GEOLOGY OF HOWARD COUNTY

BY

SAMUEL CALVIN

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Howard belongs to the northern tier of counties and is the third in order counting westward from the northeast corner of the state. With reference to the distribution of the geological formations of Iowa, its location is one of unusual interest. Along the Upper Iowa, or Oneota river, in Albion township, Howard county possesses some of the characteristics of the Driftless Area, a unique area which includes a large part of Allamakee county and parts of Winneshiek, Fayette, Clayton, Dubuque and Jackson. From this area Howard county is separated by a narrow marginal zone of Kansan drift. The border of the Iowan drift passes through the northeastern part of the county, and so northeast of the Iowan boundary the country is rolling Kansan drift covered with loess, while by far the larger part of the county, lying southwest of this well defined line of division, belongs to the level or gently undulating, uneroded, loessless Iowan plain. One of the interesting geological features of this region is the absence of the Niagara limestone or any representative of the Silurian system, for here the Devonian overlaps upon the shales and shaly limestones of the Maquoketa stage of the Ordovician. The margin of the overlap and the contact of the Devonian with the Maquoketa may be studied at various points within the limits of the county now under consideration.

The artificial boundaries of Howard county are the state of Minnesota on the north, Winneshiek county on the east, Chickasaw on the south and Mitchell on the west. The county is divided into twelve civil townships. The four southern townships, as organized for the administration of local government, are nine miles long from north to south, and so each embraces one congressional township and a half. The northern townships are each only five miles in length from north to south, sections 1 to 6 in each case being omitted. The other four townships are of the usual size. The county is a rectangle, the dimensions being approximately twenty miles from north to south and twenty-four miles from east to west. The area is therefore 480 square miles more or less, the variation from the theoretical area depending on the natural convergence of north-south lines and errors in the original surveys.

PREVIOUS GEOLOGICAL WORK.

Previous to the organization of the present Survey, Howard county received but little attention at the hands of official geologists. In connection with the survey made by Hall & Whitney during portions of the years 1855, 56 and 57, the northern counties of the eastern part of the state were hastily examined by J. D. Whitney for the purpose of determining their leading geological features, without, however, attempting anything like detailed investigations. In the report* which followed the references to Howard county are very meager and relate almost wholly to the position, importance and courses of the drainage streams. The report of Dr. C. A. White † makes no reference to the county we are now considering; but in 1872 Dr. White read a paper at the Dubuque meeting of the American Association for the Advancement of Science ‡ in which he discussed the geological significance of fossils found in the drift of Howard county near Lime Springs. McGee in his Pleistocene History of Norheastern Iowa ‖ makes a number of references to the topography, drainage, indurated rocks and glacial deposits of Howard county. Geologists and paleontologists have long been attracted by the interesting fauna which may be collected from outcrops of the Trenton and Maquoketa formations along the Upper Iowa, or Oneota river, above and below Florenceville, in the northeastern part of the county; and on this account there are frequent references in geological literature to the rocks and fossils of the Florenceville region. In the report on Fillmore

*Report on the Geol. Surv. of the State of Iowa: By James Hall and J. D. Whitney; Vol. I, Pt I, pp. 306-312, 1858.

†Report on the Geol. Surv. of the State of Iowa: By Charles A. White, M. D.; Vols. I and II, Des Moines, 1870.

‡On the Eastern Limit of Cretaceous Deposits in Iowa: By C. A. White. Proc. Am. Ass'n for the Adv. of Sci. Twenty-first Meeting. p. 187, Cambridge, 1873.

‖The Pleistocene History of Northeastern Iowa: By W J McGee. Eleventh Ann. Rept. U. S. Geol. Surv., p. 189 et seq., Washington, 1891.

county, Minnesota,* the rocks of Howard county, especially those about Lime Springs, receive more or less attention in the way of comparison of outcrops in Iowa with outcrops on the other side of the state boundary. The Devonian limestones of the area under discussion in this report are very highly dolomitized and, lithologically, they resemble certain phases of the Niagara beds farther south. While some of the exposed sections are rich in casts of fossils, there are others which are quite barren, and the result has been that nearly all the writers mentioned above, either in printed text or published maps, have referred some of the dolomitized Devonian to the Niagara series. The overlap of the Devonian on the Maquoketa is something unlooked for, unexpected.

PHYSIOGRAPHY.

TOPOGRAPHY.

The loess margin of the Iowan drift plain passes through the northeast part of Howard and divides the county into two very distinct topographic areas, each of which is again divided into smaller areas according to the extent to which the glacial deposits are developed. The line separating the two principal areas passes from Minnesota into Iowa near the northwest corner of section 11, Forest City township, from which point it bends to the west and then turns nearly due south, traversing the eastern edge of section 10. After passing into section 15 the line makes an abrupt bend to the east, passes through the northern part of section 14, whence, veering southward, it maintains, with some minor deflections and sinuosities, a general southeasterly course until it leaves the county a few rods south of the northeast corner of section 36, Albion township. The area north and east of this line is comparatively small; only about 22 square miles, all told, are here included; but within this limited space there is more of varied topographic interest than in all the rest of the county. On one side of the line, in the smaller area, the surface deposits are Kansan drift overlain by loess; on the other side the surface is occupied by a young drift sheet, the Iowan, upon which there is no loess, but large granite bowlders of types wholly

*The Geology of Fillmore County: By N. H. Winchell: The Geology of Minnesota. Vol. I, of the Final Report, pp. 268-324: Minneapolis, 1884.

absent from the northeastern part of the county, give character to the long vistas of gently undulating plain. The small northeastern area may be called the *Loess-Kansan*, the larger area to the southwest is the *Iowan*.

The Topography of the Loess-Kansan Area.—Excepting the valley of the Upper Iowa, or Oneota river, the surface of the Loess-Kansan area presents a series of rounded hills separated by ravines which have been cut by flowing water. Stream action is the dominant characteristic of the region. All its present topographic features—the hills, ravines and even the deep river valleys—are due to the carving and shaping effects of ordinary surface drainage. Outside the river valley and its immediate tributaries, the topography is a direct product of the run-off of the ordinary storm waters. The underlying drift, as already intimated, is what has been called in recent geological literature the Kansan. The surface of this ancient glacial deposit, by reason of long exposure to rains and other meteorologic agents, was deeply trenched, and the sculpturing resulted in producing, on a small scale, a mature type of erosional topography. (Fig. 1.)

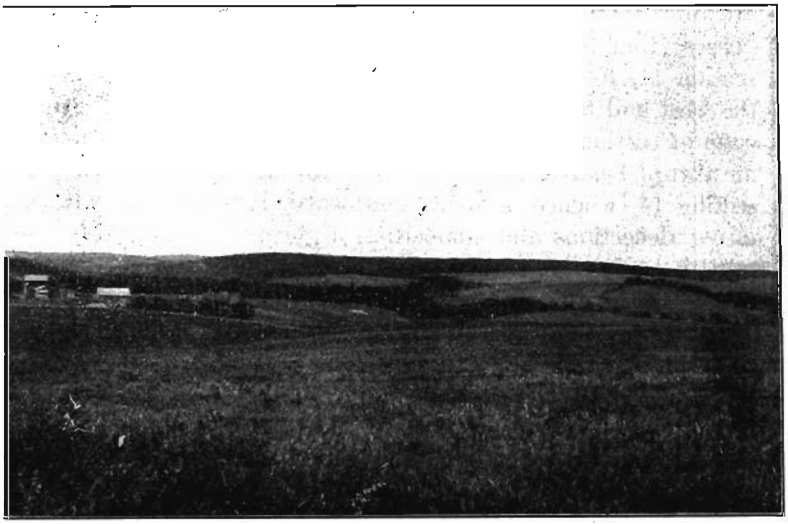


FIG. 1. Erosionally developed and well rounded hills of the Loess-Kansan area, in the northeastern part of Howard county.

At the time of maximum development of the ice sheet which deposited the comparatively recent Iowan drift, the carved surface of the old Kansan till, outside the border of the Iowan ice, was covered with a thin veneer of the fine clay called loess. This loess was moulded over the inequalities of the eroded Kansan surface. The deposit was doubtless thicker in some places than in others, but, after all, the thickness was practically uniform, the variations being no greater than would be found in a mantle of snow laid down in comparative quiet upon an uneven surface. And so it was that by the deposition of the loess the characteristics of the old topography were not veiled or obscured to any noteworthy extent. The hills and ravines into which the drift surface had been carved were not changed, but retained the same positions and the same relative heights during and after the process of loess deposition. It is true that some minor features of the topography of this region are due to trenches cut in the recently deposited loess, but in general the amount of erosion since the loess was laid down as a mantle over the trenched surface of the Kansan drift is so small as to be scarcely appreciable. This fact becomes the more evident when the Iowan area is studied, for, except in a few very limited portions of the Iowan plain where conditions have been unusually favorable to the action of erosive agents, the surface of the younger drift, which in age is contemporaneous with the main body of the loess, remains practically as the glaciers left it. Over nearly the entire extent of its area, the amount of erosion that took place in the surface of the Iowan drift between the retreat of the Iowan ice and the occupation and cultivation of the territory by the white man, would have to be expressed by zero. Except in a very few unimportant details, therefore, the topography of the Loess-Kansan region is not due to erosion of the loess, but is controlled by surface forms which had been developed long before any loess was deposited. All deep cuts, for roads or railways or for whatever purpose made, in Loess-Kansan areas of Iowa, whether in Howard county or in other portions of the state, show that the present loess surface is essentially parallel with the old eroded surface of the Kansan till. The reader will pardon the apparently unnecessary reiteration involved in the statement that all field evidence is overwhelmingly in favor of the view that the topography of Loess-Kansan areas, such topography as is shown in figure 1, is fundamentally pre-loessial. The loess never filled the valleys and trenches and levelled up the surface as some have supposed. Its thickness and relations to the surface have never been very different from what they are today.

Over the greater part of the Loess-Kansan area of Howard county, the surface forms have been developed by erosion of a sheet of drift. A marked departure from the type of topography generally prevailing in the region is found in the charmingly picturesque valley of the Upper Iowa, or Oneota river. This valley is a deep trench cut into the indurated rocks (Figs. 2 and 3). The rock-cut gorge is in places comparatively narrow, its depth ranges from 75 to 125 feet, the walls are steep, it resembles in some of its characteristics the valleys of the Driftless Area. As to age, the topography of the greater part of the northeastern division of Howard county is post-Kansan, having been chiefly developed, as already noted, by erosion of the drift surface during the long intervals between the retreat of the Kansan ice and

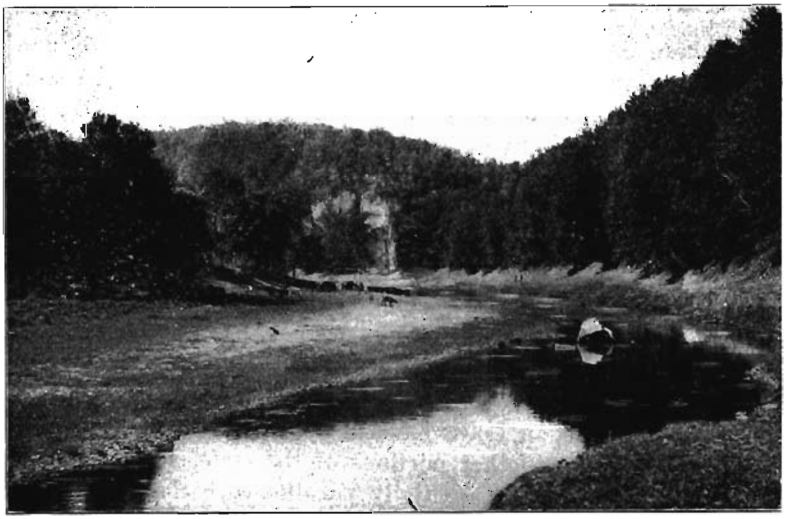


FIG. 2. View in the valley of the Upper Iowa, or Oneota river, in the northeast quarter of section 11, Albion township.

FIG. 8. The rock-walled gorge of the river in the southeast quarter of section 12, Albion township.

the deposition of the loess. On the other hand the rock-cut valley of the Oneota is much older than the Kansan, it is evidently preglacial. There are no indications that this part of Iowa was ever occupied by the ancient ice sheet that, over the major portion of the state, preceded the Kansan; but that the valley was deep and open as it is today when the ice of the Kansan stage was melting is attested by terraces of rusty Buchanan gravel at various points along the stream. A concrete illustration of these old gravels, deposited by floods from the melting Kansan ice and rising but little above the level of the water in the present channel, is found south of the bridge at Florenceville, near the middle of section 10, Albion township. The margin of the valley rises to an altitude of about 100 feet above the surface of the terrace. It is in sections 11 and 12 of this township that the most picturesque features of the Oneota valley, features most nearly allied to those which characterize the Driftless Area, are developed.

Topography of a mixed type, partly preglacial and in part due to erosion of Kansan drift, occurs in the south half of sections 11 and 12, and in sections 13, 22, 23 and 24, Albion township. The same type, indeed, occurs in small areas on both sides of the river as far west as section 10, Forest City township. The surface in these localities is quite generally covered with Kansan drift, but the drift is so thin and so meager that the present topography is largely controlled by the erosion which had taken place in the preglacial rock surface.

