather of deposition, a moraine of Kansan till. Most of the hills are covered with Iowan loess of varying thickness. But, chiefly in section 30, Beaver township, a spur marking the southernmost extension of the moraine, is not only without loess, but has been swept bare of all finer material, leaving a surface of coarse sand, gravel, cobble stones and bowlders, as unproductive as the abandoned hill farms of New England and strikingly suggestive of them in structure and appearance. Here, in marked contrast with the commodious and comfortable farm houses of the neighboring plains and prairies, may be found the original log house of the earlier settler, eloquent of the severe and unremunerative struggle with the hard conditions of this, fortunately small, area where

nature seems to have been extremely chary in her allotment of favorable resources. It affords a fine opportunity for the application of the principles of forestry, the best use that can be made of it. Indeed it is becoming more or less wooded, especially upon the south and east sides. It rises with somewhat rounded but steep slopes eighty feet above the adjacent plain of the Beaver. On the north between it and the neighboring hills lies a characteristic morainic valley in which once rested a small body of water, but which has been obliterated, mainly by the filling of its basin with debris washed in from the surrounding slopes.

At the west end of the moraine the hills are relatively low, of lenticular form and somewhat thinly covered with loess. The hilly area rapidly broadens eastward and soon reaches its maximum expression in height and breadth.

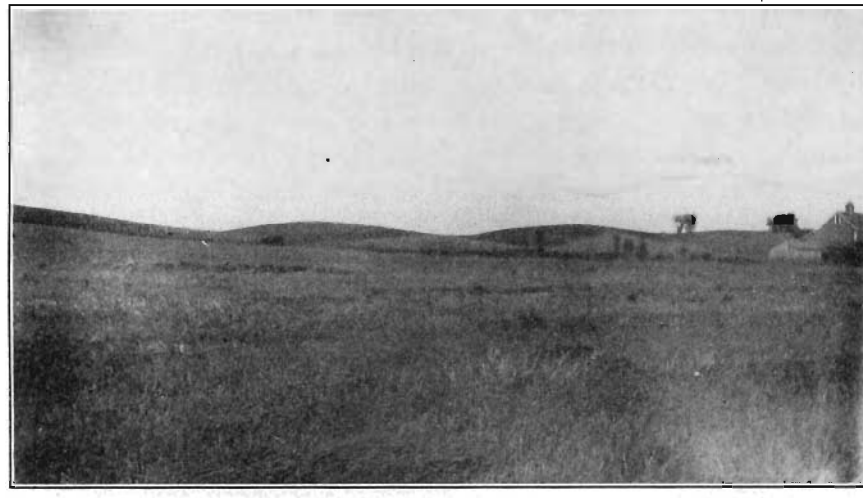

Figure 1. New Hartford hills near eastern end as seen from near center of section 26, Beaver township.

The elevations and depressions assume a confusing variety in form, size and relation to each other. There are extended ridges, elongated, rounded and irregular hills, narrow, deep valleys, wide, long valleys and short, flat bottomed valleys, having the appearance of having been the beds of small ponds that later found a ready outlet for their waters. The road on the line between the townships of Albion and Beaver passes through a

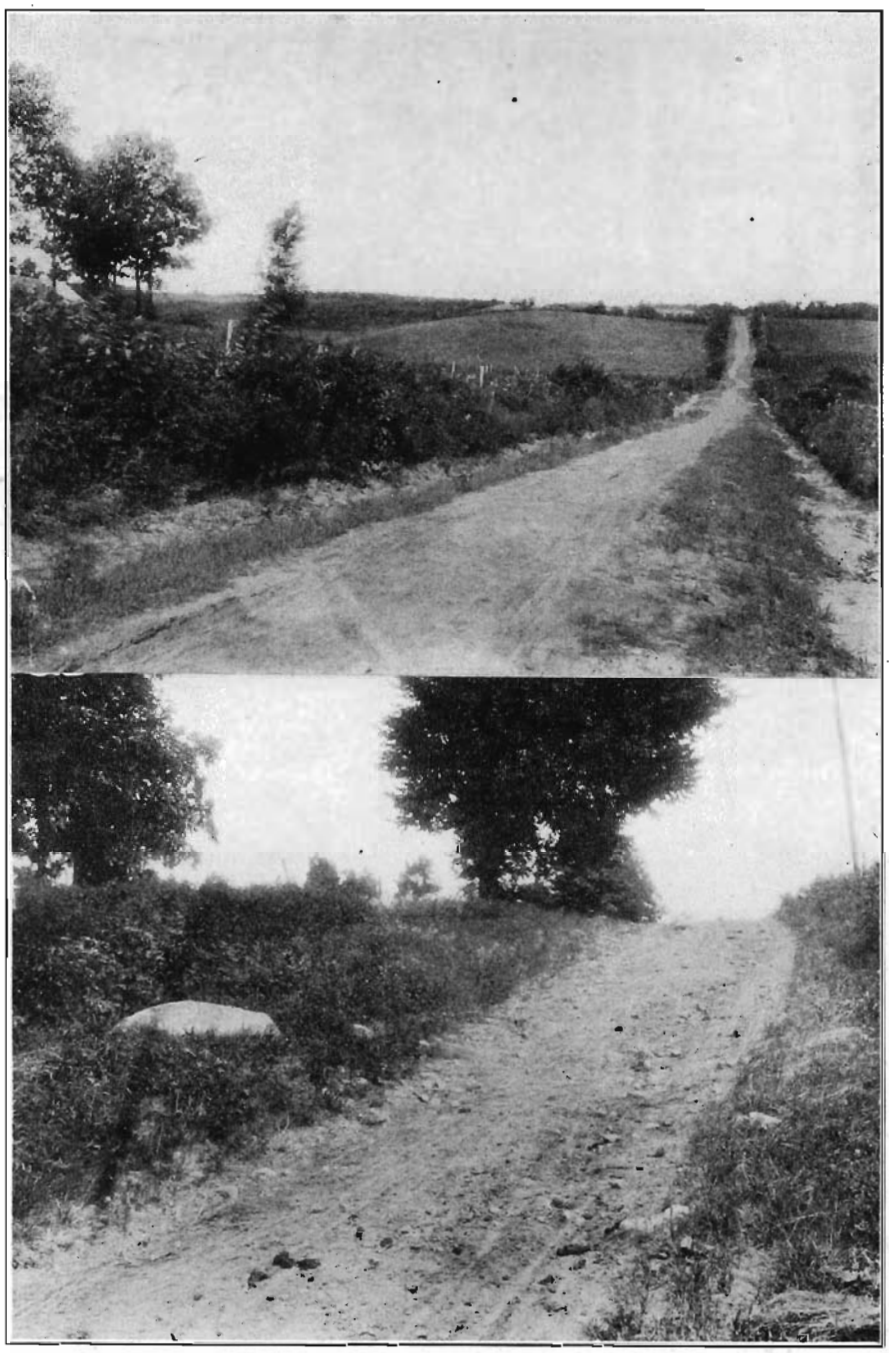

Plate VII. Upper view—Loess-Kansan topography due to what seems to be a modified recessional moraine of the Kansan stage. In the southeast quarter of section 19 and the northeast quarter of section 30, Beaver township.

Lower view—Stony road in the northwest quarter of section 25, Albion township. Some of the hills and knobs of what seems to be a recessional moraine of Kansan age are covered with deep loess; some, as in the view here shown, are bare and stony.

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very characteristic portion of the moraine. For two and a half miles it crosses a series of hills, some of which are very steep sided and narrow, others with gentle grade and lower summits. The whole western half or two-thirds of this moraine was originally heavily wooded and much of it is so still, but the eastern end is to-day well tilled everywhere, being much less rugged and intractable.

The entire congeries of elevations is covered with loess, usually yellowish in color, of varying thickness, except the portion already described, a portion that must for some reason have been bare of vegetation and thus gave a full sweep to the winds which not only left none of their burden on it, but carried away whatever of finely triturated material may have originally belonged to it. It is not clear why this spur should be thus exceptional, but as the ice retreated northward, lying as it does well out from the principal mass, it may have been exposed for some time before the rest and the fierce winds which blew off from the glacier, as must have been the case at times, at least, may have completely denuded it of everything within their power of transportation, so that later on when vegetation found the rest of the moraine an inviting field, this was then, even more than now, too forbidding to encourage any growth whatever.

Here, as elsewhere, usually the loess is moulded upon the hills, though it is heavier on the upper part and varies greatly in different portions of the moraine. The maximum depth observed is in a cut on the road between section 19, Beaver township, and section 24, Albion township, a little north of the point where the road running through the middle of section 19, turns to the east. Here some twelve feet of loess is exposed, the lower part of which is gray in color and abounds in vertical ferruginous pipes of concentric layers which often readily separate. The average diameter of these cylinders is about one and a quarter inches.

The underlying Kansan till was observed but rarely, but in the road a few rods east of the east line of section 26, Beaver township, a cut shows seven feet of Kansan till, most of which consists of well oxidized clay freely mingled with greenstone pebbles, some of which are glaciated, and granitic cobbles easily

crumbling. About a foot of the clay at the base of the cut is firmer and darker in color. Above the till are seven feet of loess, the upper foot of which is dark with vegetable mold. The Kansan appears also in the roadside in the central part of section 30, Beaver township.

Kansan bowlders are not uncommon in this neighborhood. Usually bowlders are few and these are generally concealed, but in sections 23 and 24 and in a few other localities in Beaver

Figure 2. Bowlder in section 26, Beaver township.

township, Iowan bowlders of considerable size lie in the lower levels as if the Iowan ice sheet pushed up between the less formidable hills of the eastern end without leaving much other trace of its presence there. In figure 2 is shown a large bowlder of unusual appearance that is to be seen by the roadside near the center of section 26. The surface is thickly embossed with dark, somewhat cruciform masses an inch above the surface sometimes, as if the ground-mass, hard as it is, had weathered out. The mineral constituents of the bowlder have not been determined.

The few well sections of which reliable data could be secured show not only that the entire mass above the stream level is of glacial origin, but that in places, at least, the rock beneath these hills lies at a lower level than in the stream valleys adjacent.

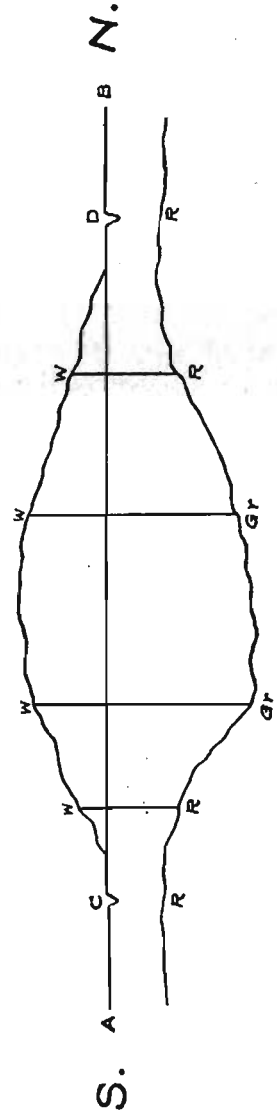

Figure 3. A diagrammatic section through sections 27, 22, 15 and 10, Beaver township, showing by the wells that the rock beneath the hills is at a lower level than that beneath the creek valleys. A B, level of the creek valleys; C, Beaver creek; D, West Fork; W, location of wells; R, rock; Gr, gravel beneath blue clay and probably just above rock.