The Topography of the Iowan Area.—The Iowan area embraces much the larger part of Howard county. There was a time, however, when the whole county, and practically the whole surface of Iowa, presented an appearance topographically like the northeastern part of Albion township. The period during which the surface of the old Kansan drift was carved and sculptured by agents of erosion was of unknown duration, but manifestly it was very long as compared with all post-glacial time. At a date very recent compared with the age of the Kansan drift, glacial conditions recurred; a new ice sheet, coming from the northwest, flowed over the eroded Kansan surface, obliterating the old erosional topography as far as it went, and leaving the surface, when the ice melted, in the form of a gently undulating plain. Constructive work of glacial ice in spreading out and piling up morainal detritus was the potent factor in developing the resulting topography. Erosion was in no way concerned. Erosion has not effected any general modification of the surface since the glacial ice disappeared from the region.

The ice sheet which, in this part of Iowa, followed the Kansan and modified the surface of the older drift, was the Iowan. Iowan glaciers covered all of Howard county except the few square miles of the Loess-Kansan area already described. The Iowan ice advanced to what is now the boundary line between the two topographic areas of the county and there stopped. On one side of that line the topography is old, on the other side it is young. Along the boundary line there is usually a great thickening of the loess; and as ordinarily seen from the Iowan plain the margin is marked by a series of hills which, from a distance, present the appearance of a terminal moraine (Fig. 4). From the summit of the marginal ridges the observer looks in one direction upon a tumultuous series of erosionally developed and well rounded hills and ridges (Fig. 1); in the other direction

FIG. 4. Hills of thickened loess, like morainal ridges, along the border of the Iowan plain, in the southern part of section 26, Albion township.

the landscape is an uneroded plain stretching away to an uninterrupted horizon, as level as a sea (Fig. 5).

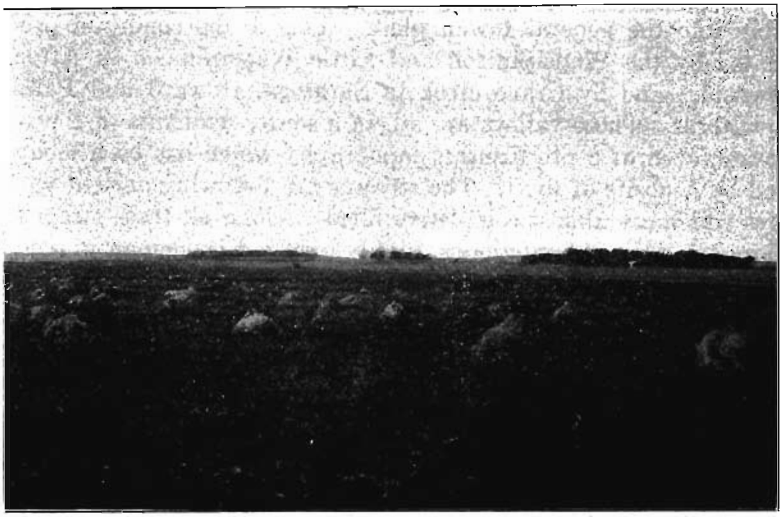


FIG. 5. Iowan plain in section 7, Oak Dale township, spreading away to the horizon, as level as a sea.

The typical characteristics of the Iowan plain are best illustrated on the broad, flat divides between the drainage courses. The region having its center at the southeast corner of Saratoga township, may be cited as a concrete example of the ideal Iowan plain. But all portions of the county lying southwest of the Iowan-Loess boundary, and not immediately adjacent to streams, present essentially the type of topography illustrated in figure 5. The surface is everywhere a plain, diversified with long, low, sweeping undulations. Such inequalities and irregularities as are present are due to the manner in which the drift material was arranged by the action of the Iowan glaciers, and not to any subsequent carving or shaping by drainage waters. Drainage is as yet very imperfectly developed. There are no definite drainage channels in these inter-stream areas. The storm waters simply flow off along the broad, shallow, concave sags which gradually blend into the gentle swells of low, flat eminences representing the higher and more perfectly drained portions of the surface.

The streams of the Iowan area, in the western three-fourths of the county, flow in shallow depressions broadly concave from side to side, the margins of the depressions blending imperceptibly into the general Iowan plain. This is the condition presented by the Wapsipinicon and Little Wapsipinicon in Afton township, and by Crane creek in Saratoga, Howard and Paris townships. These valleys are all, in a sense, remnants of a pre-Iowan, even of a pre-Kansan, topography which has been modified by deposits of drift. The streams are following ancient valleys which are almost completely filled. Along all these streams there are beds of ferruginous, highly oxidized Buchanan gravels which show that here were drainage courses when the Kansan ice was melting. The gravels rest on Kansan drift with which the old valleys, probably preglacial, were partly filled, and are in turn overlain by Iowan drift. The gracefully curving surfaces of valleys and uplands are sprinkled with Iowan bowlders. The Upper Iowa, or Oneota river, above Chester, occupies a broad-bottomed, imperfectly drained valley which is somewhat sharply set off from the adjoining uplands by a low terrace of Buchanan gravels. The old preglacial valley which was followed by the post-Kansan drainage and is still followed by a post-Iowan stream, was not so completely filled with the drift of the two recognized ice invasions as were some of the other preglacial valleys of the county. Both of the known drift sheets of this territory become much attenuated toward their margins, in the direction of the Driftless Area. Both are exceedingly variable with respect to the amount of material deposited in different localities. In some places the Kansan drift is thicker than the Iowan. In other places the reverse is true.

Along the Turkey river in the eastern part of the Iowan area, there is a region of very thin drift, and the old preglacial topography expresses itself in spite of the fact that twice at least, the surface had been overflowed by glacial ice. Beginning at Vernon Springs, the valley of the Turkey river is a deep, rock-cut gorge of the preglacial type, excavated in Devonian limestones. There is a small amount of drift over the hills; but the indurated rocks crop out in many places, and the surface of the hill slopes is strewn with untransported fragments of native limestone (Fig. 6). A few bowlders of both Kansan and Iowan

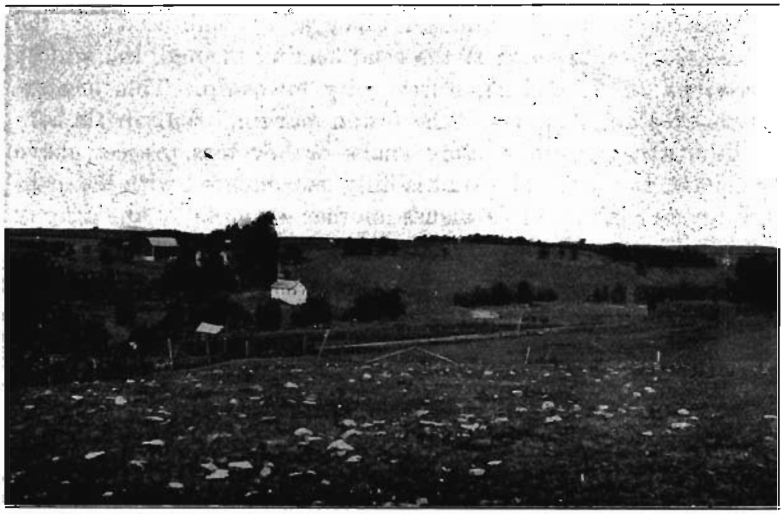


FIG. 6. Region of thin drift at Vernon Springs. The topography is preglacial, the rocks are but partially concealed, and blocks of the native limestone are scattered over the hill slopes.

types may be recognied amongst the loose surficial materials. From Cresco south to the north line of section 35, Vernon Springs township, the country is a typical Iowan plain. South of the point named the region becomes hilly; the Iowan drift thins out; knobs of thoroughly oxidized Buchanan gravel of Kansan age appear, even on the uplands; and the surface, carved into rounded rocky prominences, descends to the river valley which, at New Oregon, is more than 100 feet deep measured from the upland plain. The village of New Oregon is built on a terrace of old rusty Buchanan gravel, the structure of which is well shown a short distance west of the north end of the bridge. The gravel terrace shows that the valley, with practically its present depth, served as a drainage course to carry off the waters from the melting Kansan ice. That it served the same purpose when, later, the Iowan ice was retreating is attested by fresh stratified sands on land of W. H. Patterson, in the east half of the southwest ¼ of section 34, Vernon Springs township. The hilly area dominated by preglacial topography embraces a zone a mile or more in width on each side of the Turkey river, from Vernon Springs to the east line of the county.

Another region of unusual topography embraced in the Iowan area, occurs north of the road leading through the middle of sections 22, 23 and 24, Forest City township. This locality is within a short distance of the Iowan margin. Both drifts here are thin, and numerous stony knobs or low tors project above the general surface. The land is hilly as compared with the ordinary Iowan plain, and furnishes another example of topography controlled by preglacial erosion of the indurated rocks.

DRAINAGE.

The drainage of Howard county follows courses which were determined to a large extent in preglacial time. In places the ancient valleys were only partially filled with drift. In other places they may have been completely filled, but the settling of the loose detritus gave rise to depressions along which the later streams established themselves. The Upper Iowa, or Oneota river, is the most important stream in the county; it has its rise in the Iowan drift plain of Mower county, Minnesota, enters

Howard near the northeast corner of Oak Dale township, takes an unusual course for Iowa streams, nearly due east, and follows a valley characterized by entrenched meanders which are best developed east of the Iowan boundary at Foreston. All the northern townships of Howard county are drained by the Upper Iowa. The tributaries of this stream are, however, few and unimportant. In Albion township, where the valley is cut deeply into the rocks, the river is fed by numerous springs which represent rather shallow underground drainage. The sources of the Turkey river are found in the ill drained depressions of the Iowan plain in Howard Center and Paris townships. There are no well defined drainage channels about the headwaters of the several branches of this stream. The run-off simply follows the broad, shallow sags which were left in the surface by the melting ice of the Iowan glaciers. Below Vernon Springs the valley of the Turkey takes on preglacial characters similar to those seen in the Upper Iowa valley in Albion township. The more typical Iowan area which occupies the southwestern half of the county, is drained by Crane creek and the branches of the Wapsipinicon. Nearly all the streams of this area have their origin within the limits of the county, and they are practically branchless, so far as development of definite tributary channels is concerned. Broad "sloughs," in place of eroded creek beds, serve to collect the waters from the adjacent slopes. While the drainage courses seem to have been determined by the position of preglacial valleys, the streams of the southwestern part of Howard county have accomplished very little in the way of erosion. They have neither valleys nor flooded plains in the ordinary sense. They run in simple shallow trenches cut only a few feet below the level of the surface on which they began to flow after the withdrawal of the Iowan ice.

STRATIGRAPHY.

General Description.

The geological formations exposed in Howard county are not very numerous. The Ordovician and Devonian systems are represented in the indurated rocks, and two divisions of the Glacial series—the Kansan and the Iowan—are recognizable in the surficial or Pleistocene deposits. The country rock is completely hidden from view by deep accumulations of glacial drift, over approximately nine-tenths of the area of the county. There are a few points, principally in the northeastern townships, where the rock comes to the surface in the general uplands, but it is along stream courses that exposures chiefly occur. The best natural sections are seen in the valley of the Upper Iowa or Oneota, in the Loess-Kansan area east of Foreston. Sections of seventy-five or eighty feet in height occur in sheer cliffs at a few points along the river, and others of less range are not uncommon. There are also some satisfactory sections along the Turkey river, east of Vernon Springs. In other parts of the county rock exposures are few in number, of very limited range, and usually far apart, and so the correlation of the outcrops and the arrangement of them in a definite section are matters of great difficulty. This difficulty, so far as concerns the Devonian, is heightened by the fact that the beds have been altered by dolomitization. In the process of alteration the fossils were reduced to imperfect casts or were entirely obliterated, and so the aid that paleontology might render in correlating outcrops is not always available.

The overlap of the Devonian on the Maquoketa is one of the remarkable features of the stratigraphy of this part of Iowa. The Niagara limestone, which elsewhere intervenes between the formations named, is here absent, and both the Devonian and the Maquoketa of the region differ lithologically from outcrops of corresponding age at the localities where the formations are typically developed and have been most carefully studied. The Devonian is so largely dolomitic that some portions of it resemble certain phases of the Niagara. The Maquoketa is more calcareous than at the well known outcrops in Dubuque county; some of it is even dolomitic and might be mistaken for the Galena limestone, while other parts are more like the non-dolomitized Trenton. The phase of the Devonian which rests on the Maquoketa is not the lowest Devonian of other parts of Iowa, but it is made up of beds carrying *Productella subalata* Hall, and *Spirifer pennatus* Owen, fossils which indicate a horizon near the top of the Wapsipinicon stage. The relations of the strata suggest that, on account of local subsidence after the beginning of the Devonian, the shore line was slowly carried eastward during the time represented by the Coggan, Otis, Independence and Lower Davenport beds, as these are described by Norton in the reports on Linn and Scott counties. The greatest eastward extension of the Devonian sea occurred during the Upper Davenport age, when beds containing the fauna represented by *Productella subalata* and *Spirifer pennatus* were laid directly upon Maquoketa or Hudson River deposits containing *Leptaena unicostata, Plectambonites sericea, Orthis testudinaria* and *Orthis kankakensis*.

The study of the Niagara limestone in counties southeast of the area we are considering—in Fayette, Delaware and Buchanan—shows a decided tendency on the part of this formation to become thinner toward the northwest. It may be possible, therefore, that no Niagara was ever deposited as far north as Howard county. On the other hand there is a possibility that the Niagara is present in its proper position underneath the later deposits, some distance west of the overlapping edge of the Devonian. Owing to the dolomitization of both formations, the Devonian and the Niagara, in the northern part of the state, cannot be differentiated in the ordinary borings from wells; but the combined thickness of the beds above the Maquoketa in wells begun in Devonian limestones at Waverly, Sumner, Frederika and Osage, is so small as to indicate the actual thinning and practical disappearance of the Niagara in this direction.

The following table shows the stratigraphic relations of the geological formations recognized in Howard county:

GROUP.	SYSTEM.	SERIES.	STAGE.
Cenozoic.	Pleistocene.	Recent.	Alluvial.
		Glacial.	Iowan
			Kansan.
Paleozoic.	Devonian.	Middle Devonian.	Cedar Valley.
			Wapsipinicon.
	Ordovician.	Trenton.	Maquoketa.
			Galena-Trenton.

Ordovician System.

GALENA-TRENTON.

The Galena-Trenton is the lowest of the geological formations exposed in Howard county. It is seen in various exposures along the river valley in Albion township, from Florenceville eastward. A short distance above Florenceville the Trenton disappears beneath the level of the bottom of the valley, passing under thin-bedded, calcareous shales and shaly limestones belonging to the stage of the Lower Maquoketa. There is a general discussion of the Galena-Trenton in the chapter on the Geology of Dubuque county, in volume X of the present series of reports. In that discussion it is shown that the dolomitic phase of the formation, which has been called the Galena limestone, is a local characteristic which is best developed in Dubuque county and becomes less and less marked toword the north, and that non-dolomitized beds in the northern counties, which are the exact equivalent of dolomitized Galena, have usually been referred to as Trenton limestone. Certain persistent life zones were recognized in the Dubuque county report, among which the zone of *Receptaculites oweni,* and a zone containing a number of species of large gastropods are among the most prominent.* The place of the Receptaculites zone is about sixty feet below the top of the formation, and the gastropod zone lies a few feet lower.

In Howard county it is the upper part of the Galena-Trenton, beginning a short distance below the gastropod zone, that is represented in the cliffs along the Upper Iowa river. Rising vertically from the water at a number of points on the stream in the east half of section 12, Albion township, are sheer precipices of Trenton limestone, sixty to eighty feet in height; and from twelve to fifteen feet above the base of the scarps the characteristic species of the gastropod zone occur. The rock is gray or drab in color, rather fine-grained, somewhat magnasian but not dolomitic. It lies mostly in thin beds, though some layers near the foot of the exposed sections are eighteen inches in thickness. The fine cliffs (Fig. 7) in the northeast 1/4 of the southeast 1/4 of section 12, show at their base the lowest beds of the formation

*Iowa Geol. Surv., Vol. X, p. 409, and Nos. 8 and 9, Plate 4, opposite p, 410. Des Moines, 1900.

FIG. 7. Cliffs of Trenton limestone in the northeast quarter of the southeast quarter of section 12, Albion township. The layers at the base of the cliff are the lowest beds exposed in the county.

to be seen within the county. There are somewhat similar cliffs (Fig. 8) in the northeast 1/4 of the southeast 1/4 of section 11. The gastropod zone is here at the foot of the precipice, and Receptaculites occurs about twenty feet above the level of the water. The face of the cliff is seventy feet in height, and the height above low water in the stream is about eighty feet. To the right of the cliff is the mouth of a small, steep ravine in which the successive beds may be studied more successfully than in the cliff itself. The stone is rather fine-grained and grayish toward the base, but about the middle of the section it occurs in heavier, coarser layers which are more magnesian, and in their general characteristics show a closer approximation to the Galena type of the formation. Judging from the position of the Receptaculites zone, the top of the cliff should correspond very nearly with the top of the Galena-Trenton, and this view is supported by facts observed on the receding hill side a little higher up. For

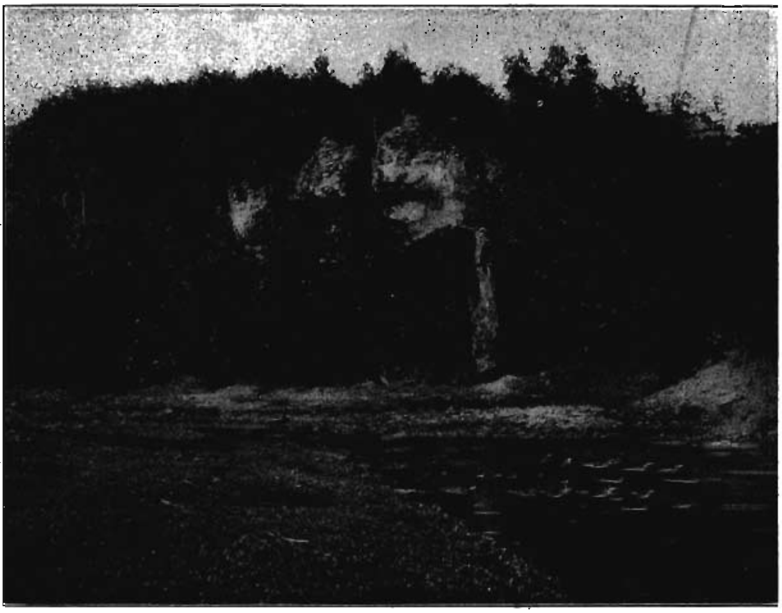


FIG. 8. Cliffs of Trenton in the northeast quarter of the southeast quarter of section 11, Albion township.

some distance back from the brow of the cliff the ground rises in a gentle slope which is covered with glacial material of Kansan age, but at an altitude of twenty feet above the base of the slope there are some beds of fine-grained, calcareous shales belonging to the Maquoketa. Fifteen feet higher there are beds of more typical Maquoketa with *Leptaena unicostata* and *Plectambonites sericea.*

The upper portion of the Galena-Trenton is exposed at the mill at Florenceville. Just below the mill the stone has been quarried to some extent. It shows the following section:

		FEET.
2.	Irregularly bedded, fine grained, fossiliferous limestone with shaly partings; some of the layers represented by detached nodules and irregular lenticular slabs of limestone embedded in shale..................	10
1.	Regularly bedded stone in layers a foot or more in thickness, without shaly partings, rather coarse-grained, beds cut by definite joints, joint faces pitted and roughened by weathering.............	8

No. 1 of this section furnishes a durable building stone well suited for use in the rough, substantial grades of masonry. The rock is quite magnesian, semi-crystalline, but is not a true dolomite. This member is the equivalent of the coarser beds observed above the middle of the cliff in section 11 (Fig. 8). Excepting some stem segments of crinoids, no fossils were seen in it at this point. A short distance above Florenceville, a few rods north of the old mill in Granger, Minnesota, there is an exposure of beds equivalent to No. 2 of the foregoing section; while less than 100 yards farther north, the heavy quarry beds of No. 1 are seen in place. A large Orthoceras, the *Cameroceras proteiforme* Hall, occurs in the quarry beds. The shaly partings of the overlying beds—the equivalents of No. 2—furnish quite a number of fossil species, among which were noted a small species of Prasopora, *Lingula philomela*, *Plectambonites sericea* represented by a number of very small individuals, *Leptaena charlottae* and *Orthis testudinaria*. The upper part of the Granger exposure is not represented at Florenceville. It is more shaly than the lower, and some of the thin beds of limestone furnish small specimens of *Rafinesquina alternata* Conrad, and *Isotelus iowensis* Owen. The great amount of shale alternating with thin, sometimes nodular, beds of limestone indicates that the conditions at the close of the Galena-Trenton in this locality, were similar in one respect at least to those which marked the close of the same stage in Dubuque county. The diminished thickness of the calcareous layers and the increased thickness of the shaly partings near the top of the Galena-Trenton, are noted at page 430 and elsewhere in volume X of these reports.

The Galena-Trenton was not seen in Howard county at any points outside of the immediate valley of the Upper Iowa, or Oneota river. There is, however, a very interesting outcrop a rod or two east of the county line, opposite the southeast corner of section 13, Albion township. The point in question is in the valley of Nichols creek and the river is in fact less than one-fourth of a mile away. The interest attaching to this exposure arises from the fact that the beds exhibit perfectly the characteristics of the Galena limestone. They are buff, granular, vesicular, crystalline, dolomitic, massive, ranging up to six feet in thickness

(Fig. 9). The characteristics are unusual in this part of the state and help to emphasize the fact that dolomitization has no formational significance but may be a purely local phenomenon of very limited extent.

MAQUOKETA OR HUDSON RIVER.

The transition from the Galena-Trenton to the Maquoketa in Howard county is not as abrupt as it is in Dubuque. There are here shales alternating with thin beds of limestone in the upper part of the Galena-Trenton, and soft clay shales alternate with thin indurated layers of calcareo-magnesian shale, at the base

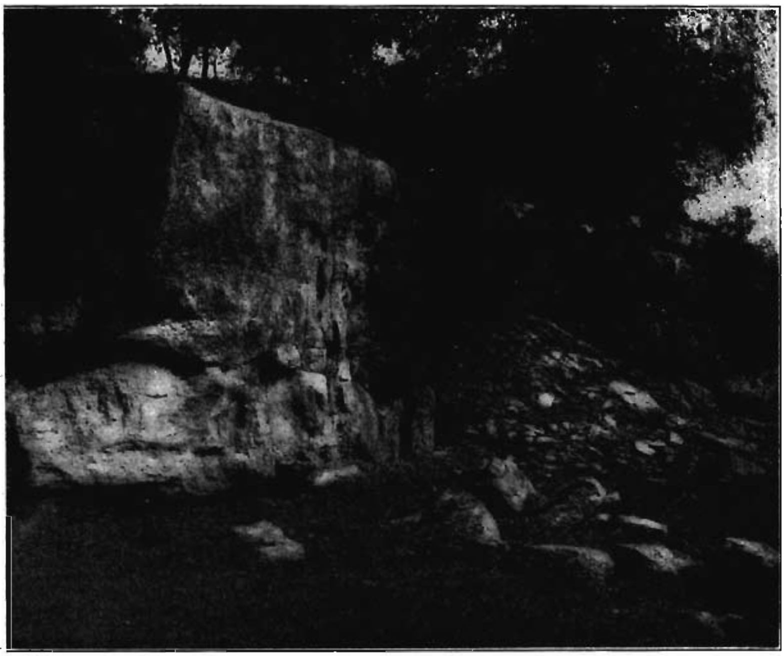


FIG. 9. Typical Galena phase of the Galena-Trenton opposite the southeast corner of section 18, Albion township.

of the Maquoketa. Some of the beds of harder shale in the Maquoketa would rank as argillaceous limestone. The lithological differences between the top of the Trenton and the base of the

Maquoketa are simply differences in the characteristics of the more indurated beds. In the Maquoketa the stony layers are lighter colored, softer, more granular, much more earthy and argillaceous than those of the upper part of the Galena-Trenton. The calcareo-magnesian beds of the Maquoketa, however, are counted of sufficient value to be quarried for building stone, one of the quarries so operated being located on the north side of the river in the southwest 1/4 of section 8, Albion township (Fig. 10). The river flows north through the western part of the northeast 1/4 of section 9, less than half a mile west of Florenceville, and on the east side of the stream rises a vertical cliff of more or less indurated shales of the Maquoketa stage, sixty to seventy

FIG. 10. Exposure of Maquoketa shales in the southwest quarter of section 8, Albion township.

feet in height. This is the best single section of the formation in the county. Cliffs showing beds of the same type, but diminishing in height as the formation is traced up the stream, occur at intervals almost to Foreston. In the western part of section

7, Albion township, and the eastern part of 12, Forest City township, the river flows between bluffs in which the Maquoketa beds rise in vertical exposures to a height of forty feet above the water. The upper parts of the bluffs in this locality are everywhere composed of Devonian dolomite. The Maquoketa finally disappears beneath Devonian, in the bottom of the river valley, one-half mile east of Foreston.

The general characteristics of the Maquoketa or Hudson River formation, as seen in the valley above Florenceville, are well illustrated at the quarry in the north bank of the stream in the northeast ¼ of section 8. Figure 10 shows the relative thicknesses of the harder and more stony layers compared with the soft, shaly partings. The beds that are sought for building stone rarely exceed four inches in thickness. The intervening seams of shale are equally as thick. All the beds yield readily to the weather, and the cliff face breaks down rapidly. All the surfaces which have been exposed to the air for any length of time, are bleached to a light gray. Fossils are not very common. It is true that some of the beds are crowded with the comminuted stipes of graptolites in such condition that neither genera nor species can be recognized. Occasionally, however, there are perfect individuals which indicate the presence of such common Hudson River types as *Diplograptus pristis, Diplograptus putillus and Diplograptus quadrimucronatus.* The second species is included on the authority of the *Geology of Minnesota,* Vol. III, Part 1, p. 82. Other fossil forms occurring sparingly are *Plectambonites sericea,* small forms of *Rafinesquina alternata, Orthis testudinaria, Isotelus gigas* and the rather short and broad trilobite with rounded cephalon and pygidium which Clarke has described in the *Geology of Minnesota,* Vol. III, Part II, as *Isotelus susae**.

*The *Isotelus susae* Whitfield species, Geology of Wisconsin, vol. IV, p. 236, is a very different form from the one referred by Clarke to this species. It is a smaller, more convex, thicker in front than posteriorly, with the anterior part of the head deflected so that near the front margin the surface of the glabella stands nearly at right angles to the general plane of the body—characteristics correctly shown in Whitfield's Figure 8, Plate 10. The eyes are more prominent, the visual surface is larger than in the species figured and described by Clarke, and the posterior limb of the glabella is much narrower in proportion to its length. In the collections of the University at Iowa City, there are three specimens of Whitfield's and Calvin's *Asaphus* (*Isotelus*) *susae*, from the Florenceville region, but they are all from the upper part of the Galena-Trenton. So far the species has not been found in the Maquoketa or Hudson River shales. In the same collections there are three specimens of the very different form referred to *Isotelus susae* in volume III of the Minnesota Survey, which are from outcrops of the Maquoketa shales on the river above Florenceville. If this broad, short, flat species of trilobite, so well figured and described by Clarke in the Geology of Minnesota, Vol. III, Part II, p. 708, requires a distinctive name, it may be called *Isotelus florencevillensis* in honor of the small village near which it is found.