Near the center of section 27, Beaver township, on the border between the valley and the moraine a drilled well is 101 feet deep, ending in rock, but its depth in rock could not be ascertained.

In the northwest quarter of section 27, on a hill seventy feet above the level of the alluvial plain a well is 190 feet deep, ending in gravel, probably Aftonian, beneath blue clay.

In the northwest quarter of section 22, a drilled well is 180 feet deep, ending in gravel beneath blue clay.

In section 15 on the north margin of the moraine a well is 122 feet deep, the last ten feet being in limestone.

The maximum height of these hills does not exceed ninety feet. Many of them, however, reach the height of eighty feet. The maximum width is more than three miles. They gradually lose their characteristic features as they pass into Black Hawk county, making way within three miles for the junction of the valley of Beaver creek with that of the Cedar river. They soon reappear on the south side of the Beaver, not however in strict alignment, but as an overlap starting farther south, and, though at first having very nearly the same trend, below the junction of the two streams just mentioned a more decidedly southeasterly course is taken and an average height of eighty feet is soon reached, bounding the Cedar valley on the south and constituting "The Bluffs" both east and west of Cedar Falls. Between Cedar Falls and Waterloo they reach their maximum expression where their morainic nature is fairly well developed in places.

Paha.

Beginning in section 16, Monroe township, and extending in a northwesterly direction into section 5, Washington township, there is an assemblage of hills tamer in aspect than those of the New Hartford moraine. Had this group continued far enough to the east it would have overlapped the New Hartford range on the south, bearing the same relation to it as do the Cedar river bluffs at its eastern end. The hills of Monroe and Washington townships are beautiful, elongated, smoothly rounded elevations, capable of tillage to their summits, loess covered and, of course, superficially free from bowlders, in this respect in marked contrast with much of the surrounding country. They do not lie in line one with another but run by

at the extremity *en echelon,* tnough in some cases so closely as to make a continuous ridge irregular in line both vertically and horizontally. The more typical central hills are steep sided. The included valleys as a rule are narrow. The north and south road between the two townships crosses over four or five ridges in close succession, the highest of which are forty or fifty feet above the adjacent valleys. Cuts in this road show beneath several feet of loess a coarse dark red sand containing pebbles of greenstone and crumbling granites. No further data as to their interior make-up was secured. Good water is obtained from hillside wells at a depth of thirty-five to forty-five feet.

West of Kesley, occupying chiefly portions of sections 26, 27 and 35, Madison township, is a cluster of heavily wooded hills, known as Bear Grove. There is little opportunity to learn the character of these hills beyond the fact that their surface is composed mostly of loess. In form they are more nearly round than are the hills a mile south of them and from which they are separated by a creek which joins the Beaver a dozen miles to the south and east. These two groups of hills and a third in Grundy county, some four or five miles south of the first named, belong to the pahoid type and are the farthest west of any known to the writer. Much discussion has been had as to the nature and origin of paha. One of the more recent occurs in the report on Bremer county.*

IOWAN AREA.

With the exception already named the surface of the county is made up of Iowan drift plains and the alluvial plains of the larger streams. In three townships of the northern tier, Fremont, Dayton and Coldwater, the drift is thin for the most part and the surfaces are determined to some extent by the underlying rock, but the drift gains in thickness to the southward, and the ordinary undulatory surface of the Iowan is manifest.

Near the center of Coldwater township, solitary and unique among the elevations of the county, stands Mt. Nebo, an ellipsoidal hill with the same trend as the pahoid hills north of

*Norton: Iowa Geol. Surv., Vol. XVI, pp. 377-382.

Aplington and the morainic hills north of New Hartford, but differing from both in the absence of loess. Superficially, at least, it is composed of gravel, but no means of ascertaining the nature of its core was presented. The topography of that part of its immediate neighborhood which is in alignment with its trend, especially to the southeast, seems to have been influenced somewhat by the same cause that produced it, but not to such an extent as to make inapplicable the term solitary as used above.

In Benezette township the drift material is much thicker, but the surface is unusually flat, there being just enough inclination to enable the excess of rainfall to find its way to Coldwater creek without anywhere cutting the sod. There is little that is exceptional or worthy of special note elsewhere in the Iowan drift area. Southeast of Clarksville, running across sections 29, 30, 31 and 32, Shell Rock township, is a series of eight ridges and intervening troughs of remarkable uniformity in trend, size and form. Their trend is nearly east and west. The three northward ones are gravelly to the tops. The others seem to be composed of Iowan drift material. Iowan bowlders are prominent in the depressions. The general effect here is that of decided ruggedness as compared with the surrounding country.

In the four northeast sections of Ripley township and sections 6 and 7 of Jefferson, the undulations assume unusual proportions culminating in the south part of sections 1 and 2 of Ripley and section 7 of Jefferson. In sections 11 and 12 they circle about in such a way as to form a huge irregular amphitheater forming a landscape of great beauty and attractiveness.

In the east and south of Pittsford township and in portions of Madison and Washington townships exposures, or the near approach to the surface, of the older formations modify the general effect of the drift to some extent, though many excellent examples of Iowan drift topography are to be seen in these townships.

The most characteristic expression of the Iowan is to be seen in West Point, Jackson, Jefferson and Shell Rock townships along the central part of the highland between the Shell Rock and the West Fork of the Cedar river. Throughout this region

everywhere is a maze of gentle swells and sags, rising here and giving way there, now persistent in long sinuous ridges and again quickly dissolving into others, but in almost imperceptible curvatures and changes of direction, never really obstructing drainage but providing for it in unexpected ways. In places bowlders are surprisingly abundant while elsewhere they are wholly wanting or found only in the sags. Sometimes they are invariably small or of moderate size, sometimes they are of truly giant proportions. Pilot rock in the west half of section 23, West Point township, has a girth of ninety-nine feet and a maximum height of twelve and one-half feet.

ALTITUDES.

A table of altitudes so far as these could be secured is appended. It will be noted that they are mostly for localities that are in the alluvial plains. The greatest elevations in the county are probably Mt. Nebo, chiefly in section 20, Coldwater township, and the hills of Bear Grove west of Kesley, but no figures are at hand to confirm the report. The highest hills about New Hartford have an elevation above the creek valley of about ninety feet. It is safe to say that the difference between the highest and lowest points in the county is about 180 feet.

LOCALITY.	ALTITUDE.	AUTHORITY.
Allison	1044	C. G. W. Ry.
Aplington	988	I. C. R. R.
Austinville	1006	I. C. R. R.
Bristow	1030	C. G. W. Ry.
Clarksville	924	C., R. I. & P. Ry.
Dumont	977	C. G. W. Ry.
Greene	955	C., R. I. & P. Ry.
New Hartford	895	I. C. R. R.
Packard	953	C., R. I. & P. Ry.
Parkersburg	951	I. C. R. R.
Shell Rock	921	C., R. I. & P. Ry.
Sinclair	921	I. C. R. R.

Drainage

Situated as it is within the Iowan drift area, the dendritic type of drainage is notably absent in Butler county, yet it can scarcely be said that it is not fairly well drained. It is wholly

within the basin of the Cedar river, its three principal streams flowing into that river within four miles of its eastern border in Black Hawk county, though the Shell Rock and the West Fork of the Cedar mingle their waters just before their common junction with that stream. Good drainage may be accounted for in part from the fact that its large streams divide its territory so equally that no large area is so distant from them but that its surface waters can be readily cared for by the multitudinous sags, intervales and wet weather streams that scarcely interfere with tillage. In the north tier of townships underground drainage is usually good through the jointed and much shattered limestone that immediately underlies the thin mantle rock.

THE SHELL ROCK RIVER.

The Shell Rock river, which rises just over the state line in Minnesota, pursues a uniform southeast course to its junction with the West Fork of the Cedar. About twenty miles of its course is in Butler county, which it enters just a little northwest of Greene and leaves a mile and a half southeast of Shell Rock. In common with its companion streams, most of its course is over a broad plain of aggraded material into which it has cut a channel of modest depth, and as it has a low gradient, its current is usually mild, and little aggressive work is done even at times of high water. At Clarksville and Shell Rock low limestone ridges run athwart its way, so that the country rock appears in its bed. At Greene and Shell Rock warrant is found for the construction of servicable mill dams. Its only noteworthy tributary from the east throughout its course is Flood creek, which rises near the northwest corner of Floyd county, and flows at an average distance of less than four miles from the Shell Rock and in strict parallelism with it till it has traversed about three miles of Butler county, when it suddenly turns at nearly a right angle and soon loses itself in the more abundant waters of the Shell Rock, which by an equally sharp turn has come half way to meet it.

Coldwater creek enters the northwest corner of the county, taking for six miles an east course, then a southeast course, till it reaches the alluvial plain of the Shell Rock, after which

it follows down that plain for four or five miles before it merges its waters with the main stream at the point where it turns towards the advancing waters of Flood creek. In its upper course, at least, it is a youthful stream and drains territory that in preglacial times paid tribute to a stream that today persists only in its lower course as a tributary of Otter creek. It occupies a narrow, well defined channel cut into the level plain of Benezette township. The tilled fields come down to the very water's edge at first, though a narrow flood plain harboring a fringe of natural timber appears lower down. Its course in Coldwater township was determined no doubt in preglacial times. A small prairie creek enters the Shell Rock west of Clarksville.

THE WEST FORK OF THE CEDAR.

Entering the county four miles north of the center of its west line, the West Fork of the Cedar river traverses the entire

Figure 4. View on the West Fork on the line between sections 10 and 11, Beaver township, showing the shallow bed of the stream.

county, a distance of twenty-seven miles in a direct line, crossing its east line in section 12, Beaver township. A single tributary enters it from the north in each of the three townships of Madison, Ripley and Beaver. The second and third are scarcely more than the average prairie creek, the name of the third, Dry Run, being suggestive of its intermittent character. The first, Otter creek, is entirely unassuming for the first six or seven miles of its course, when in section 14, Pittsford township, it quickly finds its way to the level of the old valley already mentioned under the topic, Preglacial Topography, where, skirted upon the west by an escarpment made by a series of quarries in the Devonian limestone and upon the east by high but moderately gentle slopes, it acquires an interest and importance quite beyond any ability its meager waters of today can command.

Hartgrave and Mayne creeks are considerable streams joining the West Fork on the south, the one near the southwest corner of section 35, Pittsford township, and the other near the center of section 7, Ripley township. Both perform an important part in the drainage of Franklin county, but much less is done for Butler county owing to the promptness with which they reach their master stream. Hartgrave creek has the broad alluvial valley underlain with many feet of oxidized gravels so characteristic of most of the streams of this county. Mayne creek has one or two small streams joining it in Madison township. Its valley for the most part is relatively narrow.