Distribution.—The distribution of the Maquoketa or Hudson River deposits is not limited, as is the case with the Galena-Trenton, to the walls of the immediate valley of the Upper Iowa river. A broad tongue of Maquoketa crosses the county line from Winneshiek, in sections 13, 24 and 25, and extends up the valley of Nichols creek and its tributaries to near the west line of section 22. There is another tongue of Maquoketa, but smaller than the preceding, projecting into sections 12 and 13, Vernon Springs township. The Maquoketa comes very near the county, if it does not quite enter it, in the valley of the Turkey river. At the bridge over this stream on the county line, there are exposures of the Productella beds of the Devonian, and the Devonian is continued down to the level of the water; but less than one-half mile east of the county line the Maquoketa rises fifteen or twenty feet above the bottom of the river channel, and so it is fairly probable that the formation would be found beneath the water in the stream and the soils in the bottom of the valley, in sections 1 and 12, New Oregon township.

Typical Exposures.—The lower part of the Maquoketa in Howard county, for a thickness of about 60 feet, is composed of the thin, indurated, calcareo-magnesian beds with alternating shaly partings, illustrated at the quarry in section 8, Albion township. Near the top the formation varies greatly, and the characteristics of the same horizon are quite different in different localities. The details of the upper part of the formation are best studied outside the limits of Howard, in Winneshiek county, for the reason that the greater number of exposures found here afford better opportunities for observation. For example, a section embracing the upper forty feet of the formation is seen along the south line of section 16, Lincoln township in Winneshiek. In part the rock of this section is a magnesian shale, and in part it is a crystalline dolomite resembling the Galena limestone at Dubuque. The fossils recognized here are Lingula, a fragment too imperfect to be identified specifically, *Leptaena unicostata*, *Plectambonites sericea*, *Orthis testudinaria* and *Orthis kankakensis*. The locality is especially interesting for the reason that the ground rises gradually toward the east, and near the southeast corner of the section named there are dolomitized beds containing Devonian types of Stropheodonta, Productella, Atrypa and Spirifer. The locality is especially interesting as showing very clearly the absence of the Niagara limestone and the superposition of the Devonian on the Maquoketa.

Along the county line road, on the east side of section 13, Vernon Springs township, the hill slope leading from the south into the valley of Silver creek shows, at the top, the Productella beds of the Devonian, beneath which there are light yellow magnesian shales and harder layers of granular dolomite belonging to the Maquoketa. The shaly magnesian beds begin, in descending the hill, between twenty-five and thirty feet above the level of the small valley. Diligent search failed to reveal any fossils in them, but their relations to other recognizable horizons in the Maquoketa leave little doubt that they represent the transition beds at the top of the formation, described in the reports on the counties of Delaware and Dubuque. On the north side of Silver creek the Devonian, with its usual Productellas and Spirifers, begins not more than ten feet above the floor of the valley, and there is no trace of the light colored magnesian Maquoketa. Here are indications of an unconformity. The creek valley widens rapidly in Winneshiek county, and in its floor and sides are many interesting exposures of Maquoketa, some of which are within a few feet of overlying Devonian. A short distance east of the southwest corner of section 16, New Orleans township, there is an outcrop of non-dolomitized limestone crowded with *Plectambonites sericea* and other Ordovician species. This outcrop recalls the crowded fossiliferous slabs of limestone so common everywhere in the upper part of the Maquoketa, a few feet below the transition beds, in Dubuque county. Thin layers of limestone similarly charged with the common Plectambonites occur at various points in sections 13, 14, 23, 24 and 25, Albion township. An outcrop of upper Maquoketa along the north line of the northeast ¼ of section 8, has numerous individuals of *Streptelasma corniculum* associated with the Plectambonites. The most interesting assemblage of fossils occurs in what are practically the very uppermost beds of the Maquoketa, on the east line of the southeast ¼ of section 25. At this point there are the magnesian transition beds noted in section 13, Vernon Springs township, but associated with them are some non-dolomitic layers rich in well preserved fossils which are identical in form, size and general expression with corresponding species from the Cincinnati shales of Ohio and Indiana. The Cincinnati types here include robust forms of *Rhynchotrema capax, Rafinesquina alternata* and the varietal form, *R. nasuta.* There are other species, such as *Orthis testudinaria* and *Plectambonites sericea,* which do not vary in many other exposures in Iowa from the forms occurring in the Cincinnati shales. The fossil bearing layers are pure limestone, some of them being completely crinoidal.

Correlation and Thickness.—The Maquoketa formation is much thinner in Howard county than it is in Dubuque. The lower indurated beds with numerous graptolites, exposed in the river valley above Florenceville, may be correlated with the hard, slaty, graptolite-bearing shales which make up the Lower Maquoketa in Dubuque county. The heavy body of plastic shales which compose the greater part of the Upper Maquoketa in the Dubuque county report, seems to be absent from Howard county, the upper member of the formation being represented only by the calcareous, fossiliferous layers and the magnesian transition beds which lie above the plastic clays farther south. The whole thickness of the Maquoketa does not here exceed 100 feet, while in Dubuque county the thickness is fully twice as great.

Devonian System.

GENERAL DESCRIPTION.

The Devonian rocks of Howard county are all calcareous; all are more or less magnesian; the greater portion of the entire system would be classed as impure dolomite. True shales were not observed anywhere. Dolomitization of the Devonian is more common in the northern part of the state than at the southern outcrops in Johnson, Cedar, Muscatine, and Scott counties, thus reversing the rule that has been observed in relation to the dolomitization of the Galena-Trenton. The lowest beds seen in Howard county belong to a horizon far about what has been recognized as the base of the Devonian in the southern part of the area of its distribution. The beds which rest directly on the Maquoketa contain *Stropheodonta demissa* Conrad, *Productella subalata* Hall, *Atrypa reticularis* Lin., *Atrypa aspera* Schlot., *Spirifer pennatus* Owen and *Cyrtina hamiltonensis* Hall. The fauna indicates a horizon equivalent to that represented about the middle of the quarries at Independence in Buchanan county. In this zone in Howard county, Productella is the most abundant and most characteristic fossil, and it is convenient to refer to the horizon as the *Productella beds*. This zone belongs to the Upper Davenport beds of Norton, below which, before reaching the base of the Devonian in Linn, Cedar and Scott counties, there are the divisions of the Wapsipinicon stage which have been described as Lower Davenport, Independence, Otis and Coggan.

There are here some interesting and puzzling anomalies in the distribution and vertical range of certain species, which are deserving of notice. For example the Productella beds have a thickness of forty feet, a thickness more than twice as great as that of the corresponding beds at Independence. They are overlain by fifteen to twenty feet of coarse dolomite characterized by the inclusion of large masses of crystalline calcite. In these coarse, calcite bearing beds there are occasional casts and impressions of *Favosites alpenensis* and *Acervularia davidsoni*. These corals are in their usual stratigraphic relation to Productella, and so far the succession of life zones is in accord with the Devonian section in Buchanan county. But in the Salisbury quarry at Vernon Springs, twenty feet or more above the top of the coarse, coral bearing dolomite, there are layers only slightly magnesian in which *Gypidula comis*, *Atrypa aspera*, and the lenticular, elongated, finely striated type of *Atrypa reticularis*, known heretofore only from the horizon of the Independence quarries, are well preserved. This particular form of the *Atrypa reticularis* should be found below the coral horizon and never above. Its place is with Productella. At Independence the Gypidula is found, rather sparingly, as high as the beds carrying Productella, but from Independence to Davenport, Gypidula is more characteristic of the Lower Daveport beds than of any other horizon, and yet the Lower Davenport beds are not even represented in Howard county. These forms seem to have re-migrated into this territory long after they had permanently disappeared from other parts of Iowa.

Typical Exposures.—1, The lowest member of the Devonian section in Howard county, composed of the Productella beds, is typically exposed at the bridge over the Turkey river on the Howard-Winneshiek county line. At the level of the road, at the south end of the bridge, the deposit is soft, yellow, earthy dolomite which is broken into irregular nodules as a result of weathering. The fossils occur only as casts or impressions, but it is possible to recognize *Stropheodonta demissa, Productella subalata, Spirifer pennatus* and *Cyrtina hamiltonensis.* Besides these there are casts of small undetermined gastropods and pygidia of Phacops. It is about twenty-five feet from the level of the bridge down to the water in the river. The slope is covered with waste, but 150 yards west of the bridge the wash of a small intermittent stream exposes the beds to the level of the narrow flood plain. With the exception of one or two layers that have been quarried on a small scale, the rock is soft and easily disintegrated into a yellow sand or marl. The harder layers, which occur about the middle of the section, contain indistinct impressions of a small shell like *Spirifer subumbonus* Hall. The Productella beds are well shown in the river bluffs at a number of points in section 1, New Oregon township. In the northeast quarter of the section there are massive, undecayed ledges of the Productella horizon, forty feet in thickness.

Along the east side of the northeast ¼ of section 24, Vernon Springs township, there are exposures of badly broken and weathered limestone, soft and magnesian, but rich in Productella and the forms usually associated with it. The full thickness of this part of the Devonian column, about forty feet, is indicated by the rather unsatisfactory outcrops on the long sloping hillside. Near the summit of the hill the next higher member of the series is seen, but after passing the crest the Productella beds reappear on the slope descending to the valley of Silver creek. These beds are again seen north of the southeast corner of section 1 in the same township. In Albion township the exposures of the Productella horizon are quite numerous, though they are rather unimportant and unsatisfactory. In the northeast ¼ of section 36 a small quarry has been worked at this horizon. The beds are also exposed in the northwest $\frac{1}{4}$ of section 27, at a point one-fourth of a mile north of the center of 22, and at numerous other small breaks and outcrops along the Devonian margin, in the northern part of the township.

The most important exposure of the Productella beds occurs at Foreston, near the northwest corner of section 14, Forest City township. As usual in this part of Iowa, the rock is a rough, vesicular dolomite, rather soft and non-crystalline. The bedding planes are largely obliterated, and the fossils occur only as casts. The exposed section is made up of a number of heavy ledges, all very much alike. The beds have been quarried quite extensively, the massive blocks being used in the construction of the mill dam and in other structures where weight and strength are the most desirable characteristics. Figure 11 is a view at the south end of the quarry, showing the massive character of the layers and the rough, vesicular appearance of the freshly broken surfaces. At the north end of the quarry the following section was noted:

FIG. 11. Quarry in the heavy, dolomitized Productella beds at Foreston, in Forest City township.

		FEET.
5.	Decayed ledges badly broken up and divided into comparatively small blocks	8
4.	Coarse, vesicular, undecayed bed, very fossiliferous, casts and impressions of *Productella subalata* common, impressions showing the coarse ribs and strong spines of *Atrypa aspera* numerous, pygidium of Phacops seen occasionally	5
3.	Coarse, pitted layer like No. 4, with many casts of brachiopods among which Productella is the most common	4½
2.	Soft, light yellow bed with casts of *Atrypa reticularis*	3
1.	Bed like No. 2, but softer and more granular, with few fossils, mostly *Atrypa reticularis*, bed divides in places into four parts each about one foot in thickness, in places the parts are fused together on account of the complete obliteration of the bedding planes	4

There are massive ledges of the Productella beds in the steep bluffs facing the river in section 12 of Forest City township and section 7 of Albion. The lower part of the bluffs, for thirty or forty feet, is occupied by the upper portion of the Maquoketa formation, the heavy beds of the Devonian appearing in some places quite conspicuously above the Maquoketa, well up on the steep hillsides. It is the Productella beds that are seen at the level of the water below the mill, at the old town of Lime Springs. Above this point the dip of these beds soon carries them below the level of the stream.

2, The member of the Devonian series which follows the Productella beds in Howard county is the equivalent of the *Acervularia davidsoni* beds of Buchanan county. It is made up of a succession of coarse, dolomitic layers ranging from a few inches to more than a foot in thickness. A typical exposure of these layers shown in figure 12, occurred on the north side of the stream, immediately below the mill dam, at Vernon Springs; and all the way to the east line of the county these beds may be seen in the bluffs of the Turkey river, overlying the Productella horizon. As the county line is approached they are found to occupy a position forty feet or more above the level of the stream. Lithologically these beds resemble certain phases of the Niagara limestone in Delaware and Dubuque counties, except that, in place of the chert usually found in the Niagara, there are large included masses of calcite. This calcite differs from that which will presently be described as lining spherical or definitely shaped cavities in beds higher up in the series. The spaces it occupies are shapeless and irregular and are completely filled. The formless, cleavable masses are devoid of any indications of crystal faces or crystal outlines.