BEAVER CREEK.

Beaver creek, the third of the tributaries of the Cedar in this county, flows across the county in a nearly direct line, entering it in the southwest corner of section 31, Washington township, and leaving it in the northeast corner of section 36, Beaver township. In eastern Washington, in Monroe and in western Albion townships its course is between two and three miles from the south border of the county. Elsewhere its flood plain takes in nearly all of the county south of its course. Once well within the county limits it enters a deeply eroded valley which is narrow and with little alluvium, but which within less than

two miles begins to widen and quickly assumes the more prevalent characteristics of the Butler county streams. The South Beaver comes in at Parkersburg, while two miles farther east a smaller branch enters from the northwest and yet another in section 23, Washington township. Each of these tributaries is of the usual type of prairie streams with little that is distinctive or noteworthy, even in detail.

By means of the streams mentioned above the drainage of the county is accomplished quietly but very efficiently nevertheless. With the exceptions that have been named these streams are remarkably uniform in having wide, flat valleys, moderate meanders, shallow beds, barely reaching below the alluvium, and few branches located principally near the north and west borders of the county. True swamps are practically unknown. A few ponds occur in Fremont, Dayton, Madison, Albion and Beaver townships. They are small and most, if not all of them, will disappear with the better drainage that attends upon the complete settlement and general cultivation of the land. Seepage springs are failing in like manner. A few perennial springs may be found especially along the old eroded valleys in eastern Pittsford and southern Washington townships.

STRATIGRAPHY

General Relations of Strata

The natural exposures of indurated rock in Butler county are confined to the northeast and southwest thirds of its area. The Middle Devonian alone is represented in the former and the Upper Devonian and the Kinderhook of the Lower Carboniferous in the latter area, while the Pleistocene is represented almost everywhere. No certain evidence of pre-Kansan glacial deposits is known, but the Kansan is very generally distributed, though it is pretty effectually hidden by the Iowan, despite the scantiness of the latter, since post-Iowan erosion has wrought very slight changes, due not only to the comparatively recent deposition of the Iowan drift, but quite as much to the little difference between the maximum and minimum altitudes over the greater part of the county and the consequent absence of high gradients. In the New Hartford hills and other localities where high, steep slopes prevail, thick deposits of

loess, with its well known resistance to vertical erosion, provide an adequate protection to the underlying Kansan.

No deep wells have been sunk in this county, and so nothing is known experimentally of the older underlying formations, but the deep wells of Waverly, Waterloo and Ackley, not far from its borders, as well as logical inference from well known general geological principles give every reason to believe that the preceding formations in the geological column occur in order at normal distances from the surface.

SYNOPTICAL TABLE OF FORMATIONS.

The following table gives a graphic exhibit of the sequence of the strata as recognized within the territory under consideration, named in accordance with the latest geological section adopted and used in the publications of the Iowa Geological Survey.

GROUP	SYSTEM	SERIES	STAGE	FORMATION
Cenozoic	Quaternary	Recent		Alluvial Aeolian
		Pleistocene	Iowan	Loess Drift
			Kansan	Buchanan gravels Drift
				Residual material
Paleozoic	Carboniferous	Mississippian	Kinderhook	Limestone Sandstone
	Devonian	Upper Devonian	Lime Creek	Shales Limestone
		Middle Devonian	Cedar Valley	Lithographic limestone, etc.

DEVONIAN SYSTEM

Middle Devonian Series

CEDAR VALLEY STAGE.

Exposures and Sections.

The Devonian rock system is represented over a widespread area, about fifteen-sixteenths of the whole county, eleven-sixteenths of which belong to the Cedar Valley limestone of the Middle Devonian, the remainder to the Lime Creek shales of the Upper Devonian. The terrane that here is outspread is unusually broad. The first rock exposures in the northeast corner of the county are to be seen along the midsides of the preglacial valley in Fremont township, especially in section 22. It is a stromatoporoidal limestone. In the northwest quarter of section 3, Butler township, some quarrying has been done in one of these outcrops. Here the lithographic character of the stone is apparent. Weathered specimens are of a chalky white appearance, but the conchoidal fractured surfaces are drab, though along joint planes they are yellowish with iron stains. The rock is characteristically brittle, is smooth, compact, fine grained and rings under the hammer. The Stromatoporas are usually of the sheet-like type. A few of the small spherical ones were seen. A single fish tooth was picked up here.

A quarry from which considerable stone has been taken is in the south half of section 35, Butler township, just east of the Great Western railroad track. Little of geological interest is presented, however. The stone is a thin bedded dolomitic limestone, firm textured, finely granular, or crystalline, from buff to drab in color and non-fossiliferous and very uniform in vertical section, excepting that in the fourth foot from the base pockets and seams of crystals appear.

In the southeast quarter of section 11, Shell Rock township, a quarry gives the largest section to be found in this part of the county, though it has been too much modified by the weathering agents to be considered fully representative.

	FEET.	INCHES.
6. Limestone, gray, non-fossiliferous, first four feet somewhat firm, the rest thin bedded and shattered, dolomitic	7	
5. Thin bedded limestone containing *Atrypa reticularis*, a spirifer, a small gastropod and a small branching coral	4	
4. Massive limestone with a soft yellow matrix having in it numerous small hard nodules, making a very irregular weathered surface. A single *Atrypa reticularis*, a gastropod and small branching corals were found in it	3	4
3. Limestone, at times massive, elsewhere with bedding planes, of uncertain hardness and color due to weathering	2	
2. Soft gray limestone, with numerous small yellow spots, breaking into irregular blocks that obscure the bedding planes, weathering so as to allow No. 3 to overhang	1	3
1. Drab, compact, hard, brittle limestone, lithographic in inferior degree	1	6

In the road between sections 14 and 15, same township, an outcrop of limestone of manifest lithographic character is the last rock exposure in the county towards the south and east.

The only other opportunity of observing the Cedar Valley limestone in the south half of the county is in the west half of section 9, Jefferson township. It is an artificial exposure made through the drift evidently for quarrying purposes. The following section was secured with difficulty as the mantle of waste by washing has covered much of the rock, no work having been done here for a long time apparently.

	FEET.	INCHES.
6. Iowan drift	5	
5. Weathered Kansan till	6	
4. A soft, yellow stone which has lost its lithographic character entirely, glacially smoothed and striated	1	6
3. A gray, hard, somewhat coarse grained limestone		11
2. A drab, irregularly jointed limestone	1	11
1. A very good grade of lithographic limestone irregularly layered		9

At another point six feet of blue Kansan till was observed, but the nine feet of material above it was so overgrown with vegetation and had been so mixed by washing previously, that its true nature could not be determined with assurance. The

slopes about the quarry indicate that a sink hole may have suggested the practicability of securing stone here, though no sinkholes were noted elsewhere in this vicinity.

A quarry in the center of section 35, Dayton township, furnishes the following section:

		FEET.	INCHES.
10.	Thin bedded yellow limestone, becoming thinner and more shattered toward the top	4	6
9.	Clay parting with a two-inch band of ferruginous limestone, more or less persistent, just above the middle		11
8.	Yellow limestone joining No. 7 with a comb-like suture, in three parts: (a) 2 inches, very nodular; (b) 5 inches showing on the weathered edge many fine laminæ; (c) more homogeneous, yellow, soft. This is the yellow, modified lithographic stone found just above the typical lithographic in so many places	1	
7.	Two layers, lower, laminated, upper, nodular; both gray, very brittle, much jointed and rusty along joints	1	4
6.	Clay parting		6
5.	Limestone in two layers; the lower, one foot thick, has a powdery white upper surface, beneath which is the gray compact stone which has an uneven surface of fracture, due to an obscure nodular structure	1	9
4.	Clay parting, yellowish brown below, green above		3
3.	Dolomitic limestone in two equal layers, jointed, gray, finely saccharoidal, upper surface rusty	2	3
2.	Greenish clay parting with hard nodules		3
1.	Very good lithographic limestone in two layers, upper four inches thick, lower undetermined		8

Outcroppings were seen in the road between sections 25 and 36, between sections 9 and 16, 8 and 17 and 7 and 18, Dayton township. The stone is quite like that in numbers 3 and 4 of the quarry in section 35. That between sections 8 and 17 affords specimens of papillated Stromatopora, otherwise all the rock in the outcrops readily suggests beds 3 and 4 of the quarry last mentioned.

Several quarries have been worked to a limited extent in the bluffs that mark the western border of the rocky tableland between the valleys of the Shell Rock and Flood creek just below Greene, from one of which the following section has been taken.

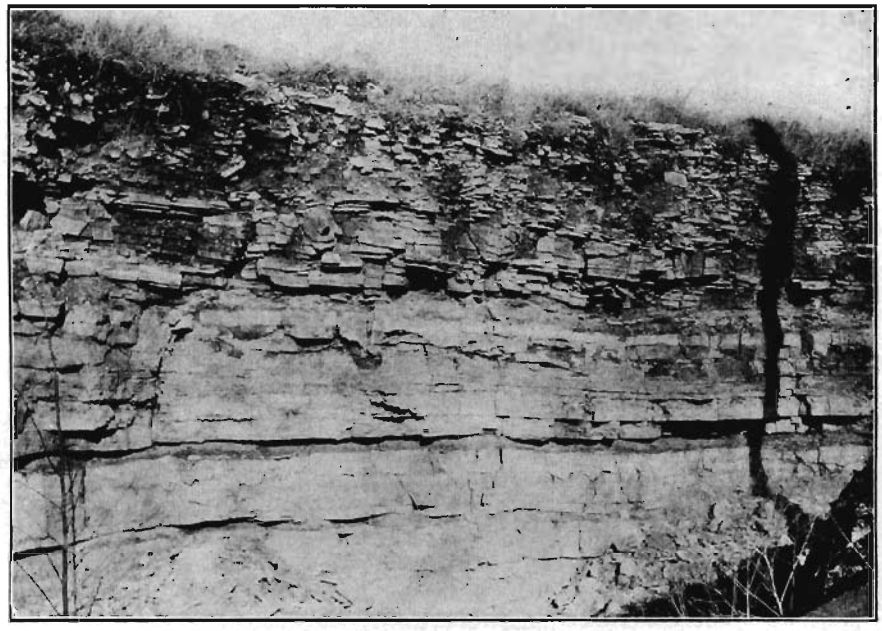

Figure 5. Schrader quarry, section 35, Dayton township, showing the flaggy, lithographic facies of the Cedar Valley stage.

		FEET.	INCHES.
8.	Limestone, the upper nine inches of which is nodular, heterogeneous, gray; the lower part is gray on fracture, yellow along joints, stromatoporoidal, smooth, firm, compact	3	5
7.	Shaly layer		7
6.	Yellow limestone in three imperfect layers; of same horizon as No. 8 in section 35	2	
5.	Thin layered, shaly limestone		10½
4.	Very brittle, nodular, gray limestone, yellow along joints	2	4
3.	Much like No. 4		10½
2.	Clay parting		10
1.	Drab, sugary limestone, dolomitic, (No. 3 of section 35)	2	2

On the west side of the river, near the southwest limit of the city, a quarry has been worked quite extensively. A section here gives the following:

		FEET.	INCHES.
14.	A many layered and fragmental limestone with a small undetermined brachiopod in the upper layers, lower beds white where weathered, but gray on fracture, and somewhat granular	4	8
	Clay parting		2
13.	Lithographic limestone, many layered, much jointed, lower layers light gray, upper drab, a nodular band in the lower part of the upper third	3	7
12.	A shelf holding quarry debris conceals the stone of this number	3	
11.	A buff limestone, the lower part very soft and earthy, the upper firmer, but many layered	4	
10.	Dolomitic limestone in three layers, (a) the lower not everywhere distinct, soft, brownish yellow, breaking into lenticular pieces, 4 inches, (b) drab, granular, breaking vertically into large conchoidal flakes, 8 inches, (c) freely spotted with small patches of calcite crystals, 5 inches	1	5
9.	A firm, compact limestone of smooth fracture, irregularly laminated, upper surface wavy		8
8.	Clay parting		1
7.	A gray to drab limestone weathering to a creamy yellow, tending to divide in irregular layers, jointed	1	5
6.	Clay parting		1
5.	A gray, fine grained limestone with powdery surface and numerous rusty spots, in three layers, middle layer inclined to buff. (No. 5 of quarry in section 15)		9
4.	Thin shales in clay		7
3.	A gray limestone in two layers joined by a toothed suture, upper layer finely granular, lower hard, brittle, but of irregular fracture on account of its nodular structure	1	8
2.	A shaly clay parting		2
1.	A very good grade of lithographic limestone in two layers, 6 and 10 inches	1	4

Near the northeast limits of Greene a quarry exposure gives beds almost wholly of the lithographic and white limestone types.

An exposure in the northeast quarter of section 14, Coldwater township, gives the following section:

		FEET.	INCHES.
3.	An indistinctly layered limestone creamy where exposed, but drab on fracture, and much streaked and spotted with calcite and iron stain.....	2	8
2.	A drab lithographic limestone.....		9
1.	A drab nodular limestone, stromatoporoidal at top, weathering oddly on account of its structure.....	2	5

For a quarter of a mile along the line of sections 11 and 14 a band of rock borders the upland terrace along the valley of Coldwater creek. In the northwest quarter of section 26, Coldwater township, is an outcrop of soft, yellow, earthy limestone similar to that in sections 11 and 14 and also very like that in number 11 of the West Greene quarry.

Numerous outcrops occur in sections 10, 15, 25 and 36, Coldwater, and sections 28, 29, 30, 31, 32 and 33, Dayton township. The rock is somewhat different in the different localities, some being stromatoporoidal, some of the white limestone type and again of the more strictly lithographic phase, evidently correlating with the rock of the outcrops and of the upper beds of the quarries east of the river.

In section 1, Benezette township, lithographic limestone occurs. Two loose pieces, unlike the rock of any other part of this region, were highly fossiliferous, being made up largely of crinoid stems, dendroidal Stromatoporas and brachiopods, in this respect suggesting an outcrop in Union township, Black Hawk county.

A belt from eight to sixteen miles wide along the northwest and southeast diagonal of the county is entirely free from natural outcrops of rocks. The old pit quarry in section 9, Jefferson township, exposes the only rock seen in place within this extensive area. The only occurrence at the surface of the Cedar Valley limestone west of this belt is within the east third of Pittsford township. The same horizons are here displayed as in the quarries east of this diagonal and the absence of fossils is even more marked than in the rock of the northeastern part of the county. For correlating the beds in Pittsford township therefore, dependence must be placed entirely upon their lithological character. Fortunately this is quite uniformly sustained in some of the beds, the lithographic stone being quite exceptional in this particular.

An outcrop on the west side of section 34, Pittsford township, has been quarried into, to some extent for a local supply. A nearby barn is built of stone evidently taken from this place. The rock is of the so-called white limestone phase, originally heavy bedded, but by weathering many irregular layers have been developed and numerous small veins of calcite appear. Calcite crystals also fill the few molds of *Atrypa reticularis* that occur. This brachiopod and a small branching stromatoporoid make the sum total of organic remains definitely manifest in the rock in this locality. Across the road near the remains of an old lime kiln considerable quarrying had been done superficially, but the mantle rock in washing had made any satisfactory observation impossible.

Along the west side of Otter creek in sections 23 and 26 and along a branch of this creek in section 11, considerable quarrying has been done. Two sections from this locality are given:

HEWITT'S QUARRY.

		FEET.	INCHES.
14.	Thin bedded limestone, the lowest 2 inches a dark drab, the rest yellowish and much iron-stained, a little granular, but often showing a firm, smooth surface with conchoidal fracture	5	6
13.	Clay parting with lenticular masses of limestone as if the matrix of stone had broken down, the more resistant portion only remaining		10
12.	Dolomitic limestone in five layers, the two lower with a toothed suture, saccharoidal, yellowish brown	2	
11.	An interesting bed varying in thickness, the beds below bending down where No. 11 is thick and up where it is thin or entirely wanting	0-2	
10.	Clay parting		2
9.	Bed of about four layers, upper stromatoporoidal	1	10
8.	Clay parting		3
7.	Lithographic limestone, several layers in places but only two usually	1	5
6.	Clay parting		2
5.	Limestone, drab, splintery on fractured surfaces, in two layers with toothed suture, 8 and 4 inches	1	
4.	Clay parting		3
3.	Lithographic limestone	1	2
2.	A dolomitic limestone, showing several layers with some constancy, grayish, brittle, splintery, saccharoidal and having patches of calcite	4	8

1. Several irregular layers varying from an earthy, granular dolomite above to a more compact stone with glints of calcite and dendrites along delicate cracks, all somewhat iron stained..... 2

At a point a little northeast of this quarry, rock below No. 1 is exposed for five and one-half feet. It is soft, yellowish or whitish, earthy, in layers about three inches thick.

The variableness in thickness of No. 11 is quite remarkable, both in linear extent and in uniformity of occurrence, seven of these alternations being found within ten rods, and is very noticeable everywhere in the escarpment along the creek. It seems to have been due to a slight deformation of the beds immediately underlying it, which produced a series of slight anticlines and synclines and thus formed an undulatory surface which the next deposit of sediment filled to an even line, with one or two slight exceptions, where the upper beds partake a little of the unevenness. At one point crushing is quite manifest, an accompaniment of the movement that took place at the time of the deformation.

S. S. JACKSON'S QUARRY, SECTION 11.

		FEET.	INCHES.
11.	Many feet of sloping drift, 2 or 3 feet of which, resting immediately upon No. 10, is exposed, a sandy loam		
10.	Very thin bedded limestone.....	1	2
9.	Clay parting		2
8.	Reddish brown limestone.....	1	
7.	Clay parting		2
6.	Thin bedded yellowish limestone. The first two layers are jointed rarely and so yield large flags serviceable in walks and the like.....	2	7
5.	Yellowish brown limestone, earthy and containing numerous patches of calcite as well as crystal lined cavities	1	
4.	A drab lithographic limestone in several beds with thin clay partings, the lowest bed in several layers, the upper in two, the uppermost more or less disintegrated. Below the middle of this stratum there is a nodular layer due perhaps to an obscure stromatoporoidal structure; about.....	7	
3.	A yellowish brown, granular dolomite in three nearly equal layers	3	2

2.	A yellowish gray dolomitic limestone with calcitic patches, the lower two-thirds having numerous yellow lined cavities of variable form, the size varying from a small fraction of an inch to an inch or more in diameter. At first soft, it soon hardens on exposure and makes a durable building stone.	2	2
1.	A gray dolomitic limestone, called sandstone by quarrymen; quite firm. A good quarry stone.....	1	5

The above mentioned sections and outcrops include nearly all the exposures of the Cedar Valley limestone in the county. In the northern half of the county it has an east and west extent of nearly twenty miles and a total vertical extent that is accessible not much exceeding thirty feet. The fossils that occur are largely of a stromatoporoidal character, including mostly those of the lamellar type, though a few are spheroidal or cylindrical. A few specimens of *Atrypa reticularis* and other brachiopods were seen. They are found only in the upper beds and as the lithological characters of the lower beds are more variable than those of the upper, conclusions can be drawn in most instances only from the superposition of the beds. As the lithographic beds are very generally distributed and certain dolomitic beds maintain quite a constant relation to them, even though they exhibit variations in thickness and other physical features, it seems unlikely that the conclusion that the vertical range of the exposures of the Cedar Valley limestone in Butler county scarcely exceeds thirty feet is incorrect.

Upper Devonian Series

LIME CREEK SHALES.

Owen Beds.

Acquaintance with the Lime Creek shales has been gained principally from the typical locality at the Hackberry Grove clay banks and neighboring exposures mostly in Cerro Gordo county. The area of this stage of the Devonian has been clearly defined only in the above named county by Calvin* and in Franklin county by Williams.† From the reports of both these writers it was evident that the Lime Creek shales extended somewhat into the northwestern portion of Butler county. Quite unexpectedly, however, it has been found that a lobe of this stage

*Iowa Geol. Surv., Vol. VII, Geol. Map, facing p. 192, and pp. 161-170.
†Iowa Geol. Surv., Vol. XVI, Geol. Map, facing p. 506, also pp. 477-481.

extends southeasterly across the county and well into Grundy county, as is evidenced by well sections, though no surface exposures are found within three miles of the south border of Butler county.

EXPOSURES AND SECTIONS.

In the road on the county line along the southwest quarter of section 6, Pittsford township, there is an exposure of a yellow calcareous rock packed with fragments of fossils so worn and weathered as to be unidentifiable, but free by the roadside were casts of small *Atrypa reticularis* Linn., also specimens of *A. aspera* var. *hystrix* Hall var., *Stropheodonta arcuata* Hall, a small unidentified brachiopod and a gastropod not recognized.

Mr. Wm. Sprole speaks of encountering a blue soapstone in sinking a well on his place near the schoolhouse in the northeast quarter of section 19, Benezette township. This undoubtedly is the blue clay of the Hackberry shales.