The exposure at the mill dam (Fig. 12) covers a comparatively large area and gives an unusually favorable opportunity for the

FIG. 12. Typical exposure of the coarse, calcite-bearing beds (Acervularia horizon), below the mill dam at Vernon Springs.

study of the beds in detail. Besides the characteristics already noted, this horizon is distinguished by the presence of casts of *Favosites alpenensis* and *Acervularia davidsoni*. The presence of the corals and the stratigraphic position of the beds both lead to a correlation of the horizon with the *Acervularia davidsoni* zone at Independence, Littleton, Waterloo and Iowa City*. The marked difference in the texture and composition of the rocks and in the perfection and abundance of the fossils are due in part at least to the great changes which were wrought during the process

*Compare the "Coral Reef Bed" in the report on Johnson county, Iowa Geol. Surv., Vol. VII, and the "Acervularia Zone" in the report on Buchanan county, Vol. VIII.

of dolomitization. These coarse dolomitic beds with their shapeless masses of calcite, are seen at intervals, above the Productella horizon, along the east line of the county from section 25, Vernon Springs township, to the north line of section 36 in Albion. They may be recognized, over and over again, in their proper relations, all around the Devonian margin. One of the most fossiliferous exposures of this phase occurs in the side of a ravine near the middle of the west line of section 15, Albion township. The common *Favosites alpenensis* is comparatively abundant. Beds belonging to essentially the same horizon are found in the Croft quarry at Elma, in section 1, south of the middle of Afton township. At the bottom of the quarry there is a dark brownish, crystalline, dolomitic layer which in general forms the floor. It has, however, been taken out over a few square yards; it is very fossiliferous, but the fossils occur only as casts. The forms recognized are *Favosites alpenensis, Stropheodonta demissa, Pentamerella dubia, Atrypa reticularis, Spirifer subvaricosus, S. asper, S. fimbriatus,* a large species of Gomphoceras, and a small species like *G. oviforme.* This fauna belong to a horizon just below the Acervularia zone, and its equivalent in the northeastern part of the county should be included in the lower part of the coarse calcite bearing beds.

3, South of the bridge at New Oregon, above the calcite bearing beds described in the foregoing paragraphs, there are twenty feet of variable strata, composed in part of soft earthy limestone grading into marly shales, and in part of fine-grained, whitish, non-dolomitic limestone. The section is not very satisfactory. In fact the beds of this horizon were not well shown at any point in the county. The non-dolomitic phase of this member of the series is seen in loose, weathered, crackled blocks, a short distance west of the middle of section 24, Vernon Springs township. A better exposure of the crackled beds occurs about eighty rods south of the northeast corner of section 10, and a still better illustration of this special phase is found in the northeast ¼ of section 12, all in Vernon Springs township. In section 12 the beds are rich in stromatoporoids similar to the forms occurring in the stromatoporoid reef from Mitchell, Worth and Cerro Gordo counties on the north, to Johnson county in the southern part of the Devonian area. Besides the stromatoporoids the beds carry a small digitate Favosites and the usual gastropod of this horizon, *Euomphalus cyclostomus*. The non-dolomitic, fine-grained, white limestone of this horizon is the equivalent of the beds described as "fine-grained, white limestone" in the reports on Johnson and Cerro Gordo counties. This phase of the Devonian, which is always associated with the stromatoporoid horizon, attains its fullest development in Mitchell county and in the northern part of Floyd, where it takes on the characteristics of a fine lithographic stone. The same lithographic phase, but less perfectly developed, occurs at LeRoy in Minnesota, a short distance from the north Howard county line. This third member of the Devonian series is quite variable. While, in the northeastern part of the county, the non-dolomitic stromatoporoid beds occur in it, these beds are not always present. The greater part of this portion of the section is a soft, magnesian, earthy limestone which breaks down rapidly into a marly clay or into irregular concretionary fragments. The exact line separating this from the next overlying member of the section could not be definitely traced.

4, The beds which follow No. 3 in ascending order are typically represented in the quarries at Vernon Springs. One of these quarries, which was formerly worked quite extensively, is located on land belonging to H. C. Salisbury, in the southwest ¼ of the southwest ¼ of section 34, Vernon Springs township. Other exposures occur in the Patterson quarries in the northeast ¼ of the same quarter section, and in a small quarry near the river in the southwest ¼ of section 33. At the base of the Salisbury quarry there are several courses of firm bluish limestone not dolomitic. The individual courses are from one to two feet in thickness, and the aggregate exposed is about eight feet. The fossils are mostly brachiopods and the shells are well preserved. Among the species noted are *Gypidula comis, Atrypa aspera* and the fine lined type of *Atrypa reticularis* found in the quarries at Independence. Reference has already been made to the fact that this fauna seems very much out of place in a position above the Acervularia and stromatoporoid horizons. The concurrence of these special types of brachiopods is unknown elsewhere* except at the horizon of the quarry stone at Independence, a horizon which corresponds to that of the Productella beds of Howard county.

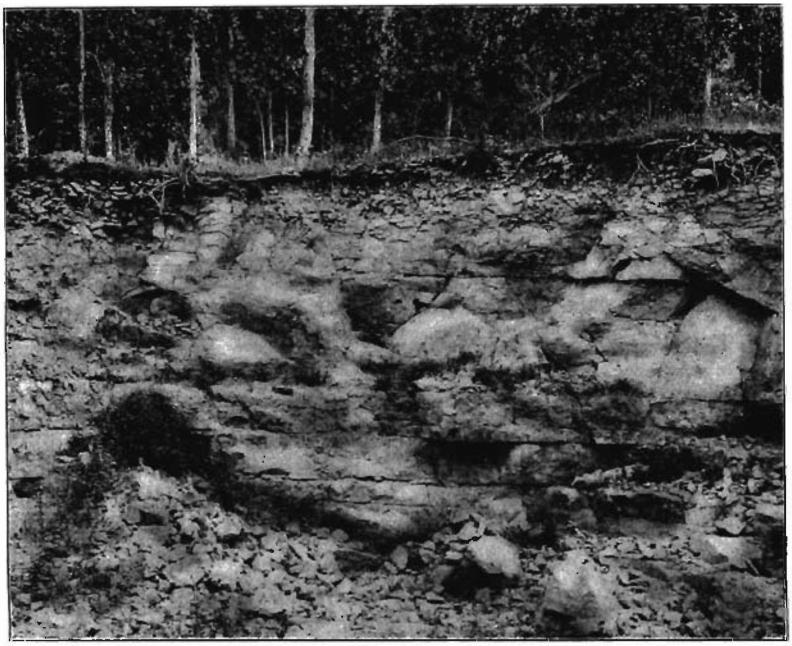


FIG. 13. The Salisbury quarry, near Vernon Springs.

5. In the Salisbury quarry (Fig. 13) the beds last described are overlain by soft, granular, magnesian limestone stained more or less with iron oxide and varying in color from dirty yellow to dull brown and red. This fifth division of the Howard county Devonian has a total thickness of at least fifty feet. It furnishes

*The three species, *Gypidula comis*, *Atrypa aspera* and *Atrypa reticularis*, occur together in the Lime Creek shales at Rockford in Floyd county and at Hackberry Grove in Cerro Gordo, but in all three cases the forms are varietally different from those at Independence. The *A. aspera* at Independence is Hall's variety *A. occidentalis*, while the similar species in the Lime Creek shales has been referred to the variety *A. hystrix*. The *A. reticularis* of the two horizons differs very strikingly in size, markings and general proportions, and the Gypidulas are sufficiently distinct to make their separation a simple and easy matter. The species as they occur in the Salisbury quarry are all of the types found at Independence. These species all persisted somewhere—in the meantime suffering more or less modification in form—during the interval which separated the age of the quarry stone at Independence from that of the shales at Rockford, and the fact that they migrated into Iowa and temporarily occupied some parts of it at different times during the interval, need occasion no surprise. The re-migration which enabled them to occupy Howard county long after they had disappeared from Buchanan, occurred before modification had progressed to any appreciable extent.

the best of the building stone quarried in the county. It is the equivalent of the "Yellow, earthy limestone" quarried near Littleton and described in the report on Buchanan county, (Iowa Geological Survey, Vol. VIII, p. 234). Lithologically the beds are very similar in Howard and Buchanan. The characteristics are unusually persistent.

The Salisbury quarry affords the following section:

		FEET.
5.	Black soil mixed with broken rock	1
4.	Rock in broken, angular fragments affording an illustration of how the stone yields to frost and weather	4
3.	Heavy courses of good building stone, soft, magnesian, yellow or brown in color, containing numerous spheroidal cavities lined with crystals of calcite, fossils rare and represented only by casts	8
2.	Band of softer, more argillaceous limestone in three or four layers, calcite lined cavities numerous	3
1.	Courses of more solid and purer limestone from one to three feet in thickness, fossil shells preserved	7

Number 1 of this section is composed of the beds already described, which constitute the fourth member of the Devonian series, while 2, 3, and 4 represent the lower part of the fifth. All the beds of the quarry are cut at short intervals by oblique joints. The other quarries in the immediate vicinity of Vernon Springs show nothing essentially different from what is seen in the quarry described. In the northwest 1/4 of section 33, Vernon Springs township, quite an amount of stone has been taken out, and the opening shows three heavy ledges ,each about three and a half feet in thickness, cut by numerous joints, and presenting many vug-like, or geode-like cavities lined with calcite. The rock resembles No. 3 of the Salisbury quarry, but the beds are higher in the series. The workable layers are overlain by from four to five feet of small, angular, worthless fragments which have resulted from the disintegration of still higher beds.

The largest quarry in the county is operated by John Hallman near the Fair ground, in the western edge of Cresco. It has been opened by working down beneath the surface of the level prairie. In stratigraphic position the beds here lie above any heretofore noted and are probably the highest to be found within our territory. The rock is earthy, magnesian, rather soft, but it seems to be capable of standing the weather fairly well. At some points the quarry has been worked to a depth of twenty feet. Toward the top the bedding is quite regular in places for a thickness of eight feet, and the stone may be taken out in courses ranging from three to six inches in thickness. The whole deposit is very irregularly jointed, the joints cutting the beds at every angle from vertical to horizontal. In the lower part of the quarry the bedding is quite irregular, the courses are thicker and they pitch and roll in the most confused way, in different directions. Crushing and movement since the deposit was laid down are indicated by the general development of slickensides on the joint faces. Fossils are very rare. A few impressions of what seemed to be *Stropheodonta demissa* were noted, together with obscure fragments of plates of fishes.

The upper part of the Salisbury quarry and the higher beds exposed in the other openings near Vernon Springs are represented in a small opening from which a considerable quantity of good building stone has been taken, in the northeast 1/4 of the southeast 1/4 of section 14, Forest City township. The location is on one of the high points in an area of thin drift and consequent preglacial topography. There is not more than six inches of soil above the four foot band of decayed and broken stone which represents the effects of frost and weather. Below the fragmentary band the stone is sound, lies in heavy ledges, is freer than usual from calcite lined cavities and is capable of affording dimension blocks of fair sizes. Much of it is streaked with iron oxide, a feature, however, better shown in the next quarry to be described. The only fossil observed here was an imperfect impression of a closely coiled, nautiloid cephalopod. The same beds are shown in a somewhat extensively worked quarry belonging to M. H. Jones, in the southeast 1/4 of the southeast 1/4 of section 24, Chester township. The beds are soft, granular and magnesian as usual. They are stained by the secondary infiltration of iron oxide which is arranged in flexuous, concentric, parallel bands around certain nuclei, the disposition of the bands being in no way influenced by joints or lamination planes. The vug-like cavities lined with calcite are common. This completes the observations made on the fifth member of the Devonian column. The beds of the Jones quarry are not as high in the series as those in the Hallman quarry at Cresco. The total thickness of this member is at least fifty feet.

In the river valley above the old town of Lime Springs, it is the members immediately overlying the Productella beds that first appear. The dip, however, is very slight in this direction, the river valley being almost parallel with the line of strike. At Glen Roy mills in section 19 of Forest City township, only about three-fourths of a mile northeast from the Jones quarry, there is an exposure in the river bank, of non-dolomitic, shaly, nodular limestone overlying some soft, yellow, marly beds, all of which belong to division 3 of the Devonian column. On higher ground in the southwest ¼ of section 18, there are the beds which lie at the base of the Salibury quarry, the beds which have been described as the fourth member of the column. All the species enumerated from that member are found here, and there is here the additional species, *Orthis iowensis*. The Jones quarry beds overlie these last and represent the uppermost member of the Howard county Devonian.

Between the mill and the bridge at Chester there is an exposure of soft magnesian limestone stained with concentric streaks of iron oxide as are the beds of the Jones quarry. The horizon, however, is near the base of the second division of the Howard county Devonian. Casts of fossils are more than usually common, and among the recognizable species are *Atrypa reticularis, Spirifer subvaricosus* and *S. fimbriatus*. The same spirifers occur elsewhere in Iowa, in the Cedar Valley stage of the Devonian, a few feet below the Acervularia beds and not far above the Productella horizon. Their position at Chester is the normal one. At Le Roy in Minnesota, some distance farther up the river, it is the lithographic phase of number 3 that is most conspicuous in the small local quarries.

Under 2, on page 55, reference is made to the Croft quarry near Elma. The fauna enumerated from the lower part of this quarry corresponds to that found near the bridge at Chester, and, notwithstanding some lithological differences, the geological position is the same. The Croft quarry lies west of the railway; another quarry is located one-fourth of a mile farther east. All the beds in both quarries may be referred to the horizon of the coarse, calcite bearing member, number 2, exposed at Vernon Springs and shown in figure 12. No fossils were seen above the basal layer of the Croft quarry. The overlying limestone is regularly bedded, coarse-grained, contains large amounts of calcite, lies in layers ten inches to a foot in thickness at the bottom, but, toward the top of the quarry, splits into thin flags two or three inches in thickness.