Just west of the bridge across Hartgrave creek, along the south line of section 29, Pittsford township, yellow calcareous shales appear in which were found *Atrypa reticularis, Atrypa aspera* var. *hystrix, Spirifer whitneyi* Hall, *Strophonella reversa* Hall and a small cyathophylloid coral. This is believed to be the same horizon as No. 3 in Calvin's section at Hackberry Grove.* At the top of the hill in the field on the north side of the road is a rocky ridge where quarrying has been done. The excavation is quite superficial and the exposed layers show little variation. The rock originally was heavy bedded, apparently, but has weathered into irregular layers and masses white, drab, gray and yellow, often made up entirely of corals, largely *Pachyphyllum woodmani* White, and less commonly an Acervularia. *Stromatoporella incrustans* H. & W., is also abundant and of considerable thickness as well as superficial extent. The two Atrypas found in the shales of the hillside and two or three other brachiopoda were noted, while the rock was sometimes made up almost wholly of fragments of their shells cemented together. This is the horizon of No. 4 in the Hackberry Grove section and therefore represents the Owen beds. This exposure may be referred to as Wickham's quarry.

*Calvin: Iowa Geological Survey, Vol. VII, p. 162.

In the southeast quarter of section 6, Madison township, a low ridge running northwest and southeast has along its eastern slope near the top an outcrop of rock of the same horizon as that at Wickham's quarry. Several similar ridges and outcroppings may be noted south of this. At one place just above the limestone is a yellow shale with numerous limestone masses in it and also with cup corals and Cladoporas. This overlying shale was noted nowhere else in connection with the outcrops of this horizon.

In the southwest quarter of section 15, some quarrying had been done in a limestone, somewhat thin bedded, similar to that in the exposures just named. About eight feet of rock is exposed. It is yellowish brown where weathered, but drab on fresh fractured surfaces. The layers show little difference except that the upper are quite fossiliferous, a cyathophylloid coral predominating. A Cladopora is quite common also. Along the road south in section 21 and east in sections 26 and 27, several outcrops were seen.

On the east side of section 35, Mr. Thomas Faint has quarried stone for a large barn, the walls of which abound in fossils, among which may be mentioned *Stromatoporella incrustans, Alveolites rockfordensis* H. & W., *Pachyphyllum woodmani, Spirifer whitneyi, Naticopsis gigantea,* one or two smaller gastropods, a Cladopora and fragments of the stems of a crinoid. The layers are quite irregular and a satisfactory section is impossible, but the following is approximately correct.

		FEET.	INCHES.
4.	A less rifted, more granular and compact limestone than was noted in the outcrops elsewhere in Madison township, but containing numerous fossils such as have already been enumerated.....	2-3	
3.	Limestone, much broken, rusty along joints, but gray on fracture, having numerous calcitic pockets	5	
2.	A dolomitic layer, compact, minutely crystalline, drab, conchoidal on fracture.....		4
1.	Two very fossiliferous layers not well seen in place for quarry debris. *Atrypa reticularis, Strophonella reversa,* two or three Spirifers, a minute branching Stromatopora, perhaps, etc., occur. Each...		4

This section belong to the Owen beds, undoubtedly, and at least a portion of it is referable to the horizon of No. 4 of the Hackberry Grove section. The rock is of fairly good quality for building purposes and in some layers differs quite materially from that seen elsewhere, but the testimony of the fossils settles all doubts as to the place of these beds in the geological column.

In the southwest quarter of section 9, Albion township, appear the most southeasterly outcrops of indurated rock to be found in the county. One is near the road along the west line of the section, the other is in a pasture an eighth of a mile or so to the east. The rock, which is a brown, finely crystalline dolomite, is fragmental and yields very many casts of *Atrypa reticularis*. No other fossils were seen. The rock as well as the fossil casts give strong evidence that this outcrop, too, belongs to the Owen beds.

The only other exposures of the Lime Creek shales noted are by the roadsides a half mile north of Aplington. Near the west line of the section in the roadside ditch about four feet of shales may be seen. The lower and greater portion is a light gray argillaceous shale, slightly ferruginous and indurated in places. Immediately above this is a thin brown layer overtopped by a darker band. Common dark soil rests upon this band. No fossils were seen. An eighth of a mile east, a north and south road cuts the hillside, leaving eight or ten feet of bank upon the east side. In the lower five or six feet of this bank the rock is brown, breaks freely into irregular blocks never more than four or five inches thick and shows no well defined layers. In the upper two feet the rock is light gray, thin layered and sparingly fossiliferous. Casts of *Atrypa reticularis* are most numerous, a few of which are of moderate size. The majority, however, are small, some being extremely so. The rarer individuals of *A. aspera* are also much reduced in size. The rest of the bank is made up of a bed of gravel overlain with a sandy loam. Here too, was found a single specimen regarded by Calvin as *Bellerophon pelops* Hall, or a form very closely related to it. "The only reason for entertaining any doubts is that Hall's specimens of the species came from the old Upper Helderberg, Corniferous, or as it is now called, the Onondago limestone, while

yours comes from the Upper Devonian. There are other cases of the same kind, however, forms characteristic of the Corniferous of New York occurring in the Lime Creek shales of Iowa."—Calvin.

In the fossiliferous beds of the Lime Creek shales the sturdy *Atrypa reticularis* is notably prevalent. *A. aspera* var. *hystrix,* though never as abundant, is nearly as universal in its occurrence. But in the southern borders of this stage of the Devonian even their hardiness and readiness of adaptation yield to the changing conditions indicated by the increased dolomitic and argillaceous character of the rocks, and variably undersized specimens predominate.

CARBONIFEROUS SYSTEM

Mississippian Series

KINDERHOOK STAGE.

Numerous outcrops of the Kinderhook stage are noted by Williams* as occurring in the eastern sections of Geneva and Osceola townships in Franklin county. These townships border upon Madison and Washington townships, Butler county. The northernmost of these outcrops is described as "a nodular, fossiliferous limestone in the road on the east edge of section 13, Geneva township." This is within a mile and a half of an exposure of the Lime Creek shales in section 17, Madison township, Butler county, from which fact it might be inferred that the rock observed by Williams is not far from the base of the Kinderhook.

EXPOSURES AND SECTIONS.

The northernmost exposure of the Kinderhook observed in Butler is in the road between sections 7 and 8, Washington township, where a light gray shale containing calcareous nodules, topped with a thin layer of chert, appears. Near the middle of the east line of section 17, a small quarry on land belonging to Mr. H. K. Brower gives a section of eight or nine feet in the Kinderhook as follows:

*I. A. Williams: Iowa Geological Survey, Vol. XVI, pp. 487-488.

		FEET.	INCHES.
3.	A yellowish shale with thin calcareous layers and a poorly developed layer of chert	2-3	
2.	Five layers of limestone, similar to No. 1		6
1.	A heavy bed of limestone with few joints and a tendency to cleave irregularly along a few imperfect seams	6	

No. 1 varies in color, ranging from a plain light gray to a darker mottled gray and even to a light tan; it varies also in structure, the plain gray being semi-oolitic, but with small rhomboidal crystals of calcite freely disseminated through it. The mottled gray is a fine breccia of brachiopod shell fragments and hollow spines of some Productus, with which are gray crystals of calcite and many spots of a yellow earthy material to which the mottling is due. In both of these, numerous minute tubular or spherical openings are very characteristic as seen under the lens. The tan variety has larger and more abundant crystals in a matrix of extremely minute earthy and shell fragments freely intermingled. Weathered edges of the mottled variety develop thin laminæ, the earthy material dissolving out and the shell fragments presenting a peculiar hackly surface. Identifiable fossils are few. Professor Calvin has recognized *Athyris proutii,* and a spirifer of uncertain relations. Two undetermined species of Productus were found. The lithological character of this rock suggests that in No. 1 of the sections at Alden and at Eagle City, Hardin county* and also faunally as well as lithologically it seems to be of the same horizon as No. 2 in Williams' section at section 10, Geneva township, Franklin county.†

On the west line of section 19, Washington township, the road makes a cut exposing several feet of Kinderhook material, the uppermost foot of which is an arenaceous limestone, not very firm, yellowish gray much streaked with a dark brown. The rest of the cut is a calcareous sand, white, yellow, brown and even red. In it are irregular indurated masses that have withstood the weathering better than the rest. Neighborhood indications are that chert overlies it where it might be found in place. Farther south chert outcrops in the road and in one

*Beyer: Iowa Geological Survey, Vol. X, pp. 268-269.
†Williams: Iowa Geological Survey, Vol. XVI, p. 486.

place along the west line of section 30, a white sugary limestone may be seen beneath the layer of chert. Chert fragments are very plentiful along the hillsides in all of the southwest sections of Washington township. In some places, as near the school house in section 32, they seriously encumber the fields.

At several places in sections 31, 32 and 28, Beaver creek has removed the talus from the bordering slopes and exposed the rocks of the Kinderhook for a considerable height. The most extensive section of the Kinderhook in the county is at the junction of a small tributary from the south with the Beaver in section 31, as follows:

		FEET.	INCHES.
7.	A thin bedded yellow to drab limestone with bands and nodules of chert	3	
6.	Brown, sugary, dolomitic limestone with a five-inch band of chert in the lower half	1	10
5.	Chert band		5
4.	Hard, compact, finely crystalline, gray to yellowish limestone in three well defined layers	4	
3.	Soft, somewhat crystalline limestone irregularly layered, but with two distinct chert bands	6	
2.	Limestone, in several poorly defined layers and having two chert bands near the middle	8	5
1.	Massive sandstone, soft, yellow, rarely jointed	1	6

No fossils were seen here and the rock has no striking characteristics that suggest sections described elsewhere by others. The chert, as has been mentioned above, is a common feature of the Kinderhook in Franklin and this county. Irregular bedding is quite noticeable.

Along the left bank of the Beaver there is an escarpment of soft calcareous sandstone for three hundred rods or more, and ten feet high. Near the top in places a cherty layer appears and near the base thin layers of dolomitic limestone may be seen. The color varies from a light red brown above to a dark brown below. A few rods west of the railroad bridge over the Beaver, just west of Austinville, some quarrying has been done, exposing ten feet of a soft, yellowish brown, calcareous sandstone with a cherty band near the top. These two last mentioned outcrops are to be identified with the basal member of the more extensive section mentioned immediately preceding this.

While the area of the Kinderhook in Butler county is not more than fifty square miles, its expression is unusually varied, each outcrop having an individuality of its own. The dip is nowhere unusual and the vertical range is believed to be moderate. In a few instances correlation with certain sections in Franklin and Hardin counties has been made with a degree of assurance, but the exposures in the southeastern part of the area, which are by far the most extensive vertically, are non-fossiliferous, show merely general similarity lithologically with beds of this stage as described in other localities, and evidence as to order of superposition is only indirect. Nevertheless, while the exact horizon of these beds may be uncertain, it is unquestionably true that their position is not far from the base of the Kinderhook column.

RESIDUAL MATERIAL

As soon as the marine deposits represented in the county had been lifted above the water, weathering became active and the exposed surface was modified, the rock crumbled or became pulverized and often leached, till only the more insoluble portions remained. In some places this leached material, mingled with rock fragments, overlies the rock, having been undisturbed by the moving ice masses of the glacial epoch.