Beds corresponding to the upper part of the Croft quarry have been worked for building stone at points from three and a half to four miles west of Elma. There is one opening on land of M. Monaghan near the center of section 8, and another on land of J. Roche in the western edge of section 9, in the southern part of Afton township. Both of these quarries were opened in the surface of the level prairie. Neither has been operated for a number of years. Soil has washed down over the face of the layers, and growth of vegetation has helped to obscure the situation. There is another abandoned quarry three-fourths of a mile south of Elma, on land belonging to Henry Miller. A rank growth of weeds and bushes conceals all the layers except one heavy, dolomitic ledge eighteen inches in thickness. This point is higher than the Croft quarry, and the beds are probably equivalent to some part of the third division of the Howard county Devonian.

Thin bedded, coarse-grained, magnesian limestone like that in the upper part of the Croft quarry, is exposed in the banks and bottom of a small branch of Crane creek, in the northeast ¼ of section 33, Saratoga township. At one point a small quarry has been opened, but the stone comes out in pieces too small to be very serviceable.

The Devonian beds show very little dip in any direction. The inclination corresponds very nearly to the general slope of the surface toward the southwest. Chester is fifty feet higher than Elma. The distance between the two points is about sixteen miles. The same beds are exposed at both places. The dip from one point to the other, which is along a line very nearly at right angles to the strike, is but little more than three feet to the mile. Cresco is 118 feet higher than Elma. The inclination of the surface between the two points—about seven feet to the mile—is greater than the dip of the strata, and hence it is that the Elma horizon is lower than the horizon of the quarry stone at Cresco. The limestones at Cresco are the highest, stratigraphically, occurring in the county.

The general section of the Howard county Devonian may be arranged in the following divisions:

		FEET.
5.	The quarry beds at Cresco, Vernon Springs, the Jones quarry in section 24, Chester township, and the quarry on high ground in the southeast ¼ of section 14, Forest City township	50
4.	Non-dolomitic beds at the base of the Salisbury quarry and exposed at a few other points, as in section 18, Forest City township, carrying Orthis, Gypidula and Atrypa like forms found in the quarries at Independence	8
3.	Beds varying in character, some of the layers white, fine-grained, lithographic, in some places rich in stromatoporoid corals	15
2.	Coarse-grained, dolomitic beds in the northeastern part of the county, less dolomitic at Elma and southwest, the horizon of Favosites, Acervularia and Pentamerella, the quarry beds at Elma and the country southwest	15
1.	Productella beds, soft, buff colored, vesicular dolomite, with casts of fossils, quarried in massive blocks at Foreston, the real equivalent of the quarry stone beds at Independence	40

Pleistocene System.

KANSAN STAGE.

Kansan Till.—The oldest drift sheet positively recognized in Howard county is the Kansan. In boring deep farm wells on the prairies, partially decayed logs and other remnants of buried forests are found at various depths ranging to 250 feet; but the evidence of a definite forest, peat or soil horizon between two distinct bodies of glacial detritus, is not clear. There is as yet no certainty that the sub-Aftonian or pre-Kansan till is present in the area we are considering, although it is very probable that it exists in the parts of the county covered with deep drift, in

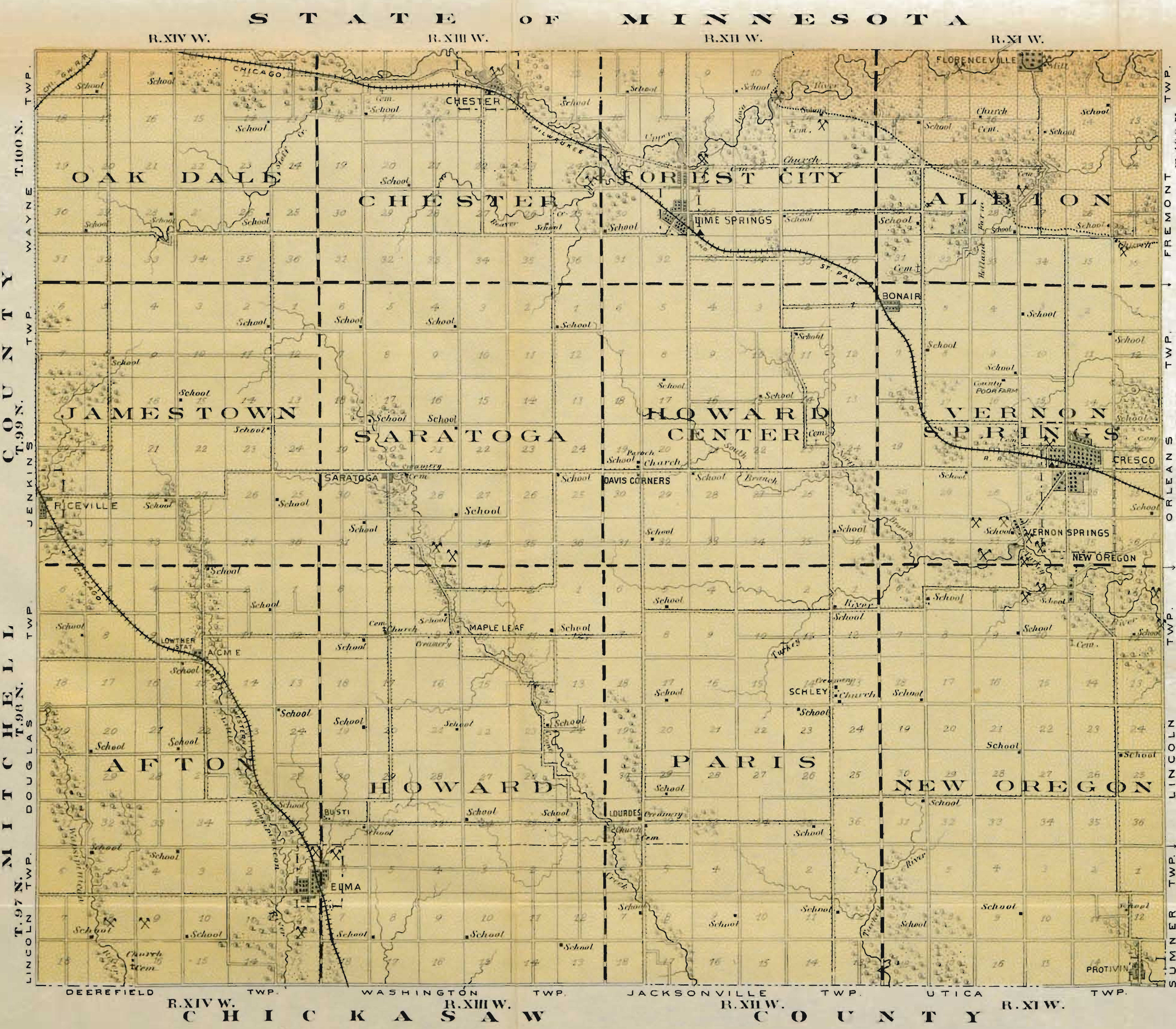
IOWA GEOLOGICAL SURVEY

MAP OF THE SUPERFICIAL DEPOSITS OF HOWARD COUNTY IOWA.

BY

SAMUEL CALVIN

1903.



Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

IOWAN DRIFT

KANSAN DRIFT OVERLAIN BY LOESS

Drawn and Engraved by The Huebinger Co. Davenport, Iowa.

Oak Dale, Jamestown, Afton and Howard townships, and in the southern parts of Paris and New Oregon. The Kansan till, overlain by a thin deposit of Iowan loess, is the surficial drift in a comparatively small area in the northeastern corner of the county, and over the larger area southwest of the loess margin it is present beneath the much later drift sheet, the Iowan. The physical characteristics of the two areas and the position of the boundary line between them have been previously discussed under the head of Topography. In the Loess-Kansan area the weathered ferruginous ferretto zone of the Kansan is seen along roadsides and in many other places, wherever rainwash has cut through the overlying loess. At the brick yard in Cresco the yellow Iowan, free from limestone pebbles, is used in brick making, but some of the excavations have gone down to the unweathered blue clay of the Kansan. A deep railway cut one and a half miles south of Elma reveals the Kansan drift in its unweathered phase. A few rods north of a wagon bridge which here spans the cut, the section shows:

		FEET.
3.	Yellow, unweathered Iowan till	6
2.	Old peaty soil developed in the intervals between the Kansan and the Iowan stages of glaciation	2
1.	Blue unweathered Kansan to bottom of the cut	15

There is here no ferretto zone at the surface of the Kansan; the organic material of the peaty soil bed was capable of more than counterbalancing any effects of oxidation which might have taken place before the Kansan surface was covered and protected from further change by the deposition of the Iowan drift. One-fourth of a mile south of the bridge there are a number of lenses of gray sand included in the blue Kansan clay, some of which are three feet in thickness and fifty feet in length. Though the hill in which the cut is made is one of the highest of the region, it shows none of the characteristics of a paha, that unique and interesting type of land forms so common at corresponding distances from the Iowan margin in Delaware, Jones, Linn and Cedar counties. When first seen from a distance it was confidently believed that it would prove to be a loess-covered pahoid ridge, but in the place of loess it is covered with a thin sheet of Iowan till and its surface is liberally sprinkled with large Iowan bowlders. The fresh Kansan till is here, as everywhere else in Iowa, a blue clay crowded with small pebbles, many of which are limestone. Greenstones are also common. Granites are relatively scarce, and none are as large as the third and fourth rate granites of the Iowan, even when first class bowlders are made to include everything above twelve feet in diameter. The earth taken out is piled on the west side of the Elma cut and covers an area of considerable width. In the few years of its exposure to the air, rains have concentrated the pebbles in a sheet over the surface, by washing away the fine clay in which the pebbles were imbedded. The dump, therefore, now corresponds in a small way to the initial stages of the condition which existed over hundreds of square miles in southwestern Iowa, before the loess was laid down. A sheet of residual gravel, sometimes fully six inches in thickness, conforming to the surface of the erosional hills and valleys, is widely distributed on weathered Kansan underneath the loess, in all the southwestern counties of the state. The fact is discussed and illustrated in the report on Page county. The dump near Elma affords an interesting and concrete illustration of the manner in which these residual gravels were developed.

Wherever there are exposures of the pre-Iowan surface of the Kansan drift, undisturbed by the later glaciation, the materials are found to be very much altered by weathering. The iron bearing constituents of all fine flour and other minute particles derived from wear of crystalline rocks, are completely oxidized, and as a result the normal blue of the unaltered clay is changed to deep reds and browns. The fresh Kansan is always rich in limestone flour and small limestone pebbles. In the weathered zone all the calcareous material, except the larger pieces of limestone, have been dissolved and leached out by descending ground waters. Many of the small granite bowlders have crumbled into minute fragments which are distributed among the other loose materials near the surface, others are ready to fall to pieces under the application of the slightest force.

Buchanan Gravels.—Beds of old weather stained gravels resting on Kansan, and overlain by Iowan drift, were first recognized as a distinct Pleistocene deposit in Buchanan county, Iowa. Later investigations show these gravels to be extensively developed all over the northeastern part of the state. Howard county has its share, and they are known to be present in the adjacent parts of Minnesota. On one side of the Loess-Kansan border they are generally covered with Iowan drift, on the other side, as is strikingly illustrated around Colesburg in Delaware county, they are overlain by loess. The gravels occur principally in two situations. They are either on the high plateaus and ridges, or they are in the river valleys; and there are very marked differences between the upland and the valley deposits. The upland gravels are distinguished by the presence of coarser and less perfectly assorted materials. Cobbles and bowlders of all sizes up to ten or twelve inches in diameter, are found indifferently mixed with pebbles and fine sand, and many of the larger erratics show glacial planing and striation on one or more sides. While the gravels have all the characteristics of deposits made in flowing water, it is certain that the planed and striated cobbles have not been rolled or transported very far. The valley gravels, on the other hand, are quite uniform as to the size of the pebbles. It is seldom that any of the material exceeds three-fourths of an inch in diameter. The usual size is about half an inch, and the great body of the valley phase is composed of well rounded, polished, silicious pebbles. Cross bedding is more common in the upland, than in the valley gravels.

A very typical example of the upland phase of the Buchanan gravels occurs in the large gravel pit in the southwest ¼ of section 27, Vernon Springs township, about midway between Cresco and Vernon Springs. The material is very rusty from the complete alteration and oxidation of the iron bearing constituents of a large proportion of the crystalline pebbles. In places the amount of iron present is sufficient to cement the gravel into a firm conglomerate. The granites, embracing small bowlders up to eight or ten inches in diameter, are decayed and fall to pieces when taken from their surroundings. Every feature of the deposit indicates age. The gravel at this point has been used extensively for road material. The pit is fully fifteen feet in depth, but it does not show the whole thickness of the deposit. The location is near the edge of an area of thin Iowan drift. There is practically no stripping, nothing above the deposit but a bed of humus stained, gravelly soil. In the adjacent parts of section 34 and in section 35 there are esker-like knobs of Buchanan gravels which have not been worked.

A feature of the landscape which should probably have been described under the head of Topography, is a conspicuous esker of Buchanan gravel which stands out prominently near the center of the southwest 1/4 of section 27, Albion township (Fig. 14).

FIG. 14. Esker of Buchanan gravel in the southwest quarter of section 27, Albion township, surrounded by Iowan drift. The hills of the Loess-Kansan margin are seen in the distance.

It is located inside the Iowan area and is surrounded by a thin sheet of Iowan drift, but the Loess-Kansan margin seen in the distance in figure 14, is less than one-fourth of a mile away. The attenuated edge of the Iowan glaciers probably overflowed it, for it has no loess such as mantles all surfaces in the neighborhood which were not covered by the Iowan ice. In general the forms assumed by deposits of these gravels suggest that they had their origin in trains or sheets of outwash from the margin of the melting Kansan ice. Occurrences of such deposits illustrating the upland phase of the gravels are numerous. It may be sufficient to mention as typical examples, the beds seen along the western edge of section 7, Vernon Springs township, and those in sections 31 and 32 of Howard Center township.