In portions of the southern sections of Washington township where the chips and blocks of chert are so prominent, there is little or no drift, and the mantle rock is a residuum chiefly of preglacial origin. Usually, however, the ice sheet obliterated the ancient residuum as a distinct factor, ultimately leaving in its place a much greater quantity of material consisting of rock flour mingled with this residual matter and fragmental rock of wide range in size and composition. In some of the northern townships this is very apparent, for the country rock appears here and there in the roads and fields rounded and smoothed like miniature *roches moutonnees,* while the thin mantle rock is manifestly till with some organic matter superadded or intermingled.

QUATERNARY SYSTEM

Pleistocene Series

KANSAN STAGE.

Kansan Drift.

No trace of any material older than the Kansan was clearly recognized anywhere in this county. In by far the greater part of the county next to the Paleozoic formations lies a body of till, always distinctly characteristic, but ever varying within certain limits. Wherever there is any considerable thickness, the basal portion consists of a very compact, jointed blue clay with intermingled pebbles and bowlders and with bands, streaks and pockets of sand and gravel. Among the indurated materials the greenstone type predominates. The larger rock fragments are often very distinctly glaciated on one or more sides. From this basal part upward there is a gradual change in the appearance of the till. It is less compact, is yellowish or reddish brown in color, the granitoid fragments are disintegrating and the soluble constituents have been well leached out. Everything indicates exposure to the weathering agents through a very great length of time. This is the Kansan till. The morainic hills north of New Hartford described earlier in this report are composed chiefly of Kansan till mantled with loess, though usually it is concealed beneath the later Iowan.

The Buchanan Gravels.

The melting of the ice was attended with the movement of much of the loose material produced by it which resulted in a sorting process by which the finer portions were swept into the remote estuaries, while the coarser sands and gravels were sooner dropped in sheets, valley trains and lenses over uplands or along the courses of the streams. As these deposits were superficial during the long pre-Iowan interval, they always have an appearance of age, that later deposits of similar character do not possess.

Along the three principal streams of the county extensive valley trains occur, having a depth sometimes of thirty or more feet. The larger tributaries of these streams have similar deposits, though of less extent. The occurrence of the Buchanan gravels, as Calvin has termed them, is not uncommon as one feature of the Kansan stage, but rarely are they more widely diffused or in greater quantities than in Butler county. Every township has its supply, but where the topography is flat as in Benezette, it is not as readily manifest. Wherever the roads cut through the Iowan ridges, the upland phase of these gravels appears, and sometimes it shows beneath the loess of the Kansan hills, though the cuts only now and then extend through the loess. Stratification and cross-bedding are very noticeable in many of these deposits, as in the gravel pits of the railroads at Clarksville and in the Butler pit just north of Greene.

Some of the deposits that already have afforded much material for various purposes are those just named, one owned by T. H. Ahrends in the southeast quarter of section 30, Pittsford township, and deposits in sections 24 and 30 in West Point township. The Ahrends pit has been proven to be eighteen feet deep. The upper part consists of unstratified pebbles with bowlders as much as a foot in diameter, but running down to a mere gravel at seven feet below. Then occurs stratified sand and gravel somewhat ferruginous. Crumbling granites are numerous in the lower part and here, too, are consolidated sand masses of considerable size.

In the West Point pits a well defined layer of pebbles and small bowlders is found just below the thin, dark, sandy soil. The gravel is well stained with the iron oxides and in section 30 it is stratified and the lower five or six feet are cross-bedded.

About half a mile north of Greene there is an extensive deposit owned by Mr. J. W. Butler who has, a few rods north of the pit, a sixty-five foot well wholly in the gravel. This pit is usually worked on two levels separated by an eighteen inch layer of clay, bluish below and grayish above, streaked and spotted with an iron stained sand. Material is taken out to a depth of twelve to fifteen feet below this clayey band. While there is much variability in the deposit, something like the following may be fairly well discerned. The lower part is beautifully cross-bedded,

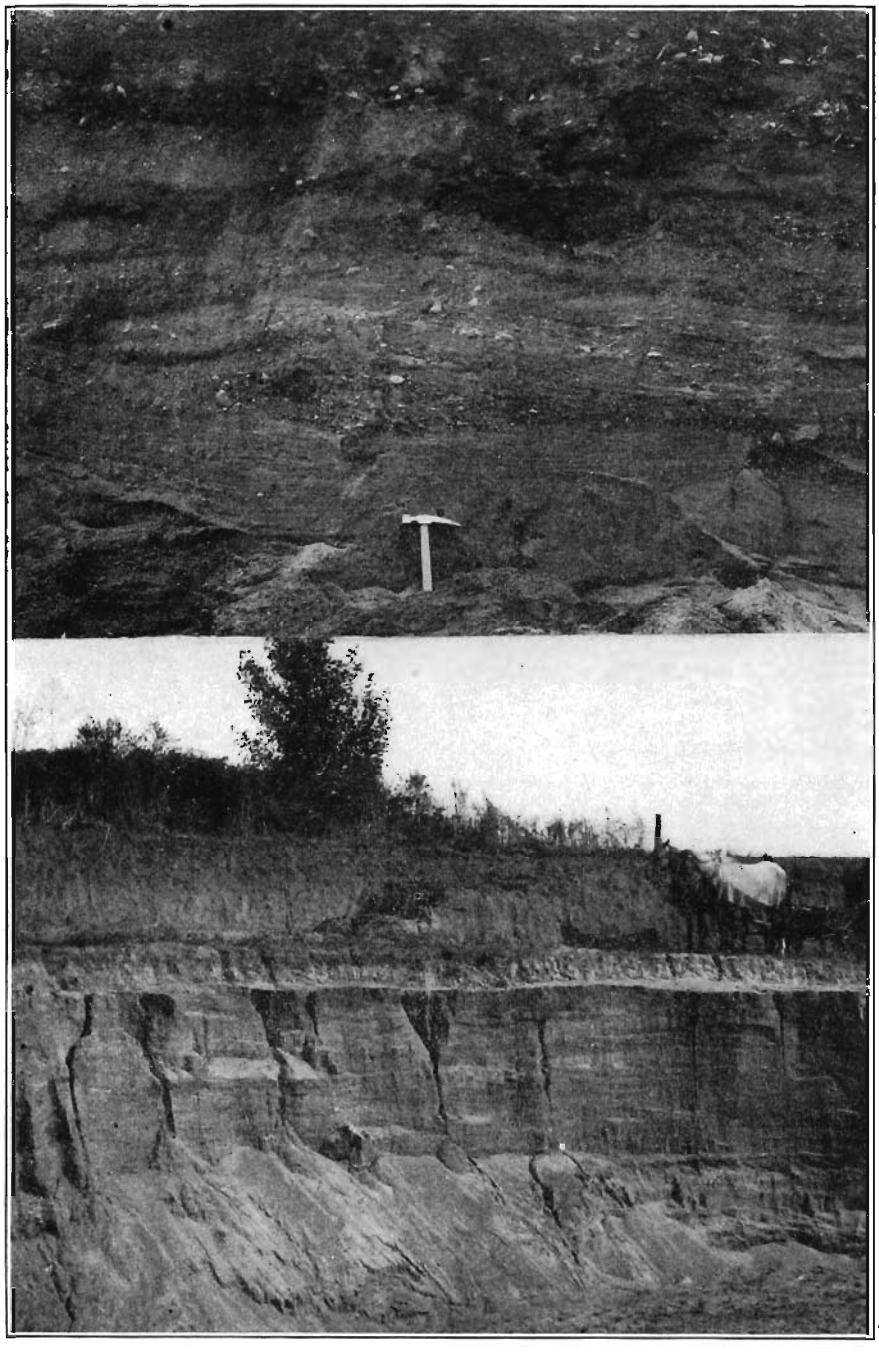

Plate VIII. Upper view—Cross-bedding in gravel pit of Chicago Great Western Railroad at Clarksville.

Lower view—View in Butler gravel pit one-fourth mile north of Greene, showing cross-bedding and the clayey band which makes a convenient platform for excavating the upper portion.

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the shifting beds taking all grades of pitch and direction and often cutting each other very abruptly, many of them being very short, thus indicating rapidly changing currents. The prevailing color is gray with iron-stained beds streaking the lower and also the extreme upper portions. The coarsest gravel, with pebbles averaging one and one-half to two inches in diameter, lies four or five feet from the present bottom of the pit. Also a coarser bed showing little cross bedding makes the uppermost foot or two of this division of the pit. The pebbles are much water worn, and chiefly of the granitoid and greenstone types though occasional pieces of limestone similar in character to the neighboring outcroppings are to be found. Next above the clayey band, which makes a convenient platform from which to work this part, is a foot or two of cross-bedded sand, fine, grayish yellow, with occasional yellowish brown streaks. Next are three feet of a homogeneous, yellowish, compact, sandy, loess-like material topped with a foot or two of sandy soil. Iron pipes occur in the lower beds as well as in the clayey bed below.

A gravel pit extensively used by the Chicago Great Western Railroad just northwest of Clarksville has been excavated to the depth of ten or twelve feet below the soil, which here is about two feet thick. The lower six or eight feet are cross-bedded, the grades running from a coarse sand to a coarse gravel containing pebbles and cobbles from two to five inches in diameter. In addition to pebbles of the usual kind there are iron nodules and numerous limestone fragments. The origin of the latter in the immediate country rock is very probable. The gravels in and about Clarksville are unusually extensive superficially, and lie immediately upon the indurated rocks. The above descriptions are sufficient to indicate the general character of the Buchanan gravels of the county.

IOWAN STAGE

Iowan Drift.

Since in regions where the continental glaciers prevailed the topography is mainly determined by the drift deposits, the discussion of the topography of the county in the previous pages has left little to be said concerning the Iowan drift. It forms the basis of the soil in by far the larger portion of the county,

though it is very thin in many places and probably nowhere has it a depth of more than seven or eight feet. In the more level townships little opportunity is afforded for testing its thickness, as the few cuts that have been made are shallow. The solid and oftentimes very large granitic bowlders universally regarded as belonging to the Iowan drift deposit are the commonest and most obvious evidences of its presence, since the soil is such a complete modification of whatever geological material may have constituted the superficial deposit as to offer little satisfaction in determining its age or origin.

From the very conditions of its formation the Iowan drift is usually a very thorough mixture of pulverized and disintegrated rocks of great variety and therefore contains all the constituents of plant food to an unlimited extent, for the comparative recency of its origin has not afforded time in which the soluble constituents could be leached out. For this reason, too, it does not have the deep color that a long period of weathering has given to the more superficial portions of the Kansan. The agricultural possibilities of the soil wherever the Iowan drift is found are therefore unsurpassed.

Loess.

This material of seeming uniformity of texture and composition and which therefore is often described as homogeneous, is really made up of siliceous, argillaceous and calcareous particles in varying proportions, which range from minute, but distinct granules to an impalpable dust. It is wholly destitute of the coarser elements of the till, yet the variety of minerals in its composition may be as great. To the naked eye it appears as a compact earth, yet it has such porosity as to make it an unusually favorable root home for most forms of vegetation in both wet and dry seasons. In its erosional forms it is as unique as in its other characteristics. Where it covers hillsides, running water cuts in it deep but steep-sided gullies and in cuts and excavations it maintains vertical faces almost as well as do the indurated rocks. It has a kind of vertical cleavage, but usually is without well defined stratification. In color it ranges from an ashen gray to a light yellow. Fossils, chiefly land snails of existing species,

are not infrequently present, and there are calcareous concretions, often of more or less fantastic forms, called loess kindchen, together with ferruginous rods and cylinders made of concentric layers as if they had developed around decaying roots. At times the loess seems to grade into a fine sand and again into a sandy clay, though often it has a well defined plane of demarkation beneath it. The upper surface shows somewhat the effect of exposure to the elements but its modifications are mostly due to the changes incident to the production of vegetation through the ages. As a rule, the effect of loess, topographically, is to soften a little the sharper contours and reliefs of the drift beneath, as it is but a veneer that overlies the drift with quite impartial variation in thickness.

Loess is commonly found broadly spread over the Kansan drift near the borders of the Wisconsin and Iowan drift sheets and capping the morainic hills and paha in the same regions. Numerous isolated patches have also been found somewhat remote from the more extensive areas.

In Butler county typical loess is confined to the hills of the New Hartford moraine and the pahoid hills in Washington and Monroe townships. North and west of Dumont a modified form of loess may be seen on the ridges lying between the two branches of the West Fork. It is more clayey than ordinary loess and is somewhat mottled and streaked. It may not be entitled to the name, but in its position, uniformity of texture and behavior under weathering, it strongly suggests at least near relationship. Its thickness here is unusually variable. On some of the slopes the Buchanan gravels were exposed, making large patches nearly destitute of vegetation. The maximum thickness noted was on the county line in section 19, Pittsford township, where it was about six feet. The average is probably from two to three feet.

Soils

Loess, alluvium and Iowan till intermingled more or less with accumulations of organic residuum have given to Butler county an enviable reputation as a prosperous agricultural district. The hill tops and slopes near the Beaver in Washington township are largely residual. A comparatively small part of the morainic

area near New Hartford is an unproductive waste of bowlders and gravel. These with one or two patches of æolian sands and a few insignificant swamps and peaty areas make up the sum total of soil variety.

In this county the one great productive source of plant food in the soil is that marvelous mixture of disintegrated and decomposed rocks of every variety, still relatively fresh and unleached, which made up the great bulk of the deposit gathered by the Iowan drift sheet as it irresistibly forced its way over the face of the northern lands. For the loess is composed of the finer particles of this deposit caught up and borne along by the winds and finally dropped upon the comparatively ancient Kansan hills and ridges that stood above the thin Iowan glacier like islands in the sea and the alluvium is that fine rich silt which the run-off waters have been constantly filching from the Iowan till ever since it has been uncovered by the melting of the ice sheet and which they have been depositing over the extensive flood plains of all the larger water courses.

Though the till has lost much in this way, its fertility is unimpaired as it has exhaustless supplies of mineral salts which, when exposed by tillage to the action of the weathering agents, are continually being set free and made ready for the use of vegetation.

These three varieties of soil endure drouth unusually well; the till, by reason of the under clay which, when once it is fully laden with water, retains it well, imparting it to the growing crops somewhat stintedly to be sure, but with a steadfastness that insures their success; the alluvium, because deeply underlain with the valley train gravels which serve as a never-failing aquifer, that readily imparts its store of moisture; the loess which, despite its seeming compactness, is minutely porous and therefore has a high degree of capillarity.

ECONOMIC PRODUCTS

Building Stone

Ample supplies of limestone of good quality for foundation walls and all forms of rough masonry are well distributed in the county. No quarries have been extensively worked, as no

attempt has been made to meet more than the local demands. Mills, shops, barns and other out-buildings with walls of stone, are not infrequent, and as a rule the material is proving durable and otherwise suitable. With the increasing cost of lumber, recourse to stone will become more and more desirable and even necessary. The Cedar Valley limestone has been most freely drawn upon not only because of its wider distribution and more usual outcrop, but unquestionably because certain of its beds are really superior in quality. Limestone from the Owen beds of the Lime Creek shales, taken from several different localities, has been used to a limited extent, though little opportunity to note its durability or appearance where used has been afforded the writer. Mr. Thomas Faint in Madison township has a large and substantial barn made from stone of the Owen beds which gives promise of great durability. The few quarries in the Kinderhook limestone have opened a good quality of stone, the product of Brower's quarry in Washington township having the appearance of being exceptionally good.

Lime

Years ago a lime kiln was operated quite extensively near the outcrop of Cedar Valley limestone along the creek west of Bristow. Possibly there were others elsewhere. The introduction upon the market of lime made from the dolomitic limestones in the eastern part of the state soon made the work in Butler county unprofitable, and it has been abandoned.

Brick Clay

The manufacture of brick and tile has never secured a foothold in the county, and nature seems to have given little encouragement along this line; though it would seem that the loess here as elsewhere would prove suitable for the purpose. Its location apart from the towns and the lack of facilities for transportation undoubtedly account for the failure to attempt to utilize it for this purpose.

Sand and Gravel

Sands and gravels in such variety as to meet all the common uses are widely and generally distributed throughout the county. So common are the deposits that to make enumeration of any of them would seem to be superfluous were it not that convenient location has led to a more general use of some of them. Both the Rock Island and the Great Western railways have made large use of the gravel deposits at Clarksville for the betterment of their road beds, for which purpose they are unusually well adapted. The Butler pit just north of Greene yields large supplies of sand and gravel of excellent quality for a variety of uses. The increasing interest in good roads has made the upland deposits of Buchanan gravels that are favorably situated particularly valuable, and free use of them has already been made in some localities to the manifest improvement of the highways. Two such pits west and northwest of Allison, as well as one west of Dumont on land owned by Mr. T. H. Ahrends, may be mentioned as having been freely drawn upon for material for the betterment of the roads. When suitable provision for drainage has been made, any country road within a few years can be made passable for loaded teams at any season of the year by a judicious use of these gravels. In a short time every road in the county could be thus improved. Properly managed, it could be done at scarcely more than a nominal expense, since ample supplies of material are readily accessible in every township.

Oil

In the immediate vicinity of the West Fork north and northwest of Dumont an iridescent film, which may be iron oxide, appears on the surface of the water that oozes from beneath the banks of the creek and its tributaries. This has long attracted the attention of the residents of the neighborhood and a suspicion that great reservoirs of oil exist somewhere in the subjacent rock strata has arisen. Men familiar with the topographic conditions of some of the well known oil regions have visited the locality and a company has been organized and an attempt has

been made to secure options on the rental of all the lands in the region with a view of making test borings. Inability to secure options on some of the land has deferred such borings. As similar conditions elsewhere have repeatedly excited interest in the question of the probable existence of oil in paying quantities in the state the subject has been fully treated in a previous volume of the Survey,* and therefore its discussion need not be entered into here. Suffice it to say that there is only the remotest possibility of finding oil in paying quantities anywhere in Iowa, due to the lack of certain conditions universally required as essential to the storage of oil in the earth.

Water Power

As has already been stated the larger streams have low gradients and little opportunity is afforded for securing adequate power for practical purposes. Fairly good power has been secured upon the Shell Rock, however, and small grist and flouring mills have been run to a good advantage.

Water Supply

IMPORTANCE AND GENERAL SOURCES.

The water supply of any territory is a matter of prime importance, the prosperity of its inhabitants being vitally related to its adequacy and the facility of its attainment.

In the earlier days of the settlement of this county, the superficial supply afforded by the streams and springs was mainly relied upon, but the increased demand made by the more complete settlement, and the changes wrought by the cultivation of the land and the clearing of the waterways from the accumulated impediments of centuries, has greatly curtailed this source of water supply and wells of one form or another have become almost universal. At first shallow wells ending in the Buchanan gravels or in the ordinary till sufficed, but later this source failed, especially in the drier portions of the year, and shallow rock wells were resorted to; even these in many instances have had to be deepened, and others are giving promise of such necessity in the near future. For sanitary reasons it is fortunate that

*Calvin: Iowa Geological Survey, Vol. XI, pp. 22-27.

it is so, as many of the shallow wells were scarcely better than pits for the accumulation of surface water, which, when for convenience they were located near outbuildings and barnyards, readily became contaminated. Ordinarily the deep rock well when properly curbed and cased yields not only an adequate supply of water, but the water is of excellent quality, though it is likely to be moderately hard.

The lowering of the ground water surface, or water table, is a matter of no little interest, for should it continue as rapidly as in the past fifty years, it will soon become the occasion of grave concern. Taking into consideration, however, the more obvious causes of this lowering in the past, as are indicated above, it is not unlikely that they have already produced their maximum effects, very nearly, and while there may be some further withdrawal of the upper boundary of the ground water, in all agricultural communities, reliance may well be placed in ordinary deep rock wells, recourse to the deeper lying aquifers, such as the sandstones of the Saint Peter and the Jordan, being necessary only in cities where there is a demand for large quantities in relatively small areas.

WATER HORIZONS.

The following horizons yield water in varying degree:

1. The lowland phase of the Buchanan gravels in the alluvial plains.
2. The upland phase of the Buchanan gravels.
3. The calciferous sandstones of the Kinderhook.
4. The base of the Owen beds.
5. The shelly rock layers at the top of the Cedar Valley limestone.
6. The earthy limestone just below the lithographic beds of the Cedar Valley limestones.

In the alluvial areas the great water horizon noted above as number 1, is very generally relied upon. The gravels range in depth from a few feet to fifty or more. The supply is abundant at all seasons of the year. As the gravels are more or less iron stained, the water sometimes has a decided taste of iron, though it does not seem to be objectionable to those accustomed to its use. Water from this source from several localities has been analyzed at different times and never more than a

trace of organic matter has been reported, yet the porous nature of these gravels, the very feature that makes them superior aquifers, creates a necessity for unusual care in the disposal of sewage and other waste, to prevent contamination from seepage.

Horizon number 2 was once the main reliance of the settlers upon the upland plains, but with the increased drainage facilities inevitably attending the more complete settlement of the country and the general cultivation of the land, the wells drawing upon this horizon began to fail during the drier seasons, and deeper wells had to put down. Today little, if any, dependence is put in wells ending in this horizon.

So far as noted the sandstone of the Kinderhook beds afford an ample supply of good water.

Accurate or reliable data respecting the merit of horizon number 4 could not be secured to any great extent. It would appear, however, that some wells in the Lime Creek shales area have been put down to horizon number 5, penetrating the Hackberry beds known locally and among the well drillers as soapstone. Usually horizon number 4 seems to afford a sufficient supply for all demands.

Horizon number 5, in the Cedar Valley limestone region, was the next recourse of the farmer who had found the upland phase of the Buchanan gravels failing him, and though this horizon is not so copious in its supply as number 1, or number 6, many still find it capable of furnishing enough water to meet all their needs. Many, however, within a few years have found it necessary to deepen their wells and go down to horizon number 6.