The valley phase of the Buchanan gravels is much more extensively developed than the upland phase. Every stream valley that served as a drainage course when the Kansan ice was melting, is bordered throughout its whole length with trains and terraces of ferruginous gravel in which the pebbles are comparatively small and of uniform size. The terrace on the south side of the river at Florenceville and that on which the village of New Oregon is located have already been mentioned. For some miles above Chester there is a wide, well marked, continuous terrace occupying an area of several hundred acres. The great beds of valley gravels about Le Roy, Minnesota, which the Chicago, Milwaukee & St. Paul railway has used so extensively for ballasting its line, are but part of the enormous gravel trains which floods from the melting Kansan ice strewed continuously along the valley of the Upper Iowa. The same valley gravels are found the whole length of Crane creek and along the branches of the Wapsipinicon, in the southwestern part of the county. In the southeast ¼ of section 1, northern part of New Oregon township, there is a terrace of the valley gravels, some parts of which are cemented into a firm conglomerate. Cementation is not uncommon in other localities.

Genesis of the Gravels.—The Kansan ice was thick, and it melted rapidly, especially when the shrinking margin was gradually retreating through northern Iowa. Large floods of water, capable of transporting great loads of material, flowed outward over the surface which had but a short time previously been vacated by the waning ice. Heavy bodies of the ice must have lingered in the lowlands and valleys long after the hill tops were laid bare, and the re-entrant sinuses in the ice margin, corresponding in position to the higher lands, were drainage channels accommodating torrential streams which were hemmed in by banks of ice. These streams carried material of all grades of fineness up to cobbles and bowlders several inches in diameter. Some of the larger bowlders found in the deposits may have been floated by detached blocks of ice. The heavy material was not carried far, however. With the glacial markings uneffaced in some cases, it was dropped on the accumulating bars of sand and gravel which the overloaded streams deposited before their exit from the ice canyons. Such imperfectly assorted accumulations, now found on the higher grounds, constitute the upland phase of the Buchanan gravels.

As soon as the upland streams emerged from their ice canyons, the waters sought the lower levels and gathered in the unobstructed valleys beyond the ends of the ice lobes. Before they reached the valleys the heavier material had all been deposited; only the smaller, well rounded and easily transported pebbles were carried, and it is of these that the valley phase is made up. The upland gravels were laid down near the most northerly points of the ice margin, not far from where the streams originated. The valley gravels give evidence of having been transported farther, and they may have been deposited at distances of several miles from the southern extremeties of the lobes of ice which occupied the lower grounds.

IOWAN STAGE.

Iowan Till.—Fully nineteen-twentieths of the area of Howard county is covered with Iowan drift. Where this drift is present in sufficient force to disguise the pre-Iowan topography, the region is a plain modified by only slight relief (Fig. 5). No loess is present, but large granite bowlders (Fig. 15) are prominent features of the landscape. The fresh Iowan till is yellow in color and carries quite a large amount of lime carbonate even at the surface. Among the pebbles limestones and greenstones are rare. The bowlders are coarse-grained and light colored, and it is a surprising fact that in all northeastern Iowa approximately three-fourths of the entire bulk of the Iowan erratics represent but one type of granite which might all have come from a single locality. Iowan bowlders are large and numerous as compared with bowlders in the Kansan drift, but the variety and number of rock species are far greater in the Kansan than in the Iowan.

Over parts of Howard county lying southwest of the Loess-Kansan boundary, the Iowan drift is thin or even absent. As would be expected the thin spots are near the margin where the ice became attenuated and the movement approximated zero.

FIG. 15. Iowan bowlder in the southwest quarter of section 22, Jamestown township. Dimensions above ground are 20x12x9 feet.

The load of glacial detritus carried by the Iowan glaciers seems to have been very unequally distributed, and there must have been places where it was altogether wanting. Quite a large area of thin Iowan, or no Iowan, occurs along the Turkey river from section 31, Vernon Springs township, to section 1 of New Oregon. The original topography developed in the old rock surface by preglacial erosion, is but imperfectly masked by all the Pleistocene deposits. The tops and slopes of the hills are covered with loose fragments of the magnesian Devonian limestone (Fig. 6). The small amount of drift present is of the weathered Kansan type, and yet the surface is strewn with Iowan bowlders. A typical area of thin Iowan, where knobs and tors of Devonian limestone project through the drift, is found in section 14, Forest City township. Bowlders seem to be the only element of the Iowan drift ever deposited in the locality. Along Crane creek and the branches of the Wapsipinicon the later drift is so thin that the Buchanan gravels come practically to the surface in many places, and the same thing is true of the valley of the Upper Iowa above Chester. Taking the Iowan area as a whole, the distribution of the bowlders seems unaccountably irregular. There are some belts and patches,—as near the center of Jamestown township and in the southern sections of Howard Center,—where the rounded blocks of northern granite are liberally sprinkled over the surface, and again there are areas of miles in extent in which scarcely a trace of a bowlder can be discovered.

Iowan Loess.—The fine, yellow, pebbleless clay called loess forms a mantle of approximately uniform thickness over that portion of the surface of the old eroded Kansan drift which lies outside of the Iowan margin. All that part of the county upon which the Iowan ice advanced, up to the edge and terminus of the glaciers, is free from loess. The loess is fresh and young as compared with the weathered, leached and otherwise altered drift upon which it rests. In this part of the state, it seems very clear, the loess is of the same age as the Iowan till, and was derived from it by some process of transportation outward from the terminal border of the Iowan glaciers. In Mitchell county, as well as in many other counties in Iowa, there are thin deposits of a loess that is younger than the Iowan, probably of the age of the Wisconsin drift. Near Peoria, Illinois, Wisconsin loess is as strongly developed as is the Iowan in Howard county. Loess may indeed, have been formed during any age of the Pleistocene. Along the Missouri river the process of loess deposition seems to be still active. Wherever found, and to whatever age it may belong, it is wholly unlike drift or alluvium,—unlike any glacial, aqueo-glacial, or aqueous deposit known. The origin of the loess of the Mississippi and Missouri valleys has long remained a puzzle to careful and thoughtful geologists. On account of its unique structure, peculiar distribution and fossil contents, the trend of opinion among the best informed students of loess problems is, today, toward the view that it is an aeolian deposit, that winds have been the active agents in its transportation and deposition.

ALLUVIUM.

In Howard county alluvial deposits are very meager. If the Turkey river between Vernon Springs and the east line of the county be left out of consideration, it may be said that throughout the Iowan area the stream valleys in their present aspects and relations are young. There are here no true valleys of erosion, no flood plains, no notable deposits of river silt. Along the Upper Iowa, or Oneota river, east of Foreston, the valley is old, it is well widened out in places, and there are occasional narrow fringes of alluvial plains between the stream and the bluffs. The same is true, but to a more limited extent, of the old part of the Turkey river valley east of Vernon Springs.

THICKNESS OF THE PLEISTOCENE DEPOSITS.

The sheets of drift and other Pleistocene deposits vary greatly as to thickness. There are two areas where the indurated rocks come near to the surface. One is northeast of a line drawn from Chester to the middle of the eastern boundary of New Oregon township; the other is at Elma and in the country south and west of that locality. All the quarries and rock exposures are in these two areas. At all the quarries the stripping consists largely of disintegrated limestone. Not infrequently the overlying soil, as shown in figure 13, fails to attain the dimensions of a distinct layer. So far as data could be collected, the Pleistocene reaches its greatest thickness in Jamestown township and in the territory immediately surrounding it. Well drillers report that limestone has been struck at 200 feet in the southern part of Oak Dale township, but some wells end in drift at a depth of 300 feet. The well of John P. Thelen in Jamestown township found water in gravel at 252 feet from the surface. Near the center of section 30, Jamestown township, a well in process of boring was down 130 feet and still in blue clay. "Chips of an old rotten log" were reported from a well in the northern part of Jamestown, at a depth of 250 feet. The Pleistocene clays are therefore known to range in thickness from practically zero in the northeastern part of the county, to more than 300 feet in Jamestown and contiguous parts of adjacent townships.

Soils.

The soils of Howard county rank with the best to be found in Iowa. There are (1) loess soils which are limited to the small Kansan area in the northeast corner of the county. Where the surface slopes are comparatively gentle, there are no better soils than those developed on the loess. The loess is a fine, porous, calcareous clay, free from sand on the one hand and bowlders on the other. In many respects it makes an ideal soil. It absorbs and retains moisture well. The roots of plants easily penetrate it to great depths. Where the surface is relatively level, a very fine, fertile, brownish, easily tilled loam develops on its surface. On the steeper slopes, however, the loess erodes easily, the vegetable loam is washed away as fast as it accumulates, and steep sided gullies are cut by surface drainage. A hard, stiff, intractable soil usually results from the fact that surface erosion continually exposes fresh loess which has not been modified by the growth and decay of plants, by burrowing animals, by frosts or other mellowing agencies. Fortunately, in the county, the area where soils of the quality last described occur, are small. The farms of the Loess-Kansan area give every evidence of generous production. The porosity and depth of the loess render it capable of successful cultivation in times of drought, such as prevailed in 1901, or during periods of excessive rainfall as in 1902.

(2) There are some small areas of rich, mellow, alluvial soil in the valley of the Upper Iowa river, between Foreston and the eastern border of the county, and a small number of acres of the same type of soil occur in the valley of the Turkey. east of Vernon Springs. Above Chester on the Upper Iowa, at New Oregon on the Turkey, and at many points along the streams draining the southwestern part of the county, the Buchanan gravels come near enough to the surface to produce (3) a gravelly and sandy soil. Buchanan gravels play an important part as subsoils over extensive areas along the branches of the Wapsipinicon in southwestern Howard, giving perfect underdrainage to the surface loams. The typical characteristics of these areas are well illustrated in the level plain from one to two miles west of Elma.

(4) By far the most important of the soil types occurring in Howard county is that which is developed on the Iowan drift. The area in which this type is found is many times larger than that of any other type, and its fertility, ease of cultivation, and lasting qualities set it far above any other. The atmosphere, the rains and frosts of the changing seasons, the growth and decay of plants, the work of the burrowing gophers and ants and earth-

worms, have all combined to produce a deep, rich, black, warm soil of ideal quality; and this soil is spread over a surface so level and unbroken that farm machinery of every kind can be operated on its to the very highest advantage.

Unconformities.

Some interesting examples of unconformities are furnished by the geological formations of this part of Iowa. The first and most important is that between the Devonian and the Maquoketa shales. The overlap of the Devonian referred to at the beginning of this report, was a true transgression of the sea upon an eroded surface. The contact of the Devonian with the Ordovician is seen in only a few sections, and these are of limited extent; but the relative altitudes of the two formations at a number of points indicate that the Devonian was deposited on an uneven floor. One or two concrete illustrations will show the nature of the evidence on which conclusions are based. One-fourth of a mile south of the center of section 8, Albion township, magnesian limestone containing remains of fishes and Devonian brachiopods, occurs at a much lower level than that at which undoubted Maquoketa is found along the north line of the same section. At the bridge over the Turkey river near the northeast corner of section 12, New Oregon township,, the Devonian beds are continued down to the level of the water in the stream, while less than half a mile east of the county line Maquoketa shales rise fully twenty feet above the water. Furthermore the phase of the Maquoketa seen in the outcrop referred to is not that which belongs at the top of the formation. The difference in the relative altitudes of the river and the Ordovician strata at the bridge and at the springs a short distance below, cannot be accounted for by either the fall of the stream or the dip of the shales, but by irregularities in the surface on which the Devonian was laid down. Along the east line of section 13, Vernon Springs township, on the hill slope forming the south side of the valley of Silver creek, the Devonian occurs well up toward the top of the slope, and gives place to buff or ash colored Maquoketa about twenty-five feet above the bottom of the valley. On the north side of the valley Devonian rocks in place are exposed less than ten feet above the small flood plain. How much lower the Devonian may go is not known, for at this point there is no Maquoketa in sight. The other unconformities need only be mentioned without giving specific illustrations. The Kansan drift is unconformable on the rock surface upon which it rests; and the loess and Iowan drift are spread unconformably upon the old eroded surface of the Kansan.

ECONOMIC PRODUCTS.

Quarry Stone.

The northeastern part of Howard county is fairly well supplied with building stone. The Trenton limestone and the shaly limestone of the Maquoketa are both utilized in the vicinity of Florenceville. Figures 7, 8 and 9 illustrate the possibilities of the Trenton as a source of building material. At present the resources of this formation are undeveloped. The only place in the county where it has been quarried to any considerable extent, is at the Florenceville mill; but the Trenton can furnish inexhaustible supplies of a good grade of stone for rough masonry whenever the demand justifies the operation of quarries in this formation. The availability of the calcareous shales of the Maquoketa stage is illustrated at the quarry located one-fourth of a mile northeast of the center of section 8, Albion township (Fig. 10).

By far the greater part of the quarry stone produced in the county is obtained from strata of Devonian age; and practically all the quarries belonging to this age have been previously noted in the general discussion of the stratigraphy. Owing to the almost universal dolomitization of the local Devonian, the building stone from this formation in Howard county is greatly superior to that furnished by beds of corresponding age in the southern part of the Devonian area in Iowa. The beds are here thicker, they are less frequently broken by joints, and they yield less readily to the disintegrating effects of frosts and general weathering. The most important quarry in the county is that operated by Mr. John Hallman in the western part of the city of Cresco. The beds in this quarry are irregularly jointed in places, and the slickensided joint faces show the effects of crushing. In other parts of the quarry the crushing has been less energetic and destructive, and stones of fairly good dimensions may be taken out. The best layers are soft and easily cut. The product of the quarry includes rubble, range stone and a small amount of cut dimension stone. All the stone produced in the county is used in simply supplying the local demand, and the Hallman quarry has the preeminent advantage of proximity to the best local market. The Salisbury quarry (Fig. 13), Patterson quarry and the many other small quarries near Vernon Springs have not been worked to any noteworthy extent in recent years, although they are capable of furnishing a large amount of very excellent stone. There are at present no shipping facilities, and the local demand does not justify continuous operation.