This latter so far has proven entirely reliable, always affording an abundance of good wholesome water. Some wells are reported as ending in the Kansan drift, where perchance they have struck some unusual pocket or streak of gravel or sand that serves as a local aquifer; others are reputed to end in the midst of the lithographic beds or some local modifications of them, but they are exceptional and worthy of little notice here.

WELLS.

For convenience the county may be divided into seven districts on a topographic basis.

District number 1: This area embraces all of the county northeast of the valley of the Shell Rock. It includes all of Fremont township and, loosely speaking, the northeast halves of Butler and Dayton townships. The topography is that of the Iowan drift plain. The mantle rock is thin, the rock, especially in the northwest portion, often coming to the surface. Dug or driven wells do not occur. Little in the way of exact data respecting the wells could be secured. The following, believed to be accurate, concerns a well situated in the north half of section 22, Fremont township. A drilled well completed in 1894 has a diameter of five inches and a depth of eighty-seven feet. Soil and Iowan drift followed by Buchanan gravel, seven feet. Yellow clay and broken stone twenty feet. Cedar Valley limestone with occasional clay partings sixty feet; ends in limestone. Water medium hard, plentiful. From such other information as could be secured it is believed that this fairly represents the wells of this district, allowance having been made for surface altitude, and for the varying depths to which the wells have been sunk into the rock after the true water bearing beds had been reached. The aquifer of the district is the soft limestone below the lithographic beds.

District Number 2: This includes the alluvial valley of the Shell Rock river. As a rule the wells of this district are of the dug or driven type, the exceptions being at Clarksville and Shell Rock chiefly, where the rock lies near the surface. At Shell Rock driven wells twenty to thirty feet deep supply the southeast portion of the town with water of good quality, but elsewhere the wells are sixty to eighty feet deep, entering the rock within ten to twenty feet of the surface. At Clarksville a well, reported to be a typical one, is twenty-five feet deep, the upper twenty feet being in gravel. Greene has a public well of the driven type which affords an ample supply of pure water, as has been proven by repeated analyses. However, many private driven wells are in use. These wells are about twenty-five feet deep. The eastern part of the town is upon an elevated bench and there the wells are about fifty feet deep.

District Number 3: This district embraces all the area of upland between the valleys of the Shell Rock and the West Fork of the Cedar. In the east half of section 22, Shell Rock township, a drilled well is 140 feet deep, forty feet in rock. Water good, abundant. Water was found in drift, but not plentiful enough. A half mile north of this in the same section is a dug well seventy-five feet deep, and near it a drilled well ninety feet deep, fifteen feet in rock, very good water. One mile north of the latter is a drilled well 128 feet deep, four feet being in Iowan, fifty-one feet in Kansan, five feet in gravel and sixty-eight feet in rock.

In the northeast quarter of section 10, Jefferson township, is a well 128 feet deep, twenty feet in rock. In the southwest quarter of section 23, Jackson township, a drilled well is 128 feet deep, sixteen feet in rock.

In the north half of section 18, Jefferson township, a drilled well is 185 feet deep, eight feet of this depth being Iowan, twenty feet weathered Kansan, 142 feet dense blue Kansan, rock fifteen feet.

In section 32, West Point township a well is 200 feet deep, forty feet being in rock. Wells in this vicinity average from 160 to 180 feet in depth.

In the east half of section 22, same township, a well wholly in the drift is eighty feet deep and yields good water in abundance.

In the northeast quarter of section 33, Coldwater township, a drilled well is 138 feet deep, twenty-six feet in rock. In the north half of section 31, same township, a drilled well is 100 feet deep, forty feet in rock.

In the northeast quarter of section 19, Benezette township, a well is 207 feet deep. The owner could not be certain of all data, but reported sixty feet of drift, thirty-nine feet of loose rock, and that the well ends in solid rock. A letter to the well driller, seeking more definite information, brought no reply. The loose rock reported here is believed to belong to the Owen beds of the Lime Creek shales. A kind of "soapstone" was also reported below these beds which, no doubt, answers to the Hackberry beds. The well ends in the Cedar

Valley limestone. Another well one-half mile south gives good water at a depth of 189 feet. Another, one mile north, is but seventy-five feet deep, the water being found in the Owen beds.

In the northeast quarter of section 5, Pittsford township, a well is 106 feet deep, six feet being in loose rock which belongs to the Owen beds probably; for it is but a few miles east of an exposure of these beds, though it must be not far from their eastern border.

Water in all cases noted above has been reported as abundant all the year round and of a good quality, and all those wells ending in rock, excepting the last two, find water in the Cedar Valley limestone.

District Number 4: This district includes the alluvial plain of the West Fork which is from two to three and a half or four miles wide, and more than thirty miles long. None but dug or driven wells have been reported in this area. They vary from ten to thirty feet in depth, the difference being due to the thickness of the Buchanan gravels, any part of which usually furnishes water in good supply.

District Number 5: This is the upland area between the West Fork and the Beaver. Its western end is wide and more varied in topography as well as in the underlying rock than any other of the districts. It narrows towards the east until it is occupied almost exclusively by the Kansan morainic hills described under the topic, Topography. It is to be regretted that very little reliable data could be secured for the greater part of this district.

In the west half of section 8, Madison township, a well 376 feet deep is reported, but no details could be secured. Some wells in this neighborhood are reported as shallow, ending in gravel.

A well in the north half of section 35, Madison township, is 180 feet deep, reaching rock. It is near the Bear Grove cluster of hills, reported elsewhere. Two miles north of Austinville, section 10, Washington township, a well is forty feet deep, three feet in the Kinderhook limestone. The well driller says water is hard, but plentiful. The broad valley of a tributary of the Beaver shares with the latter the most of the area of Monroe township, in which the wells are all driven and shallow.

In the eastern third of this district where the morainic hills constitute the prevailing topography the following wells are characteristic. Along the line between sections 3 and 10, Albion township, a well is seventy feet deep, ending in gravel. In the east half of section 28, Beaver township, a well twenty-six feet above the creek plain is fifty-five feet deep, no rock appearing. In section 23, a drilled well is 141 feet deep and ends in coarse gravel beneath Kansan blue clay. Water is soft and plentiful.

Near the center of section 27 a well is 101 feet deep, ending in rock, depth in rock not learned.

In the northwest quarter of same section a drilled well on top of a hill seventy feet above the creek valley is 190 feet deep, ending in gravel beneath blue clay.

In the northwest quarter of section 22, a drilled well is 180 feet deep, ending in gravel under Kansan clay.

In section 15 a drilled well is 122 feet deep, ten feet being in limestone. This well is on the northern border of the hills.

District Number 6: This includes the alluvial plain of the Beaver, more narrow than the other alluvial plains, but in other respects quite similar. It does not extend into the last few miles of the course of the Beaver where it has cut its channel through the Kinderhook formation. The wells are of the driven type, usually, and rarely exceed twenty feet in depth, the average being from ten to sixteen feet only. The public well at New Hartford is a driven well and derives its supply from the Buchanan gravel of this area. Austinville, Aplington and a portion of Parkersburg are in this area and derive their water supply from the valley train material.

A mere border of the upland south of the Beaver is in this county. A few wells are given. Two miles east of Parkersburg a drilled well eighty feet above the creek valley is 180 feet deep, twenty feet in limestone. In the southeast part of Parkersburg a drilled well gives the following section:

	FEET.
Drift	142
Limestone, water-bearing but not sufficiently so	28
"Soapstone," described as a greasy, compact clay	87
Limestone, firm	5

Water plentiful but hard.

There is no outcrop in this vicinity. The nearest rock exposure is a limestone of the Owen beds, three miles northeast. The limestone above the "soapstone" is evidently of these beds, while the soapstone belongs to the Hackberry beds. The water bearing limestone in which the well ends is the Cedar Valley limestone. In the southeast part of Parkersburg at an elevation of thirty or forty feet above the railroad station a well is 142 feet deep, ending in gravel just above the rock.

Most of the wells in south Parkersburg are driven and end in the gravels of the drift, probably of the upland phase of the Buchanan gravels, though this could not be ascertained with certainty.

Three miles west of Parkersburg a drilled well is sixty-five feet deep, the last five feet being in rock, undoubtedly of the Owen beds.

In the east half of section 32, Washington township, a drilled well is thirty feet deep, fourteen feet being in rock. This is in the Kinderhook area and the surface is at least forty feet above the creek level. The character of the rock could not be ascertained.

SPRINGS.

Small springs are not uncommon in some portions of the county. Many of these have their source in the drift and issue from some slope where the interglacial gravels chance to be exposed. They can rarely be relied upon for a perennial supply of water in considerable quantity. A few springs issue from limestone or sandstone where stream erosion has sectioned the beds. A spring of this kind is in the southeast quarter of section 11, Pittsford township, near Jackson's quarry. Another is near the center of section 31, Washington township. Yet another is in the southwest quarter of section 28, same township. The rock here is a calciferous sandstone, as, undoubtedly, is that of the one previously named, since the horizon is the same, though the rock could not be seen.

Springs of the type first mentioned are in the southwest quarter of section 29, Fremont township, in the northeast quarter of section 11, and the southwest quarter of section 15, West

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF BUTLER COUNTY, IOWA.

BY

M. F. AREY
1910

Scale 1/125000

1 ½ 0 1 2 3 4 5 Miles.

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

PLEISTOCENE
KANSAS DRIFT
OVERLAIN BY LOESS

MISSISSIPPIAN
KINDERHOOK

UPPER DEVONIAN
LIME CREEK

MIDDLE DEVONIAN
CEDAR VALLEY

INDUSTRIES

QUARRIES

GRAVEL PITS.

IOWA LITHO. CO.

DRAWN BY F. C. TAYE

Point township. Several are reported in Shell Rock township that afford sufficient supply for the stock in the pasture. Professor Norton reports a hillside spring on the place of Annias Best, near Clarksville, that has been piped to the buildings and that gives a good supply of excellent water.

ARTESIAN PROSPECTS.

Artesian water from water-bearing beds anywhere above the Saint Peter sandstone is not likely to be found. Water from the Cedar Valley limestone rises at varying heights above the water-bearing beds, but, so far as could be ascertained, in no case does it reach the surface. Experience with wells at Waterloo, Waverly, Sumner, Ackley and elsewhere gives assurance that, should the occasion arise, water can be secured from the Jordan sandstone, if not from the Saint Peter, sufficient to meet all demands that are likely to be made. The necessary depth would vary, but from 1300 to 1800 feet ought to suffice in any part of the county.

ACKNOWLEDGMENTS

The writer is under obligations to many who have kindly given information and otherwise rendered assistance in the prosecution of the work. Dr. T. A. Dumont of Dumont has been especially helpful. Harry L. Eells, principal of the Schaller schools, was a valuable volunteer assistant in the summer of 1906. Professor Samuel Calvin, the State Geologist, has freely given his counsel and has identified all fossils referred to him. To all our sincere thanks are given.