The quarry at Foreston (Fig. 11), operated in the massive beds of the Productella zone, illustrates the differences in the thickness of beds and the lasting quality of the stone brought about by the process of dolomitization. Bedding planes are obliterated so that what would otherwise be a number of independent layers is blended into one heavy stratum. The quarry represented by figure 1, plate XIV, volume VIII, belongs to the same geological horizon as the quarry at Foreston. In one the joints and bedding planes divide the rock into numberless, small, shapeless pieces which are easily disintegrated; in the other it is possible to get massive blocks of porous but indestructible rock, suitable for the heaviest bridge piers and foundations.

The quarry in section 14, Forest City township, and that in section 24 of Chester are worked in beds corresponding to those in the upper part of the Salisbury and Patterson quarries at Vernon Springs. These beds are equivalent to those quarried at Raymond in Black Hawk county and on the bluff northwest of Littleton in Buchanan county. Other places where stone has been quarried in Howard county are section 33, Saratoga township, and the region about Elma. Of these various openings, the Croft quarry at Elma is at present the most important. All of these quarries in the southwestern part of Howard illustrate varying phases of the coarse, calcite bearing beds at Salisbury's mill (Fig. 12).

Not the least important of the sources of building stone in this part of the state, may be reckoned the numberless granite bowlders of the Iowan drift (Fig. 15). These vary in size up to great blocks twenty or thirty feet in diameter. The amount of indestructible building material present in the glacial bowlders, it would be difficult to estimate. Furthermore the material is ready to hand, requiring no long haulage, on practically every farm in the Iowan area.

Clays.

Howard county is not well provided with raw materials suitable for the manufacture of clay products. It is true that drift clays are widely spread and attain a very great thickness, but they are everywhere filled with such large numbers of pebbles and small cobblestones as seriously to interfere with their use as a basis for any extensive manufacturing enterprise. With suitable machinery for crushing the pebbles it is possible to use the yellow clay of the Iowan drift in making a good grade of structural brick. There is little possibility of using the blue Kansan clay on account of the fact that it contains many pebbles and fragments of limestone. The loess of Howard county is too rich in silica to be used with much success.

The most successful clay working plant in the county is that of the Cresco brick and tile works, owned by Wheeler and Marshall. The clay used is Iowan drift which is passed between rollers to crush the pebbles. The plant is equipped with a stiff mud, end cut Brewer machine having a capacity of 20,000 brick per day. A part of the product is passed through a Raymond re-press machine. In addition to brick the works turn out drain tile ranging from three to eight inches in diameter. The raw product is dried in sheds with little loss from checking. The burning is done in two round down-draft kilns. The plant is operated a little more than half of each year and turns out annually a very respectable amount of mechantable brick and tile.

There is a small brick yard north of the railroad in the eastern edge of Lime Springs. The location was rather unfortunately chosen, for the clay pit shows nothing but blue Kansan clay overlain by from fourteen inches to two feet of Buchanan gravel.

The clay is very pebbly and the pebbles were not crushed. As usual in the Kansan, some limestone fragments are present. The effort to make brick out of such materials was not very sucessful, and the plant was shut down at the time the locality was visited. If there are to be future attempts at brick making in the neighborhood of Lime Springs, the plant should be located at some point where there is a good supply of the yellow Iowan drift.

Lime.

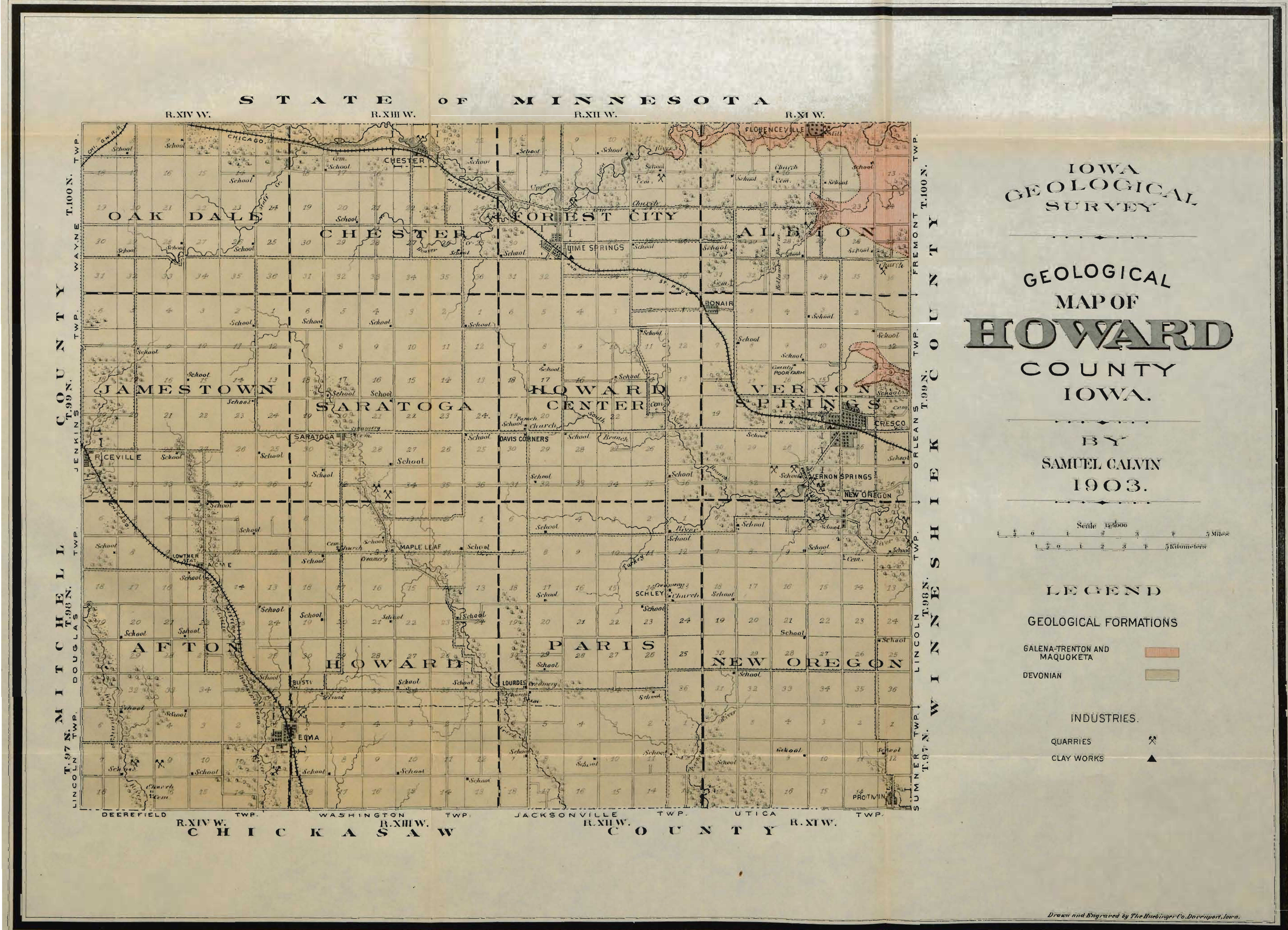
At present no lime is made in the county, but the dolomitic Devonian is capable of furnishing inexhaustible supplies of excellent material for lime burning. Some years ago lime kilns were operated at Vernon Springs and near Lime Springs. The lime made at Vernon Springs was reputed good; that made near Lime Springs is said to have been made from a non-dolomitic rock, which may explain the fact that it was not esteemed so highly. Large kilns at Dubuque and elsewhere, operated on a commercial scale, have driven the small producers out of the local market.

Road Materials.

The Devonian and Ordovician limestones of the county are inexhaustible resources from which supplies of crushed stone for macadamizing streets and roads may be drawn. Not much of this material has as yet been used. The city of Cresco has availed itself of the opportunities offered by readily accessible beds of limestone, and on a small plat of ground at the east end of the Hallman quarry it owns and operates a stone crusher to furnish the macadam used in making permanent street improvements. More widely distributed, more important and more generally useful than accessible ledges of limestone for purposes of road making, are the Buchanan gravels. These furnish material at once inexpensive and of the highest utility and lasting quality. They are everywhere, ready for use as soon as taken from the ground. Every neighborhood may have its gravel pit within easy hauling distance of any piece of road needing improvement.

Water Supplies.

Water for domestic and farm purposes is obtained from the permanent streams, from springs, from wells in gravel terraces, wells in the drift and wells bored into the limestones beneath the drift. Springs are most numerous along the valley of the Upper Iowa or Oneota river. In the Buchanan gravels above Chester water in unfailing abundance is reached at depths of from sixteen to twenty feet,—a little below the level of the water in the adjacent stream. In the region of deep drift in the southern part of Oak Dale, and the northern part of Jamestown township, all the wells, so far as could be ascertained, end in drift at depths varying from forty to 300 feet. In the southwest ¼ of section 10, Jamestown township, water was found in a layer of gravel beneath blue clay at a depth of 250 feet. Bands of water bearing sand and gravel, lying at various depths between beds of blue clay, are very commonly reported by well borers and seem to be quite universally distributed. Some of the more extensive occurrences of these deep lying sandsand gravels may possibly be of Aftonian age, but the railway cut south of Elma, described in this report, and numerous other drift sections throughout the state, show that it is no unusual thing for the Kansan till to include great lenses of stratified materials having all the characteristics of true aqueous deposits. In the northeastern corner of the county the mantle of loose materials is thin, the limestones lie near the surface, wells are bored into the rock, and water is found in fissures at varying depths. The city of Cresco obtains supplies of water from two drilled wells which do not exceed 200 feet in depth, the water coming from the base of the Maquoketa or the upper part of the Galena-Trenton. A deeper boring at Cresco is referred to by Norton, in volume VI of these reports, page 201, in these words: "The well at this place, owned by the Chicago, Malwaukee & St. Paul Railroad Co., is 1,158 feet deep. It was drilled about the year 1875, and has not been used for an unknown length of time." This well must have gone down some distance into the Saint Croix sandstone. Nothing was ascertained concerning the quality of the water which it furnished.


IOWA GEOLOGICAL SURVEY
GEOLOGICAL MAP OF
HOWARD
COUNTY
IOWA.
BY
SAMUEL CALVIN
1903.
LEGEND
GEOLOGICAL FORMATIONS
GALENA-TRENTON AND MAQUOKETA
DEVONIAN
INDUSTRIES.
QUARRIES
CLAY WORKS
STATE OF MINNESOTA
MITCHELL COUNTY
WINNESHIEK COUNTY
CHICKASAW COUNTY
R.XIV W.
R.XIII W.
R.XII W.
R.XI W.
T.100 N.
T.99 N.
T.98 N.
T.97 N.
OAK DALE
CHESTER
FOREST CITY
ALBION
JAMESTOWN
SARATOGA
HOWARD CENTER
VERNON SPRINGS
AFTON
HOWARD
PARIS
NEW OREGON
CHESTER
FLORENCEVILLE
LIME SPRINGS
BONAIR
CRESCO
RICEVILLE
SARATOGA
DAVIS CORNERS
VERNON SPRINGS
NEW OREGON
MAPLE LEAF
SCHLEY
LOURDES
ELMA
PROTIVIN
WAYNE TWP.
JENKINS TWP.
DOUGLAS TWP.
LINCOLN TWP.
FREMONT TWP.
ORLEANS TWP.
LINCOLN TWP.
SUMNER TWP.
DEERFIELD TWP.
WASHINGTON TWP.
JACKSONVILLE TWP.
UTICA TWP.
Drawn and Engraved by The Huebinger Co. Davenport, Iowa.

Water Powers.

Water power has been developed along the Upper Iowa or Oneota river at a number of points in Howard county. There is a well built and excellently equipped mill at Florenceville; and above Florenceville we find the Foreston, Lime Springs, Glen Roy and Chester mills, all busy in supplying the needs of the local or more distant markets. On the Turkey river there are two mills, the Sovereign mill about a mile above Vernon Springs and the Salisbury mill at the village named. There was formerly a mill at New Oregon, but some years ago the property was wrecked by high water and no effort has been made to restore it.

SUMMARY.

Howard will always rank as one of the great agricultural counties of the state. Apart from her soils her chief geological resources are found in inexhaustible deposits of road materials forming widely distributed beds of sand and gravel, in excellent lime burning rocks which the conditions of the market may some time make it possible to utilize, and in an inexhaustible supply of a fair quality of building stone. As fuel becomes scarcer, and cheaper methods of generating electrical energy are developed, the water powers will be gratly improved and their energy utilized in a variety of profitable ways. There is nothing to indicate the possibility of successful mining of any kind. It is certain that there are no workable coal beds in the county, and there are no probabilities of finding either gas or oil no matter how far borings may be carried. Various lines of manufacturing may possibly be established with success; but the chief resources of the county will always lie in her excellent soils, her chief industry will be their cultivation. It is to the development of the possible productiveness of the soil that the attention of the most earnest and most thoroughly trained minds should be directed. To energy expended in this direction it is possible to predict satisfactory rewards.